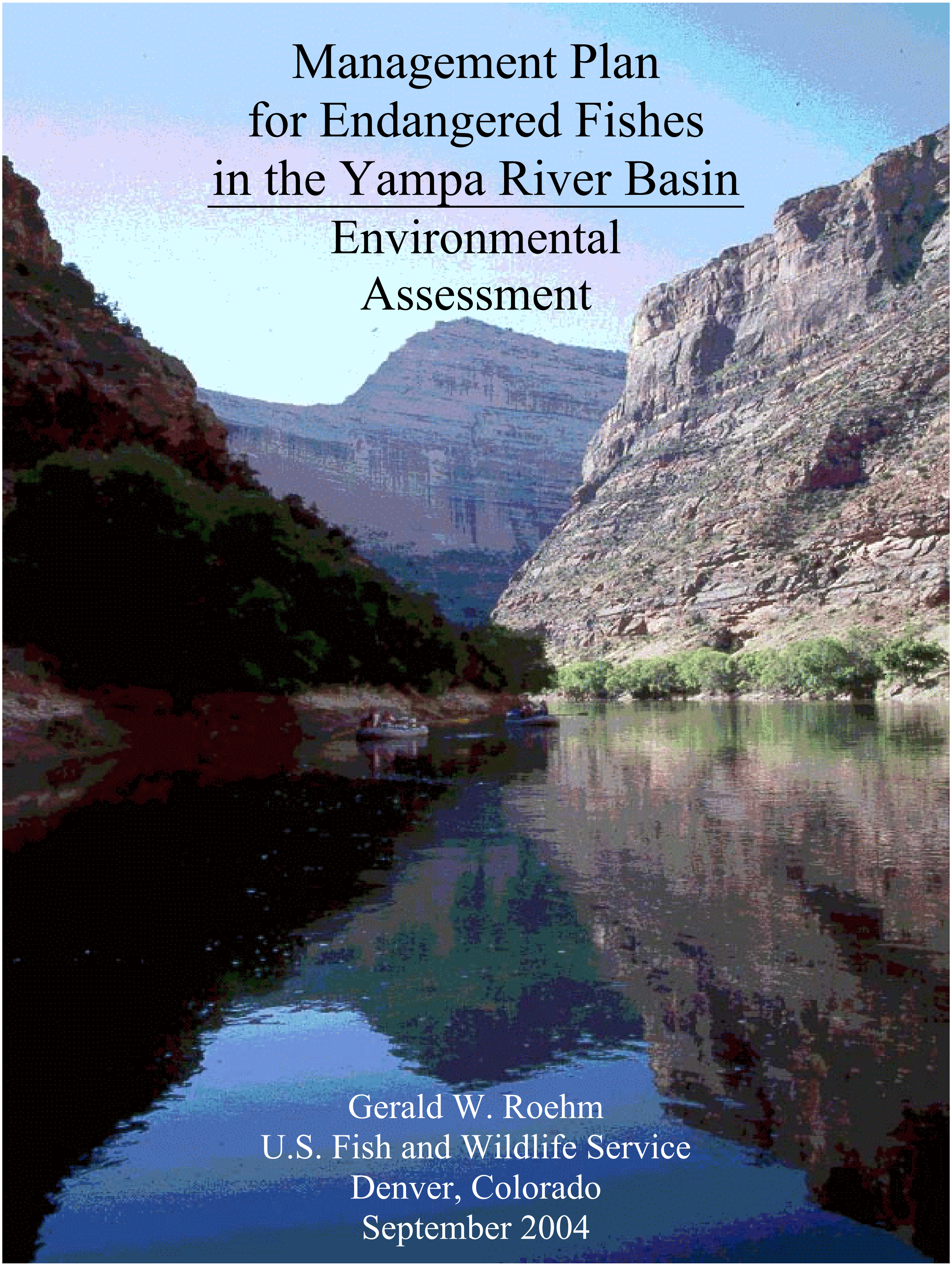

Management Plan for Endangered Fishes in the Yampa River Basin

Environmental Assessment

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Denver, Colorado

September 2004

Recommended citation:

Roehm, G. W. 2004. Management plan for endangered fishes in the Yampa River Basin and environmental assessment. U.S. Fish and Wildlife Service, Mountain-Prairie Region (6). Denver.

MANAGEMENT PLAN FOR ENDANGERED FISHES IN THE YAMPA RIVER BASIN AND ENVIRONMENTAL ASSESSMENT

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Final

Upper Colorado River Endangered Fish Recovery Program
Project No. C-9

September 2004

ACKNOWLEDGMENTS

This management plan was funded by the Recovery Implementation Program for Endangered Fish Species in the Upper Colorado River Basin. The Recovery Program is a joint effort of the U.S. Fish and Wildlife Service, U.S. Bureau of Reclamation, Western Area Power Administration, states of Colorado, Utah, and Wyoming, Upper Basin water users, environmental organizations, the Colorado River Energy Distributors Association, and the National Park Service.

The author wishes to thank Ray Alvarado, Bob Muth, Tom Nesler, John Shields, George Smith; Ray Tenney and Robert Wigington for their significant contributions to the content of this management plan. In addition, the author would like to acknowledge Margot Zallen for her extensive legal and editorial review; Patty SchraderGelatt for her valuable input to and review of the management plan; and Kathy Wall, Debbie Felker, Amie Hart and Ellen Szczesny, Recovery Program staff, for their administrative, editorial, and technical assistance. Thanks also go to the Yampa River Basin Partnership which provided a forum for local public participation in project planning and development; Ayres Associates and Pioneer Environmental Services for technical assistance; and members of the Yampa Project Management Team and Yampa Programmatic Biological Opinion Workgroup, who provided their advice and technical expertise: Ray Alvarado, Dan Birch, Greg Espegren, Paul Flack, Bill Haffner, Don Halffield, John Hamill, Tom Iseman, Eric Kuhn, Henry Maddux, Dave Mazour, Dan McAuliffe, Bob Muth, Brian Nazarenus, Tom Nesler, Tom Pitts, Bob Plaska, John Shields, George Smith, Ray Tenney, Brent Uilenberg, and Robert Wigington.

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ACRONYMS, ABBREVIATIONS AND UNITS OF MEASURE

AF – Acre-feet/Acre-foot; a volume of water = 43,560 cubic feet (~325,000 gallons)

CBM – Coal bed methane (also CBNG)

CBNG – Coal bed natural gas (also CBM)

CDNR – Colorado Department of Natural Resources

CDOW – Colorado Division of Wildlife

CDPHE – Colorado Department of Public Health and Environment

CEQ – Council on Environmental Quality

CFR – Code of Federal Regulations

CFS – Cubic feet per second

CRDSS – Colorado River Decision Support System

CRWCD – Colorado River Water Conservation District

CULR – Consumptive Use and Loss Report

CWA – Clean Water Act

CWCB – Colorado Water Conservation Board

DNM – Dinosaur National Monument

EA – Environmental Assessment

EIS – Environmental Impact Statement

EPA – Environmental Protection Agency (also USEPA)

ESA – Endangered Species Act

GOCO – Great Outdoors Colorado

KAF – Thousand acre-feet

KCFS – Thousand cubic feet per second

MAF – Million acre-feet

mg/L – Milligrams (10^{-3} gram) per liter; e.g., concentration of solutes in water

µg/L – Micrograms (10^{-6} gram) per liter; e.g., concentration of solutes in water

$\mu g/m^3$ – Micrograms (10^{-6} gram) per cubic meter; e.g., concentration of pollutants in air

µm – Micrometers (10^{-6} meter) or microns; e.g., size (diameter) of particulates in air

µS/cm – Microsiemens per centimeter ($S = ohm^{-1}$); a measure of electrical conductivity

NEPA – National Environmental Policy Act

NNSP – Nonnative Stocking Procedures

ACRONYMS, ABBREVIATIONS AND UNITS OF MEASURE (continued)

NPS	– National Park Service
PBO	– Programmatic Biological Opinion
RIPRAP	– Recovery Implementation Program Recovery Action Plan
RM	– Rivermile(s)
RMBO	– Rocky Mountain Bird Observatory
TDS	– Total dissolved solids (salts)
UCRRIP	– Upper Colorado River Recovery Implementation Program
UDWR	– Utah Division of Wildlife Resources
USBR	– U.S. Bureau of Reclamation
USDI	– U.S. Department of the Interior
USEPA	– U.S. Environmental Protection Agency (also EPA)
USFS	– U.S. Forest Service
USFWS	– U.S. Fish and Wildlife Service
USGS	– U.S. Geological Survey
WDEQ	– Wyoming Department of Environmental Quality
WGFD	– Wyoming Game and Fish Department
WQCC	– (Colorado) Water Quality Control Commission

EXECUTIVE SUMMARY

This management plan assists in the recovery of four endangered fish species as water depletions from the Yampa River Basin continue to serve human water needs in Colorado and Wyoming. The plan anticipates that depletions will increase to meet projected future human needs. In this plan, we quantify current depletions, as well as future depletions projected through 2045. The plan describes specific management actions to promote recovery of the listed species in the face of those depletions and criteria by which to measure the success of management actions.

The U.S. Fish and Wildlife Service (Service) lists the humpback chub (*Gila cypha*), bonytail (*G. elegans*) Colorado pikeminnow (*Ptychocheilus lucius*), and razorback sucker (*Xyrauchen texanus*) as endangered under the Endangered Species Act (ESA). Endemic to the Colorado River Basin, populations of these fishes had declined throughout their historic range due largely to habitat loss or degradation and introduction of competitive and predatory nonnative fish species.

The ESA requires that "recovery goals" be developed which provide "objective, measurable criteria which, when met, would result in a determination...that the species be removed from the list" and that site-specific recovery measures be developed. Each of the endangered fish species can be downlisted and subsequently delisted when all of the species-specific recovery criteria have been met. Final recovery goals for these species were published in August 2002. These goals include both numerical population criteria and habitat criteria and specifically address five listing/delisting factors: (1) present or threatened destruction, modification, or curtailment of its habitat or range; (2) overutilization for commercial, recreational, scientific, or educational purposes; (3) disease or predation; (4) inadequacy of existing regulatory mechanisms; or (5) other natural or manmade factors affecting its continued existence.

It is the policy of the Services to "[d]evelop cooperative approaches to threatened and endangered species conservation that restore, reconstruct, or rehabilitate the structure, distribution, connectivity and function upon which those listed species depend." Moreover, this policy requires the Services to "[d]evelop and implement agreements among multiple agencies that allow for sharing resources and decision making on recovery actions for wide-ranging species" (59 FR 34274; USFWS and NMFS 1994). Consistent with this intent, the Upper Colorado River Endangered Fish Recovery Implementation Program (Recovery Program) was established in 1988 with the goal of recovering the endangered fishes in the face of current and foreseeable future water depletions from the Upper Colorado River Basin. The Recovery Program developed and periodically updates a Recovery Action Plan that identifies specific measures to benefit the endangered fishes. These measures address the listing factors by providing and protecting instream flows, acquiring and managing habitat, constructing fish passage facilities, managing competitive and predatory nonnative fish, propagating and stocking endangered fishes into their historic habitats, and monitoring the status of endangered fish populations and their habitats.

The Yampa River is important to these endangered fishes, and the Service designated critical habitat for all four species within its lower reaches. Razorback sucker and Colorado pikeminnow spawn in the lower reaches of Yampa Canyon, which also harbors one of five remaining populations of humpback chub in the Upper Colorado River Basin. Peak flows are particularly important in creating and maintaining spawning habitats for the endangered fishes in the Yampa River, as well as nursery habitats for Colorado pikeminnow and razorback sucker in the Middle Green River downstream from the Yampa River confluence.

This management plan is intended to offset impacts to the endangered fishes due to existing and certain new depletions from the Yampa River Basin in Colorado and Wyoming. It anticipates that new depletions would result from direct-flow diversions, small tributary reservoirs and/or modest expansion(s) of existing reservoir(s). Although the plan considers impacts to the Green River due to depletions from the Yampa River, it does not address impacts of depletions from the Green River mainstem or any of its tributaries other than the Yampa River. Total existing and future depletions, representing an estimated 15% of the average annual yield of the Yampa at its confluence with the Green River, are expected to have a modest impact on peak flows. The Recovery Program will implement management actions described below to offset depletive impacts to base flows, minimize impacts to peak flows, and reduce impacts due to competitive and predatory nonnative fishes.

To implement these actions, the U.S. Fish and Wildlife Service (Service) and the States of Colorado and Wyoming, as partners in the Recovery Program, intend to sign a Cooperative Agreement to implement the various elements of the plan. The Recovery Program will incorporate these elements in its Recovery Action Plan, establish schedules to initiate and complete recovery actions described herein, and fund and implement these actions, subject to appropriations, except as noted below.

The Service recommended that daily average base flows in the Yampa River not fall below 93 cubic feet per second (cfs) at Maybell from August through October at any greater frequency, magnitude or duration in the future than had occurred historically (Modde et al. 1999). Historical records show that base flows at Maybell occasionally have fallen below the 93-cfs flow target in July, as well. Therefore, the base-flow period was expanded to include July. Moreover, uncertainty with respect to the winter flow needs of the fishes prompted the Service to extend the base-flow period through the winter months (November-March) with a 33% buffer added to the 93-cfs flow target (i.e., 124 cfs) during this period, which is consistent with observed hydrologic patterns.

This plan proposes to augment base flows in accordance with these recommendations to compensate for impacts to base flows due to depletions. Hydrologic modeling demonstrated that 7,000 acre-feet (AF) would satisfy base-flow needs in all but the driest years. In developing this plan, 13 base-flow augmentation alternatives were identified and evaluated. Alternatives include both structural and non-structural options, which rely upon one <u>or more</u> of the following six potential sources:

1. Supply interruption contracts (3,700–7,000 AF)
2. Instream flow water rights (up to 7,000 AF)
3. Steamboat Lake (2,000–7,000 AF by lease)
4. Elkhead Reservoir (3,700–7,000 AF by lease, exchange and/or enlargement)
5. Stagecoach Reservoir (1,300–7,000 AF by lease, exchange and/or enlargement)
6. New tributary reservoir(s) (up to 1,300 AF total)

Structural alternatives include both single-source and multiple-source options. Each of 13 action alternatives was subjected to a preliminary feasibility analysis, using the following evaluation criteria: (1) ability to meet base-flow needs; (2) estimated cost; (3) impacts on Colorado State Parks and water-related recreation therein; (4) impacts on agriculture; (5) impacts on peak flows; and (5) legal and institutional constraints. Based on this analysis, an enlargement of Elkhead Reservoir provided the most reliable supply at a moderate cost, with minimal impacts to parks and water-related recreation, agriculture and peak flows. Steamboat Lake and Stagecoach Reservoir alternatives, as well as combinations with these reservoirs, were somewhat less reliable, and caused greater impacts to park and recreation and peak flows.

Among the non-structural options, supply interruption contracts provide greater potential reliability than instream flow water rights, because the latter would be junior to all prior water rights. However, supply interruption contracts face significant legal and institutional hurdles and, if adjudicated for instream use, that use may not enjoy the same seniority as the underlying irrigation right. Base-flow augmentation will not interfere in any way with Yampa Basin water users exercising their water rights.

Nonnative fishes adversely impact the endangered fishes and other native species by feeding upon and/or competing with them. Management actions herein include measures to reduce the impacts of sportfish such as northern pike, smallmouth bass and channel catfish, on the endangered fishes. Measures include screening reservoirs to prevent escapement of sportfish to the river, implementing stocking regulations to preclude stocking nonnative species to any water from which escapement to the river is likely, and active removal of nonnative fishes from the river. While some species may be lethally controlled in some river reaches, Yampa Basin residents desire to maintain healthy in-basin sport fisheries. Therefore, sport fish such as northern pike and smallmouth bass removed from the river will be placed in publicly accessible ponds and reservoirs, subject to availability, that are hydrologically isolated from the river, screened or otherwise modified to preclude escapement.

The Recovery Program will identify and evaluate high-priority flooded bottomland habitats along the Middle Green River between Ouray and Jensen, Utah, acquire an interest in the best habitats, and improve their habitat value by removing levees to allow spring floods to inundate floodplain depressions, overflow channels, backwaters and oxbows, which serve as nursery habitats for Yampa/Green river populations of razorback sucker and Colorado pikeminnow.

The Recovery Program has determined that existing diversion structures within critical habitat on the Yampa River (Echo Park to Craig, Colorado) do not impede passage of Colorado pikeminnow during their seasonal migrations. These diversions are upstream from reaches utilized by razorback sucker and humpback chub. The Recovery Program will develop guidelines to ensure that any new diversion structures and dams accommodate fish passage and to reduce impacts of maintaining diversion structures within critical habitat. The Recovery Program also will determine whether Colorado pikeminnow enter and become stranded by existing Yampa River diversions by sampling ditches after the irrigation season. If Colorado pikeminnow are found stranded in any of the ditches, the Recovery Program will implement measures, such as installing screens near ditch intakes, to reduce or eliminate such incidental take due to existing structures.

The Recovery Program developed the following genetic management goals for endangered fishes: (1) prevent immediate extinction; (2) conserve genetic diversity through recovery efforts to establish viable wild stocks by removing or significantly reducing factors that caused the population declines; (3) maintain the genetic diversity of captive-reared fish; and (4) produce genetically diverse fish for augmentation efforts. Supplemental stocking of the Middle Green/Lower Yampa razorback sucker population is a high priority of the Recovery Program. Restoring bonytail populations in Lodore Canyon (Green River) and Echo Park (Yampa River) through stocking also is a high priority.

Separate performance criteria will be developed for each of the management actions described in this plan to 1) ensure that they are implemented in a timely manner, 2) evaluate their effectiveness in accomplishing their stated objectives, and 3) determine if and to what extent they contribute to the recovery of the endangered fishes. Monitoring also will be necessary to determine how well the endangered fishes are doing, and assess their prospects for recovery. The Recovery Program will ascertain the status of endangered fish populations at 5-year intervals. Based on the results of monitoring, the Recovery Program will re-evaluate the effectiveness of its recovery actions and may modify those actions (i.e., using adaptive management) as it deems necessary and appropriate. The Recovery Program will implement any modifications or additions to its recovery actions and bear any costs resulting therefrom. The Service intends to review the status of the listed fishes at least once every 5 years, based on species' population point estimates and trend data provided by the Recovery Program, to determine if these species should be "downlisted" from endangered to threatened status or "delisted" (i.e., removed from the list). Recovery goals for each of the four endangered fish species state that recovery will be achieved "when management actions and associated tasks....have been implemented and/or completed to allow genetically and demographically viable, self-sustaining populations to thrive under minimal ongoing management and investment of resources." Genetic and demographic viability criteria which must be met for each species are identified in their respective recovery goals.

The Service intends to enter into a cooperative agreement with the states of Colorado and Wyoming for the purpose of implementing this plan. To comply with ESA requirements for this federal action, the Service will initiate an intra-Service Section 7 consultation. The expected product of this consultation will be a programmatic biological opinion (PBO) for the Yampa River Basin that will determine whether implementation of this plan along with the impacts of existing and foreseeable future depletions are likely to jeopardize threatened and endangered species or adversely modify their designated critical habitats.

The PBO also is expected to address incidental take for certain activities not covered under previous biological opinions, because these activities either predate the ESA or were otherwise exempted from ESA section 7 consultation requirements (e.g., non-federal actions). The PBO will quantify anticipated levels of incidental take and specify reasonable and prudent measures (RPM) and Terms and Conditions which, if implemented, would minimize or preclude such take. Full compliance with the RPM would exempt these activities from the take prohibitions of ESA section 9.

MANAGEMENT PLAN

INTRODUCTION

Purpose and Need

The Colorado River Basin encompasses 245,000 square miles in the southwestern United States. Roughly the same size as the Columbia River Basin, its annual average yield is less than 7% that of the Columbia. Moreover, demand for water in this arid region in many years is greater than the volume of water available. In November 1922, the Colorado River Compact was signed, allocating 15 million acre-feet (MAF) of the Colorado River equally between the Upper Basin states (Colorado, New Mexico, Utah and Wyoming) and Lower Basin states (Arizona, California and Nevada). Under the Compact the Upper Basin must deliver an annual average of 7.5 MAF to the Lower Basin during any 10-year period (Gelt 1997). Lake Powell, a 27-MAF reservoir behind Glen Canyon Dam, allows Upper Basin states to store water during periods of surplus to meet their Compact obligations to the Lower Basin during periods of drought. Glen Canyon Dam effectively serves as the boundary between Upper and Lower basins.

Dammed and diverted for irrigation, municipal and industrial consumption, the Colorado River and many of its major tributaries have become a series of lakes and cold, clear tailwaters. Large dams attenuate peak flows, increase base flows and significantly reduce or modify the habitats to the detriment of many endemic fish species adapted to warm, turbid, free-flowing rivers. Native species evolved under a highly variable hydrologic regime, characterized by seasonally high flows in spring and dramatically lower flows in late summer and fall. Reservoirs and their tailwaters also create conditions conducive to propagation of highly valued nonnative game fishes, several species of which were stocked or escaped to the river in the past. These and other nonnative fishes inadvertently introduced to the basin compete with and/or prey upon many native fish species.

The Endangered Species Act (ESA) was enacted in 1973 to identify and conserve threatened and endangered species. It requires the U.S. Fish and Wildlife Service (Service) to consider the status of, and potential threats to, plant and animal species in determining whether it is appropriate to list these species as threatened and endangered. Section 4(a)(1) of the ESA identifies <u>five threat factors</u>: (1) present or threatened destruction, modification, or curtailment of its habitat or range; (2) overutilization for commercial, recreational, scientific or educational purposes; (3) disease or predation; (4) inadequacy of existing regulatory mechanisms; or (5) other natural or manmade factors affecting its continued existence. If one or more of these factors is met for any species, that species should be listed as endangered or threatened. Pursuant to this section, the Service listed as endangered two fish species endemic to the Colorado River Basin: bonytail (*Gila elegans*) and razorback sucker (*Xyrauchen texanus*). Two other endemic Colorado River species, the humpback chub (*Gila cypha*) and Colorado squawfish (*Ptychocheilus lucius*), now referred to as the Colorado pikeminnow, originally were listed on March 11, 1967 (32 FR 4001) and were among the first species listed under the ESA on June 4, 1973 (38 FR No. 106). Populations of these fishes have declined throughout their historic range due largely to habitat loss or degradation. Nonnative fish represent a significant impediment to recovery.

Section 4(c)(2) requires that the status of listed species be reviewed at least once every 5 years to determine if species should be "delisted" (i.e., removed from the list), "downlisted" from endangered to threatened status, or reclassified from threatened to endangered status. Section 4(f)(1) requires the Service to develop and implement "recovery plans" that incorporate "a description of such site-specific management actions as may be necessary to achieve the plan's goal for the conservation and survival of the species; [and] objective, measurable criteria which, when met, would result in a determination....that the species be removed from the list." Such management actions and recovery criteria must address the five threat factors considered in listing the species.

The ESA further prohibits federal agencies from taking any actions that are likely to jeopardize the continued existence of listed species or adversely modify their designated critical habitats. Section 7 outlines procedures for interagency cooperation in conserving federally listed species and their designated critical habitats. Section 7(a)(1) requires federal agencies to carry out programs within their authority to conserve listed endangered and threatened species. Section 7(a)(2) and ESA regulations require these agencies to consult with the Service whenever actions they authorize, fund or carry out "may affect" listed species. Section 7(b)(4) provides a process to permit federal actions that may result in "taking" some individuals of listed species incidental to that action, although such incidental take cannot be to the extent that it jeopardizes the continued existence of the species.

Section 9 defines "take" to mean "harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or attempt to engage in any such conduct." "Harm" is defined under the ESA as "...an act which actually kills or injures wildlife. Such act may include significant habitat modification or degradation where it actually kills or injures wildlife by significantly impairing essential behavioral patterns including breeding, feeding or sheltering." "Harassment" is defined as "...an intentional or negligent act or omission which creates the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavioral patterns which include, but are not limited to, breeding, feeding, or sheltering" (50 CFR § 17.3). Section 9(a)(1) and ESA regulations prohibit taking members of any listed species unless such take is specifically permitted.

The *Interagency Cooperative Policy for the Ecosystem Approach to the Endangered Species Act* (59 FR 34274; USFWS and NMFS 1994) directs the Services to "[d]evelop cooperative approaches to threatened and endangered species conservation that restore, reconstruct, or rehabilitate the structure, distribution, connectivity and function upon which those listed species depend." This policy requires the Services to "[d]evelop and implement agreements among multiple agencies that allow for sharing resources and decision making on recovery actions for wide-ranging species." Consistent with this intent, the governors of Wyoming, Colorado and Utah, Secretary of the Interior, and Administrator of the Western Area Power Administration signed a cooperative agreement in 1988 establishing the Upper Colorado River Endangered Fish Recovery Implementation Program (Recovery Program) in response to concerns within the regulated community that enforcement of the ESA in the Upper Colorado River Basin would impact allocation and use of water under existing state laws and interstate compacts. In 2001, this agreement was extended to 2013. The goal of the Recovery Program is to recover the endangered fishes in the face of current and future water depletions from the Upper Colorado River Basin by offsetting the impacts of these depletions.

On October 15, 1993, the *Section 7 Consultation, Sufficient Progress, and Historic Projects Agreement* (Section 7 Agreement) and *Recovery Implementation Program Recovery Action Plan* (RIPRAP) were finalized. The Section 7 Agreement was revised March 8, 2000 (Appendix A). The RIPRAP is updated annually. The Section 7 Agreement refined and clarified the framework for conducting consultations under Section 7 of the ESA on certain impacts of current and future water depletions in the Upper Basin and established procedures to determine if there has been sufficient progress in the recovery of the four listed fishes to enable the Recovery Program to continue to serve as a reasonable and prudent alternative for these depletions under Section 7.

The RIPRAP outlines specific recovery actions, including such measures as acquiring and managing aquatic habitat and water, re-operating existing reservoirs to provide instream flows for fishes, constructing fish passage facilities, controlling nonnative fishes, and propagating and stocking listed fish species. It also stipulates which entity is responsible for taking action, when these actions would be undertaken, and how they would be funded. The RIPRAP has been reviewed and updated annually since 1993.

One RIPRAP element, under the FY 2002 Green River Action Plan: Yampa and Little Snake Rivers, subsection I.A.2., is to develop a management plan for the Recovery Program in the Yampa Basin. This element calls for: (1) developing and implementing a public involvement plan for the Basin (ongoing), (2) updating estimates of human water needs in the Basin (completed 1998), (3) estimating the low-flow needs of fishes and identifying impediments to fish passage on the Yampa River below Craig (completed 1999), (4) carrying out hydrologic analyses to identify and evaluate flow augmentation needs and strategies (ongoing), (5) installing, operating and maintaining stream gages (ongoing), and (6) developing and implementing an aquatic management plan to reduce nonnative fish impacts, while providing sportfishing opportunities (approved in 1998 and initiated in 1999).

In this context, the purpose of this Yampa River Management Plan is to promote recovery of four listed endangered fish species as water is depleted from the river to serve projected human needs in the Yampa River Basin through the year 2045. This plan is intended to promote the recovery of these species by supporting and facilitating needed management actions specifically identified in the recovery goals. This plan provides a synoptic summary of current and anticipated future depletions, identifies management actions believed necessary to recover the listed fishes in consideration of these depletions and other environmental stressors, and describes specific recovery actions to be taken under this plan and criteria by which to measure their success.

This plan also is needed to address the impacts of activities not covered under existing biological opinions pursuant to Section 7 of the ESA, including non-federal actions which required no federal authorization or funding and for which no habitat conservation plans were developed pursuant to ESA Section 10. It also covers federal actions (i.e., authorization and/or funding) prior to enactment of the ESA and, therefore, not subject to any prior Section 7 consultation. To this end, this plan incorporates measures to identify, quantify and, if necessary, minimize incidental take due to water diversions, as well as state-managed recreational fisheries, in the Yampa Basin. It addresses the impacts of existing projects that currently deplete water from the Yampa River but for which no consultation had been initiated to date, and projects whose depletions fall within a defined increment of future depletions, as well as other potential impacts to the endangered fishes, including take.

Setting

The Yampa River Basin covers roughly 8,000 square miles, or 7% of the Upper Colorado River Basin (108,000 square miles), in northwest Colorado and south central Wyoming (Figure 1). Headwater tributaries of the Yampa River arise along the Continental Divide and the White River Plateau above 11,000 feet elevation, descending more than 6,000 feet to its confluence with the Green River near the Colorado-Utah state line. The Yampa River contributes about the same average annual water volume as the Green River above its confluence with the Yampa. Flaming Gorge Dam, located on the Green River about 65 rivermiles (RM) upstream from the Yampa River confluence, impounds a 3.8-MAF reservoir, reducing peak flows and elevating base flows in the Green River downstream from the dam.

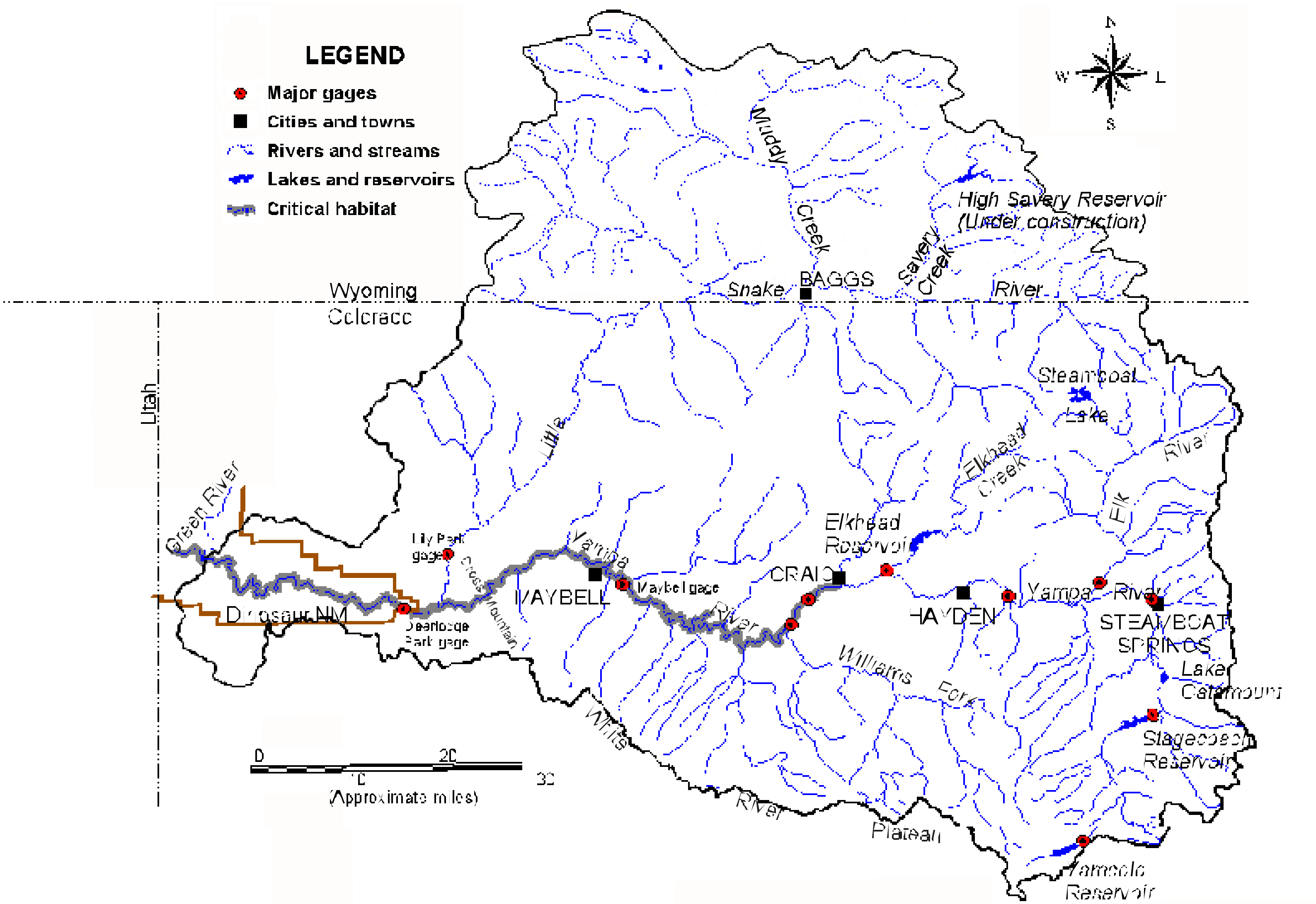


Figure 1. Map of the Yampa River Basin

The seasonal hydrograph of the Yampa River has not been substantially modified by large dams and reservoirs or large out-of-basin diversions. The Yampa River is the only stream of its size in the Upper Colorado River Basin in which spring peak flows have changed relatively little since water development began near the turn of the 20th Century. Spring peaks result from melting snowpack accumulated at higher elevations during the winter. Spring runoff typically begins as early as mid-March and wanes no later than mid-July, with peak flows at Maybell occurring between April 25 and June 19 (Figure 2). However, more than 60% (57 of 94 occurrences) of these occurred within a 3-week period (May 10–31), during which period more than one-fourth of the average annual discharge passed the Maybell gage.

A typical spring snowmelt hydrograph consists of three distinct segments: (1) ascending limb, (2) peak, and (3) descending limb. Each of these segments serves a specific function to maintain the aquatic habitats essential for the endangered fishes, initiate pre-spawning and post-spawning migrations, cue spawning behavior, and transport larval fish to nursery habitats downstream. However, snowmelt at lower elevations can produce early minor peaks prior to onset of the major peak, and severe thunderstorms occasionally produce transient peaks in the hydrograph during the summer.

From 1916 through 1998, the highest flow recorded at the Maybell gage was 24,400 cfs which occurred on May 17, 1984, while the lowest peak flow (3,180 cfs) was recorded on June 5 and June 10, 1977. Flow maxima from 6,000 to 12,000 cfs occurred at Maybell in 56 out of 83 years (67%) with an average recurrence interval of 1.5 years (Figure 3). Peak flows greater than 12,000 cfs occurred in 9 of 83 years (11%), while peaks less than 6,000 cfs occurred in 18 of 83 years (22%). Flows as high as 32,000 cfs have been recorded by the gage at Deerlodge Park, 5 RM downstream from the confluence of the Little Snake River, the largest tributary to the Yampa.

Peak flows are particularly important for transporting sediment that creates and maintains suitable spawning habitats for the endangered fishes in the Yampa River, as well as numerous backwaters and floodplain depressions along the Green River from Jensen to Ouray, Utah. These floodplain habitats serve as nurseries for the Colorado pikeminnow and razorback sucker, critical to survival of larvae (Andrews 1978, 1986; Elliott et al. 1984; O'Brien 1987). These relatively quiet, warm, shallow habitats allow smaller fish to escape predation and grow more rapidly than in the more rigorous environment of the main channel. Rapid growth is the key to their survival and eventual recruitment into adult populations. Recovery goals for the Colorado pikeminnow and razorback sucker (USFWS 2002c,d) require establishment and maintenance of self-sustaining populations of these species in the Green River. Adequate, suitable spawning and nursery habitats are essential to recovery of Yampa/Green River populations of these fish species (Day & Crosby 1997; Holden 1978, 1980; Muth et al. 2000; Rakowski & Schmidt 1996; Schmidt 1996; Tyus 1987; Tyus & Karp 1991; Wick 1997). Therefore, the peak flows that provide these habitats are critical to recovery.

The Yampa River not only contributes as much water as the Green River, but also provides a more natural shape to the hydrograph downstream from their confluence (Figure 4). The hydrographs in Figure 4 were derived by averaging daily flow data across the concurrent period of record for the three gages (1982–1994). They show that the hydrograph at Jensen, on average, approximates the sum of the hydrographs at Greendale and Deerlodge. They also demonstrate the differences between the highly regulated Green River hydrograph (Greendale) and a relatively unregulated Yampa River hydrograph (Deerlodge).

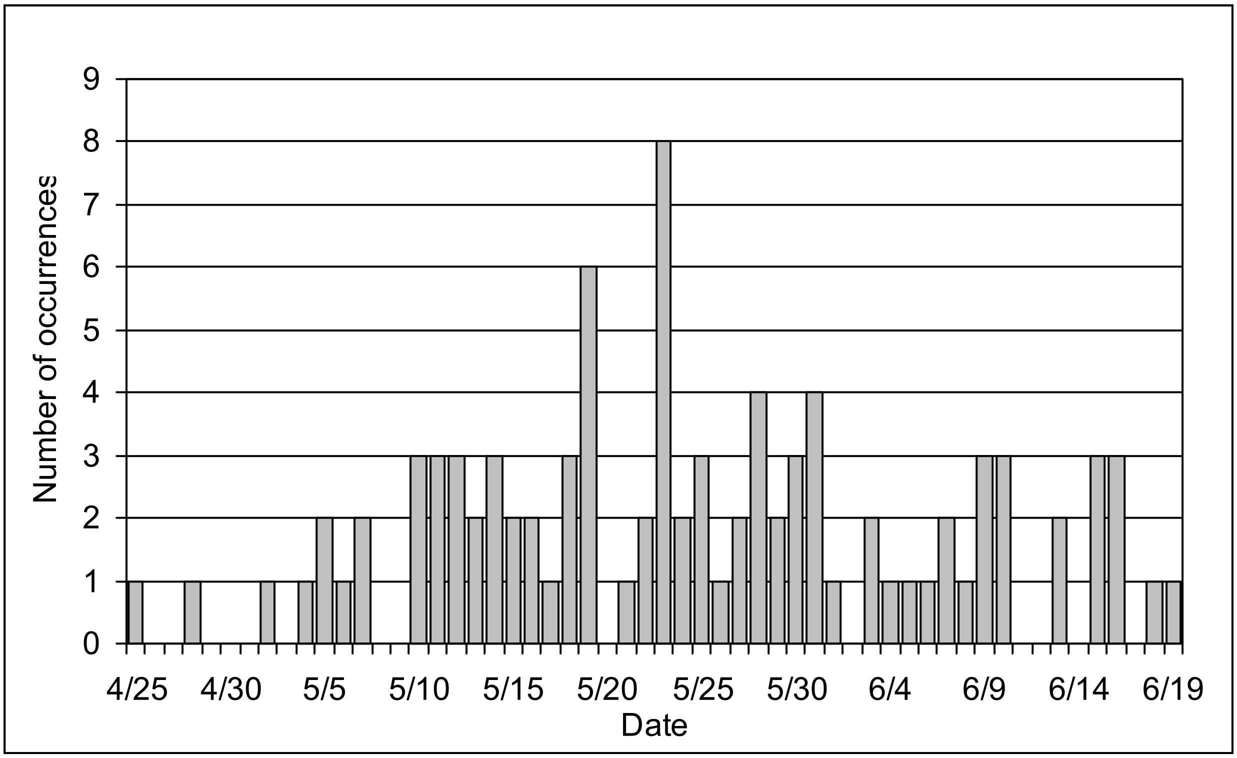


Figure 2. Temporal distribution of annual flow maxima ($N = 94^{a}$) at the Maybell gage (1916–1998)
[a] Maxima occurred more than once in some years.

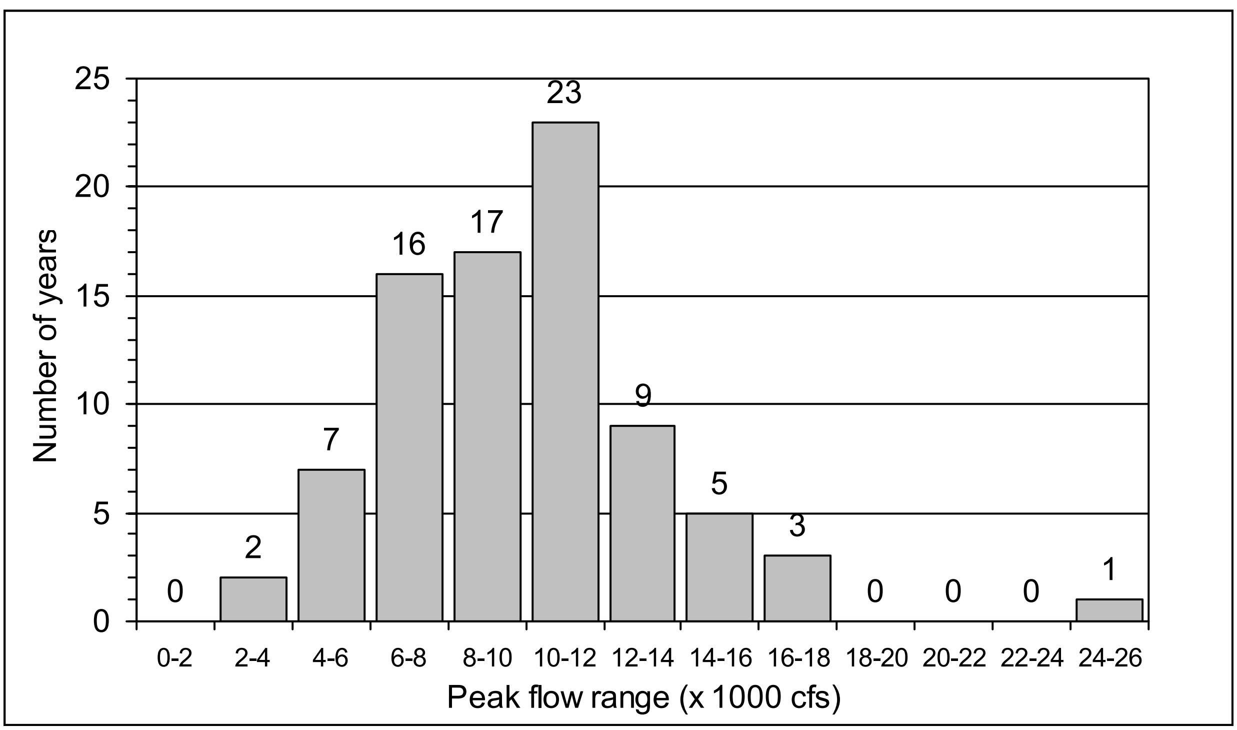


Figure 3. Magnitude and relative frequency of annual flow maxima ($N = 83$) at the Maybell gage (1916–1998)

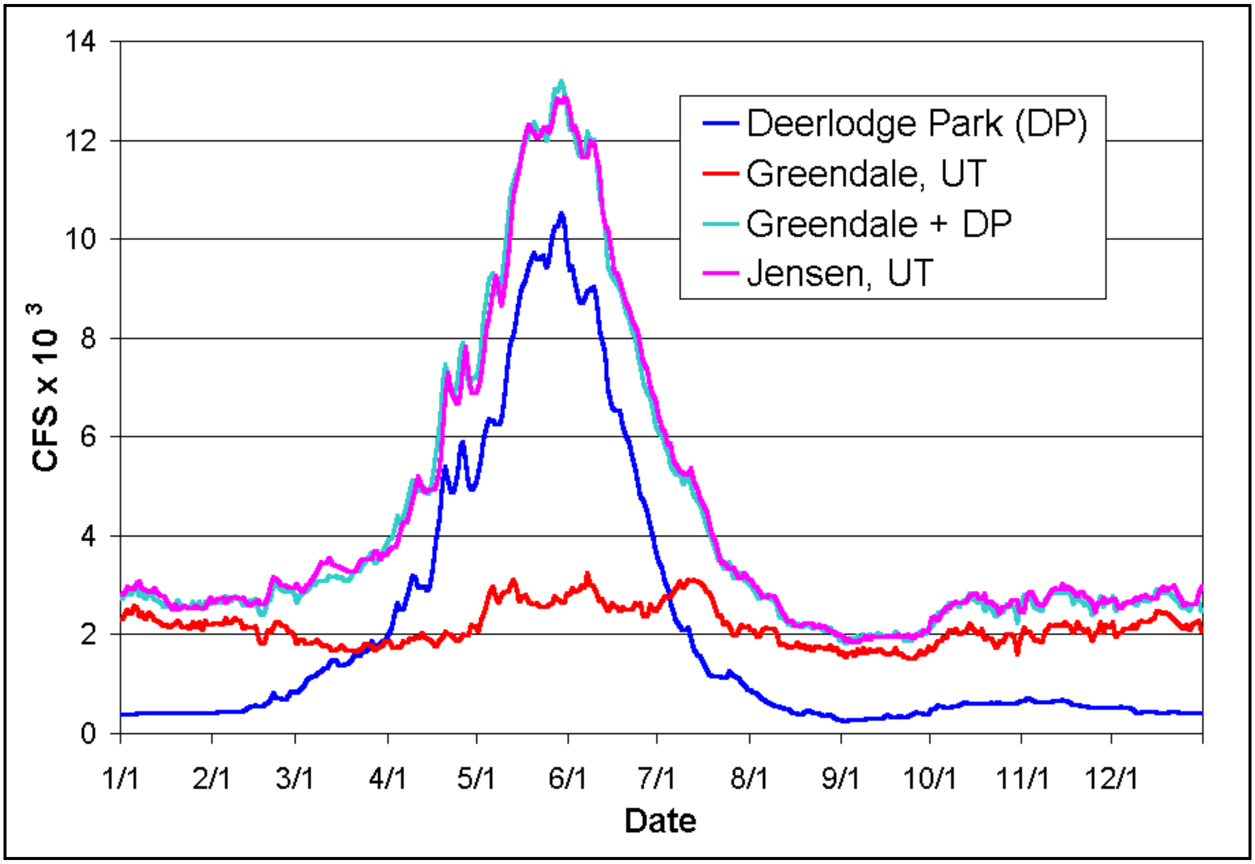


Figure 4. Comparison of average annual hydrographs for the Yampa River at Deerlodge Park and the Green River at Greendale and Jensen, Utah (1982–1994)

In contrast to spring flows, the lowest flows typically occur from August through October, with the lowest recorded flows generally occurring in September. Although the Yampa River has not been impounded by large mainstem dams, naturally low river flows in late summer and early fall are exacerbated by diversions for agriculture, electric power generation, and municipal and industrial uses. Annual flow minima at the Maybell gage averaged 137 cfs during the period 1916–1998, but had fallen as low as 2 cfs during this period (1934). Intra-annual variation is very high; there is a 73-fold difference between the averages of annual flow minima (137 cfs) and maxima (10,000 cfs).

Inter-annual variation also is high. For example, during 1984, the wettest year of record, 2.22 MAF of water passed the Maybell gage, almost twice the average annual discharge of 1.15 MAF. In contrast, during 1977, the driest of the 90 years that were modeled, the Maybell gage measured only 345,000 acre-feet (AF), less than one-third the annual average. However, patterns of precipitation during any year may be at least as important as the total precipitation throughout the year in determining low stream flows. Inadequate rainfall during the irrigation season, even after an average or better snowpack, can exacerbate low-flow conditions as natural spring peak flows wane and irrigation demand increases. Conversely, wet conditions during the irrigation season, even after a lower than average snowpack, can alleviate low-flow conditions.

Base flows also are important for maintaining populations of the endangered fishes. Generally, riffle habitats are shallow, well oxygenated, free of fines, and highly productive in macroinvertebrate biomass. Because they are shallow, riffles also are sensitive to changes in stream flow; Modde et al. (1999) found that available riffle habitat declined rapidly below 93 cfs. During lower flows, larger fishes may abandon ephemeral shallows and retreat into deeper, more persistent, though less productive, pools. Colorado pikeminnow are less mobile at this time (Modde et al. 1999); therefore, their ability to pass through shallow riffles is not critical to their survival. However, higher summer temperatures and overcrowding combined with a reductions in their food supply could affect their viability. Adequate base flows also are needed to freshen pools and moderate temperatures.

The Little Snake River is the largest tributary to the Yampa both in terms of watershed area and volume of discharge. The Little Snake River subbasin, including about 1,331 square miles (35%) in Wyoming, encompasses roughly half of the total watershed area upstream from the Deerlodge Park gage on the Yampa River. However, its average annual discharge at Lily Park is only 27% (428,000 AF) of the average annual discharge of the Yampa River at Deerlodge Park. The Lily Park gage is located on the Little Snake River 9 RM upstream from its confluence with the Yampa River, or 14 RM upstream from the Deerlodge Park gage. Annual flow maxima at Lily Park have ranged from a low of 865 cfs in 1934 to as much as 13,400 cfs in 1984, with a 76-year average peak of 4,607 cfs (1922–1997). During this period, flow maxima at Lily Park ranged from 20% to 57% of their respective peak flows at Deerlodge Park [1] with an average of 32%. The Little Snake River also contributes a significant quantity of sediment, considered important for building and maintaining spawning bars and nursery habitats for the endangered fishes in Yampa Canyon and the middle Green River (Andrews 1978, 1986; Elliott et al. 1984; Muth et al. 2000; O'Brien 1987; USDI 1998).

Moreover, the Middle Green River, which extends from the confluence of the Yampa River downstream to the confluence of the White River near Ouray, Utah, is ecologically inseparable from the Lower Yampa in that the Green River not only benefits from the flows of the Yampa River, but also benefits Yampa River populations of the endangered fishes by providing them important nursery habitats from which fish are recruited as sub-adults into the Yampa River.

Flaming Gorge Dam, operated by the U.S. Bureau of Reclamation (USBR) primarily for irrigation water supply and power generation since 1964, diminishes spring peak flows, while increasing base flows during the remainder of the year. However, this plan is not intended to, nor will it, mitigate the impacts of the dam on endangered fishes. Nevertheless, the Green River downstream from the Yampa River is the product of both rivers (Figure 4). Therefore, for the Middle Green River, this plan recognizes the impacts of the dam, as well as the opportunities it affords for flow management in the Green River, both above and below the Yampa River. Water can be released from Flaming Gorge to reinforce or extend the peak flow of the Green River below the Yampa confluence. By increasing base flows, the dam can partially offset impacts to the Green River due to depletions from the Yampa. However, the dam cannot mitigate depletion impacts to the Yampa River itself. Moreover, re-operation of Flaming Gorge Dam to mitigate its impacts on the endangered fishes in the Green River and support their recovery will be addressed in a separate biological opinion and, therefore, its re-operation is not part of this plan.

[1] Comparison of annual flow maxima. Prior to 1982, daily flows at Deerlodge Park were synthesized as the sum of gaged flows at Maybell and Lily Park. Flow maxima at Lily Park did not necessarily occur on the same day as flow maxima at Deerlodge Park.

Status and Current Distribution of Endangered Fish Species

An endangered species is defined by the ESA as "any species which is in danger of extinction throughout all or a significant portion of its range..." Implicit in the ESA definitions of threatened and endangered and in the principles of conservation biology is the need to consider the following in the development of recovery goals:

Genetics: numbers are too low to maintain genetic viability
Demographics: populations are small and declining (i.e., mortality exceeds recruitment)
Population redundancy: populations are too few, scattered or concentrated
Threats: persistent threats are significant (as identified in the five listing factors)

In August 2002, the Service issued final recovery goals for the four listed Colorado River fishes to amend and supplement existing recovery plans for these fishes (USFWS 2002a-d). These recovery goals not only identify demographic criteria (e.g., distribution, population size, mortality and recruitment) that must be achieved to recover the four endangered Colorado River fishes (Table 1), but also prescribe management actions that specifically address the five listing factors of ESA Section 4(a)(1). These recovery goals state "[r]ecovery is achieved when management actions and associated tasks [to minimize or remove threats associated with the five listing factors] have been implemented and/or completed to allow genetically and demographically viable, self-sustaining populations to thrive under minimal ongoing management and investment of resources." Some of the prescribed management actions are species-specific and, in some cases, subbasin-specific. Others are more general in nature and/or basin-wide in scope. The following 11 actions are applicable to the Yampa/Green River populations of the endangered fishes, with the species to which each action applies shown in brackets [ ]:

1. Re-establish populations with hatchery-produced fish [bonytail and razorback sucker].
2. Provide and legally protect habitat (including flow regimes necessary to restore and maintain required environmental conditions) necessary to provide adequate habitat and sufficient range for all life stages to support recovered populations [all].
3. Investigate habitat requirements for all life stages and provide those habitats [bonytail].
4. Minimize entrainment of subadults and adults in diversion canals [Colorado pikeminnow].
5. Ensure adequate protection from overutilization [all].
6. Ensure adequate protection from diseases and parasites [all]
7. Regulate nonnative fish releases/escapement into the main river, floodplain, tributaries [all].
8. Control problematic nonnative fishes as needed [all].
9. Minimize risk of increased hybridization among *Gila* spp. [humpback chub and bonytail].
10. Minimize risk of hazardous-materials spills in critical habitat [all].
11. Provide for the long-term management and protection of populations and their habitats beyond delisting (i.e., conservation plans) [all].

The management actions relevant to each species are identified in each of the species descriptions which follow. Each of these management actions is addressed in this plan in the context of the **DESCRIPTION OF THE PROPOSED ACTION** beginning on page 18.

Table 1. Current status of four endangered Colorado River fish species and demographic criteria required to downlist/delist (Page 1 of 2)

Humpback Chub	Wild Adult Population Estimates	To Reclassify from "Endangered" to "Threatened" (Downlisting)	To Remove from Endangered Species List (Delisting)
Upper Basin	– Black Rocks: 1,000 – Westwater Canyon: 2,200–4,700 – Cataract Canyon: 500 – Yampa Canyon: ~400 – Desolation/Gray Canyons: ~1,500–1,700	• Five self-sustaining populations are maintained over a 5-year period; AND • One of these is maintained as a core population greater than 2,100 [a] adults; AND	• Five self-sustaining populations are maintained over a 3-year period beyond downlisting; AND • Two of these are maintained as core populations greater than 2,100 [a] adults; AND
Lower Basin	• Grand Canyon: 2,000–4,000	• Maintained as a core population greater than 2,100 [a] adults	• Maintained as a core population greater than 2,100 [a] adults
Bonytail	**Wild Adult Population Estimates**	**To Reclassify from "Endangered" to "Threatened" (Downlisting)**	**To Remove from Endangered Species List (Delisting)**
Upper Basin	• Few wild bonytail exist; fish being stocked in Colorado, Green and Yampa rivers	• Maintain (after establishing) populations in Green River and UCR [b], each > 4,400 [a]; AND	– Maintain populations in Green River and UCR [b], each >4,400[a]; AND
Lower Basin	– Few wild bonytail exist	– Maintain (after establishing) genetic refuge [c] in suitable location; AND – Maintain (after establishing) two populations, each > 4,400 [a]	– Maintain genetic refuge [c] in a suitable location AND – Maintain two populations, each > 4,400[a]

[a] Numbers of fish are based on genetic and demographic viability for each species and refer to adult fish with adequate recruitment. Recovery will be achieved by minimizing or removing threats (e.g.,. controlling nonnative fish, protecting instream flows and developing conservation plans and agreements.)

[b] UCR = Upper Colorado River; SJR = San Juan River.

[c] A "genetic refuge" is a group of fish that, as a whole, represent a substantial portion of the genetic variability of the species (50,000 fish is the estimated number for the Lake Mohave genetic refuge).

Table 1. Current status of four endangered Colorado River fish species and demographic criteria required to downlist/delist (Page 2 of 2)

Colorado Pikeminno	Wild Adult Population Estimates	To Reclassify from "Endangered" to "Threatened" (Downlisting)	To Remove from Endangered Species List (Delisting)
Upper Basin	– Middle Green River: ~3,500 – Lower Green River: TBD – Upper Colorado River: 700 – San Juan River: ~20	– Green River and UCR populations maintained AND – Green River core population >2,600 [a]; AND – UCR [b] population >700 [d]; AND – SJR [b] establish 1,000 age-5+ fish [d]	– Green River and UCR populations maintained AND – Green River core population >2,600 [a]; AND – UCR [b] population >1,000 [d]; **<u>OR</u>** – UCR [b] population >700 [d] and SJR [b] population >800 [d] AND
Lower Basin	– No existing populations	– Reevaluate need for populations and, if needed, maintain (after establishing) two populations, each 2,600 [a]	– Maintain two populations, each >2,600*

Razorback Sucker	Wild Adult Population Estimates	To Reclassify from "Endangered" to "Threatened" (Downlisting)	To Remove from Endangered Species List (Delisting)
Upper Basin	– Middle Green River: <100 – Lower Green River: few – Upper Colorado River: few – San Juan River: few	– Establish and maintain populations in Green River > 5,800 [a] AND – **<u>EITHER</u>** UCR or SJR [b], > 5,800 [a]; AND	– Maintain populations in Green River and **<u>EITHER</u>** UCR or SJR [b], each population >5,800 [a]; AND
Lower Basin	– Lake Mojave: <10,000 (1999) – Lake Mead: ~ 400 (1999) – Verde River: <100 (1993)	– Maintain genetic refuge [c] in Lake Mohave; AND – Maintain two populations > 5,800 [a]	– Maintain genetic refuge [c] in Lake Mohave; AND – Maintain two populations > 5,800 [a]

[a] Numbers of fish are based on genetic and demographic viability for each species and refer to adult fish with adequate recruitment. Recovery will be achieved by minimizing or removing threats (e.g.,. controlling nonnative fish, protecting instream flows and developing conservation plans and agreements.)

[b] UCR = Upper Colorado River; SJR = San Juan River.

[c] A "genetic refuge" is a group of fish that, as a whole, represent a substantial portion of the genetic variability of the species (50,000 fish is the estimated number for the Lake Mohave genetic refuge).

[d] Numbers of fish based upon inferences about carrying capacity.

Humpback chub (*Gila cypha*)

This species is restricted to deep, swift, canyon-bound reaches of the Colorado, Green, Yampa and Little Colorado rivers. Six extant wild populations are known: (1) Black Rocks, Colorado River, Colorado; (2) Westwater Canyon, Colorado River, Utah; **(3) Yampa Canyon, Yampa River, Colorado**; (4) Desolation/Gray Canyons, Green River, Utah; (5) Cataract Canyon, Colorado River, Utah; and (6) the mainstem Colorado River in Marble and Grand Canyons and the Little Colorado River, Arizona (USFWS 2002a). The first five populations are in the Upper Colorado River Basin, while the sixth population is in the Lower Colorado River Basin (Table 1, Figure 5).

Large members of the minnow family (cyprinidae), adult humpback chub may reach up to 19 inches in total length and weigh up to 2.5 pounds. They require eddies and sheltered shoreline habitats maintained by high spring flows. High spring flows maintain channel and habitat diversity, flush sediments from spawning areas, rejuvenate food production, and deposit gravel and cobble used for spawning. Humpback chub spawn on the descending limb of the spring hydrograph at water temperatures typically from 16 to 22°C. Young require low-velocity shoreline habitats, including eddies and backwaters, that are more prevalent under base-flow conditions. Threats to the species include streamflow regulation, habitat modification, predation by nonnative fish species, parasitism, hybridization with other native *Gila*, and pesticides and other pollutants (USFWS 2002a).

Pursuant to Section 4(b)(2) of the ESA, on March 21, 1994 (59 FR 13374) the Service designated critical habitat for the humpback chub within its historic range, including the Yampa River from the boundary of Dinosaur National Monument (DNM) in T.6 N., R.99W., section 27 (6th Principal Meridian) to the Green River confluence in T.7N., R.103W., section 28 (6th Principal Meridian). The Yampa River humpback chub population is less mobile than those of the Colorado pikeminnow or razorback sucker; the humpback spends its entire life cycle within a relatively narrow home range in DNM from Yampa Canyon downstream to Whirlpool Canyon on the Green River.

The recovery goals for the humpback chub prescribe 10 management actions needed for recovery. Of these, the following eight are applicable to the Yampa/Green River complex:

1. Provide and legally protect habitat (including flow regimes necessary to restore and maintain required environmental conditions) necessary to provide adequate habitat and sufficient range for all life stages to support recovered populations.
2. Ensure adequate protection from overutilization.
3. Ensure adequate protection from diseases and parasites.
4. Regulate nonnative fish releases/escapement into the main river, floodplain, and tributaries.
5. Control problematic nonnative fishes as needed.
6. Minimize the risk of increased hybridization among *Gila* spp.
7. Minimize the risk of hazardous-materials spills in critical habitat.
8. Provide for the long-term management and protection of populations and their habitats beyond delisting (i.e., conservation plans).

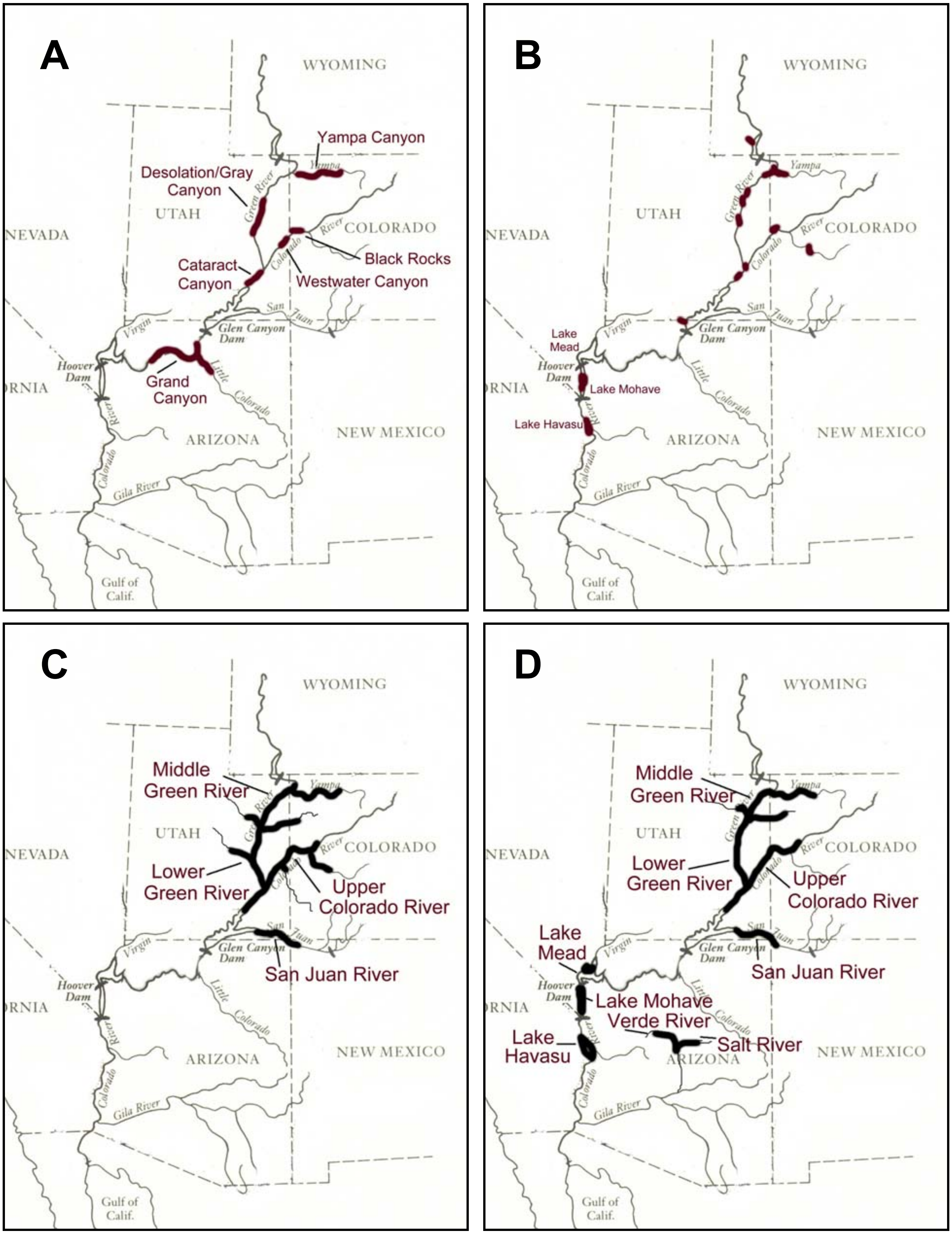


Figure 5. Distribution of **A**) humpback chub, **B**) bonytail, **C**) wild Colorado pikeminnow, and **D**) wild or stocked razorback sucker in the Colorado River Basin

Bonytail (*Gila elegans*)

Adult bonytail, large members of the minnow family (cyprinidae), may reach up to 22 inches total length and weigh up to 2.4 pounds. An unknown number of wild adults exist in Lake Mohave on the mainstem Lower Colorado River (i.e., downstream from Glen Canyon Dam), and there are small numbers of wild individuals in the Green River and Colorado River subbasins of the Upper Colorado River Basin (Figure 5). Historically, bonytail were common to abundant from Mexico to Wyoming in warm-water reaches of larger rivers in the Colorado River Basin. Little is known about its specific habitat requirements, because the bonytail was extirpated from most of its historic range prior to extensive fishery surveys. It is considered to be adapted to mainstem rivers where it has been observed in pools and eddies. Similar to other closely related *Gila* species, bonytail probably spawn in rivers in spring over rocky substrates; spawning has been observed in reservoirs over rocky shoals and shorelines. Based on available distribution data, flooded bottomland habitats probably are important for bonytail growth and conditioning, particularly as nursery habitats for young. Threats to the species include stream flow regulation, habitat modification, predation by introduced nonnative fish species, hybridization, and pesticides and other pollutants (USFWS 2002b).

Only 11 wild adults have been reported recently from the Upper Basin (Valdez et al. 1994). Bonytail were transferred from Lake Mohave to hatcheries to develop broodstock for artificial propagation and subsequent release of progeny into several locations in Upper and Lower basins (Hamman 1981, 1982, 1985). Roughly 130,000 hatchery-produced bonytail were released into Lake Mohave between 1981 and 1987 as part of an effort by the Service to prevent the extinction of the species and promote its eventual recovery. However, survival of bonytail stocked into riverine reaches has been low (Chart and Cranney 1991), and no recruitment or reproduction of stocked fish has been documented to date. Nevertheless, the bonytail is so severely depleted in the wild that management actions to prevent its extinction must take priority. Self-sustaining populations need to be established through augmentation (USFWS 2002b). In Colorado, 5,000 fingerling bonytail were stocked in the Green River above Lodore Canyon and 5,000 were stocked in the Yampa River at Echo Park in July 2000 by the Colorado Division of Wildlife (CDOW). In March 2001, CDOW stocked 13,000 fingerling bonytail in the Green River.

Pursuant to Section 4(b)(2) of the ESA, on March 21, 1994 (59 FR 13374) the Service designated critical habitat for the bonytail within its historic range, including the Yampa River from the boundary of DNM in T.6N., R.99W., section 27 (6th Principal Meridian) to the confluence with the Green River in T.7N., R.103W., section 28 (6th Principal Meridian). Self-sustaining populations of bonytail are not known to occur in the Yampa River at this time. However, such populations had occurred in both the Yampa and Green rivers in the past.

Recovery goals for the bonytail prescribe 15 management actions needed for recovery, of which the following 10 actions are applicable to the Yampa/Green River complex:

1. Re-establish populations with hatchery-produced fish.
2. Provide and legally protect habitat (including flow regimes necessary to restore and maintain required environmental conditions) necessary to provide adequate habitat and sufficient range for all life stages to support recovered populations.
3. Investigate habitat requirements for all life stages and provide those habitats.
4. Ensure adequate protection from overutilization.

5. Ensure adequate protection from diseases and parasites.
6. Regulate nonnative fish releases/escapement into the main river, floodplain, and tributaries.
7. Control problematic nonnative fishes as needed.
8. Minimize the risk of increased hybridization among *Gila* spp.
9. Minimize the risk of hazardous-materials spills in critical habitat.
10. Provide for the long-term management and protection of populations and their habitats beyond delisting (i.e., conservation plans).

Colorado pikeminnow (*Ptychocheilus lucius*)

The Colorado pikeminnow is the largest member of the minnow family (cyprinidae) in North America. Adult pikeminnow may grow up to 6 feet in length and weigh as much as 80 pounds. Wild, reproducing populations occur in the Green River subbasin, including the Yampa River, and in the Colorado River subbasin of the Upper Colorado River Basin (i.e., upstream from Glen Canyon Dam). Small numbers of wild individuals also exist in the San Juan River subbasin, although their reproduction is limited. The species was extirpated from the Lower Colorado River Basin in the 1970's, but has been reintroduced into the Gila River subbasin, where it exists in small numbers in the Verde River. Geographic distribution of the Colorado pikeminnow is shown in Figure 5. Table 2 describes its current distribution in the Green River subbasin (USFWS 2002c).

Table 2. Distribution of Colorado pikeminnow within the Green River subbasin

River	Occupied Habitat/Rivermiles	Limits of Distribution
Green	Lodore Canyon to Colorado River confluence (360 RM)	Releases from Flaming Gorge Dam have been warmed and species has naturally expanded upstream into Lodore Canyon; species distributed downstream to Colorado River confluence.
Yampa	**Craig, CO, to Green River confluence (141 RM)**	**Present distribution similar to historic.**
Little Snake	**Wyoming to Yampa River confluence (50 RM.)**	**Habitat is marginal; flows are reduced; historic distribution unknown.**
White	Taylor Draw Dam to Green River confluence (62 RM)	Upstream distribution blocked by Taylor Draw Dam.
Price	Lower 89 RM above Green River confluence	Streamflow reduced; barriers occur above current distribution.
Duchesne	Lower 6 RM above Green River confluence	Streamflow reduced; barriers occur above current distribution.

The Colorado pikeminnow is a long-distance migrator; moving hundreds of miles to and from spawning areas. Adults require pools, deep runs, and eddy habitats maintained by high spring flows. These high spring flows maintain channel and habitat diversity, flush sediments from spawning areas, rejuvenate food production, form gravel and cobble deposits used for spawning, and rejuvenate backwater nursery habitats. Spawning occurs after spring runoff at water temperatures typically between 18 and 23°C. After hatching and emerging from spawning substrate, larvae drift downstream to nursery backwaters that are restructured by high spring flows and maintained by relatively stable base flows. Threats to the Colorado pikeminnow include streamflow regulation, habitat modification, competition with and predation by nonnative fishes, and pesticides and other pollutants. However, its longevity (40+ years) and adaptability maintain the long-term viability and stability of its populations, under environmental variation, through pulsed recruitment from periodic, strong year classes (USFWS 2002c).

Pursuant to Section 4(b)(2) of the ESA, on March 21, 1994 (59 FR 13374) the Service designated critical habitat for the Colorado pikeminnow within its historic range, including the Yampa River and its 100-year floodplain from the Colorado State Highway 394 bridge at Craig, Colorado, in T. 6 N., R. 91 W., section 1 (6th Principal Meridian) to the confluence with the Green River in T. 7 N., R. 103 W., section 28 (6th Principal Meridian). The Colorado pikeminnow is a highly mobile, wide-ranging species. Individuals of this population can be found throughout critical habitat in both the Middle Green and Yampa rivers, and occasionally may occur as far upstream as Hayden, Colorado. In spring, Colorado pikeminnow congregate on spawning bars in Yampa Canyon, dispersing on the descending limb of the hydrograph after spawning.

Recovery goals for the Colorado pikeminnow prescribe 11 management actions needed for recovery, of which the following eight actions are applicable to the Yampa/Green River complex:

1. Provide and legally protect habitat (including flow regimes necessary to restore and maintain required environmental conditions) necessary to provide adequate habitat and sufficient range for all life stages to support recovered populations.
2. Minimize entrainment of subadults and adults in diversion canals.
3. Ensure adequate protection from overutilization.
4. Ensure adequate protection from diseases and parasites.
5. Regulate nonnative fish releases/escapement into the main river, floodplain, and tributaries.
6. Control problematic nonnative fishes as needed.
7. Minimize the risk of hazardous-materials spills in critical habitat.
8. Provide for the long-term management and protection of populations and their habitats beyond delisting (i.e., conservation plans).

Razorback sucker (*Xyrauchen texanus*)

This Colorado River endemic species from the sucker family (catostomidae) is the only member of a monotypic genus (*Xyrauchen*). Adults may attain a maximum size of about 40 inches total length and weigh 11–13 pounds. Remaining wild populations are in seriously depleted (Table 3, Figure 5). Razorback sucker currently are found in small numbers in the Green River, Upper Colorado River, and San Juan River subbasins; Lower Colorado River between Lake Havasu and Davis Dam; Lake Mead and Lake Mohave; in small tributaries of the Gila River subbasin (Verde River, Salt River, and Fossil Creek); and in local areas under intensive management, such as Cibola High Levee Pond, Achii Hanyo Native Fish Facility, and Parker Strip. Most populations are comprised of aged and senile adults with little or no recruitment, except for the middle Green River and Lake Mead, where the presence of small numbers of juveniles and young adults indicate low recruitment levels (USFWS 2002d). The largest razorback sucker population in the Upper Colorado River Basin is found in low-gradient, flat-water reaches of the middle Green River between the Duchesne and Yampa rivers (Table 3).

Table 3. Distribution of razorback sucker within the Green River subbasin

River	Occupied Habitat/Rivermiles	Limits of Distribution
Green	Lodore Canyon to Colorado River confluence (360 RM): ~100 adults from Yampa River to Duchesne River; population augmentation ongoing.	Coldwater releases from Flaming Gorge Dam previously restricted distribution; warmed releases may allow for range expansion upstream into historic habitat.
Yampa	**Craig, CO to Green River confluence (141 RM); few wild fish remaining.**	**Present in low numbers in historic habitat.**
White	Taylor Draw Dam to Green River (62 RM.); few wild fish remaining.	Found in low numbers; distribution upstream blocked by Taylor Draw Dam.
Duchesne	Lower 1.2 RM above Green River; few wild fish remaining.	Found as small aggregations at river mouth during spring runoff.

Historically, razorback sucker were widely distributed from Mexico to Wyoming in warm-water reaches of larger rivers of the Colorado River Basin. Riverine habitats required by adults include deep runs, eddies, backwaters, and flooded off-channel environments in spring; runs and pools often in shallow water associated with submerged sandbars in summer; and low-velocity runs, pools, and eddies in winter. Spring migrations of adult razorback sucker were associated with spawning in historic accounts, and a variety of local and long-distance movements and habitat-use patterns have been documented. Spawning in rivers occurs over bars of cobble, gravel, and sand substrates during spring runoff at widely ranging flows and water temperatures (typically warmer than 14^{o}C). Spawning also occurs in reservoirs over rocky shoals and shorelines. Young razorback sucker require nursery environments with quiet, warm, shallow water, such as tributary mouths, backwaters, or inundated floodplain habitats in rivers, and coves or shorelines in reservoirs. Threats to the species include streamflow regulation, habitat modification, competition with and predation by nonnative fish species, and pesticides and pollutants (USFWS 2002d).

Pursuant to Section 4(b)(2) of the ESA, on March 21, 1994 (59 FR 13374) the Service designated critical habitat for the razorback sucker within its historic range, including the Yampa River and its 100-year floodplain from the mouth of Cross Mountain Canyon in T. 6 N., R. 98 W., section 23 (6th Principal Meridian) to the confluence with the Green River in T. 7 N., R. 103 W., section 28 (6th Principal Meridian). Razorback suckers generally are found in the Middle Green River between the confluence of the Duchesne and the Yampa. They occupy the lower reaches of Yampa Canyon during spawning and may occur irregularly elsewhere in Yampa Canyon.

Recovery goals for the razorback sucker prescribe 14 management actions needed for recovery, of which the following eight actions are applicable to the Yampa/Green River complex:

1. Reestablish populations with hatchery-produced fish.
2. Provide and legally protect habitat (including flow regimes necessary to restore and maintain required environmental conditions) necessary to provide adequate habitat and sufficient range for all life stages to support recovered populations.
3. Ensure adequate protection from overutilization.
4. Ensure adequate protection from diseases and parasites.

5. Regulate nonnative fish releases/escapement into the main river, floodplain, and tributaries.
6. Control problematic nonnative fishes as needed.
7. Minimize the risk of hazardous-materials spills in critical habitat.
8. Provide for the long-term management and protection of populations and their habitats beyond delisting (i.e., conservation plans).

DESCRIPTION OF THE PROPOSED ACTION

Historic, Current and Projected Depletions

This plan includes management actions intended to satisfy, at least in part, the recovery goals by reducing or removing threats to the four listed fish species that inhabit the Yampa River. These management actions were developed by considering likely impacts due to current and anticipated future depletions from the Yampa River and its tributaries through 2045. This section describes current depletions (i.e., CRDSS average annual depletions as of 1998), as well as anticipated new depletions due to direct flow diversions, small tributary reservoirs, modest expansions of existing reservoirs, and/or increased use of existing, currently under-utilized reservoir capacity. The assumptions used to develop these estimates are based on the best information available to date.

Although future depletions are quantified below by sector and geographic area, actual future depletions may not be limited exclusively to those sectors/areas nor allocated to those sectors or areas in the proportions described below. However, certain assumptions were made in order to assess the impacts of potential depletions to the endangered fishes. This assessment will serve as the basis for an intra-Service biological opinion on this management plan. If the assumptions upon which the assessment is based should change substantially—for example, if average annual depletions exceed the future increment defined herein or new projects are proposed whose impacts were not fully evaluated—the Service may reinitiate intra-Service consultation and supplement or amend its biological opinion.

Colorado Depletions

The Yampa River Basin in Colorado has nine reservoirs larger than 2,000 acre-feet (AF) active storage. These reservoirs range in size from 2,250 to 30,000 AF, with a total active storage capacity of 97,160 AF (Table 4). However, several include conservation pools and/or other accounts that generally are not fully exercised (i.e., drained and refilled) each year (Boyle Engineering 1999). Eight of these reservoirs are in the Upper Yampa Basin and one (Elkhead Reservoir) is in the Lower Yampa Basin.

The Colorado River Decision Support System (CRDSS) was used to estimate depletions from the Yampa River in Colorado during a 90-year period of record (October 1908-September 1998). On this basis, historic annual depletions averaged about 103,845 acre-feet (AF) in Colorado. Based on more recent water demands viewed in the same hydrologic context, current average depletions were estimated to be about 125,271 AF per year (Table 5). Agriculture (irrigation), thermoelectric generation (power), evaporation, and municipal and industrial (M&I) water users are the largest consumers. M&I water use includes mining, potable water supply, commercial and industrial uses (other than thermoelectric generation), livestock and snowmaking.

Table 4. Principal reservoirs in the Yampa River Basin, active storage capacities and uses

Reservoirs	Capacity (AF)	Year Built	Principal Intended Use(s)
Stillwater Reservoir	6,088	1935	Supplemental irrigation supply
Yamcolo Reservoir [a]	8,500	1981	Supplemental irrigation supply, M&I (excludes 1,000 AF of dead storage)
Allen Basin Reservoir	2,250	1953	Supplemental irrigation supply
Stagecoach Reservoir [a]	33,275	1988	Includes 11,000 AF[a] for Tri-State G&T, 15,000 AF for recreation and 4,000 AF for M&I
Lake Catamount	7,422	1977	Used primarily for recreation
Fish Creek Reservoir	4,167	1942	M&I; annual releases have averaged 1,000 AF
Steamboat Lake	26,364	1961	5,000 AF for Hayden Station (Xcel); 21,364 AF for recreation and instream flow (2,000–3,300 AF)
Pearl Lake	5,657	1959	Used exclusively for fisheries and recreation
Elkhead Reservoir	13,700	1974	Includes 1,668 AF M&I and 8,754 AF industrial
TOTAL	107,423		

[a] Irrigation supply (4,000 AF) exchanged from Stagecoach to Yamcolo for 4,000 AF of industrial supply contracted to Tri-State from Yamcolo and delivered from Stagecoach.

Table 5. Historic and current depletions from the Yampa Basin in Colorado by sector

Sector	Average annual depletions (AF)			Hydrologic Basis of Current Depletions
	Historic	Current	Change	
Agriculture (irrigation)	81,116	87,765	6,649	1975-1998 average [a]
Municipal & Industrial (M&I)	4,012	5,201	1,189	1998 consumption
Thermo-electric Generation	8,680	16,947	8,267	1985-1998 average
Exports (trans-basin diversions)	2,388	2,815	427	1975-1998 average
Reservoir Evaporation	7,649	12,543	4,894	Includes stock ponds
TOTAL	103,845	125,271	21,426	

[a] Taken directly from CRDSS calculated data set. Estimated depletions prior to 1975 used 1975–1998 average calculated demands for the same month and hydrologic condition, without constraint of net cumulative decree. Does not include any fallow lands that may be irrigated in the future.

Current depletions identified herein include about 6,400 AF/year by Tri-State Generation and Transmission Association, Inc., for Craig Station Unit 3. Under the terms of a Water Management Plan (Knutson 1992) developed pursuant to a 1980 biological opinion for Craig Station Unit 3 (USFWS 1980), Tri-State agreed to bypass up to 1,000 AF/year of its Wessel Canal direct-flow water right to augment instream flows for fish. Water is bypassed if river flows fall below certain flow targets: 150, 110 and 115 cfs in August, September, and October, respectively.

As one of the terms of Tri-State's Water Management Plan, the Service and Tri-State agreed that the Water Management Plan would terminate after the Recovery Program acquired and legally protected water in the Yampa River Basin sufficient to protect August through October target flows from depletions, including those of Craig Station Unit 3. Flow recommendations adopted by the Service in 1999 (Modde et al. 1999) are considered to supercede target flows specified in Tri-State's Water Management Plan. The augmentation proposal in this document (see **Proposed Action for Base-flow Augmentation** on page 75) is intended to satisfy these revised flow recommendations. Although CRDSS accounted for Tri-State's depletions, it did not account for these bypass flows for Craig Station Unit 3. Therefore, the estimated volume of water needed to augment instream flows to satisfy the Service's flow recommendations (see **Quantification of Augmentation Needs** on page 36) is considered sufficient to cover the 1,000 AF of water Tri-State agreed to bypass. However, before Tri-State can be relieved of its obligation to bypass flows under the 1980 biological opinion, water for augmentation must be decreed for instream flow purposes (see **Water Rights Administration** on page 29).

Based on projections of growth in human demand through 2045, the CRDSS estimates average annual future depletions from the Yampa River and its tributaries of about 155,375 AF per year in Colorado (Table 6), an increase of about 30,104 AF over current Colorado depletions. This estimate assumes there is sufficient water supply available to meet anticipated future demands regardless of current (i.e., 1998) supplies and legal/institutional constraints.

Table 6. Current and future depletions from the Yampa Basin in Colorado by sector

Sector	Current[1] AF of depletions	Future (2045) average annual AF of depletions			Unlimited minus Current
		Limited[2]	Unlimited[3]	Shortage[4]	
Agriculture	87,765	87,755	92,258	4,503	4,493
M&I	5,201	15,100	15,307	207	10,106
Power	16,947	32,350	32,350	0	15,403
Exports	2,815	2,814	2,917	103	102
Evaporation	12,543	12,543	12,543	0	0
TOTALS	125,271	150,562	155,375	4,813	30,104

[1] Based on estimated demands as of 1998, limited by supplies and legal constraints (Table 5).
[2] Limited by 1998 supplies and legal constraints; agriculture affected by senior M&I and power.
[3] Not limited by 1998 supplies and legal constraints.
[4] Shortage = Unlimited minus Limited depletions.

The CRDSS also provides a geographic and temporal distribution of estimated current and future depletions from the Yampa River Basin (Table 7). The CRDSS distribution of depletions does not include the estimated 4,813-AF shortages in Colorado. However, these shortages would likely occur in Water District 58 (Upper Yampa Basin) and WD 44 (Lower Yampa Basin), which account for roughly two-thirds of agricultural consumption in the Yampa Basin in Colorado (Figure 6, Table 8).

Table 7. Geographic and temporal distribution of current and supply-limited future [a] depletions in the Yampa River Basin.

	Water District [b]	Average depletions (AF) during CRDSS 90-year period of record												
		OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Annual
Current Demand	58	1,104	207	273	162	127	319	787	4,210	9,362	10,912	9,146	4,774	41,386
	57	558	399	459	441	378	461	341	1,155	2,584	3,088	2,950	1,647	14,460
	44	2,133	919	1,034	957	870	1,085	2,045	5,368	10,096	11,668	9,448	5,163	50,784
	54	314	0	0	0	0	0	442	1,890	3,908	4,302	3,405	1,501	15,763
	55	103	1	1	1	1	23	127	328	612	717	625	342	2,878
	Month	4,212	1,526	1,767	1,561	1,376	1,888	3,742	12,951	26,562	30,687	25,574	13,427	125,271
2045 Demand [a]	58	1,565	600	621	596	525	780	1,180	4,595	9,775	11,515	9,642	5,166	46,562
	57	1,310	1,061	1,114	1,038	994	1,148	976	1,881	3,531	4,111	3,898	2,536	23,596
	44	3,086	1,451	1,732	1,812	1,627	1,930	2,881	6,365	11,270	12,881	10,650	6,052	61,733
	54	314	0	0	0	0	0	442	1,890	3,908	4,302	3,405	1,501	15,763
	55	108	4	5	5	4	27	130	329	613	718	626	343	2,908
	Month	6,383	3,116	3,472	3,451	3,150	3,885	5,609	15,060	29,097	33,527	28,221	15,598	150,562
Difference	58	461	393	348	434	398	461	393	385	413	603	496	392	5,176
	57	752	662	655	597	616	687	635	726	947	1,023	948	889	9,136
	44	953	532	698	855	757	845	836	997	1,174	1,213	1,202	889	10,949
	54	0	0	0	0	0	0	0	0	0	0	0	0	0
	55	5	3	4	4	3	4	3	1	1	1	1	1	30
	Month	2,171	1,590	1,705	1,890	1,774	1,997	1,867	2,109	2,535	2,840	2,647	2,171	25,291

[a] Limited by 1998 supplies and legal constraints; agriculture affected by senior M&I and power (excludes shortages of 4,813 AF).

[b] See Figure 6 (next page).

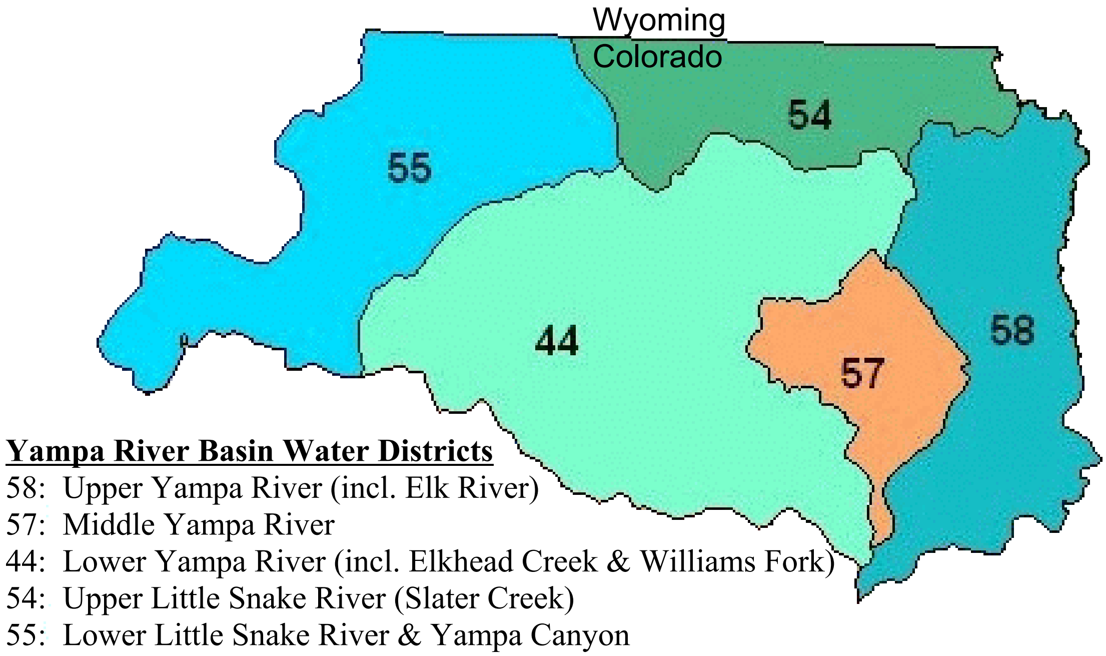


Figure 6. Yampa River Basin Water Districts in Colorado

Table 8. Geographic distribution of current and supply-limited future depletions by sector

	Sector	Average annual depletions (AF) within Colorado Division 6 Water Districts					Sector Totals
		58	57	44	54	55	
Current Demand	Agriculture (irrigation)	30,012	9,089	30,750	15,763	2,151	87,765
	Municipal & Industrial (M&I)	2,735	484	1,969	–	13	5,201
	Thermoelectric Generation	–	4,887	12,060	–	–	16,947
	Exports (trans-basin diversions)	2,815	–	–	–	–	2,815
	Reservoir Evaporation	5,824	–	6,005	–	714	12,543
	Water District totals	41,386	14,460	50,784	15,763	2,878	125,271
2045 Demand [a]	Agriculture (irrigation)	30,008	9,089	30,744	15,763	2,151	87,755
	Municipal & Industrial (M&I)	7,916	2,765	4,376	–	43	15,100
	Thermoelectric Generation	–	11,742	20,608	–	–	32,350
	Exports (trans-basin diversions)	2,814	–	–	–	–	2,814
	Reservoir Evaporation	5,824	–	6,005	–	714	12,543
	Water District totals	46,562	23,596	61,733	15,763	2,908	150,562

[a] Limited by 1998 supplies and legal constraints; agriculture affected by senior M&I and power (excludes shortages of 4,813 AF).

Figure 7 shows how the pattern of CRDSS average monthly depletions throughout the year differs between sectors. Depletions by agriculture for irrigation occur only during the growing season (April-October), whereas thermo-electric power generation consumes water more evenly during the year. Peak consumption by agriculture typically occurs during July and is an order of magnitude higher than the current peak of any other sector (solid lines). The CRDSS predicts depletions by agriculture, trans-basin diversions (export) and reservoir evaporation will remain relatively stable through 2045, while M&I and power will experience significant increases (dashed lines).

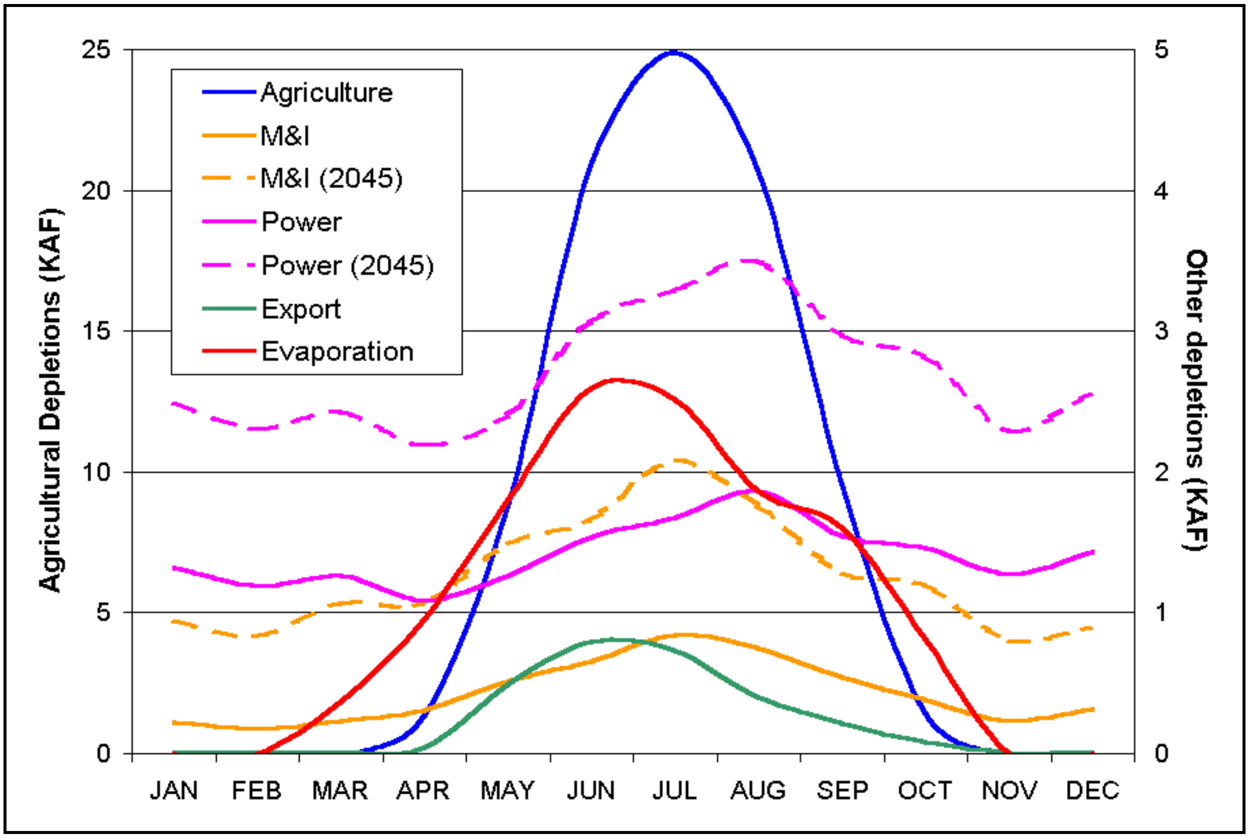


Figure 7. Temporal distribution of monthly depletions from the Yampa River Basin by sector

The CRDSS predicts that average annual depletions in excess of 150,562 AF in the Yampa Basin in Colorado cannot be met every year with existing reservoir capacity. Therefore, new reservoirs may be developed to satisfy estimated future shortages of 4,813 AF/year as expressed in Table 8. Moreover, Yampa Basin water users in Colorado wish to reserve an option to develop new water supplies, if necessary, to serve an additional 20,000-AF/year increment of demand (i.e., 50,000 AF/year above current depletions). For modeling purposes, this increment was assumed to be allocated equally between Agriculture, M&I and Power (i.e., 6,667 AF to each sector), with the entire demand placed on the mainstem of the Yampa River and distributed throughout the year based on each sector's current temporal pattern. On this basis, the CRDSS predicted average shortages of about 600 AF/year. This is reasonable for M&I and Power, which can be served from the mainstem. However, if a portion of irrigation demand were placed on smaller tributaries, shortages likely would be greater, because these streams may not yield enough water in late-summer to serve peak demands. To satisfy these shortages, new reservoir storage or greater utilization of existing storage may be required, with impacts to peak flows proportional to annual storage volumes.

Current information regarding the specific location(s) and volume(s) of any new reservoir(s) is insufficient to accurately predict these impacts. Impacts of new reservoirs would be addressed in separate, site-specific Section 7 consultations; however, the expectation is that their depletions would be covered by the PBO for this management plan up to the first 30,000-AF increment of depletions (see the section entitled **Depletion Accounting** on page 30). At such time as future depletions from the Yampa Basin approach this first increment, an intra-Service Section 7 consultation would be reinitiated as required by the PBO to address the impacts of developing an additional 20,000-AF increment of depletions.

Yampa River flows were modeled in CRDSS under historic, current and future demands (limited by 1998 supplies and institutional constraints) to assess the impacts to base flows due to current and future depletions in Colorado in historical context. These data provided the basis to estimate volumes of water needed to augment instream flows for the endangered fishes within the critical habitat reaches of the Yampa River (see the section entitled **Provide and Protect Instream Flows** beginning on page 32). Current depletions (Table 5) are intermediate between historic and future depletions (Table 9).

Table 9. Historic and future depletions from the Yampa Basin in Colorado by sector

	Average annual CRDSS depletions (AF)		
Sector	Historic Demand	2045 Demand [a]	Difference
Agriculture (irrigation)	81,116	87,755	6,639
Municipal & Industrial (M&I)	4,012	15,100	11,088
Thermoelectric Generation	8,680	32,350	23,670
Exports (trans-basin diversions)	2,388	2,814	426
Reservoir evaporation	7,649	12,543	4,894
TOTALS	103,845	150,562	46,717

[a] Limited by 1998 supplies and legal constraints; agriculture affected by senior M&I and power (excludes shortages of 4,813 AF).

Because water would have to be released from storage to serve average annual depletions above 150,562 AF, depletions in excess of this amount should have minor, if any, impact to base flows. Moreover, return flows to the river from water stored on the peak of the hydrograph and released during base flow periods potentially could increase base flows and reduce both the frequency and magnitude of base flow augmentation needed in the future. Therefore, the estimated volume needed to augment base flows to compensate for an initial 30,000-AF increment of depletions is believed to be sufficient to satisfy a second 20,000-AF increment, as well.

Wyoming Depletions

The average annual water yield from the Little Snake River Basin is about 428,000 AF near its confluence with the Yampa River, roughly 27% of the combined flow of these two rivers. Streamflow data indicate that an average annual discharge of 372,600 AF passes the gage near Dixon, Wyoming. Below the Dixon gage, two significant tributaries, Muddy Creek and Willow Creek, annually contribute an average of about 10,690 AF and 7,440 AF, respectively, for a total of 390,730 AF/year. These gaged flows already reflect losses due to depletions from the Little Snake River Basin upstream in both Colorado and Wyoming.

Sources of depletions in Wyoming include irrigated agriculture, environmental use, municipal in-basin use and trans-basin diversions for the City of Cheyenne. As in Colorado, irrigation is the largest water consumer in the Little Snake River Basin of Wyoming. Irrigation consumption in Wyoming was estimated by multiplying the number of acres devoted to each type of crop by a crop-specific Consumptive Irrigation Requirement (CIR). The CIR is the amount of irrigation needed in excess of rainfall to produce a crop. However, the maximum consumptive use of any crop is achieved only with an adequate water supply (States West Water Resources 2000).

The CIR at Dixon has been estimated to be about 1.9 feet for alfalfa and 1.75 feet for pasture grass or grass hay. For the Green River Basin Water Plan, these numbers were modified to include mountain meadow hay, for which irrigated lands above Baggs have been estimated to experience 1.63 feet of annual CIR (States West Water Resources 2000). There are 11,571 acres under irrigation above Baggs, 10,298 acres in meadow hay and 1,272 acres in alfalfa; below Baggs there are 4,358 irrigated acres, 3,879 acres in pasture grass/grass hay and 479 acres in alfalfa (Table 10).

Table 10. Calculation of Consumptive Irrigation Requirement, Little Snake River Basin, Wyoming

		Grass/Meadow	Alfalfa	Totals
Above Baggs	Irrigated acreage	10,298	1,273	11,571
	CIR (feet/year)	1.63	1.90	–
	CIR (AF/year)	16,786	2,419	19,205
Below Baggs	Irrigated acreage	3,879	479	4,358
	CIR (feet/year)	1.75	1.90	–
	CIR (AF/year)	6,788	910	7,698
	Total irrigated acreage	14,194	1,755	15,929
	Total CIR (AF/year)	23,574	3,329	26,903

A review of irrigation diversion records show actual depletions less than CIR would predict, which is to be expected. Estimates of agricultural depletions, based on studies for the Little Snake Supplemental Irrigation Water Supply (High Savery) Project (Burns and McDonnell 1999), indicate the basin currently receives about 75% of its needs, with average annual irrigation depletions estimated to be 20,050 AF. Nevertheless, full CIR provides a reasonable estimate of the needs and aggregate consumptive demands for irrigation in the basin.

Annual depletions due to the High Savery Project are expected to average 7,724 AF. Of this amount, approximately 869 AF is attributed to evaporation from the reservoir, and 6,855 AF is attributed to irrigation. This project assumes that no additional acreage will be brought under irrigation; it will provide supplemental late-season water to currently irrigated lands. If 6,855 AF of annual irrigation depletions due to High Savery are added to 20,050 AF of estimated current annual irrigation depletions, total annual depletions for irrigation would be 26,905 AF, essentially 100% of the CIR. High Savery depletions have been formally addressed in a biological opinion issued by the FWS on July 14, 1999; therefore, this project is included under current depletions even though it has yet to be constructed.

The towns of Baggs and Dixon, with a combined population of only 375, account for 76 AF of annual in-basin M&I annual depletions. However, trans-basin diversions to serve the City of Cheyenne account for 14,400 AF of annual depletions, second only to irrigation in depletions from the Little Snake River. Total average annual depletions from the Little Snake River subbasin in Wyoming have been estimated to be 42,583 AF as of 1994 (Table 11). States West Water Resources (2000) estimated that annual depletions from the Little Snake in Wyoming could grow by 23,428 AF to an average annual depletion of 66,011 AF by 2045 (Table 12).

Table 11. Current estimated depletions from the Yampa Basin in Wyoming by sector

Sector	Average annual depletions (AF)	Hydrologic Basis
Agriculture (irrigation)[1]	26,905	Includes High Savery Project
Municipal and Industrial (M&I)	76	Consumption by towns of Baggs & Dixon
Exports (trans-basin diversions)	14,400	Cheyenne I & II (1995-1997 usage)
Evaporation[1]	1,202	Diked wetlands & small reservoirs
TOTAL	42,583	

[1] Portions of High Savery Project allocated to agriculture (6,855 AF) and evaporation (869 AF)

Table 12. Current & future estimated depletions from the Yampa Basin in Wyoming by

Type of Use	Average annual AF of depletions		
	Current	Future (2045)	Difference
Agriculture (irrigation)	26,905	37,451	10,546
Municipal and Industrial (M&I)	76	88	12
Industrial	0	3,000	3,000
Exports (trans-basin diversions)	14,400	22,656	8,256
Evaporation	1,202	2,816	1,614
TOTALS	42,583	66,011	23,428

Using moderate growth estimates of 16% for both Baggs and Dixon, in-basin M&I depletions are expected to increase to 88 AF/year. Maximum annual capacity of the Cheyenne Stage I/II system (22,656 AF/year) is dictated by a one-fill limitation on Hog Park Reservoir. Although the City of Cheyenne has no immediate plans to enlarge this system, under current growth estimates, it should reach full capacity in the 2040-2050 timeframe (States West Water Resources 2000).

The difference between current and future agricultural depletions (10,546 AF/year) is attributable to eight small projects whose individual annual depletions range from 100 to 2,656 AF (Table 13).

Table 13. New depletions from the Little Snake River in Wyoming due to agriculture

Project Name	Surface Acres	CIR[a]	AF/year
Miscellaneous stock reservoirs (~200)	variable	–	2,000
Dolan Mesa Canal (Savery Creek)	1,600	1.66	2,656
Willow Creek	1,000	1.66	1,660
Cottonwood Creek	500	1.66	830
Grieve Reservoir	300	1.66	500
Muddy Creek	1,200	1.77	2,100
Focus Ranch	200	0.50	100
Pothook – Beaver Ditch	400	1.77	700
TOTALS	5,200		10,546

[a] Crop-weighted basis: CIR above Baggs = 1.66 feet/year; CIR below Baggs = 1.77 feet/year.

Estimated future average annual depletions due to evaporation (2,816 AF) represent a 1,614-AF increase over current average annual depletions. These new depletions are attributed to a threefold expansion of constructed wetlands (1,000 AF) by the Little Snake River Conservation District, and the Little Snake River Basin Small Reservoirs Project (614 AF), 10 small impoundments with a combined surface area of 245 acres that the District proposes to build for stock watering, rangeland improvement, and wildlife enhancement. Two other impoundments will be constructed under existing funding, with a combined surface area of 19.5 acres and combined depletions of 49 AF/year, assuming a net evaporation of 30 inches/year. These two reservoirs were included under existing depletions (States West Water Resources 2000).

Combining depletions from the Little Snake River in Colorado and Wyoming results in basin-wide depletions as shown in Table 14. In this summary, Colorado Water District 54 depletions are included with Wyoming depletions above Baggs, while WD 55 depletions are included with Wyoming depletions below Baggs. Future depletions in Wyoming that were not attributed to a specific geographic region (i.e., 7,816 AF total depletions for evaporation, miscellaneous stock reservoirs, and industrial uses) were prorated in the same proportion as regional depletions by irrigation, assigning 5,471 AF (70 %) to the region above Baggs and 2,345 AF (30 %) to the region below Baggs.

Table 14. Basin-wide distribution of current & future depletions from the Little Snake River

Region and State		Average annual depletions (AF)		
		Current	Future	Change
Above Baggs	Colorado (WD 54)	15,763	15,763	0
	Wyoming	34,540	53,067	18,527
	SUBTOTALS	50,303	68,830	18,527
Below Baggs	Colorado (WD 55)	2,878	2,908	30
	Wyoming	8,043	12,944	4,901
	SUBTOTALS	10,921	15,852	4,931
BASIN-WIDE TOTALS		61,224	84,682	23,458

It bears mentioning at this point that although all of the irrigation depletions attributable to the High Savery Project have been assigned to Wyoming, this project also serves about 3,400 acres of irrigated lands in Colorado. This acreage is roughly 14% of the 24,000 acres served by the project. On a *pro rata* basis, therefore, we estimate that about 960 AF out of the 6,855 AF average annual irrigation depletions by the project can be attributed to lands in Colorado served under Wyoming water rights.

Water Rights Administration

With the exception of certain tributaries and the Yampa River upstream from the town of Yampa, most water rights in the Yampa River Basin have enjoyed freedom from strict administration by the Colorado State Engineer. Similarly, water users in the Wyoming portion of the Basin (e.g., the Little Snake River Basin and its tributaries) have generally not experienced regulation and curtailment of uses by water administration officials of the Wyoming Board of Control. The water users of the Basin desire to continue this practice. No one can guarantee that water rights will not be strictly administered in the Basin in the future. This plan has no authority to require nor preclude such administration nor interfere in any way with exercising water rights in the Yampa Basin.

Due to concerns expressed by the Service and other Recovery Program participants, Colorado withdrew its application for certain instream-flow water rights on the Colorado and Yampa rivers. The Recovery Program agreed to re-evaluate the need for instream-flow water rights every 5 years. Upon completion of each review, a determination will be made regarding the need to file for instream flow water rights for the endangered fishes. During the final year of the first 5-year period, the Recovery Program and Colorado will develop a process to assess the need for instream-flow protection for endangered fishes. Without instream-flow rights, the Colorado Water Conservation Board (CWCB) cannot place a call on the river to serve the flow needs of the endangered fishes. However, such water rights would be junior to most other water rights on the Yampa River and, therefore, subject to be “called out” by senior water rights, when water is most critically needed.

However, Colorado may deliver water from storage for this purpose, as it has done in the past using water leased to the Service from Steamboat Lake. At present, 3,300 AF/year from Steamboat Lake has been reserved for instream use and other purposes. Under the terms of a 5-year lease between the Service and the Colorado Division of Parks and Outdoor Recreation (Parks), the Service augmented natural flows in the Yampa River by leasing up to 2,000 AF/year from Steamboat Lake through September 2000. A 1-year extension of the lease continued deliveries through November 2001. No water was released from Steamboat Lake for this purpose in 2002. Parks and the Service are attempting to negotiate an interim lease, as part of the proposed augmentation water supply alternative (see **Formulation of an Augmentation Strategy** beginning on page 42).

The Colorado State Engineer ensures that such contract deliveries reach their point(s) of delivery, less any transit losses, using available streamflow gages to track leased water from their source(s). However, in accordance with Colorado water law, only the contract delivery would be protected from diversion by other water users; the underlying natural flow of the river may be diverted in priority. For example, if river flows were augmented by 50 cfs, water users in priority would be entitled to divert any flows in excess of 50 cfs. Although return flows may restore a portion of any diverted flow, a series of intervening diversions between the augmentation source and point(s) of delivery could effectively limit river flows at the point of delivery to the flow rate of the augmentation releases (i.e., 50 cfs).

In addition, Tri-State currently bypasses up to 1,000 AF/year of its direct-flow water right for Craig Station, pursuant to a biological opinion for Unit 3 (USFWS 1980), when river flows fall below certain targets (150, 110 and 115 cfs in August, September and October, respectively). Once base-flow augmentation proposed in this plan is implemented and legally protected, Tri-State would be entitled to curtail bypassing flows as stipulated in a Water Management Plan for Craig Station Unit 3 (Knutson 1992).

Depletion Accounting

Water depletions are defined herein simply as diversions less return flows. Diversions include water diverted from the river, as well as evaporation from reservoirs and other impoundments, such as stock ponds. Depletions represent an annual reduction in the volume of stream flow that would have reached the critical habitat of the endangered fishes. Normal water losses due to direct evaporation from streams and rivers, transpiration by riparian vegetation, percolation to groundwater and bank storage are not considered depletions, as these also are characteristic of unmodified river systems.

Current average annual depletions from the Yampa River in Colorado have been estimated using the CRDSS to be about 125,000 AF/year, while comparable depletions from the Little Snake River in Wyoming are estimated to be about 43,000 AF/year. Based upon projections of human water demands, depletion increments of 30,000 AF/year in Colorado and 23,000 AF/year in Wyoming were added to current depletions to account for anticipated water consumption *circa* 2045. Ranges of annual depletions, if normally distributed, would exceed projected average annual depletions of about 155,000 AF in Colorado and 66,000 AF in Wyoming in half of the years.

An environmental impact assessment (see **ENVIRONMENTAL ASSESSMENT** beginning on page 108) considered the entire range of depletions represented by these annual averages, and management actions described in this plan were designed to offset the impacts of these depletions on the listed fishes. An intra-Service biological opinion pursuant to ESA Section 7 will be based on the best information currently available; however, if any of the assumptions/information upon which the opinion is based should change significantly in the future, it may be necessary for the Service to reinitiate consultation and supplement or amend its opinion on the implementation of this management plan.

For example, if average annual depletions reach or exceed the estimated depletions considered by the Service in rendering its biological opinion (i.e., 155,000 AF/year in Colorado and 66,000 AF/year in Wyoming), the Service would likely reinitiate consultation. Therefore, annual water demand from the Yampa River Basin in Colorado and Wyoming will be quantified periodically, and <u>average</u> annual depletions will be estimated following a process similar to that used to estimate 1998 and 2045 depletions. In Colorado, the USBR prepares a *Consumptive Uses and Losses Report* (CULR) every 5 years, using information provided by the CWCB. Data from the CULR or State-approved demand estimate will be backcast over the 90-year CRDSS period of record for the Yampa River to estimate annual depletions that would have occurred in each of the years of the hydrologic record. Averaging depletions over this period would minimize the influence of exceptional years and produce results more directly comparable to those projected future depletions that will be considered in the consultation.

Every 5 years, beginning in 2005, the States of Colorado and Wyoming will report to the Recovery Program estimated average annual volumes of depletions from the Yampa and Little Snake rivers and their tributaries. When estimated average annual depletions reach 155,000 AF in Colorado or 66,000 AF in Wyoming, the Service is expected to reinitiate intra-Service consultation under ESA Section 7, and, depending upon the outcome of that consultation, this plan and/or the cooperative agreement with the Service to implement this plan may need to be modified or supplemented.

Framework for Recovery Actions and Cooperative Agreement

This plan provides a framework for recovery actions designed to offset impacts to the four listed endangered fish species of the Upper Colorado River Basin due to current depletions and foreseeable future depletions from the Yampa River Basin. Moreover, it requires that a variety of recovery actions be undertaken by the Recovery Program to offset both the direct and depletion impacts of historic projects, as stipulated in paragraph III.2. of the Section 7 Agreement (Appendix A):

> *The* [Recovery Program] *is intended to offset the direct and depletion impacts of historic projects occurring prior to January 22, 1988 (the date when the Cooperative Agreement for the* [Recovery Program] *was executed) if such offsets are required to recover the fishes. Under certain circumstances, historic projects may be subject to consultation under Section 7 of the ESA. An increase in depletions from a historic project occurring after January 22, 1988, will be subject to the depletion charge.* [Otherwise,]*...depletion charges or other measures will not be required from historic projects which undergo Section 7 consultation in the future.*

To implement this plan the Service will sign a Cooperative Agreement with the States of Colorado and Wyoming (Appendix B). This constitutes a "federal action" by the Service, for which the Service must initiate intra-Service consultation under Section 7 of the ESA, as well as comply with the requirements of the National Environmental Policy Act (NEPA). Due to the basin-wide scope of depletion impacts and recovery measures, the product of this consultation is expected to be a programmatic biological opinion (PBO) for the Yampa River Basin.

Current average annual depletions from the Yampa River Basin have been quantified as 125,271 AF in Colorado and 42,583 AF in Wyoming. By the year 2045, depletions are expected to increase by 30,104 AF/year in Colorado and 23,428 AF/year in Wyoming (Appendix C). State, local and private projects associated with the continuation of existing depletions and ~53,500 AF/year of new depletions from the Yampa River Basin which have, or are likely to have, a federal nexus may choose to rely on the implementation of the Yampa River Management Plan to avoid the likelihood of jeopardy to the endangered fishes, adverse modification or destruction of their critical habitat, or violation of ESA Section 9 take prohibitions. Therefore, these non-federal projects are treated as interrelated to the federal action for the purposes of determining the scope of an ESA Section 7 consultation. It is expected that the Yampa PBO would continue to be in effect unless specific identified conditions (i.e., reinitiation criteria) occur or until all four of the endangered fishes of the Upper Colorado River Basin are removed from the list of threatened and endangered species.

Nevertheless, new or existing water development projects may be subject to consultation in the future under Section 7 of the ESA to assess the potential impacts on threatened and endangered species due to construction, operation or modification of these projects. These consultations would determine, among other things, if the recovery actions described herein are sufficient for the Recovery Program to serve as the reasonable and prudent alternative for the proposed action(s), or whether additional measures are necessary to preclude jeopardy to any listed species. They would also determine if construction, operation and/or modification of these projects would cause levels of incidental take higher than those anticipated in the Yampa PBO, and may propose additional reasonable and prudent measures, as necessary to reduce or eliminate take.

The recovery actions described herein are intended to contribute to the ultimate recovery of these species, consistent with the purpose of the Recovery Program. These RIPRAP actions are classified into five broad categories:

1. Provide and Protect Instream Flows
2. Reduce Negative Impacts of Nonnative Fishes
3. Restore Habitat (Habitat Development and Maintenance)
4. Manage Genetic Diversity/Augment or Restore Populations
5. Monitor Populations and Habitat

These recovery actions, and the process for their development, are specified in this management plan, along with approaches to account for depletions, monitor fish populations, and evaluate the effectiveness of these actions in recovering the endangered fishes. Schedules to initiate and/or complete recovery actions will be specified in the RIPRAP and incorporated into annual work plans. The Recovery Program will be responsible for funding and implementing these recovery actions.

Provide and Protect Instream Flows

Background

In the Yampa River, peak flows have not been significantly reduced by large reservoirs, direct diversions and their associated depletions; however, with relatively little water storage capacity in the Yampa River Basin to augment flows from mid-July through mid-March, depletions may reduce base flows to a greater extent, based on the percent reduction of natural (i.e., undepleted) flows. Moreover, depletions generally peak in July (Table 7; Figure 7), after spring runoff has subsided. Nevertheless, because peak flows play a significant role in the life histories of the endangered fishes (see discussion of peak flows on page 5), impacts to peak flows are considered, as well.

Flows in the Yampa River typically are low during August through October, as water demand for irrigation, power production and municipal consumption remains high (Table 7; Figure 7), and stream flows naturally decline following spring runoff. The lowest flows generally occur in September, with an average minimum flow at Maybell of 137 cfs; however, flows as low as 2 cfs have been recorded. Modde et al. (1999) recommended that daily average flows at the Maybell gage should not fall below 93 cfs during August through October with any greater frequency, magnitude or duration in the future than had been observed under historical conditions. The rationale for their recommendation is that the area of available riffle habitat begins to fall off sharply at flows less than 93 cfs. Riffles serve as primary production areas for macro-invertebrates which, in turn, are an important constituent of the food web for the endangered fishes. Because riffles are especially sensitive to changes in flow, Modde et al. (1999) considered maintenance of riffle habitats, and the invertebrate prey base they support, to be one of the most important functions of base flows in the Yampa River.

Gage records also show that daily average flows in July historically fell below 93 cfs in 3 of 83 years, whereas the CRDSS predicts that July daily average flows will fall below 93 cfs in roughly 10% of years by 2045. Therefore, the Service extended the low-flow period to encompass all base-flow conditions from July 1 through October 31 and adopted the 93-cfs flow target of Modde et al. for this period (Appendix D).

Although the authors made no specific flow recommendations with respect to the remainder of the base-flow period (November through March), the Service believes that flows of sufficient magnitude also are needed during this period to ensure over-winter survival of the endangered fishes. However, uncertainties exist as to the magnitude of winter flows needed. Therefore, the Service extended base-flow recommendations through March, adding a 33% (31-cfs) buffer to the 93-cfs flow target beginning November 1 (Appendix D). That is, flows at Maybell should not fall below 124 cfs during the winter with any greater frequency, magnitude or duration than they had under historic conditions.

This buffer is consistent with historic hydrologic patterns, wherein average base flows after October 31 rose by 33% or more in half of the years of record (41/83) with respect to comparable average base flows prior to November 1. The Service made no numerical flow recommendations with respect to spring peak flows, except that reductions in peak flows be minimized to the greatest extent practicable. Nevertheless, the Service recognizes that some reduction of peak flows is unavoidable. Under this plan, base flows in the Yampa River will be augmented, as necessary, to satisfy flow recommendations; however, the use of reservoir storage to augment base flows will be evaluated for its potential impacts to peak flows.

The CRDSS was used to estimate volumes of augmentation needed to satisfy Service base-flow recommendations. The CRDSS for the Yampa River is a hydrologic model encompassing a 90-year historical set of atmospheric and hydrologic conditions, which serve as a template on which to compare alternative water supply and demand conditions. The period of record for the Yampa River CRDSS is water-years 1909–1998 (i.e., October 1, 1908 - September 30, 1998). While no model can predict the future, climatic and hydrologic patterns in the foreseeable future are likely to be replicated with the same frequency as they occurred in the recent past. In this context, the CRDSS applies a statistical probability of future atmospheric and hydrologic conditions that affect both the supply of and demand for water based on actual observations of past conditions.

The CRDSS estimated stream discharges in AF/month at Maybell under historic, current and 2045 demand conditions. These monthly discharges subsequently were distributed on a daily basis in proportion to gaged flows during the same time period and converted to average daily flows in cfs by applying the following conversion factor:

$$AF/day \div 1.98 = \text{daily average cfs.}$$

Using these synthesized daily flows, the Service estimated gross daily deficits of summer (93 cfs) and winter (124 cfs) flow targets (Figure 8). White bars in Figure 8 represent daily net deficits of flow targets in historical context based on the difference between future average daily flows in cfs and the lesser of 93 cfs or the corresponding historic daily average flows. Annual deficits were calculated as the sum of daily deficits. Days with estimated future streamflows exceeding 93 cfs did not offset days in which there were deficits. Annual net deficits were calculated by subtracting historic gross deficits from future (or current) gross deficits (Table 15). Net deficits represent the smallest augmentation volumes needed to precisely satisfy the flow targets in their historical context and were used to quantify augmentation needs.

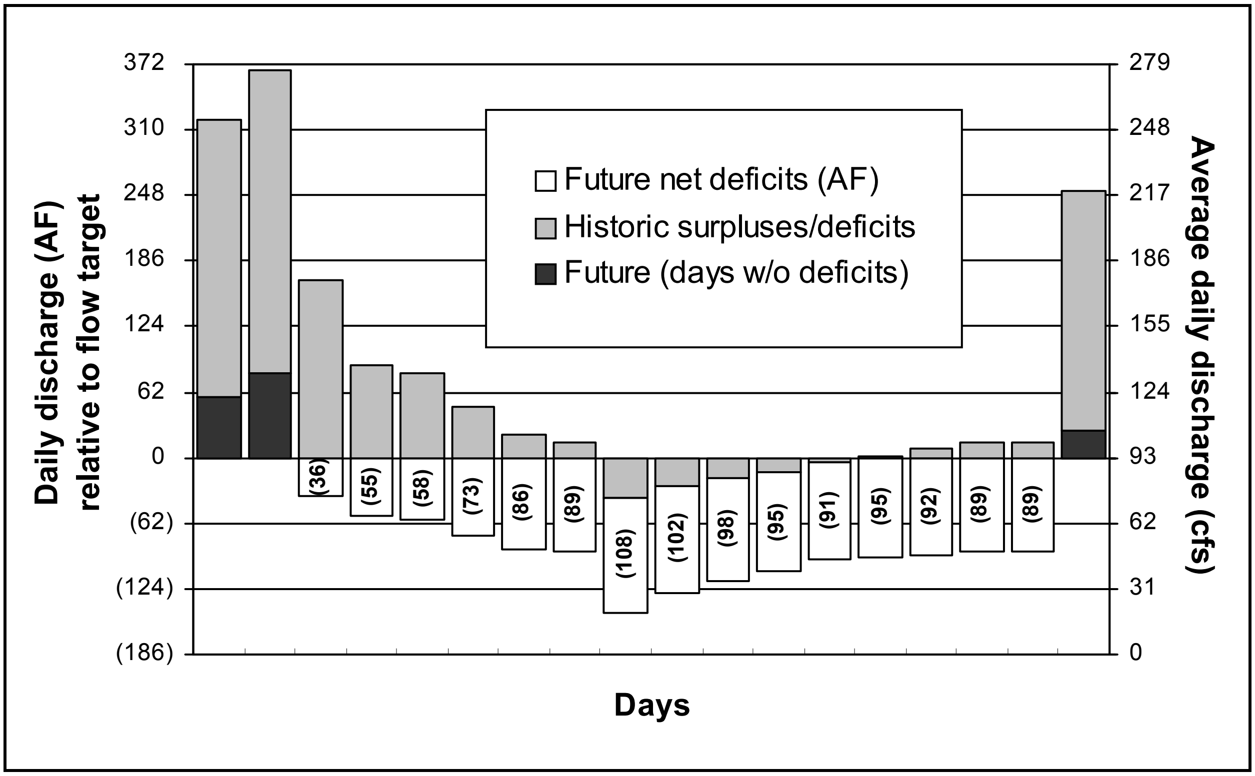


Figure 8. Illustration of hypothetical daily deficits of fish flow targets

Net deficits under 2045 demand conditions ranged from zero during moderately wet to wet years (≤30% exceedance), up to 9,689 AF in 1977, an extremely dry year (100% exceedance). For the driest 10% (9 out of 90 years) annual net deficits average 8,390 AF, whereas in 80 years annual net deficits are less than 6,000 AF (Table 15). On this basis, the Service concluded that 6,000 AF, plus an allowance for transit losses, would be sufficient to satisfy the base-flow recommendations for the endangered fishes through 2045 in all but the driest years. This volume also would serve to reduce, though not totally eliminate, net deficits in the driest years (Table 16).

To evaluate augmentation water supply alternatives, a subcommittee representing Yampa River Basin water users, Upper Basin water users, the Colorado River Water Conservation District, Colorado Water Conservation Board, Colorado Division of Water Resources, Service and The Nature Conservancy adopted the 6,000-AF augmentation volume, and added 1,000 AF (16.67%) to account for transit losses.

Table 15. Comparison of average annual historic, current and future deficits of instream flow targets in the Yampa River at Maybell under various hydrologic conditions[a]

Hydrologic Conditions[a]	Average gross deficits			Average net deficits[b]	
	Historic	Current	2045	Current	2045
Wet (0-10% exceedance)	0	0	0	0	0
Moderately wet (11-30% exceedance)	0	0	0	0	0
Average (31-70% exceedance)	92	183	709	91	617
Moderately dry (71-90% exceedance)	996	3,146	5,518	2,150	4,522
Dry (91-100% exceedance)	3,169	7,265	11,559	4,096	8,390

[a] CRDSS Period of Record (Water-years 1909-1998) ranked by gross annual deficits
[b] Net deficits equal gross current/2045 deficits minus gross historic deficits

Table 16. Ability of augmentation volumes to satisfy deficits of instream flow targets for the Yampa River at Maybell

Augmentation Volume[a] (AF)	Gross deficits satisfied (% of years[b])			Net deficits[c] satisfied (% of years[b])	
	Historic	Current	2045	Current	2045
1,000	84.4%	72.2%	60.0%	78.8%	61.1%
2,000	88.9%	76.7%	70.0%	84.4%	72.2%
3,000	94.4%	80.0%	72.2%	88.9%	73.3%
4,000	96.7%	86.7%	75.6%	95.6%	82.2%
5,000	97.8%	90.0%	82.2%	98.9%	87.8%
6,000	**98.9%**	**94.4%**	**85.6%**	**98.9%**	**90.0%**
7,000	98.9%	96.7%	88.9%	100.0%	91.1%
8,000	98.9%	96.7%	91.1%	100.0%	96.7%
9,000	98.9%	97.8%	91.1%	100.0%	96.7%
10,000	100.0%	98.9%	94.4%	100.0%	98.9%

[a] Not adjusted for transit losses of 16.67%
[b] CRDSS Period of Record (water-years 1909-1998)
[c] Current or future net deficits equal current or future gross deficits minus historic deficits

Quantification of Augmentation Needs

A practical approach was needed to determine when river flows should be augmented. Such an approach was developed by the Service in consultation with the subcommittee, using upper and lower set points like a thermostat to turn augmentation on when streamflows fall below a specified lower set point or threshold and turn augmentation off once streamflows reach a specified upper threshold (Figure 9). These thresholds bracket the summer/winter flow targets previously described and are applied in accordance with the following protocol:

- When unaugmented streamflows fall below the seasonally appropriate lower threshold, water would be delivered at a fixed rate until such time as augmented streamflows exceed the seasonally appropriate upper threshold.
- At that point, augmentation would cease until unaugmented flows again fall below the lower threshold.
- Streamflow augmentation would continue throughout the augmentation period (July-March), in accordance with this protocol, or until the available augmentation water supply has been exhausted.

The objective of this protocol is to emulate, as closely as possible, historical base flows such that stream flows do not fall below the 93-cfs and 124-cfs flow targets with any greater frequency, magnitude or duration than occurred historically. A variety of thresholds and augmentation rates were evaluated using simulated daily flows based on the 90-year CRDSS data to determine which of these augmentation scenarios best simulates historic streamflows under a variety of hydrologic conditions. In addition, the volume of water needed to satisfy each scenario was estimated.

Thresholds were defined according to three criteria:

1. Flow targets (previously described)

2. Differential — Five values (80, 60, 50, 40 and 30 cfs) were selected, representing the numerical difference between upper and lower thresholds. Increasing the differential lowers the lower threshold and raises the upper threshold. Decreasing the differential raises the lower threshold and lowers the upper threshold. Too small a differential would require continual, intermittent augmentation.

3. Skew — Five values of skew were selected (+25%, +10%, 0%, -10% and -25% of the differential) the net effect of which is to increase or decrease both thresholds by the same amount relative to flow targets. At 0% skew, flow targets are centered between upper and lower thresholds.

For example, with a flow target of 93 cfs, a differential of 60 cfs, and 0% skew, lower and upper thresholds would be 63 cfs (93 - 30) and 123 cfs (93 + 30), respectively. Whereas, with +25% skew (25% × 60 = 15 cfs), the thresholds would be 78 cfs (63 + 15) and 138 cfs (123 + 15) and with -25% skew the thresholds would be 48 cfs (63 - 15) and 108 cfs (123 - 15). Because positive skew raises and negative skew lowers both thresholds by the same amount, positive skew would call for more water, and negative skew would call for less water relative to 0% skew.

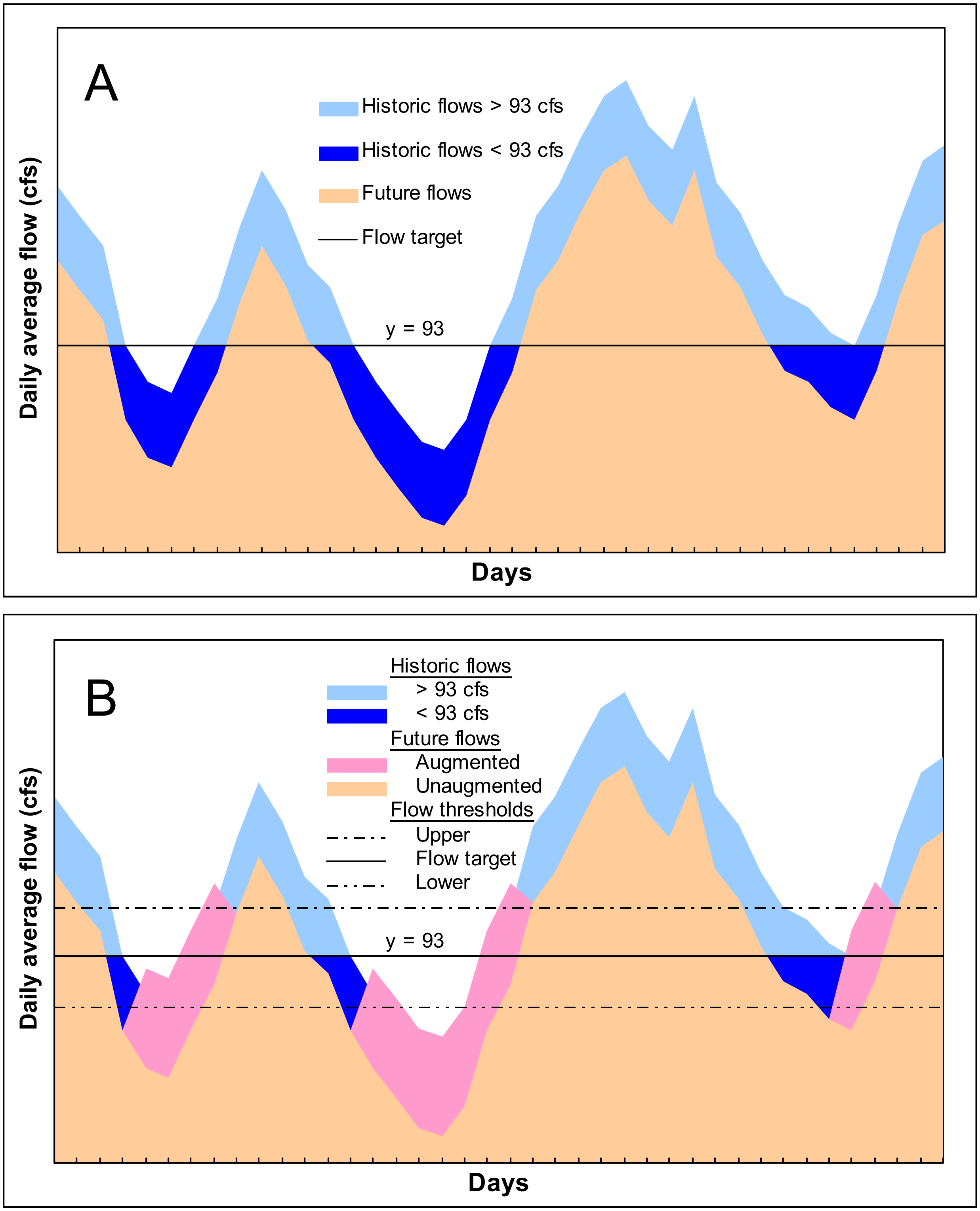


Figure 9. Application of flow thresholds to initiate base-flow augmentation in the Yampa River

Graph A in Figure 9 depicts hypothetical historic and future hydrographs for the same modeling period. The historic hydrograph (blue) is further differentiated into flows greater than the 93-cfs flows target (light blue) and flows less than 93 cfs (dark blue). In Graph A, the future hydrograph (tan) is unaugmented. Graph B duplicates the two hydrographs in Graph A, but overlays the effects of augmentation (pink) on the future hydrograph. Ideally, flow augmentation should precisely compensate for the difference between future flows and historic flows less than 93 cfs, filling the dark blue area completely. Although the application of flow thresholds cannot precisely match the historic hydrograph, such an augmentation protocol can reasonably approximate it. Granted this is an idealized example. For example, augmentation in Graph B assumes an immediate and direct effect on streamflows. That is, augmented flows (pink) are the exact sum of future flows (tan) plus the volume of augmentation delivered. It does not consider potential lag time or attenuation of delivered flows as a function of distance from their augmentation source(s). But it assumes that sufficient water is provided to offset any transit losses from the source(s) to the point of delivery. Augmentation volumes were estimated using these same assumptions. However, because the effects of lag time and flow attenuation diminish as the duration of augmentation increases, these effects are considered insignificant for modeling purposes.

Three different augmentation rates were selected for each threshold differential, in proportion to differential. Augmentation rates were never more than 90% nor less than 50% of differential. Therefore, the highest augmentation rates were associated with the largest differentials and the lowest rates with the smallest differentials. Rates greater than or equal to 100% of each differential were not considered due to their potential to produce a "yo-yo" effect. Rates less than 50% of differential were not evaluated because at values of skew less than or equal to zero, they failed to achieve flow targets. If water supplies were unlimited, more aggressive augmentation scenarios (i.e., positive skew, larger differentials, higher augmentation rates) would require more water than less aggressive strategies. However, if supplies were limited, more aggressive strategies would exhaust supplies earlier and potentially fail to meet augmentation needs later in the season. The following evaluation assumes supplies are limited to 6,000 AF delivered to the Maybell gage.

Seventy-five augmentation scenarios (5 differential values × 5 skew values × 3 augmentation rates) were evaluated and ranked according to their relative performance in achieving augmentation objectives. No one scenario performed better than all the others under all demand and hydrologic conditions. And none of the scenarios was superior under 2045 demand conditions during the driest hydrologic conditions. However, the analysis revealed that less aggressive scenarios (negative skew <u>and</u> lower augmentation rates) failed to achieve the flow targets with greater frequency than did more aggressive scenarios. Four of the best performers, which all used the maximum value of skew (+25%), satisfied an average 63–71% of gross deficits during dry conditions (Table 17). Moreover, they met 79–90% of net deficits under moderately dry hydrologic conditions and 41–65% under average hydrologic conditions. All scenarios performed better under moderately dry conditions than they did under average hydrologic conditions. The most and least aggressive strategies did not perform as well as an intermediate strategy. This can be attributed to more aggressive strategies over-augmenting initially and using all of the available water earlier than less aggressive strategies, which continued to provide a lower level of augmentation, as needed, for the duration of the base-flow period. Although the least aggressive strategies allow for augmentation to continue longer during the base-flow period, they may not provide sufficient volume in dry years to satisfy larger deficits, which may be better satisfied by somewhat more aggressive strategies.

Table 17. Relative performance of four augmentation scenarios in reducing flow deficits

Augmentation Criteria (differential, skew, rate)	% Reduction of Current Deficits			% Reduction of Future Deficits		
	Dry	Mod. Dry	Average	Dry	Mod. Dry	Average
80 cfs, +25%, 70 cfs	**72%**	92%	28%	66%	79%	41%
80 cfs, +25%, 55 cfs	71%	92%	35%	70%	79%	44%
60 cfs, +25%, 50 cfs	71%	**95%**	52%	**71%**	**90%**	**65%**
60 cfs, +25%, 33 cfs	60%	79%	**54%**	63%	81%	**65%**

The best performances in each hydrologic category are highlighted in Table 17 (**bold** typeface). One of the four scenarios above (**bold** typeface) was marginally better than the other three and was selected to evaluate a variety of augmentation water supply alternatives with the CRDSS. The selected scenario applied the following augmentation criteria: Differential, 60 cfs; Skew, +25%; Augmentation rate, 50 cfs. These criteria produced lower thresholds of 78 cfs in summer (July-October) and 109 cfs in winter (November-February) and upper thresholds of 138 cfs in summer and 169 cfs in winter. These criteria determined when and how much water should be delivered from one or more sources (Table 18). A series of simulations with the CRDSS were used to assess the relative ability of one or more sources to satisfy net deficits and quantify impacts on any reservoir(s) from which water was delivered. Using the same augmentation scenario, streamflow augmentation "demand" (in AF/month) was calculated and entered into the CRDSS as a contract delivery from storage. At a nominal augmentation rate of 50 cfs delivered at Maybell, an augmentation water supply of 7,000 AF/year would provide about 116 AF/day (99 AF/day plus a 17-AF allowance for transit losses) for a maximum of 61 days. The number of days augmentation would be called for during each CRDSS month and year is presented in Table 19.

Tables 18 and 19 show only those 44 years during which some augmentation was required by the selected augmentation protocol. If augmentation water supplies were unlimited, 71% of the average annual augmentation demand would occur from July 1 through September 30, peaking in September (42%), with only 29% of the demand from November 1 through February 28. If augmentation supplies were limited to ~7,000 AF, the percent of volume used from July through September would increase to 72% (September, 41%) with the volume used after September declining an average of only 58 AF, or 14% of demand during the post-September period. The shaded cells in Tables 18 and 19 indicate those months in which all or a significant portion of augmentation demand was not met because available augmentation water supplies had been exhausted in previous months. Augmentation demand exceeded supply in 5 years, of which only 3 years had shortages greater than 1,000 AF. Shortages were greatest in September, exceeding 1,000 AF in both years in which there were shortages (1934 and 1977). However, shortages could be mitigated by reducing augmentation rates in these drier years to extend supplies later into the base-flow period.

Table 18. Streamflow augmentation in AF/month as required by protocol

Year at start	Augmentation demand (AF/month) during base-flow period[a]									Year at end	AF/Year[b]
	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR		
1913	0	1,273	116	0	0	0	0	0	0	1914	1,389
1915	0	463	579	0	0	0	3,587	3,240	0	1916	**7,869**
1931	0	0	1,620	0	0	0	0	0	0	1932	1,620
1933	0	0	0	0	0	0	926	116	0	1934	1,042
1934	3,587	3,587	3,471	116	0	0	0	0	0	1935	**10,761**
1935	0	0	1,967	2,083	3,008	3,124	0	0	0	1936	**10,182**
1936	0	0	0	0	347	0	0	0	0	1937	347
1937	0	0	347	0	231	0	0	0	0	1938	578
1939	0	1,157	926	0	0	0	1,504	0	0	1940	3,587
1940	0	3,008	2,777	0	0	926	694	0	0	1941	**7,405**
1941	0	0	0	0	231	0	0	0	0	1942	231
1942	0	0	0	0	0	0	347	0	0	1943	347
1943	0	0	0	0	0	0	0	347	0	1944	347
1944	0	2,545	3,471	694	347	0	0	0	0	1945	7,057
1946	0	0	0	0	0	231	0	0	0	1947	231
1948	0	0	1,736	0	0	0	0	0	0	1948	1,736
1950	0	116	1,504	0	0	231	0	0	0	1951	1,851
1954	0	1,736	1,736	0	116	579	0	579	0	1955	4,746
1955	0	0	2,661	0	0	0	0	0	0	1956	2,661
1956	0	0	1,967	463	0	0	0	0	0	1957	2,430
1957	0	0	0	0	231	0	0	0	0	1958	231
1959	0	0	1,388	0	0	579	0	0	0	1960	1,967
1960	0	0	1,967	0	0	0	0	0	0	1961	1,967
1961	0	1,967	347	0	0	0	0	0	0	1962	2,314
1963	0	810	0	0	0	0	0	0	0	1964	810
1964	0	0	0	0	347	1,967	0	0	0	1965	2,314
1966	0	1,504	2,083	0	0	0	0	0	0	1967	3,587
1967	0	0	0	0	347	579	0	0	0	1968	926
1968	0	0	0	0	0	231	0	0	0	1969	231
1972	0	1,504	347	0	0	0	0	0	0	1973	1,851
1974	0	0	2,198	810	0	0	0	0	0	1975	3,008
1976	0	0	810	0	0	0	0	0	0	1977	810
1977	2,661	3,008	3,355	579	231	0	0	0	0	1978	**9,834**
1978	0	0	0	0	231	579	0	0	0	1979	810
1981	0	463	1,736	579	0	0	0	0	0	1982	2,778
1988	0	694	1,620	0	0	0	0	0	0	1989	2,314
1989	0	347	1,504	0	0	0	0	0	0	1990	1,851
1990	0	2,198	3,471	926	0	0	0	0	0	1991	6,595
1991	0	0	579	0	0	0	0	0	0	1992	579
1992	0	1,157	3,471	1,041	0	0	0	0	0	1993	5,669
1994	1,041	1,736	1,620	0	0	0	0	0	0	1995	4,397
1995	0	0	0	1,736	1,967	116	0	0	0	1996	3,819
1996	0	0	1,504	0	0	0	0	0	0	1997	1,504
1998	0	0	347	–	–	–	–	–	–	–	347
Average[c]	81	325	591	100	85	102	78	48	0	Average[d]	1,287
AF/mo.	Number of years that monthly augmentation demand[c] is greater than "AF/mo."									AF/year	#Years
> 0	3	19	31	10	12	11	5	4	0	>1,000	29
>1,000	3	13	22	3	2	2	2	1	0	>3,000	13
>2,000	2	5	9	1	1	1	1	1	0	>5,000	8
>3,000	1	3	5	0	1	1	1	1	0	≥7,000	6

[a] Augmentation year begins July 1 and ends March 31 of the following year; only years for which augmentation is required are shown; shaded cells have all or a significant portion of demand unmet due to limited water supply.

[b] Total annual demands (AF/year in **bold**) are supply-limited to ~7,000 AF, including transit-loss allowance.

[c] Average monthly demand (AF/month) of all years based on unlimited supply.

[d] Average annual demand (AF/year) of all years based on water supply limited to ~7,000 AF.

Table 19. Streamflow augmentation in days/month as required by protocol

Year at start	Augmentation demand (days/month) during base flow period[a]									Year at end	Days[b]/Year
	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR		
1913	0	11	1	0	0	0	0	0	0	1914	12
1915	0	4	5	0	0	0	31	28	0	1916	**68**
1931	0	0	14	0	0	0	0	0	0	1932	14
1933	0	0	0	0	0	0	8	1	0	1934	9
1934	31	30	30	1	0	0	0	0	0	1935	**92**
1935	0	0	17	18	26	27	0	0	0	1936	**88**
1936	0	0	0	0	3	0	0	0	0	1937	3
1937	0	0	3	0	2	0	0	0	0	1938	5
1939	0	10	8	0	0	0	13	0	0	1940	31
1940	0	26	24	0	0	8	6	0	0	1941	**64**
1941	0	0	0	0	2	0	0	0	0	1942	2
1942	0	0	0	0	0	0	3	0	0	1943	3
1943	0	0	0	0	0	0	0	3	0	1944	3
1944	0	22	30	6	3	0	0	0	0	1945	61
1946	0	0	0	0	0	2	0	0	0	1947	2
1948	0	0	15	0	0	0	0	0	0	1949	15
1950	0	1	13	0	0	2	0	0	0	1951	16
1954	0	15	15	0	1	5	0	5	0	1955	41
1955	0	0	23	0	0	0	0	0	0	1956	23
1956	0	0	17	4	0	0	0	0	0	1957	21
1957	0	0	0	0	2	0	0	0	0	1958	2
1959	0	0	12	0	0	5	0	0	0	1960	17
1960	0	0	17	0	0	0	0	0	0	1961	17
1961	0	17	3	0	0	0	0	0	0	1962	20
1963	0	7	0	0	0	0	0	0	0	1963	7
1964	0	0	0	0	3	17	0	0	0	1964	20
1966	0	13	18	0	0	0	0	0	0	1965	31
1967	0	0	0	0	3	5	0	0	0	1968	8
1968	0	0	0	0	0	2	0	0	0	1967	2
1972	0	13	3	0	0	0	0	0	0	1973	16
1974	0	0	19	7	0	0	0	0	0	1975	26
1976	0	0	7	0	0	0	0	0	0	1977	**7**
1977	23	26	29	5	2	0	0	0	0	1978	**85**
1978	0	0	0	0	2	5	0	0	0	1979	7
1981	0	4	15	5	0	0	0	0	0	1982	24
1988	0	6	14	0	0	0	0	0	0	1989	20
1989	0	3	13	0	0	0	0	0	0	1990	16
1990	0	19	30	8	0	0	0	0	0	1991	57
1991	0	0	5	0	0	0	0	0	0	1992	5
1992	0	10	30	9	0	0	0	0	0	1993	49
1994	9	15	14	0	0	0	0	0	0	1995	38
1995	0	0	0	15	17	1	0	0	0	1996	33
1996	0	0	13	0	0	0	0	0	0	1997	13
1998	0	0	3	–	–	–	–	–	–	–	3
Average[c]	1	3	5	1	1	1	1	0	0	Average[d]	12
Days/mo.	Number of years augmentation frequency[c] is greater than or equal to "Days/mo."									Days/yr.	#Years
>0	3	19	31	10	12	11	5	4	0	>0	44
≥10	2	13	22	2	2	2	2	1	0	≥15	26
≥20	2	4	7	0	1	1	1	1	0	≥30	13
≥30	1	1	4	0	0	0	1	0	0	≥60	6

[a] Augmentation year begins July 1 and ends March 31 of the following year; only years for which augmentation is required are shown; shaded cells have all or a significant portion of demand unmet due to limited water supply.

[b] Total annual demands (days/year in **bold**) are supply-limited to ~7,000 AF, including transit-loss allowance.

[c] Average monthly demand (days/month) of all years based on unlimited supply.

[d] Average annual demand (days/year) of all years based on water supply limited to ~7,000 AF.

November exhibits slightly less augmentation demand than either October or December. This dip in demand may be indicative of the so-called "bounce" in the hydrograph at this time of year, typically after irrigation diversions cease. This pattern has been attributed to latent return flows to the river from irrigation earlier in the year (September-October). However, the rise in base flows may be a natural phenomenon due to cooler temperatures, the onset of vegetation winter dormancy, and correspondingly lower transpiration losses.

Formulation of an Augmentation Strategy

A variety of augmentation water supply alternatives, with and without storage, were identified and evaluated. "Non-structural" options do not utilize storage, but rely instead on instream flow water rights or supply interruption contracts with water users. These contracts also could involve water conservation measures to make more water available for purchase. Supply interruption contracts also were evaluated in combination with structural options.

"Structural" options rely on storage in new and/or existing reservoirs, including leases or contracts for water from existing storage. Eleven alternatives rely on structural options or a combination of structural and non-structural options. The following structural sources were evaluated:

- Steamboat Lake (by lease)
- Elkhead Reservoir (by lease, exchange and/or enlargement)
- Stagecoach Reservoir (by lease, exchange and/or enlargement)
- New tributary reservoir(s)

Steamboat Lake is 26 highway miles north of Steamboat Springs, Colorado, on Willow Creek, a tributary to the Elk River, 33 RM upstream from the Yampa River and 77 RM upstream from Craig, Colorado. Covering 1,100 surface acres, this reservoir provides both storage and water-related recreation, with a total storage capacity of about 26,000 AF, including 18,068 AF for recreation and 5,000 AF for industrial purposes (Table 4). Up to 3,300 AF also is available for instream flow. In the past, the Recovery Program augmented Yampa River flows with 2,000 AF from this pool, which the Service leased from Parks. Up to an additional 1,300 AF of water could be leased subject to availability. The entire 3,300 AF has been decreed for instream use, and the Service sublet it to the CWCB for this purpose. Water was released from Steamboat Lake at the request of the Recovery Program and CWCB to serve the instream flow needs of the endangered fishes. The Colorado State Engineer delivered the water from Steamboat Lake downstream to the Deerlodge Park gage, less any transit losses. The lease expired on September 30, 1999, and new terms have not be negotiated. Several of the structural alternatives include leasing water from this reservoir, the cost of which would be borne by the Recovery Program.

Elkhead Reservoir covers about 675 surface acres on Elkhead Creek, 8 RM upstream from the Yampa River and about 17.5 RM upstream from Craig, Colorado. This 13,700-AF reservoir provides both water storage and recreation, including 8,310 AF for industrial purposes, 1,668 AF for municipal purposes and 3,722 AF of dead storage (Hydrosphere 1995). There is no current storage volume available nor allocated to augment stream flows. To create a pool for this purpose in Elkhead, it would be necessary to either enlarge the reservoir or purchase or lease water from one or more of the existing pools.

Stagecoach Reservoir, about 16 highway miles south of Steamboat Springs, is located on the Yampa River, 75 RM upstream from Craig. This 700-acre reservoir has a total capacity of 33,275 AF allocated to industrial (11,000 AF), municipal (2,000 AF) and recreational (15,000 AF) purposes (Table 4), with the remainder (5,275 AF) currently unallocated. In addition to these uses, water stored in Stagecoach Reservoir also is used to generate hydro-electric power and to maintain minimum instream flows below the dam (Hydrosphere 1995).

New reservoirs may be developed on tributaries to serve unmet human demand. Although there is no current consensus within the Recovery Program to construct new reservoirs for the sole purpose of augmenting flows for fishes on either a permanent or interim basis, the Recovery Program may consider, on a case-by-case basis, the potential impacts and benefits of purchasing water from such new storage projects that may be developed in the future to meet human water needs.

The Colorado River Water Conservation District (CRWCD) identified several candidate sites for construction of small reservoirs to serve human needs (Montgomery Watson 2000). Although this report focused on sites higher on tributaries, the CRWCD (Ray Tenney, CRWCD, personal communication) estimates that sites with sufficient yield to serve the needs of both humans and fish may be found on Fortification Creek, Milk Creek, and Morapos Creek. However, existing hydrologic data for these sites is insufficient to carry out detailed CRDSS analyses.

Fortification Creek originates along the southwestern slopes of the Elkhead Mountains and flows generally south to its confluence with the Yampa River at Craig, Colorado. Draining 34 square miles, the subbasin yielded a 4-year (1956–1959) annual average of about 8,400 AF. CRWCD identified two potential reservoir sites, Rampart Reservoir (Sec. 34, T8N, R90W) and Ralph White (Sec.12, T9N, R91W). Ralph White is the site of an existing breeched dam. Because it is lower in the watershed, its potential yield is greater. However, Rampart has the potential to supplement native inflow. Both suffer from potential sedimentation problems.

Milk Creek arises from the White River Plateau and flows generally north-northwest to its confluence with the Yampa River west of Craig, Colorado. Its watershed covers 65 square miles and yields a 33-year (1953–1986) annual average of about 22,000 AF. CRWCD evaluated several sites on Milk Creek and recommended two for further evaluation: Three Points (Sec. 9, T2N, R81W) and Thornburgh (Sec. 32, T3N, R92W).

Morapos Creek also arises from the White River Plateau, and flows north-northwest to its confluence with the Williams Fork at Hamilton, Colorado, covering 14 square miles and yielding an annual average of 4,600 AF over 2 years (1966–1967). Only one site on Morapos Creek, Monument Butte (Sec. 24, T4N, R92W), was recommended for further evaluation.

Description of Alternatives

Thirteen alternatives (11 structural and 2 non-structural) were identified and evaluated to provide 6,000 AF of delivered streamflow augmentation. A "No Action"alternative also was evaluated. Structural alternatives were subdivided into single-source and multiple-source options (Table 20). The following narrative describes each of the alternatives and the hydrologic assumptions used to model them.

Non-structural alternatives

Alternative 1 (No Action): This alternative provides no flow augmentation for endangered fishes.

Alternative 2: Supply interruption contracts with irrigators were evaluated as a sole-source option, as well as in combination with other augmentation sources (Alternative 13). Any such leases would be pursuant to voluntary, consensual agreement(s) with one or more water users and would be fully compensated by the Recovery Program at fair market value. Long-term contracts would provide the greatest certainty for the fishes. However, shorter terms may be considered in the interim until long-term contracts become available. To model this alternative, instream flows were assigned a higher priority (i.e., earlier adjudication date) than one or more senior water users, allowing the model to call out those users when augmentation was necessary.

Conservation measures, which could be used in conjunction with supply interruption contracts, were modeled by adjusting irrigation efficiencies. "Conservation," in this case, is intended to reduce diversions from the river. Traditional flood-irrigation practices used in the Yampa River Basin are only 60% efficient, requiring 10 AF be diverted from the river for every 6 AF of consumption. Sprinkler or drip irrigation requires less water to be diverted. For modeling purposes, efficiencies were raised from 60% to 80%, requiring smaller volumes of diversion to achieve the same level of consumption. However, higher efficiencies also would result in smaller volumes of return flows.

Alternative 3: As a result of concerns expressed by the Service and other Recovery Program participants, the CWCB withdrew the base-flow and recovery-flow instream flow filings on the Colorado and Yampa rivers. In compliance with the Colorado River PBO (USFWS 1999), water users from both the Upper Colorado River Basin and Front Range have delivered water from their reservoirs to augment instream flows. These water deliveries are administered to support flow recommendations in the Colorado River; therefore, new instream flow water rights may not be needed for this purpose.

The Recovery Program agreed to evaluate the need for further instream flow water rights every 5 years. Upon completion of this review, a determination will be made regarding the need to protect instream flows for the endangered fishes. During the final year of the first 4-year period, the Recovery Program and CWCB will develop a process to assess the need for further instream flow protection for endangered fishes. Therefore, beginning 5 years after a Yampa PBO is completed, the Recovery Program and CWCB will evaluate the performance of this management plan in terms of meeting current or revised flow recommendations. Although instream flow water rights could stand alone as a means to satisfy base-flow recommendations, their junior priority would make them subject to senior calls during drier conditions, when they would be most needed. However, they could provide greater reliability in combination with firm water supplies (Alternatives 4–14).

Table 20. Streamflow augmentation water supply alternatives: Water source(s) and volume(s)

		Non-structural (AF)		Structural Options											
				Single source (AF)				Multiple sources (AF)							
	Alternative Number	2	3	4	5	6	7	8	9	10	11	12	13	14	PA[c]
Water Source(s)	Steamboat Lake lease (1° draw)			7000				2000	2000	2000	2000	2000	2000		
	Steamboat Lake lease (2° draw)							1300	1300					2000	
	Elkhead Reservoir enlargement				3700	7000		3700		5000	3700	3700		3700	5000
	Elkhead Reservoir lease				3300									1300[b]	2000
	Stagecoach Res. enlargement								3700						
	Stagecoach Reservoir lease						7000				1300		1300		
	New tributary reservoir lease											1300		1300[b]	
	Supply interruption contracts[a]	6000											3171		
	Instream flow water rights[a]		6000												
	Total AF available	6000	6000	7000	7000	7000	7000	7000	7000	7000	7000	7000	6471	7000	7000

[a] Supply interruption contracts and instream flow rights do not include an allowance for transit losses (1,000 AF).
[b] Lease of 1,300 AF from either Elkhead human use pool (primary) and/or new tributary reservoir (secondary), if developed.
[c] Proposed Action

Structural alternatives

Single-source options

Alternative 4: This alternative relies entirely on Steamboat Lake for the full 7,000-AF augmentation requirement. No enlargement of the reservoir would be necessary. The volume would be taken from the existing 3,300-AF instream flow pool, plus an additional 3,700 AF to be leased from Parks out of its existing 18,000-AF recreation pool. Current priorities were used for modeling.

Alternative 5: This alternative relies exclusively on Elkhead Reservoir for 7,000 AF of augmentation. It involves a 3,700-AF enlargement of the reservoir with the balance (3,300 AF) to be derived via an exchange with Steamboat Lake. Under this exchange, 3,300 AF would be reallocated from the 8,310-AF industrial pool to a fish augmentation pool at Elkhead in exchange for reallocating a like volume from the instream flow pool in Steamboat Lake for industrial purposes. This reallocation would reduce the industrial pool in Elkhead to Reservoir 5,010 AF and increase the industrial pool in Steamboat Lake to 8,300 AF. Because transit losses from Steamboat are likely to be greater than from Elkhead, the owner of industrial storage would be compensated for the difference in losses. For modeling purposes, the Steamboat exchange would retain its priority, and the enlargement of Elkhead would be assigned a new priority, junior to all current water rights but senior to all future water rights.

Alternative 6: This alternative involves a 7,000-AF enlargement of Elkhead Reservoir to meet the instream flow requirement. This pool would be assigned a new priority, junior to all current water rights but senior to all future water rights.

Alternative 7: This alternative would assign the entire 7,000 AF of augmentation to Stagecoach Reservoir. However, no reservoir enlargement would be necessary. Under this alternative, 3,300 AF would be exchanged between the Steamboat instream flow pool and the Stagecoach industrial pool. In addition, 3,700 AF would be leased from Tri-State's industrial pool in Stagecoach. These pools would retain their respective priorities for modeling purposes.

Muliple-source options

Alternative 8: Under this alternative, the Recovery Program would draw water first from Steamboat Lake, up to 2,000 AF from the existing pool adjudicated for instream use. When the total volume of releases from Steamboat Lake reaches 2,000 AF, the Recovery Program would begin drawing water from a 3,700-AF pool in Elkhead Reservoir created by an enlargement of the reservoir. This pool would be assigned a new priority, junior to all current water rights but senior to all future water rights. Once this pool is exhausted, the Recovery Program would return to Steamboat Lake to release the 1,300-AF balance of the adjudicated instream flow pool.

Alternative 9: This alternative is identical to Alternative 8, except that it requires a 3,700-AF enlargement of Stagecoach Reservoir, rather than Elkhead. This pool would be assigned a new priority, junior to all current water rights but senior to all future water rights.

Alternative 10: Like Alternatives 8 and 9, this alternative first releases up to 2,000 AF from Steamboat Lake. However, the balance of releases would be made from a 5,000-AF enlargement of Elkhead Reservoir. This pool would be assigned a new priority, junior to all current water rights but senior to all future water rights.

Alternative 11: Similar to Alternative 8, except that the secondary draw on Steamboat Lake would be replaced with a lease of 1,300 AF from the industrial pool of Tri-State Electric Generation & Transmission Cooperative in Stagecoach Reservoir. For modeling purposes, this pool retained its current priority.

Alternative 12: Similar to Alternative 8, except that the secondary draw on Steamboat Lake would be replaced with 1,300 AF from a new tributary reservoir. This alternative cannot be modeled until a specific site for the new reservoir is identified and hydrologic data for the site is compiled.

Alternative 13: This alternative relies upon leases from existing storage facilities and supply interruption contract(s) to provide water for the fishes. Under this alternative, the primary draw would come from Steamboat Lake (2,000 AF), followed by 1,300 AF from Stagecoach through a lease with Tri-State. Finally, 3,700 AF would be derived from contracts with irrigators who would agree not to divert water from the river they would otherwise be entitled to divert in priority. At this time, no willing irrigators have been identified and no modeling has been done.

Alternative 14: Similar to Alternative 8 , except the 2,000-AF lease from Steamboat Lake would be secondary to a 3,700-AF enlargement of Elkhead Reservoir specifically for augmentation, with the remaining 1,300 AF to be supplied by leasing a portion of either a proposed enlargement of Elkhead for human use and/or new tributary reservoir(s).

<u>Other alternatives considered</u>

Winter/off-peak water storage

Winter/off-peak storage options were considered to minimize impacts of storage on spring peak flows while providing all, or a portion of, the 7,000-AF maximum annual augmentation requirement. Principal limitations are inadequate hydrology, high cost and/or potential impacts to winter flows. The winter yield of most tributaries to the Yampa River would not support a volume of this size in most years. However, preliminary modeling has shown that in some years storage could begin as early as November, following the irrigation season. Winter storage was specifically considered as an option with an enlargement of Stagecoach Reservoir. Although Stagecoach is situated on the mainstem of the Yampa River, its headwater location limits its usefulness for this purpose similar to that of a large tributary. It yields roughly half the volume of the Yampa River measured at the U.S. Geological Survey (USGS) gage at Steamboat Springs. The basins above Steamboat Lake and Elkhead Reservoir cannot provide winter storage without significant impacts to their tailwaters. They also would be less likely to fill during drier winters, and high demand during the following summers would not be met.

One potential, though expensive, option would be to divert or pump water from the mainstem of the Yampa River into a tributary or other off-channel reservoir. This option would require construction of either a long gravity-flow canal or a pumping plant and pipeline to deliver water to the reservoir. In addition, it would require construction of a new reservoir or enlargement of an existing reservoir, such as Elkhead. Utility costs for pumping water from the river into the reservoir also could be a prohibitive operational expense. Moreover, it would be difficult to store water in winter while maintaining a winter base-flow target of 124 cfs in the Yampa River.

Water conservation

Water conservation was considered as an alternative to storage, but rejected as a stand-alone option. However, water conservation could be used in conjunction with a firm water supply to enhance the reliability of both. A variety of options are available; each would involve changing agricultural practices within the Yampa River Basin. Among these, crop conversion, land leveling, conversion from flood to sprinkler irrigation, ditch lining and installation of check structures were evaluated.

In their *Final Environmental Impact Statement, Little Snake Supplemental Irrigation Water Supply*, Burns and McDonnell (1999) stated:

> *Under normal conditions, conservation measures generally reduce water loss and provide a more even distribution of existing, available water. However, conservation cannot produce new water and conservation cannot save water when water is not available. Without concurrent storage, conservation cannot affect the timing of, or the season when, water is available.*

Burns and McDonnell (1999) estimated that conversion from irrigated pasture to alfalfa hay would cost about $1,000/acre and recover 0.2 AF/acre/year. Therefore, to achieve savings of 6,000 AF, 30,000 acres of pasture would need to be converted to alfalfa, at a cost of $30M or about $5,000/AF. The cost of land leveling per AF of water conserved would be comparable to crop conversion and involve the same acreage. These estimates both include costs of replacement hay during the period the land would be out of service (2.5 years for crop conversion and 1.5 years for land leveling).

The CRDSS estimates the efficiency of flood irrigation to be about 60% throughout the Yampa River Basin. Improving irrigation efficiencies potentially could require less water to be diverted from the river. Conversion of agricultural lands from flood irrigation to center-pivot sprinkler irrigation could significantly improve irrigation efficiency. The CRDSS estimates an efficiency of 80% for sprinklers, a 20% improvement over flood irrigation. If 40,000 acres of flood-irrigated land were converted to sprinkler systems, the potential water “savings” could be more than 11,000 AF from July through October (Table 21). But more than 40% of these savings occurs in July, when water is rarely needed for augmentation, whereas less than 20% is available in September, when demand for augmentation is greatest. Therefore, without storage there would be no way to bank the savings from July for subsequent use later in the season. Moreover, this estimate assumes that potential savings would be available every year, whereas less water is likely to be available from conservation in dry years, because irrigators may be unable to utilize their full entitlement when river flows are low. Water conservation measure in such dry years could benefit the irrigators, but not necessarily provide sufficient water to meet instream flow demands.

Some irrigators have voluntarily converted to sprinkler systems. However, it would cost $20M to convert 40,000 acres to sprinklers at $500/acre (Burns and McDonnell 1999 estimate). This would not meet the entire augmentation need (Table 21). Moreover, whatever savings accrue to the river would be available for the next irrigator in line to divert, and irrigators who conserve water would risk losing, through abandonment, the water they saved. To further confound the quantification of benefits from water conservation, most of the inefficiency of flood irrigation is attributed to groundwater return flows to the river. Improving efficiency would reduce return flows and, consequently, reduce whatever benefits accrue from these return flows.

Table 21. Estimation of water conserved due to conversion from flood to sprinkler irrigation

Acreage converted	Acre-feet available[a] by month and acreage converted				Total
	JUL	AUG	SEP	OCT	
0	0	0	0	0	0
5,000	611	489	245	61	1,405
10,000	1,221	977	489	122	2,809
20,000	2,442	1,954	978	244	5,618
40,000	4,884	3,908	1,956	488	11,236
60,000	7,326	5,862	2,934	732	16,854
Max. demand	3,074	2,926	2,975	1,785	

[a] Based on 68,230 irrigated acres depleting 20,000 AF in July, 16,000 AF in August, 8,000 AF in September and 2,000 AF in October, and 20% improvement in irrigation efficiency. Cells shaded green ( ) approximate or exceed the maximum demand; cells shaded tan ( ) do not.

Ditch lining also would conserve water otherwise lost to return flows, allowing for diversion of less water from the river to meet the same irrigation requirement. The Natural Resources Conservation Service (NRCS 1997) found typical application efficiencies to be 10–25%, but also found that efficiencies of 30–50% are possible "with properly designed, maintained and managed systems." Improving average application efficiencies from 20% to 40% could cut water diversions in half.

However, the costs of lining can be very expensive. The NRCS (2002) found that the average cost of 51 ditch lining projects completed under its CALFED Water Use Efficiency Program to be almost $53 per linear foot, or about $280,000 for every mile of ditch lined. To meet the augmentation requirement in most years, about 15 miles of ditch likely would need to be lined, at an approximate cost of $4M. Although this is less than that of reservoir construction, the amount of water available from ditch lining under dry conditions would decline, as less water is available for diversion under those conditions. Moreover, there would be surpluses in months with lower augmentation requirements and shortfalls in other months with higher augmentation requirements. But without any reservoir storage capacity, there would be no way to conserve these surpluses for use later in the irrigation season or during the winter.

To ensure that water users toward the tail end of irrigation ditches receive their full share of water, ditch operators often must overcharge their ditches toward the head end. Check structures installed strategically within a ditch can create small impoundments that increase hydraulic head near each water user's turnout to ensure each water user has access to its full share of the ditch's water rights without overcharging the head end of the ditch. Seven such check structures were installed within the Government Highline Canal in the Grand Valley to conserve an estimated 28,000 AF from August through September that would otherwise be diverted upstream from the 15-mile reach of the Colorado River and spilled to the river downstream from the 15-mile reach (USBR 1998). Costing roughly $500,000 each, these check structures have proven beneficial not only to the endangered fishes that inhabit the 15-mile reach, but also to the people who rely on the Government Highline Canal for water. During the 2002 drought, although endangered fish realized no tangible benefit from the check structures, water users were able to make better use of the water available.

Under such extreme drought conditions, without the check structures the Grand Valley Water Users Association would have required a larger volume of water to satisfy water deliveries during late summer and early fall. At that rate, available water supplies would have been exhausted early in September. However, the canal checks significantly reduced the amount of water needed to operate the canal system and deliver water to the water users. The checks enabled a 36% reduction in water diversions. Because less water was diverted from the Colorado River, water was released from storage at a slower rate, extending available supplies through late October (USFWS 2002e).

However, a similar project in the Yampa River Basin would not likely produce comparable benefits. The Government Highline Canal is capable of conveying over 1,600 cfs. The potential benefits of such conservation measures on a single project of this size are enormous. Few irrigation canals in the Yampa Basin are capable of conveying as much as 50 cfs. Moreover, their smaller size makes these canals less conducive to installing check structures, which may require extensive modifications to the canals themselves to ensure there is adequate freeboard above the checks to prevent water from overtopping and breaching the ditch embankments. In addition, whereas it was necessary to obtain the cooperation of only a single entity in the Grand Valley, in the Yampa Basin it would be necessary to work with many more water-user organizations to realize similar water conservation benefits. As with ditch lining, tangible benefits would decline under drier-than-average conditions, and there would be no water available from conservation to augment winter flows without additional storage.

Evaluation of Alternatives

Each of 12 alternatives was subjected to a preliminary sensitivity analysis, using the following evaluation criteria: (1) ability to meet base-flow needs; (2) estimated cost; (3) impacts on parks and water-related recreation; (4) impacts on agriculture; (5) impacts on peak flows and (6) legal and institutional constraints. Because the No Action alternative would not provide an augmentation water supply for instream flow, it cannot satisfy any of the instream flow demand and, therefore, was not modeled. However, it was used as a baseline for comparison with other alternatives.

Ability to meet base-flow needs

For each of nine alternatives (3–11), the CRDSS estimated monthly volumes of augmentation water delivered to determine their ability to satisfy demand under a broad range of hydrologic conditions. The CRDSS water-year data were reformatted on an "augmentation-year" basis (July-March) for this analysis; augmentation reservoir pools, if any, were expected to refill during the subsequent spring runoff period (April-June) in most years. Annual sums of monthly delivered volumes were compared against augmentation demand during the augmentation year to determine the performance of each alternative. To determine the water volumes needed for augmentation, an allowance of 16.67% (up to 1,000 AF) had been included for structural alternatives. However, for comparison with the non-structural alternatives (2, 3 and 13, in part), which are presumed to suffer no transit losses, the transit-loss allowance was excluded from the volumes of the alternatives with structural elements (4–14) in Table 22. Differences in alternatives ranked 1–6 were negligible.

Alternatives 2 and 13, that relied on Supply Interruption Contracts *in toto* (2) or in part (13), were modeled by determining the water volume available through contracts based on estimated average monthly depletions, acreage available for contracts, and irrigation efficiency. Average monthly depletions from the Yampa River upstream from the Little Snake were estimated at 20,000 AF, 16,000 AF, 8,000 AF and 2,000 AF for July, August, September and October, respectively. Irrigated acreage was determined to be 68,230 acres, and irrigation efficiency was estimated to be 60%. Therefore, the total volume of water available for contracts would be 33,333 AF (20,000 ÷ 0.6) in July, 26,667 AF in August, 13,333 AF in September, and 3,333 AF in October (Table 23). However, for this analysis, no more than 10,000 acres were assumed to be available for contracts at any time. On this basis, the water volume available from contracts was estimated to be 4,885 AF in July and 3,908 AF in August, more than sufficient to meet these monthly augmentation demands. However, available water declines to 1,954 AF in September and 489 AF in October, as demand for augmentation peaks in September. Moreover, water from Supply Interruption Contracts was assumed to be unavailable for base-flow augmentation after October 31, the traditional end of the irrigation season. Therefore, augmentation demand from September through February could not be met from contracts alone.

Alternative 3, which relied entirely on Instream Flow Water Rights, was assumed to maintain the *status quo*, in that the water right would be junior to those serving current (and potentially some future) depletions. That is, base flows would be maintained at roughly current conditions into the future. However, because current depletions exceed historic depletions, and flow recommendations are based on historic conditions, we would expect that Instream Flow Water Rights alone would not be able to serve the entire augmentation requirement. This presumption was borne out by modeling.

Table 22. Comparison of the ability of streamflow augmentation water supply alternatives to serve augmentation demand [a]

		Non-structural Options			Structural Options										
					Single source				Multiple sources						
	Alternative Number	1	2[b]	3	4	5	6	7	8	9	10	11	12[c]	13[b]	14[d]
Criteria	Number of years with shortages	44	26	29	13	0	0	1	3	4	1	0	0	12	1
	Percent of years[e] with shortages	100%	58%	66%	29%	0%	0%	2%	7%	9%	2%	0%	0%	27%	2%
	Maximum annual shortage (AF)	6000	5107	6000	5104	0	0	324	1	455	22	0	0	3171	27
	90th percentile[f] shortage (AF)	6000	1454	2489	288	0	0	0	0	0	0	0	0	643	0
	Average[e] annual shortage (AF)	2256	618	1411	176	0	0	7	0	33	0.5	0	0	236	0.5
	Average[e] volume delivered (AF)	0	1638	845	2080	2256	2256	2249	2256	2223	2256	2256	2256	2020	2256
	Percent of avg. demand delivered	0%	73%	37%	92%	100%	100%	100%	100%	99%	100%	100%	100%	90%	100%
	Rank (based on avg. shortage)	14	12	13	10	1	1	8	5	9	6	1	1	11	7

[a] Excluding transit losses (16.67% of delivered volume for structural options).

[b] Assumptions: Average depletions in July, August, September, and October are 20 KAF, 16 KAF, 8 KAF, and 2 KAF, respectively; 10,000 acres are available for contract every year; irrigation efficiency is 60%; no water is available from contracts after October 31.

[c] Not modeled, but similar to Alternative 11, assuming tributary reservoir(s) with sufficient inflow to reliably deliver 1,300 AF/year.

[d] Not modeled, but similar to Alternative 10.

[e] Based on 44 years that augmentation is required.

[f] Shortages exceed this value in 10% of the years that augmentation is required (5% of all modeled years).

Table 23. Estimation of acreage required for supply interruption contracts

Acres under contract	Acre-feet available[a] by month and acreage under contract				Avg. annual[b] shortage (AF)
	JUL	AUG	SEP	OCT	
0	0	0	0	0	2,256
5,000	2,443	1,954	977	244	1,021
10,000	4,885	3,908	1,954	489	618
20,000	9,771	7,817	3,908	977	485
40,000	19,542	15,633	7,817	1,954	455
68,230	33,333	26,667	13,333	3,333	455
Max. demand[c]	3,074	2,926	2,975	1,785	

[a] Based on 68,230 irrigated acres depleting 20,000 AF in July, 16,000 AF in August, 8,000 AF in September and 2,000 AF in October, with an irrigation efficiency of 60%.
[b] Includes winter shortages averaging 455 AF.
[c] Based on 100% of 6,000-AF augmentation requirement served by contracts (Alternative 2).
Cells shaded green ( ) meet or exceed the maximum demand; cells shaded tan ( ) do not.

Alternative 12 was not modeled because no site-specific hydrologic data were available for any potential new reservoir site(s). However, it is most similar to Alternative11, and for this criterion, the tributary reservoirs were assumed to perform as well as Stagecoach Reservoir. Alternative 14 was considered to be similar in performance to Alternative 10.

Non-structural options generally did not perform as well for this criterion as structural options. Alternative 3, Instream Flow Water Rights, performed the worst, suffering shortages in 29 out of 44 years with a maximum shortage of 6,000 AF and an average shortage of 1,411 AF. Alternative 2, Supply Interruption Contracts, suffered shortages in 26 years, with a maximum shortage of 5,107 AF and an average shortage of 618 AF. Alternative 13, the only other alternative that relied on contracts, fared better than Alternative 2, because contracts accounted for only 3,171 AF of the total 6,000-AF augmentation requirement. However, it fared worse than any of the exclusively structural alternatives.

Structural alternatives which relied solely on Elkhead Reservoir (5, 6) and Alternative 11, which used Steamboat Lake, Elkhead and Stagecoach reservoirs, performed the best in terms of reliability. There were no shortages of delivered volumes in any of the 44 years during which water was required by the augmentation protocol. Of the 10 exclusively structural alternatives, the Steamboat-only option (4) performed the worst, suffering shortages in 13 of 44 years, with a maximum shortage of 5,104 AF. This shortage occurred in 1977, the driest year of the CRDSS period of record, when the augmentation protocol called for the maximum volume, following another dry year (1976) when the maximum 6,000-AF of augmentation would have been delivered according to the protocol. However, shortages in the remaining 12 years were less than 500 AF/year with this alternative. The other four alternatives modeled (7–10) ranked eighth, seventh, fifth, and sixth, respectively. Alternatives 12 and 14 were considered to be similar to Alternatives 11 and 10, respectively.

Comparison of estimated costs

The USBR performed an economic evaluation to compare the costs of leasing water from Steamboat Lake relative to the costs of developing new storage. This estimate was applied to all leases, regardless of source(s). In addition, a higher lease cost estimate also was developed by pro rating the Bureau estimate. The USBR used the following basis for its estimate:

Current annual lease cost: 2,000 AF/year × $32/AF = $64,000/year
Long-term interest rate: i(r) = 5%
Long-term inflation rate: i(i) = 3%
Effective interest rate: i(e) = i(r) - i(i) = 2%
Lease term: 100 years

Then:

Present worth of annual series factor: (P/A, i(e) = 2%, n = 100) = 43.098
Present worth of lease: $64,000 × 43.098 = $2,758,272
Present worth of lease/AF: $2,758,272/2,000 AF = $1379/AF

Because lease rates may vary between potential sources, a higher lease rate ($50/AF) also was used, pro rated at a present worth of $2,155/AF. Both high and low unit values were applied to leases in the cost comparison (Table 24).

The CRWCD provided comparative cost estimates for a small enlargement of Elkhead Reservoir (~5,000 AF) solely for stream-flow augmentation and a greater enlargement (~12,000 AF), shared between stream-flow augmentation and human use. Due to economies of scale, the cost of the larger reservoir ($1,750/AF) was less than that of the smaller reservoir (~$2,500/AF). Both high and low unit values were applied to reservoir construction in the cost comparison (Table 25).

Alternative 1 (No Action) and Alternative 3 (Instream Flow Water Rights) would incur no direct lease or construction costs. However, legal and administrative costs could apply to Alternative 3 for adjudication of water rights. These costs are reflected under Legal and institutional constraints.

Not surprisingly, by applying higher lease costs and lower construction costs, alternatives with higher leased volumes cost more than those with higher constructed volumes. Conversely, applying lower lease costs with higher construction costs produced lower-cost lease options relative to construction. When both high-lease/high-construction or low-lease/low-construction values were applied, lease options fared somewhat better than construction options. Three all-lease options (Alternatives 2, 4 and 13) cost between $8.9 and $15.1M, whereas, the one all-construction option (Alternative 6) ranged from $12.3M to $17.5M, depending on unit costs. Lease costs were reduced somewhat for Alternatives 2 and 13 in proportion to the volumes of water derived from supply interruption contracts. For contracts, there was no allowance needed for transit losses; therefore, the leased volumes were reduced to 6,000 AF for Alternative 2 and 6,471 AF (3,300 AF from leased storage plus 3,171 AF from contracts) for Alternative 13. The remaining options included both leases and constructed storage ranging in cost from $11M to $16.8M, depending on unit costs and the relative proportions of leased/constructed volumes.

Table 24. Cost estimates for streamflow augmentation water supply alternatives based on a range of lease and construction unit costs

		Non-structural Options		Structural Options											
	Alternative Number	2[b]	3	4	5	6	7	8	9	10	11	12	13[b]	14	PA[c]
Lease	Leased volume (AF/year)[a]	1719	–	7000	3300	–	7000	3300	3300	2000	3300	3300	3696	3300	500
	High cost @ $2,155/AF ($$10^6$)	3.7	–	15.1	7.1	–	15.1	7.1	7.1	4.3	7.1	7.1	8.0	7.1	1.1
	Low cost @ $1,379/AF ($$10^6$)	2.4	–	9.7	4.6	–	9.7	4.6	4.6	2.8	4.6	4.6	5.1	4.6	0.7
Reservoir	Constructed volume (AF/year)	–	–	–	3700	7000	–	3700	3700	5000	3700	3700	–	3700	5000
	High cost @ $2,500/AF ($$10^6$)	–	–	–	9.3	17.5	–	9.3	9.3	12.5	9.3	9.3	–	9.3	12.5
	Low cost @ $1,750/AF ($$10^6$)	–	–	–	6.5	12.3	–	6.5	6.5	8.8	6.5	6.5	–	6.5	8.8
Totals	High lease/Low reservoir ($$10^6$)	3.7	–	15.1	13.6	12.3	15.1	13.6	13.6	13.1	13.6	13.6	8.0	13.6	9.9
	Low lease/High reservoir ($$10^6$)	2.4	–	9.7	13.8	17.5	9.7	13.8	13.8	15.3	13.8	13.8	5.1	13.9	13.2
	High lease/High reservoir ($$10^6$)	3.7	–	15.1	16.4	17.5	15.1	16.4	16.4	16.8	16.4	16.4	8.0	16.4	13.6
	Low lease/Low reservoir ($$10^6$)	2.4	–	9.7	11.0	12.3	9.7	11.0	11.0	11.5	11.0	11.0	5.1	11.1	9.5

[a] Leased volumes and annual costs may vary from year to year, depending upon the lease terms and conditions.
[b] Based on the assumption that 10,000 acres of irrigated land are available for Supply Interruption Contracts, resulting in average delivered volumes from contracts of 1,719 AF for Alternative 2 and 396 AF for Alternative 13 (added to 3,300 AF from other leases).
[c] Proposed Action (see description beginning on page 75)

Impacts to parks and water-related recreation

Impacts to Colorado State Parks (Parks) facilities and water-related recreation at each of three reservoirs (Steamboat Lake, Stagecoach Reservoir and Elkhead Reservoir) are discussed below for the 11 structural alternatives. Using CRDSS, end-of-month values were estimated for total reservoir contents, streamflow augmentation account contents (a subset of total contents), water surface elevation, water surface area, and volume of water released for augmentation. Frequencies and magnitudes of augmentation from each of these reservoirs were estimated as the change in streamflow augmentation account contents (Table 25). Each of the bars (▮) in Table 25 represents 9 years (10%) of the 90-year CRDSS period of record, as follows:

▮▮▮▮▮	Volume drawn 44 years (50%) or less
▮▮▮▮	Volume drawn 36 years (40%) or less
▮▮▮	Volume drawn 27 years (30%) or less
▮▮	Volume drawn 18 years (20%) or less
▮	Volume drawn 9 years (10%) or less

Figures 10–17 provide graphical representations of the magnitudes of the augmentation pool volumes relative to the total volumes of the affected reservoirs, as well as the relative impacts of augmentation pool operations compared with other reservoir uses (i.e., balance of contents). Fluctuations in reservoir volumes at Steamboat Lake and Elkhead Reservoir generally vary in direct relation to the operation of their augmentation pools due to limited use of other reservoir accounts. However, Stagecoach Reservoir exhibits much larger fluctuations than augmentation alone. These are likely attributable to contract deliveries to Tri-State and other water consumers, as well as releases of water through the penstocks of Stagecoach Dam for hydropower production. Moreover, fluctuations in the 7,000-AF Steamboat Lake augmentation pool (Figure 10) are larger than those of Elkhead (Figures 11 and 12) or Stagecoach (Figure 13). This is presumed to result from partial refilling of the augmentation pools in Elkhead and Stagecoach <u>during</u> the augmentation period.

Parks requested that changes in water surface elevation at Steamboat Lake should not exceed 2 feet prior to September 15. This threshold was established primarily to ensure safe access to the marina during the summer peak-use period, and serves as the basis for the existing 2,000-AF lease. To compare alternatives, this threshold also was applied to Elkhead and Stagecoach, although the sensitivity to a change of this magnitude may be greater at Steamboat Lake due to the relatively flat contours of its basin. For example, a 2-foot drawdown at Steamboat Lake reduces its size by about 65 acres, whereas it would require drawdowns of more than 6 feet at Stagecoach Reservoir and almost 8 feet at Elkhead Reservoir to affect the same area. The tiered use of the Steamboat Lake 3,300-AF instream flow pool in Alternatives 8 and 9 attempts to comply with this recommendation.

However, the monthly CRDSS output does not allow for that level of precision. Nevertheless, estimates of mid-September surface elevations and reservoir areas were derived by averaging August and September EOM data. Moreover, a preliminary assessment indicated that reservoir levels occasionally fluctuated more than 2 feet even when there were no releases for fish. To segregate those impacts, the analysis focused only on months during which streamflow augmentation releases were made. To further refine this estimate, EOM differential values of elevation and surface area were multiplied by a factor equal to the difference in the EOM augmentation pool contents divided by the difference in the EOM total reservoir contents to determine the portion of elevation/area changes for which augmentation releases were responsible.

Table 25. Frequency and magnitude of augmentation demand drawn from 13 structural water supply alternatives, by water source

Vol. drawn (AF)	Proposed Action					Alternative 4					Alternatives 5 & 6					Alternative 7				
	Frequency drawn by source[a]					Frequency drawn by source[a]					Frequency drawn by source[a]					Frequency drawn by source[a]				
	SL1	ER1	SL2	SR	ER2	SL1	ER	SL2	SR		SL1	ER	SL2	SR		SL1	ER	SL2	SR	
>0	–	████	–	–	█	█████	–	–	–	–	–	█████	–	–	–	–	–	–	█████	–
≥500	–	████	–	–	█	████	–	–	–	–	–	████	–	–	–	–	–	–	████	–
≥1000	–	████	–	–	█	████	–	–	–	–	–	████	–	–	–	–	–	–	████	–
≥2000	–	███	–	–	█	███	–	–	–	–	–	███	–	–	–	–	–	–	███	–
≥3000	–	██	–	–	–	██	–	–	–	–	–	██	–	–	–	–	–	–	██	–
≥5000	–	█	–	–	–	█	–	–	–	–	–	█	–	–	–	–	–	–	█	–
=7000	–		–	–	–	█	–	–	–	–	–	█	–	–	–	–	–	–	█	–
max.	–	5,000	–	–	2,000	7,000	–	–	–	–	–	7,000	–	–	–	–	–	–	7,000	–
avg.	–	1,171	–	–	179	1,350	–	–	–	–	–	1,350	–	–	–	–	–	–	1,350	–

Vol. drawn (AF)	Alternative 8					Alternative 9					Alternative 10					Alternative 11				
	Frequency drawn by source[a]					Frequency drawn by source[a]					Frequency drawn by source[a]					Frequency drawn by source[a]				
	SL1	ER	SL2	SR		SL1	ER	SL2	SR		SL1	ER	SL2	SR		SL1	ER	SL2	SR	
>0	█████	███	█	–	–	█████	–	███	██	–	█████	███	–	–	–	█████	███	–	█	–
≥500	████	██	█	–	–	████	–	██	██	–	████	██	–	–	–	████	██	–	█	–
≥1000	████	██	█	–	–	████	–	██	██	–	████	██	–	–	–	████	██	–	█	–
≥2000	███	██	–	–	–	███	–	–	█	–	███	██	–	–	–	███	██	–	–	–
≥3000	–	█	–	–	–	–	–	–	█	–	–	█	–	–	–	–	█	–	–	–
≥5000	–	–	–	–	–	–	–	–	–	–	–	█	–	–	–	–	–	–	–	–
max.	2,000	3,700	1,300	–	–	2,000	–	1,300	3,700	–	2,000	5,000	–	–	–	2,000	3,700	–	1,300	–
avg.	707	533	110	–	–	707	–	256	387	–	707	643	–	–	–	707	533	–	110	–

Vol. drawn (AF)	Alternative 12					Alternative 13					Alternative 14A					Alternative 14B				
	Frequency drawn by source[a]					Frequency drawn by source[a]					Frequency drawn by source[a]					Frequency drawn by source[a]				
	SL1	ER	SL2	SR	Trib	SL1	ER	SL2	SR	SIC	SL1	ER	SL2	SR		SL1	ER	SL2	SR	Trib
>0	█████	███	–	–	█	█████	–	–	███	██		█████	█	–	–	–	█████	██	–	█
≥500	████	██	–	–	█	████	–	–	██	██		████	█	–	–	–	████	██	–	█
≥1000	████	██	–	–	█	████	–	–	██	██		████	█	–	–	–	████	█	–	█
≥2000	███	██	–	–	–	███	–	–	–	█		███	█	–	–	–	███	█	–	–
≥3000	–	█	–	–	–	–	–	–	–	█		██	–	–	–	–	██	–	–	–
≥5000	–	–	–	–	–	–	–	–	–	–		█	–	–	–	–	–	–	–	–
max.	2,000	3,700	–	–	1,300	2,000	–	–	1,300	3,700		5,000	2,000	–	–	–	3,700	2,000	–	1,300
avg.	707	533	–	–	110	707	–	–	256	387		1,171	179	–	–	–	1,022	218	–	110

[a] Steamboat Lake (Primary - SL1; Secondary - SL2); Elkhead Res. (ER); Stagecoach Res. (SR); Supply Interruption Contracts (SIC)
New tributary reservoir (Trib)

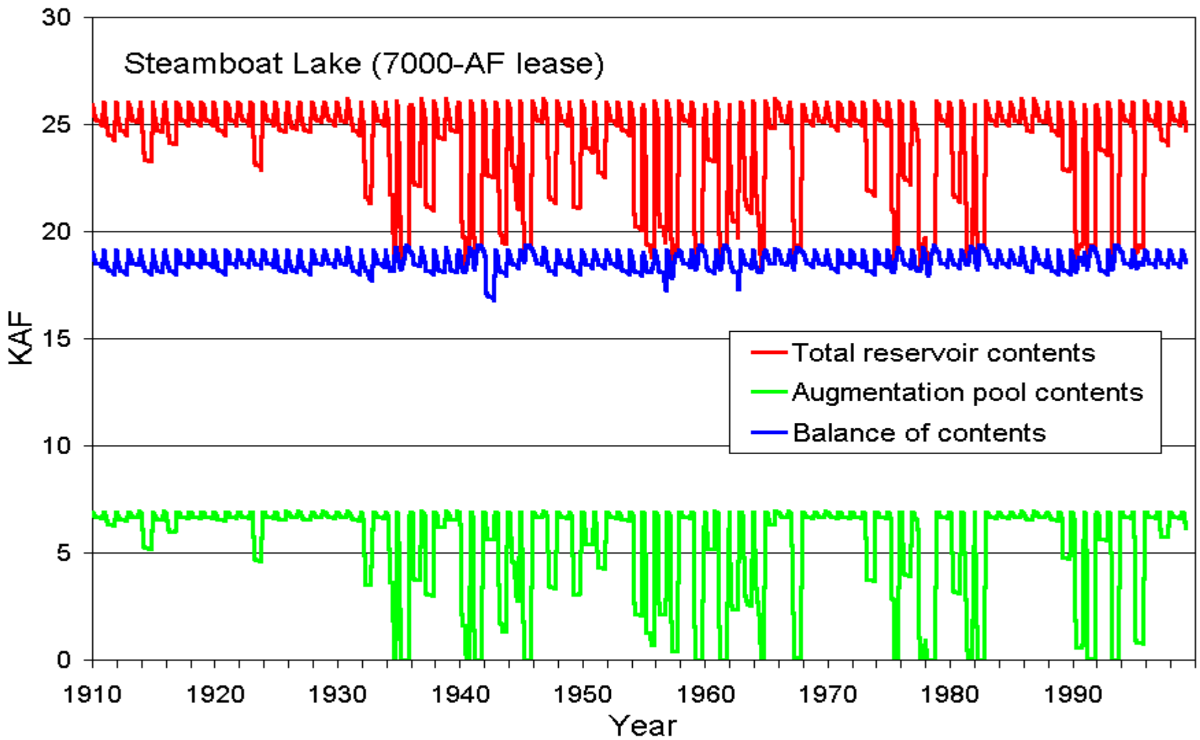


Figure 10. Alternative 4: EOM total reservoir contents, augmentation pool contents and balance of contents in Steamboat Lake

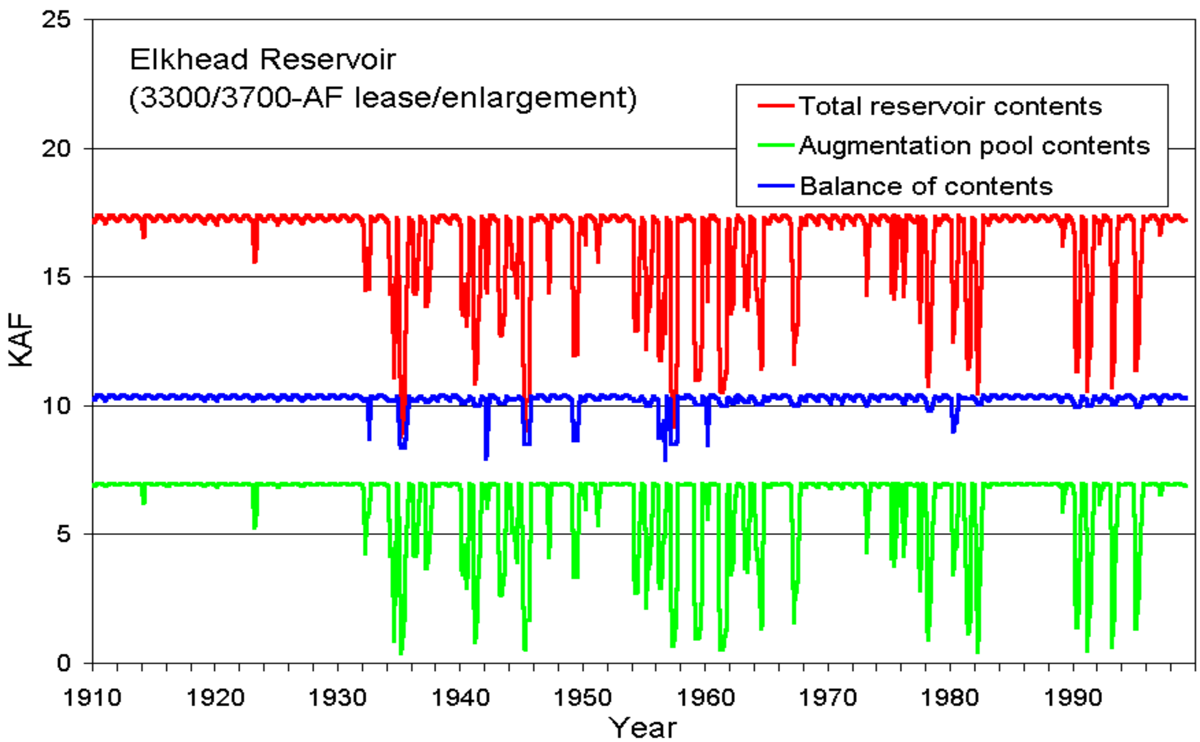


Figure 11. Alternative 5: EOM total reservoir contents, augmentation pool contents and balance of contents in Elkhead Reservoir

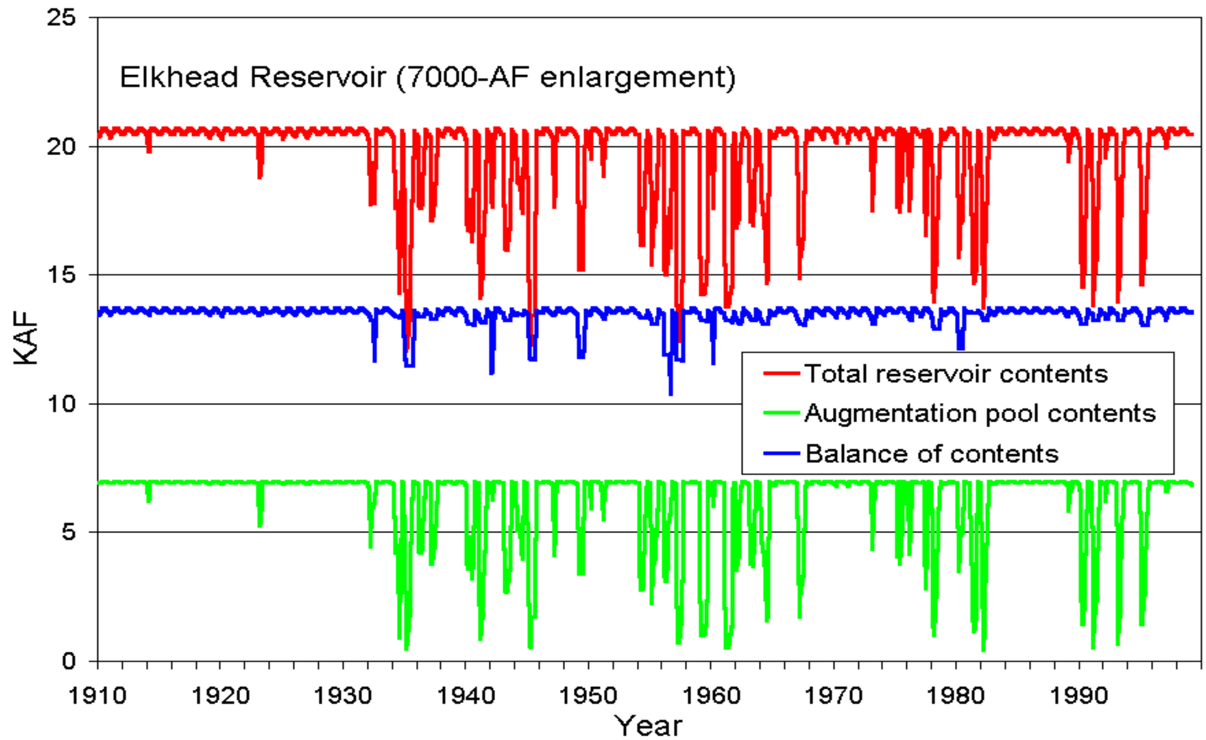


Figure 12. Alternative 6: EOM total reservoir contents, augmentation pool contents and balance of contents in Elkhead Reservoir

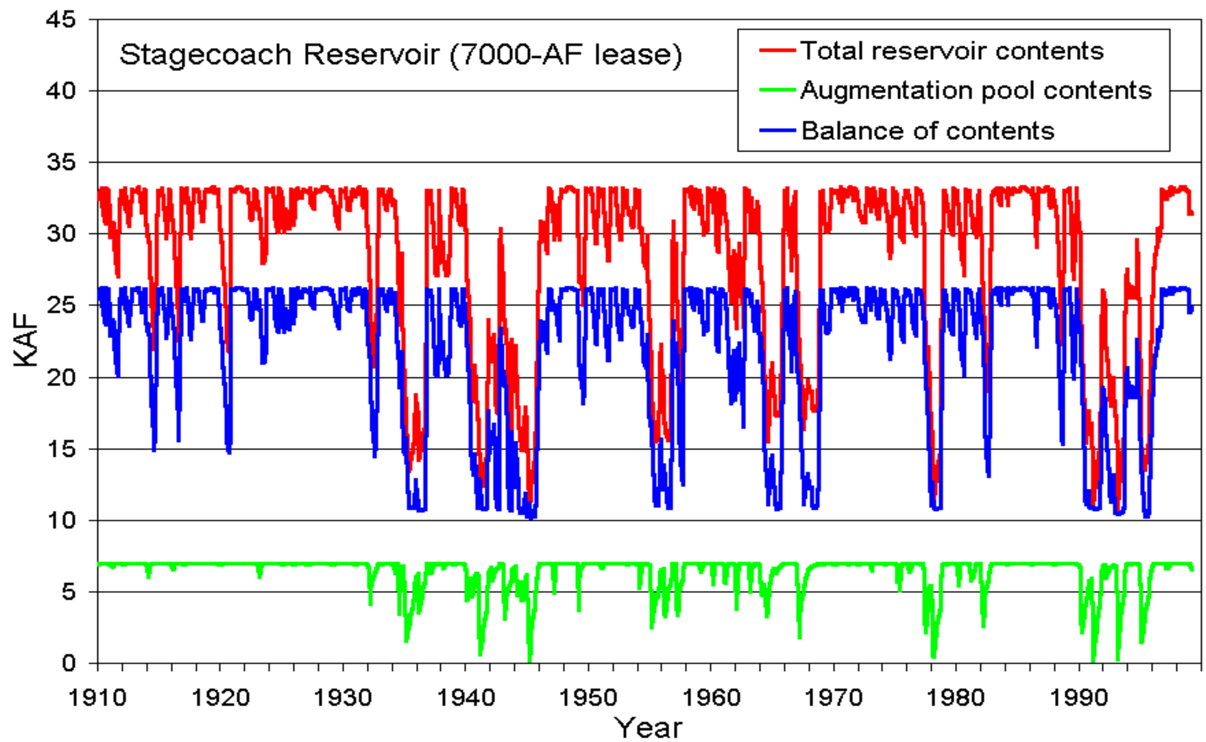
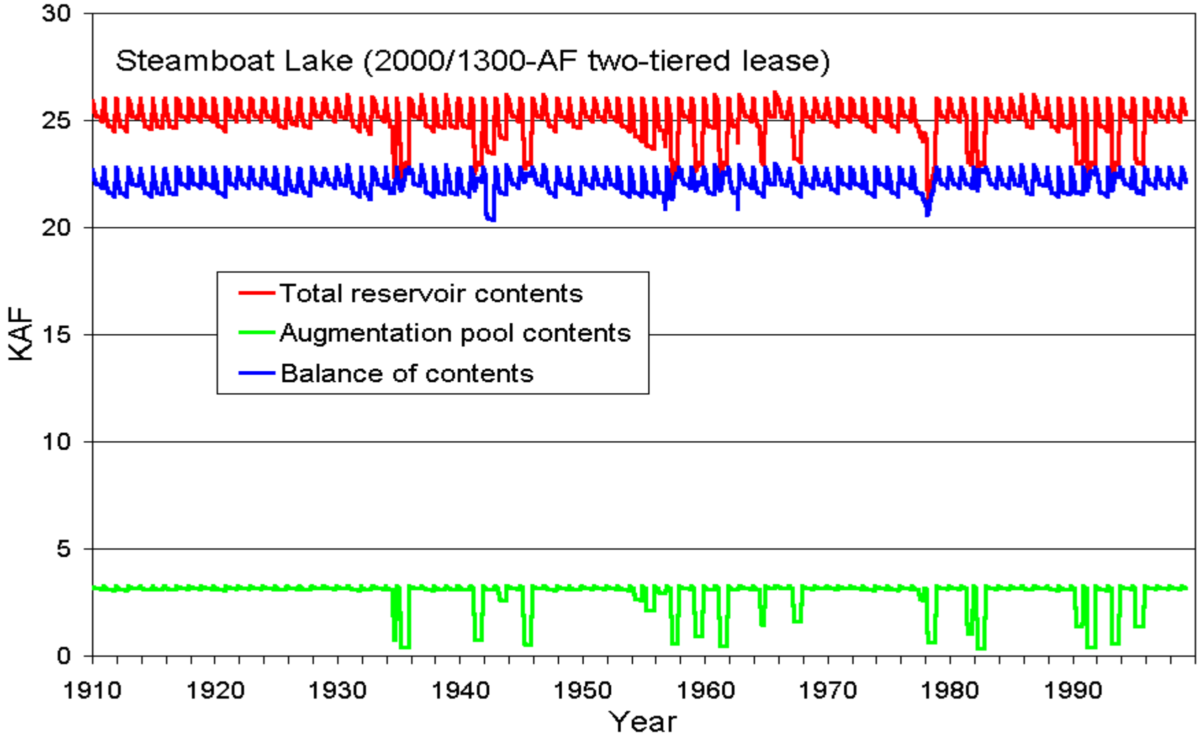


Figure 13. Alternative 7: EOM total reservoir contents, augmentation pool contents and balance of contents in Stagecoach Reservoir



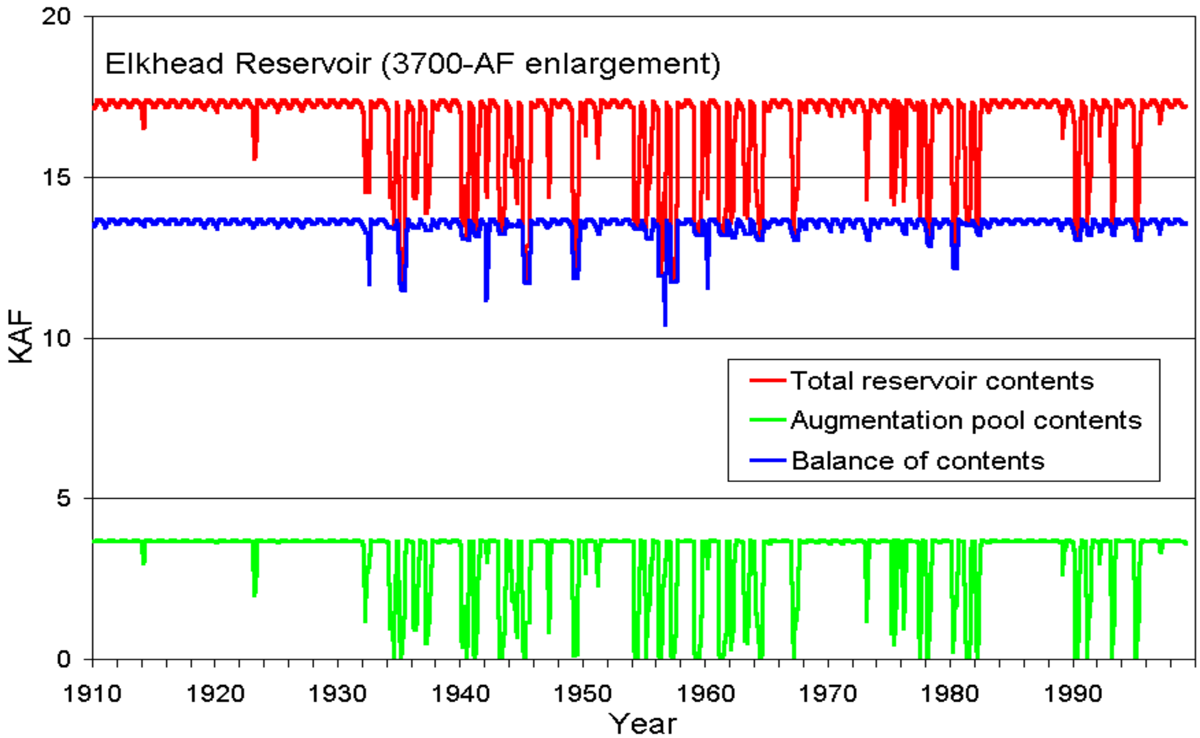


Figure 14. Alternative 8: EOM total reservoir contents, augmentation pool contents and balance of contents in Steamboat Lake and Elkhead Reservoir

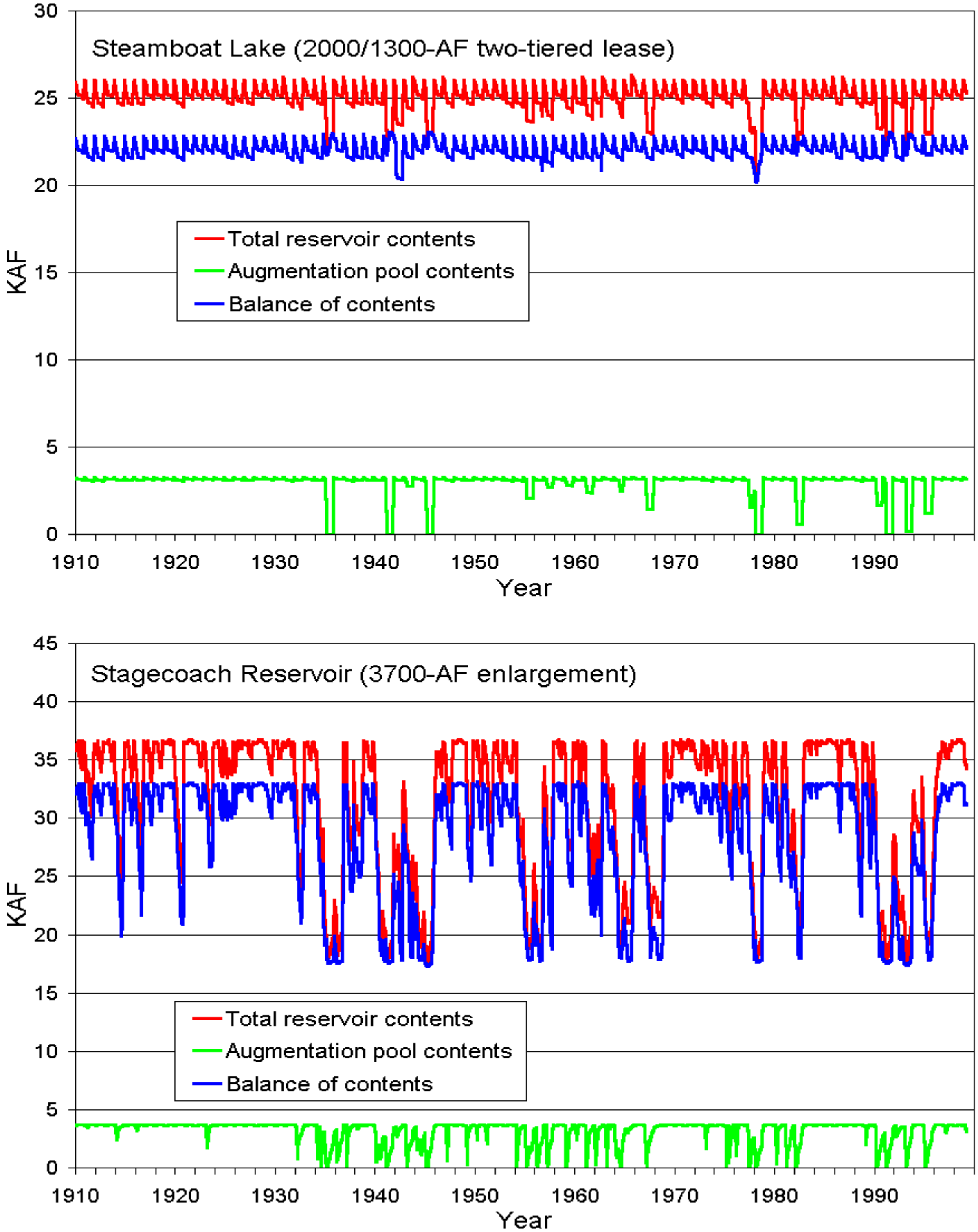


Figure 15. Alternative 9: EOM total reservoir contents, augmentation pool contents and balance of contents in Steamboat Lake and Stagecoach Reservoir

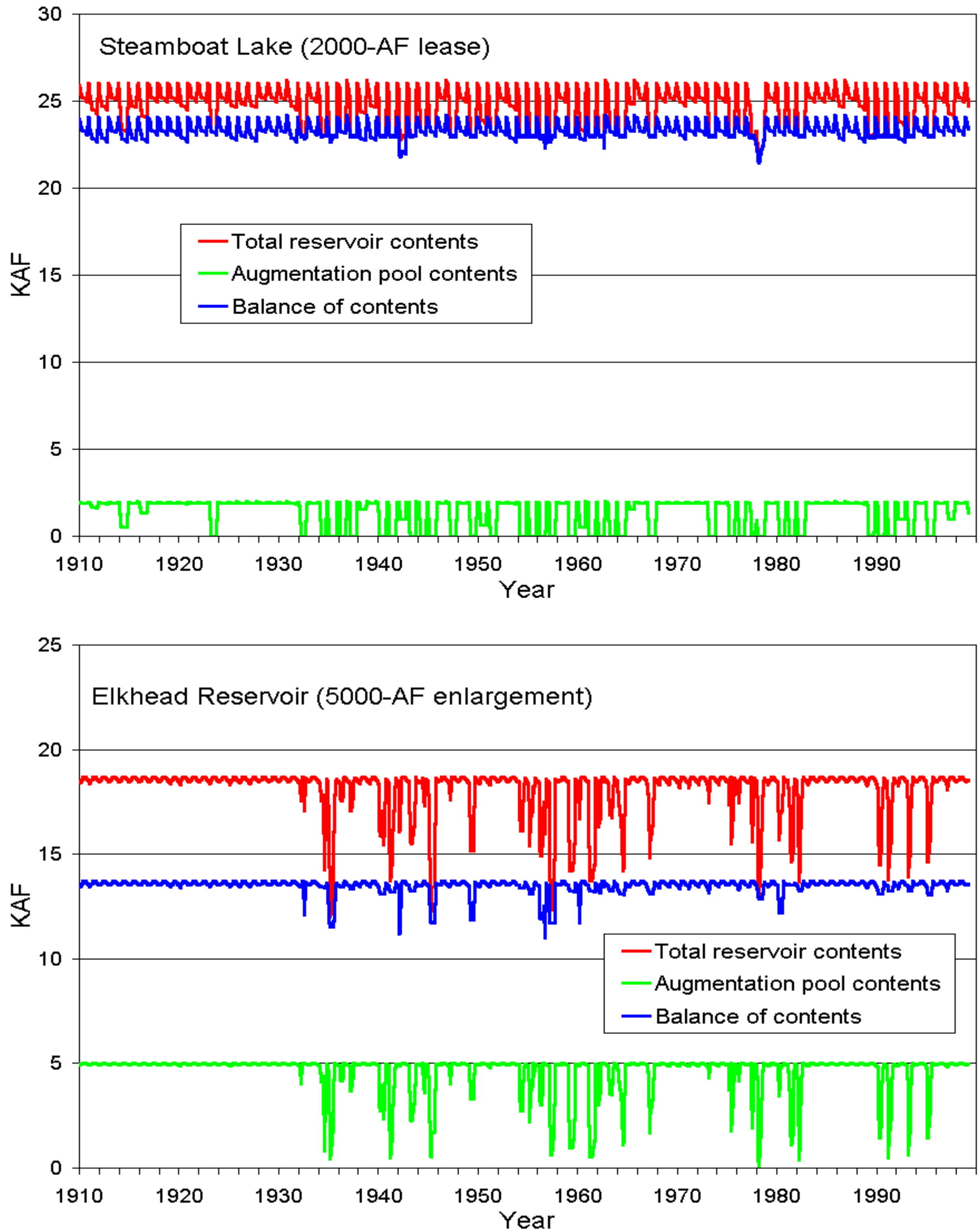


Figure 16. Alternative 10: EOM total reservoir contents, augmentation pool contents and balance of contents in Steamboat Lake and Elkhead Reservoir

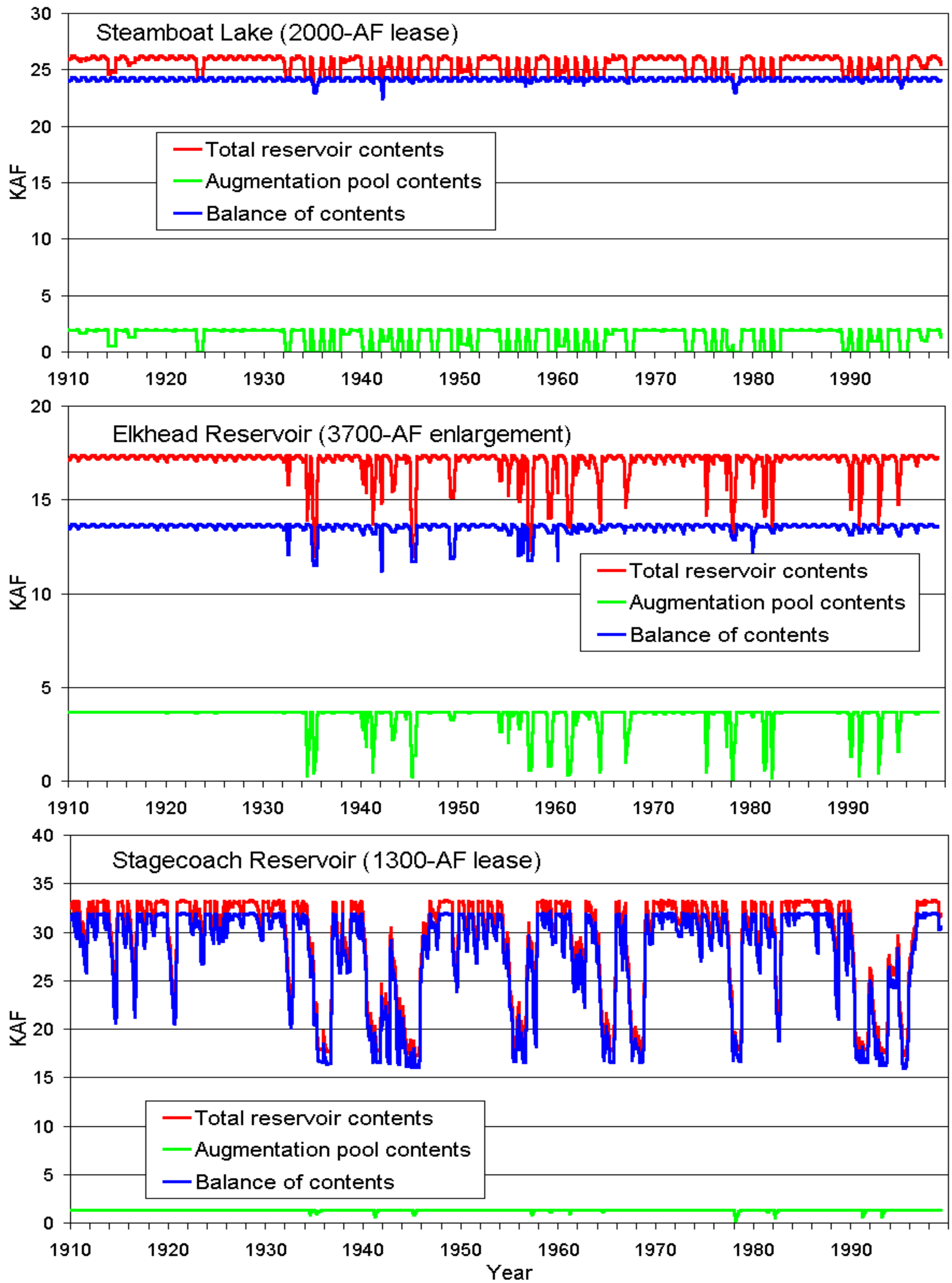


Figure 17. Alternative 11: EOM total reservoir contents, augmentation pool contents and balance of contents in Steamboat Lake, Elkhead Reservoir and Stagecoach Reservoir

Alternatives 1–3: Unless supply interruption contracts (Alternative 2) use agricultural storage water rights, non-structural alternatives would require no reservoir storage for streamflow augmentation; therefore, they would have no adverse impacts on reservoirs, parks or water-related recreation.

Alternative 4: As expected, alternatives that relied entirely on a single reservoir had a far greater impact on that reservoir than did alternatives where demand was distributed across several sources. Steamboat Lake suffered losses in water surface elevation (WSEL) greater than 2 feet, 34 out of 90 years, with a maximum loss of 6.8 feet (Figure 10). Losses greater than 2 feet (6.2 feet maximum) occurred prior to September 15 in 16 years. Losses in surface acreage also were significant, exceeding 10% in 27 years (20% maximum), 13 years prior to September 15 (19% maximum).

Alternative 5: Although a 3,700-AF enlargement of Elkhead raised the maximum WSEL only 7.6 feet and increased surface area by 64 acres, the magnitude of impacts on WSEL and surface acreage were proportional to the entire 7,000-AF volume of the augmentation water supply, which included 3,300 AF of leased water. Losses in WSEL (Figure 11) exceeded 2 feet in 37 years (13 feet maximum), 32 years prior to September 15 (12 feet maximum), while areal losses exceeded 10% in 27 years (24% maximum), 13 years prior to September 15 (19% maximum).

Alternative 6: A 7,000-AF enlargement of Elkhead will raise its maximum WSEL by 13.8 feet and increase its surface area by 117 acres; however, the greater enlargement relative to Alternative 5 served to slightly attenuate impacts to WSEL and area. Losses in WSEL (Figure 12) exceeded 2 feet in 36 years (11.4 feet maximum), 32 years prior to September 15 (10.7 feet maximum), while areal losses exceeded 10% in 21 years (19% maximum), 12 years prior to September 15 (15% maximum).

Alternative 7: Stagecoach Reservoir was not enlarged with this alternative, so there was no increase in reservoir WSEL or area. However, significant impacts to WSEL and area resulted from drawing the entire 7,000-AF fish account from this reservoir. The WSEL fell more than 2 feet in 29 years (Figure 13), 17 years prior to September 15 (14.2 feet maximum). This is the largest WSEL loss of any alternative. Areal losses would exceed 10% in only 12 years (20% maximum); however, the maximum loss in acreage (141.5 acres) also is greater than that of any other alternative.

Alternative 8: Steamboat Lake experienced WSEL losses greater than 2 feet in 11 years, with a maximum loss of 2.7 feet (Figure 14). However, before September 15, only one year experienced a loss greater than 2 feet (2.2 feet maximum). Steamboat Lake experienced no losses of surface acreage greater than 8%. As in Alternative 5, Elkhead Reservoir was enlarged by 3,700 AF, but WSEL and areal losses were less than with Alternative 5, because Elkhead served only 3,700 AF of augmentation with this alternative. The WSEL losses were greater than 2 feet in 36 years (32 years before September 15), but maximum losses were only 11.7 feet (7.7 feet before September 15, compared with 13 feet (12 feet before September 15) under Alternative 5. Areal losses greater than 10% occurred in 25 years (18% maximum), 12 years prior to September 15 (12% maximum).

Alternative 9: Steamboat Lake experienced elevation losses greater than 2 feet in 7 years, with a maximum loss of 2.7 feet (Figure 15). However, prior to September 15, losses greater than 2 feet occurred in only 2 years (2.4 feet maximum). Steamboat Lake experienced no areal losses greater than 10% before or after September 15 (9% maximum). Stagecoach Reservoir gained 4.4 feet in WSEL due to a 3,700-AF enlargement. It experienced losses in WSEL greater than 2 feet in 36 years (27 years before September 15), with maximum losses of 7.2 feet. Surface acreage increased by 45 acres due to enlargement and suffered losses greater than 10% in 4 years (12% maximum), only 1 year prior to September 15.

Alternative 10: Because the draw on Steamboat Lake was limited to 2,000 AF with this alternative, it experienced no WSEL changes greater than 2 feet in any year, with maximum losses of only 1.9 feet (Figure 16). Moreover, Steamboat Lake experienced no areal losses greater than 6%. Elkhead Reservoir gained 10.1 feet WSEL due to the 5,000-AF enlargement. It experienced WSEL losses greater than 2 feet in 29 years (15 years before September 15), with maximum losses of 8.3 feet. Surface acreage increased by 86 acres due to the enlargement and suffered losses greater than 10% in 10 years (13% maximum), only 1 year prior to September 15.

Alternative 11: As expected, this alternative performed about the same as Alternative 10 in terms of its impact on Steamboat Lake (Figure 17). Frequency and magnitude of changes in both WSEL and surface area were comparable. This alternative performed somewhat better than Alternative 10 in terms of its impacts on Elkhead Reservoir. Elkhead Reservoir gained 7.6 feet WSEL due to the 3,700-AF enlargement. It experienced WSEL losses greater than 2 feet in 21 years (11 years prior to September 15), with maximum losses of 7.3 feet. Surface acreage increased by 64 acres due to enlargement and suffered losses greater than 10% in 7 years (11% maximum), only 1 year prior to September 15. Of all the alternatives that utilized Stagecoach Reservoir, this had the least impact to Stagecoach. Stagecoach Reservoir was not enlarged with this alternative, so neither WSEL nor area increased. Moreover, it utilized only 1,300 AF from Stagecoach, compared with 3,700 AF with Alternative 9 and 7,000 AF with Alternative 7. Losses in elevation did not exceed 2 feet (1.2 feet maximum), and areal losses did not exceed 10% (3% maximum).

Alternative 12: Although this alternative was not specifically modeled, its impacts to Steamboat Lake should be similar to those of Alternatives 10 and 11; whereas, its impacts to Elkhead Reservoir should be similar to those of Alternative 8. There is insufficient information available to assess impacts to any potential new tributary reservoir(s).

Alternative 13: Although this alternative was not specifically modeled, its impacts to Steamboat Lake should be similar to those of Alternatives 10 and 11. Because this alternative would release 1,300 AF of water from Stagecoach as the second priority source (versus the third priority under Alternative 11), frequency and magnitude of impacts to Stagecoach Reservoir should be greater than those of Alternative 11, but less than those of Alternatives 8 and 7, which would deliver up to 3,700 AF and 7,000 AF, respectively.

Alternative 14: This alternative has two sub-options.

Option A – Steamboat Lake 2,000-AF lease and
Elkhead Reservoir 3,700-AF enlargement and 1,300-AF lease

Option B – Steamboat Lake 2,000-AF lease and
Elkhead Reservoir 3,700-AF enlargement and
New tributary reservoir 1,300-AF lease

Option A was similar to Alternative 10 in that impacts were restricted to Steamboat Lake and Elkhead Reservoir in comparable magnitudes. Option B was similar to Alternative 12, except that Steamboat Lake was secondary to Elkhead. Because Option B derived 1,300 AF of augmentation from a new tributary reservoir, the contribution of Elkhead Reservoir was reduced by that amount to the same levels as with Alternative 12 (Table 25). Impacts also would result to any new reservoir(s) from which water is delivered, but these impacts were not assessed because there is insufficient information available to assess impacts to any potential new tributary reservoir(s).

Impacts on agriculture

Most structural alternatives had little, if any, impacts to irrigated agriculture. Alternatives 2 and 13, which relied solely or in part on supply interruption contracts, had greater potential impacts than the other alternatives. For this analysis, once irrigated acreage was removed from irrigation at any time during the growing season it remained dry for the rest of the season. Water available from this source was a function of the number of acres irrigated, the amount of water applied per acre, and the efficiency of the application. Lower efficiencies require more water to be diverted from the river for the same acreage, but also increase return flows downstream from the diversion. However, the volume of water available from any individual irrigator could diminish during the growing season as river flows decline. For example, an irrigator that could physically divert as much as 10 cfs under free-river conditions, may be able to divert only 5 cfs during periods of extremely low flows. Therefore, the volume available to lease from that irrigator for instream flow purposes would be reduced by 50%, and additional contracts with other irrigators may be needed to serve the augmentation requirement. Moreover, supply interruption contracts with irrigators cannot provide water for augmentation November through March (see Ability to meet base-flow needs on page 51).

Table 26 demonstrates that potential impacts to agriculture would be proportionately greater with Alternative 2 than with Alternative 13. The top half of the table displays monthly average augmentation volumes, as well as the magnitudes and frequencies of monthly volumes required. Volumes are in 500-AF increments from 0 to 3,000 AF (the maximum monthly value is 3,075 AF). Frequencies are depicted as solid black bars, each representing 9 years (10%) of the CRDSS period of record, like those in Table 25.

Table 26. Comparison of potential impacts to agriculture due supply interruption contracts.

			Alternative 2				Alternative 13			
			JUL	AUG	SEP	OCT	JUL	AUG	SEP	OCT
Augmentation/month	Freq. Exceeded [a,b]	>0 AF	█	███	████	█	█	█	█	█
		>500 AF	█	██	███	█		█	█	█
		>1000 AF	█	██	███	█		█	█	
		>1500 AF	█	█	██	█		█	█	
		>2000 AF	█	█	█			█	█	
		>2500 AF	█	█	█			█	█	
		>3000 AF	█							
	Average [a] AF		139	554	909	126	5	110	224	66
	% Total AF		8%	32%	53%	7%	1%	27%	55%	16%
Cumul. augmentation	Freq. Exceeded [a,b]	>0 AF	█	███	████	████	█	█	█	██
		>1000 AF	█	██	███	████		█	█	█
		>2000 AF	█	█	██	██		█	█	█
		>3000 AF	█	█	█	█		█	█	█
		>4000 AF		█	█	█				
		>5000 AF		█	█	█				
		>6000 AF								
	Average [a] AF		139	693	1,602	1,728	5	116	340	405
	% Total AF		8%	40%	93%	100%	1%	29%	84%	100%

[a] Based on 90-year period of record

[b] Each bar = 10% of 90 years (i.e., █1–9, ██10–18, ███19–27, ████28–36, █████37–44 years).

The bottom half of the table provides cumulative end-of-month (EOM) data for the same variables. In this case, magnitudes are expressed in increments of 1,000 AF from 0 to 6,000 AF, the maximum volume Alternative 2 would require to be delivered for augmentation in any year. However, in 81 of 90 years (90%), Alternative 2 would require less than 3,000 AF/year from supply interruption contracts, and the maximum delivered volume (6,000 AF) would be needed only in the two driest years (1934 and 1977). Some augmentation would be required by the end of July in 3 of 90 years; by the end of August, 19/90 years; and by the end of September, 32/90 years. Augmentation greater than 3,000 AF would be required by the end of October 10% of the time (9/90 years).

Alternative 13 would require no more than 3,171 AF/year (excluding transit losses) from supply interruption contracts, and contracts would be exercised only after all other sources are exhausted. In 80 of 90 years, no water from contracts would be needed, and the maximum delivered volume (3,171 AF) would be needed only in the two driest years. Moreover, because contracts under this option would be the last priority, potential impacts would be delayed until later in the growing season. Augmentation from Supply Interruption Contracts would be needed in 1 of 90 years by the end of July, 2 of 90 years by the end of August, and 9 of 90 years (10%) by the end of September. Augmentation greater than 2,000 AF would be required in 6 of 90 years by the end of October.

These volumes represent relatively small fractions of average annual agricultural depletions (69,851 AF) upstream from the Little Snake River (Table 8). However, augmentation needs increase as the water available per acre declines under drier hydrologic conditions, because less water is available for irrigation. Therefore, the number of acres taken out of irrigation is likely to be non-linear with respect to the volumes of augmentation required. Moreover, augmentation needs in a single dry month may dictate the number of acres withdrawn in any year. Reducing the augmentation rate from 50 cfs to 33 cfs will not necessarily reduce the maximum acreage withdrawn (in fact, it may increase the maximum acreage), but it may delay the withdrawal of some lands from irrigation until later in the season, reducing overall impacts. Such an example can be found in 1977 (Table 27).

Table 27. Calculation of acreage taken out of irrigation to serve 1977 augmentation needs.

		1977 Augmentation Period				Totals
		JUL	AUG	SEP	OCT	
CRDSS Depletions (AF/month)		13,019	11,123	7,814	1,405	33,361
AF available (10,000 acres at 60% eff.)[a]		3,180	2,717	1,909	343	8,231
Alt. 2	Augmentation (AF) at 50 cfs	2,281	2,578	1,141	–	6,000[b]
	Equivalent acreage[c]	7,173	9,488	5,978	–	35,637[d]
	Augmentation (AF) at 33 cfs	1,505	1,702	1,898	327	5,432
	Equivalent acreage[c]	4,732	6,264	9,944	9,528	30,884[d]
Alt. 13	Augmentation (AF) at 50 cfs	–	2,030	1,141	–	3,171[b]
	Equivalent acreage[c]	–	7,471	5,978	–	22,414[d]
	Augmentation (AF) at 33 cfs	–	378	1,898	327	2,603
	Equivalent acreage[c]	–	1,391	9,944	9,528	21,279[d]

[a] Depletions multiplied by 10,000 acres divided by 68,230 acres, then divided by 0.6 (efficiency)
[b] Arbitrarily limited to 6,000 AF for Alternative 2 and 3,171 AF for Alternative 13
[c] Total acreage available (10,000 acres) multiplied by monthly Augmentation divided by corresponding AF available (e.g., 10,000 acres × 2,281 AF ÷ 3,180 AF = 7,173 acres);
[d] Totals are expressed as "acre-months" (see page 68).

Land taken out of irrigation remains out of irrigation for the rest of the season; therefore, impacts are expressed as the sum of all months (acre-months), where the maximum acreage in any month is used for all subsequent months. Although greater acreages are required to meet augmentation needs under Alternative 2 at 33 cfs (9,944 acres), versus 50 cfs (9,488 acres), augmentation demand peaks earlier at 50 cfs (August) than at 33 cfs (September); therefore, the overall impact is greater at 50 cfs than at 33 cfs (35,637 vs. 30,884 acre-months). Under Alternative 13, no land is taken out of irrigation before August, resulting in lesser impacts (22,414 acre-months at 50 cfs) than Alternative 2, which requires more than 7,000 acres to be taken out of irrigation in July 1977.

Impacts on peak flows

Alternative 1 (No Action) and Alternative 3 (Instream Flow Water Rights) involve no storage and, therefore, were not evaluated. Supply interruption contracts with irrigators (Alternatives 2 and 13) may or may not impact peak flows, depending on whether these irrigation water rights are supported by reservoir storage. Use of direct-flow water rights without reservoir storage should not impact peak flows.

Structural alternatives (4–14 and the Proposed Action) rely on reservoir storage to meet 3,300–7,000 AF of the streamflow augmentation requirement. One hybrid option (Alternative 13) also requires up to 3,700 AF from supply interruption contracts. Because reservoirs would deliver water during base-flow periods (typically July through February) and store water principally during peak-flow periods (typically April through June), structural alternatives may impact peak flows.

Timing of impacts also is important. The highest peak flows are considered most important, followed by the ascending limb and finally the descending limb. The nature and magnitude of the impact would vary with volume(s) of storage allocated to augmentation and location(s) of reservoir(s). Because of its down-valley location, Elkhead Creek generally peaks earlier than the mainstem of the Yampa River. Therefore, Elkhead Reservoir typically stores water on the ascending limb of the Yampa River. Steamboat Lake is higher in the basin and typically stores water closer to the peak of the mainstem (Table 28).

Whether water for stream-flow augmentation is obtained from a lease of existing stored water or from new or enlarged reservoir(s), impacts is essentially identical for the same volume(s) and location(s) of storage, but impacts vary in frequency with the relative priorities for delivery from the various sources in multiple-source alternatives. Evaporation from any new or enlarged reservoirs would increase impacts slightly over using existing storage, because reservoir evaporation is proportional to its surface area. However, reservoir evaporation is a relatively minor component of depletions.

An analysis of the four single-source structural alternatives (4–7) was carried out using end-of-month total reservoir contents and streamflow augmentation account (fish pool) contents, as a subset of total reservoir contents. An increase in reservoir contents indicates storage, with a commensurate decrease in streamflow downstream from the reservoir. Conversely, reservoir contents decrease whenever reservoir outflows exceed inflows (i.e., releases are being made from storage), with a commensurate increase in stream flows below the reservoir relative to inflow. Changes in reservoir contents were expressed in acre-feet and added to or subtracted from a baseline of future "without-the-project" flow conditions. These data subsequently were converted to average monthly flows in cfs and compared with "without-the-project" conditions (Table 28).

Table 28. Impacts of base-flow augmentation on year-round flows in 12 stream reaches

Gage location	Predicted future average monthly stream flows (cfs) augmented from Stagecoach Res.											
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Yampa, abv. Stagecoach	50	51	42	40	41	61	111	120	113	98	71	50
Yampa, blw. Stagecoach	66	58	51	49	48	58	127	153	129	97	84	68
Yampa, Steamboat Spgs.	131	120	100	96	96	158	646	1716	1785	356	150	113
Elk River, Clark	81	67	62	56	55	69	281	1170	1368	456	129	82
Elk River, Milner	140	108	90	86	89	166	727	2091	2163	665	163	111
Yampa, blw. Elk River	271	228	191	182	185	323	1372	3808	3947	1022	312	224
Elkhead Creek	10	13	11	13	15	77	375	646	143	13	6	7
Yampa, Craig	298	282	219	212	267	748	2320	4812	3949	935	240	214
Yampa, Maybell	208	325	271	250	305	680	2566	6202	5439	1341	344	221
Little Snake, Slater	39	36	32	32	33	51	263	1077	932	159	39	29
Little Snake, Lily Park	83	93	72	62	96	348	1038	2526	1930	258	29	22
Yampa, Deerlodge Park	510	547	390	373	507	1393	3666	8180	6714	1505	417	314

Gage location	Predicted future average monthly stream flows (cfs) augmented from Steamboat Lake											
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Yampa, abv. Stagecoach	50	51	42	40	41	61	111	120	113	98	71	50
Yampa, blw. Stagecoach	65	60	51	49	50	63	130	155	129	96	80	61
Yampa, Steamboat Spgs.	130	122	101	96	98	163	648	1718	1785	355	145	105
Elk River, Clark	82	68	63	57	55	69	279	1155	1366	457	134	89
Elk River, Milner	141	109	91	87	90	165	725	2076	2163	666	167	119
Yampa, blw. Elk River	271	231	192	183	188	328	1374	3793	3947	1022	312	224
Elkhead Creek	10	13	11	13	15	77	375	646	143	13	6	7
Yampa, Craig	298	284	220	213	270	753	2320	4797	3949	935	240	214
Yampa, Maybell	208	328	273	251	308	685	2568	6189	5439	1341	344	221
Little Snake, Slater	39	36	32	32	33	51	263	1077	932	159	39	29
Little Snake, Lily Park	83	93	72	62	96	348	1038	2526	1930	258	29	22
Yampa, Deerlodge Park	510	550	392	374	510	1397	3669	8164	6714	1505	417	314

Gage location	Predicted future average monthly stream flows (cfs) augmented from Elkhead Reservoir											
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Yampa, abv. Stagecoach	50	51	42	40	41	61	111	120	113	98	71	50
Yampa, blw. Stagecoach	65	60	51	49	50	63	130	155	129	96	80	61
Yampa, Steamboat Spgs.	130	122	101	96	98	163	648	1718	1785	355	145	105
Elk River, Clark	81	67	62	56	55	69	281	1170	1368	456	129	82
Elk River, Milner	140	108	90	86	89	166	727	2091	2163	665	163	111
Yampa, blw. Elk River	270	230	191	182	188	328	1375	3808	3947	1020	308	217
Elkhead Creek	11	13	10	12	12	72	371	646	143	14	11	15
Yampa, Craig	298	284	218	211	267	748	2317	4812	3949	935	240	214
Yampa, Maybell	208	327	271	249	305	680	2566	6202	5439	1341	344	221
Little Snake, Slater	39	36	32	32	33	51	263	1077	932	159	39	29
Little Snake, Lily Park	83	93	72	62	96	348	1038	2526	1930	258	29	22
Yampa, Deerlodge Park	510	549	390	371	507	1393	3666	8180	6714	1505	417	314

Key to color coding: No reduction; ≤2% reduced; >2% reduced; Increased; No reduction during runoff months

Table 28 highlights the differences between alternatives, expressed as average monthly flows for 12 different stream reaches. Stream-flow reductions greater than 2% of the future baseline occur infrequently during the spring with any of the structural alternatives. None of the alternatives would impact, beneficially or adversely, the Yampa River upstream from Stagecoach Reservoir, or the Little Snake River. Similarly, Stagecoach Reservoir (Alternative 7) would impact neither the Elk River nor Elkhead Creek; Steamboat Lake (Alternative 4) would impact neither Elkhead Creek nor the Yampa River upstream from the Elk River; and Elkhead Reservoir (Alternatives 5 and 6) would not impact any stream reaches upstream from the Elkhead Creek confluence.

Augmentation can occur in any month from July through February. However, flows are augmented most frequently in August and September, and rarely in February. Conversely, storage can begin as early as September, but more commonly begins late in October once irrigation ceases. Several months (typically September-February) exhibit increasing flows in some years and decreasing flows in others, depending upon whether or not the augmentation protocol calls for water to be delivered from storage. For most alternatives, storage (as indicated by decreasing stream flows) generally is greatest from March through May, peaking in April, and rarely lasts into June. However, because flows typically are higher during this period, the percentage reduction may be less than at other times of the year.

Notable exceptions are Alternative 4, Steamboat Lake only, where most reservoir storage occurs in May, and Alternative 7, Stagecoach Reservoir only, where storage is more evenly distributed from October through May. Steamboat Lake and Stagecoach Reservoir are located high in the basin (8,040 and 7,200 feet elevation, respectively). The Willow Creek watershed above Steamboat Lake is not large enough to produce reliable year-round inflows; most inflows are produced by spring snowmelt. Although Stagecoach Reservoir is on the mainstem of the Yampa, the river at this point produces only about half of the average annual stream flow at Steamboat Springs. Nevertheless, its volume is sufficient even during non-runoff periods to store water in fall and winter in many years.

At 6,370 feet elevation, Elkhead Reservoir is lower than either Stagecoach or Steamboat, where snowmelt typically begins, peaks and wanes earlier than at those higher elevations. Therefore, Elkhead Reservoir typically stores early on the peak and usually is full by the end of April. This hydrologic pattern is reflected in the two Elkhead-only options (5–6), which exhibit the smallest impact on peak flows, except for a few, large magnitude (>100 cfs), but infrequent (<5%), stream-flow reductions in April. Most storage occurs in February and March, with rarely any in May.

Impacts of multiple-source options (8–11) are expected to be intermediate between those of the various single-source alternatives, varying in proportion to the volumes and priorities assigned to Steamboat, Stagecoach and/or Elkhead reservoirs. Because all multiple-source alternatives rely on Steamboat Lake to some extent (2,000–3,300 AF), the timing of impacts for these alternatives is more skewed toward May than either Elkhead (5–6) or Stagecoach (7) options, but less so than Steamboat alone (4).

In summary, the differences in impacts between single-source alternatives are most dramatic. Steamboat Lake exhibits the greatest impact on peak flows, because most storage occurs in May, coincident with peak runoff. Impacts of storage in Stagecoach Reservoir are more evenly distributed from October through May, whereas Elkhead stores from October through April, skewed toward February and March. Multiple-source alternatives are more difficult to distinguish, except that Steamboat Lake, the primary source of each of these alternatives, throws some bias toward the peak.

Legal and institutional constraints

Every alternative has its own unique set of legal and institutional constraints. However, they can best be classified according to the source(s) of augmentation, whether these sources are structural or non-structural. These constraints also can have operational implications, in that delivery of water for augmentation could impact upon other reservoir purposes, such as recreation and hydropower production.

Although Alternative 1 (No Action) has no legal or institutional constraints per se, it does not meet the Service's base-flow recommendations. Although this plan could be implemented without the base-flow augmentation element, the outcome of an ESA Section 7 consultation could hinge on whether or not Service flow recommendations are met.

Supply interruption contracts, elements of Alternatives 2 and 13, would compensate water users for bypassing stream flows they otherwise would be entitled to divert in priority. However, unless downstream water users enter into voluntary forbearance agreements, or bypassed flows are adjudicated for instream use, these flows could be subsequently diverted by other water users before the flows reach their desired point(s) of delivery. Moreover, the Upper Yampa Water Conservancy District (Sharp 2002) maintains that "unless every downstream user executes substantially similar forbearance agreements, augmentation water passing the headgates of those who [sign forbearance agreements] will simply act as carriage water to increase the ability of those users downstream who don't sign agreements to take their decreed flows. For that reason, there will be a tendency in the future [for water users who sign agreements] to react negatively to those users who don't...."

Irrigation water rights adjudicated for instream use also would need to retain their original decreed use, so water users may continue to enjoy the benefits of its use. Water users would need some measure of certainty that water would be available for their use when they need it. Legal costs for such changes of use could be prohibitive, and changes of use may permit the Water Court to assign a more junior priority to the instream use of those rights, compromising the potential instream flow benefits of supply interruption contracts.

Instream flow water rights (Alternative 3) also require adjudication. They would not directly affect water users whose rights are senior to the instream flow rights. However, water users who wish to apply for new or expanded water rights that would be junior to instream flow rights would likely object in Water Court. Given the questionable reliability of junior instream flow rights in meeting base-flow recommendations, the legal costs of their adjudication could outweigh their benefits.

Constraints associated with structural alternatives (4–14) vary with existing uses of the reservoir(s) involved, whether the augmentation water supply is the product of an enlargement, reallocation of existing storage, or lease, and site-specific requirements of new/enlarged reservoirs. In addition, the State of Colorado asserts: "Augmentation plans which derive their waters from storage vessels which do do not have waters decreed for an instream flow right must obtain that right through the Colorado Water Conservation Board" (Walcher 2002). A water-right application filed by the CRWCD (Colorado District Court 2003) for its proposed Elkhead enlargement project includes among its beneficial uses "piscatorial and recreational (including in-reservoir and in-river fish habitat and river flow maintenance and enhancement uses, and uses in furtherance of the Upper Colorado River Basin Fishes Recovery Program)". Issues that may arise regarding administration of such a right need to be resolved in consultation with the Colorado Division of Water Resources.

A portion of Steamboat Lake already has been decreed for instream use, so it probably has the fewest, if any, legal constraints attached to it. However, Parks has expressed concern that the use of this 2,000–3,300 AF pool, especially in conjunction with Xcel Energy using its 5,000-AF backup water supply for Hayden Station, will adversely impact water-related recreation at the lake. Parks considers the impacts to its facilities at Steamboat Lake to be onerous and would rather shift these impacts to Elkhead Reservoir, where its facilities are not developed to the extent they are at Steamboat Lake. Moreover, Alternative 4, which may draw up to 7,000 AF of augmentation from Steamboat Lake, would require as much as 27% of the capacity of the lake, potentially promoting winter-kill of its excellent trout fishery and impacting recreation in subsequent years. Therefore, this alternative is not desirable to Parks or the CDOW (CDNR 2001).

Stagecoach Reservoir appears to offer an alternative to Steamboat Lake. Its inflow is more reliable than that of Steamboat Lake, and there is unutilized or under-utilized capacity in Stagecoach Reservoir. However, the Upper Yampa Water Conservancy District, which operates this reservoir, has identified a number of significant, and potentially intractable, constraints:

- Unallocated storage (3,275 AF) is intended for municipal, industrial, irrigation and power generation. Use of this pool and/or the recreational pool (15,000 AF) for other purposes is not authorized (Sharp 2002).

- Tri-State Electric Generation and Transmission Cooperative also cannot lease any of its allocated industrial storage from Stagecoach Reservoir for instream flows. An exchange of Tri-State's stored water for its direct-flow water right at Craig Station was considered, but ultimately rejected by Tri-State as unacceptable (Sharp 2002; Beaton 2001).

- The Upper Yampa District wishes to retain its option to enlarge Stagecoach Reservoir to expand its storage capacity up to 6,000 AF to serve future human water needs. This is the largest expansion of the reservoir that can be accomplished "with significant but not onerous costs of modification to the dam" (Sharp 2002). Therefore, any further enlargement for instream flows (Alternative 9) could be prohibitively expensive and would likely meet with local opposition.

With regard to an enlargement of Elkhead Reservoir, Yampa Participants who hold storage water rights in Elkhead note that there must be an agreement with the Participants to protect their existing water rights and storage interests therein, before any enlargement of the reservoir can proceed (Beaton 2001). Moreover, it may be necessary to negotiate flood easements with adjacent landowners if their properties would be inundated by an enlarged reservoir.

New reservoirs, as well as any expansion or other structural modification to existing reservoirs likely would require a federal permit under Section 404 of the Clean Water Act (CWA). The CWA is a 1977 amendment to the Federal Water Pollution Control Act of 1972, which established the basic structure to regulate discharges of pollutants into waters of the United States. Section 404 regulates placement of fill materials, such as those placed in conjunction with the construction of dams and diversions. The "404 Program" is administered by the U.S. Army Corps of Engineers (Corps) with oversight from the Environmental Protection Agency (EPA). For non-federal water projects, the Corps' issuance of a 404 permit constitutes a "federal action" that requires compliance with both the ESA and National Environmental Policy Act (NEPA), and the Corps is considered the federal "action agency." However, if another federal agency authorizes, funds and/or constructs such a project, that agency may be designated the lead agency for these regulatory compliance activities.

The NEPA requires federal agencies to identify and document the impacts of their actions. Through the Service's participation by entering into a cooperative agreement to implement this management plan, the Service is required to assess the individual and cumulative environmental impacts of its action. Cumulative impacts are defined by regulation (40 CFR §1508.7) as "the incremental impact of the action when added to other past, present and reasonably foreseeable future actions [emphasis added] regardless of what agency (federal or non-federal) or person undertakes such other actions." Both the NEPA and ESA limit the assessment of cumulative impacts to actions that are reasonably likely to occur in the foreseeable future, and do not include speculative actions. However, for ESA purposes, cumulative impacts relate only to foreseeable non-federal actions.

Neither the Recovery Program nor this management plan were intended to compensate for the impacts of current and potential future depletions on resources other than the four listed endangered fish species and their designated critical habitat. However, we recognize that other resources may be affected by implementing this plan including, but not limited to, other threatened and endangered species, fish and wildlife not listed as threatened or endangered, riparian and riverine habitat, and recreation. Moreover, provisions of 16 U.S.C. 1, as amended, direct the Secretary of the Interior to manage National Park Service (NPS) areas, including Dinosaur National Monument, "...in such manner and by such means as will leave them unimpaired...."

In conformance with NEPA requirements, the Service prepared an environmental assessment (EA) for this management plan to address its potential impacts on these and other resources. However, this EA is programmatic in nature and does not address site-specific impacts due to implementing certain management actions identified in the plan. Additional NEPA document(s) also may be required for these actions including, but not limited to, reservoir construction or expansion.

Evaluation summary

The performance of the 13 "action" alternatives with respect to the 6 evaluation criteria are summarized in Table 29. For each criteria, alternatives were awarded 0–5 points as follows:

0 points – no impact or not applicable
1 point – very good
2 points – good
3 points – average
4 points – fair
5 points – poor

Using this system, the alternative(s) with the fewest points fared best against the criteria. Because the primary objective of the augmentation water supply alternatives is to provide sufficient water to satisfy base-flow recommendations, this criterion (A) was given greater weight than the others. Also, to analyze impacts to parks and recreation, Colorado State Parks indicated that impacts to Steamboat Lake were more critical than impacts to Stagecoach Reservoir which, in turn, were more critical than impacts to Elkhead Reservoir. Therefore, weighting factors of 5, 3 and 2, respectively, also were applied to these individual water sources. Moreover, scores assigned to Stagecoach Reservoir were comparatively lower than those assigned to the other reservoirs, because the magnitude of fluctuations due to augmentation is masked by fluctuations in Stagecoach Reservoir due to other uses (i.e., other contract deliveries from storage and hydropower production). However, the resultant average score of the three reservoirs was given the same weight as the remaining four criteria (B, D, E & F in Table 29).

Legal and institutional constraints (F) was further broken down into four sub-criteria: Feasibility/acceptance, Litigation/adjudication, Complexity, and Regulatory process. Feasibility/acceptance relates to the intractability of issues or societal acceptability of alternatives. Litigation/adjudication addresses the extent to which issues must be resolved through legal action, such as decrees obtained from the Water Court for instream flow water rights. Complexity bridges the other sub-criteria, dealing with the diversity of interests that may be in conflict. In general, single-source options should be less complex than multiple-source options, including supply interruption contracts. Regulatory process speaks to the need to obtain state and federal permits, including compliance with NEPA and ESA requirements. Each of these was given equal weight under Legal/institutional constraints, the average of which was given equal weight to B, C, D & E.

Table 29. Summary of the evaluation of augmentation water supply alternatives

Evaluation Criteria	Weight	Performance [a] of action alternatives												
		2	3	4	5	6	7	8	9	10	11	12	13	14	PA[b]
A. Ability to meet base-flow needs	5	4	5	3	1	1	2	1	2	1	1	1	3	1	1
B. Estimated costs [c]	3	1	–	3	4	5	3	4	4	4	4	4	2	4	3
C. Impacts to parks & recreation [d]	3	–	–	3	1	1	1	2	2	1	1	1	1	1	1
(1) Steamboat Lake	5	–	–	5	–	–	–	2	3	1	1	1	1	1	–
(2) Stagecoach Reservoir	3	–	–	–	–	–	3	–	2	–	1	–	2	–	–
(3) Elkhead Reservoir	2	–	–	–	5	4	–	3	–	2	1	1	–	2	4
D. Impacts on agriculture	3	4	1	–	–	–	–	–	–	–	–	–	2	–	–
E. Impacts on peak flows	3	–	–	5	2	2	3	4	3	5	5	5	2	2	2
F. Legal/institutional constraints [e]	3	4	3	3	2	2	3	3	4	3	4	4	4	3	2
(1) Feasibility/acceptability	1	5	3	5	2	2	5	3	5	2	5	4	4	2	2
(2) Litigation/adjudication	1	5	4	2	2	2	2	3	3	3	3	3	5	4	2
(3) Complexity	1	5	4	2	2	3	3	4	4	2	4	4	5	3	3
(4) Regulatory process	1	2	1	3	3	2	2	3	3	3	3	4	3	4	2
Total [f]		48	37	56	33	35	40	44	49	42	46	45	49	35	29
Rank		11	5	14	2	3	6	8	12	7	10	9	12	3	1

[a] Points awarded from 1 (very good) to 5 (poor); not applicable (–) treated as zero

[b] Proposed Action (see description beginning on page 75)

[c] Low lease/Low reservoir costs. Other costs are captured in Legal/institutional constraints.

[d] Weighted average = $[5 \times C(1) + 3 \times C(2) + 2 \times C(3)] \div 10$

[e] Unweighted average = $[F(1) + F(2) + F(3) + F(4)] \div 4$

[f] Weighted total = $5 \times A + 3 \times (B + C + D + E + F)$; maximum (worst) possible = 100 points.

Proposed Action for Base-flow Augmentation

The proposed action would enlarge Elkhead Reservoir by 5,000 AF specifically to augment base flows through the critical habitat reach. This "Permanent Water Supply" is part of a larger proposed expansion by the CRWCD — an additional 6,750 AF of the 11,750-AF total reservoir expansion would be allocated for current and future human use. The Permanent Water Supply represents a one-time capital construction cost to the Recovery Program of approximately $8.7M (Table 30), based on 20/47th share of the total project cost, plus annual *pro rata* operation, maintenance and repair (OM&R) of the dam and reservoir. Construction and operation of the reservoir enlargement and conveyance of water storage space within the reservoir enlargement and its associated water rights will be implemented through a series of interagency agreements.

Table 30. Elkhead Reservoir Enlargement, detailed cost estimate [a]

	CRWCD	Recovery Program	Total
Permitting	396,383	293,617	690,000
Engineering	925,468	685,532	1,611,000
Property acquisition	402,128	297,872	700,000
Wetland and other mitigation	1,148,936	851,064	2,000,000
Construction	7,224,034	5,351,136	12,575,170
Interim water supply	86,170	63,830	150,000
Subtotal	10,183,119	7,543,051	17,726,170
Project management (10%)	1,018,312 [b]	754,305	1,772,617
Contingency	574,468	425,532	1,000,000
Total	11,775,899	8,722,888	20,498,787

[a] Source: URS Engineering 4-2-2003 preliminary design report
[b] In-kind services (value of services included here only to balance account)

In December 2002, the CRWCD applied to the District Court, Colorado Water Division 6 (Case No. 02CW106), for a conditional water right to store 13,000 AF of water within the "Elkhead Creek Reservoir Enlargement." The application identified the following beneficial uses for the water: "...municipal, commercial, industrial, domestic, irrigation, livestock, hydro-power production, evaporation, augmentation, exchange, replacement, power generation and cooling, wastewater treatment, piscatorial and recreational (including in-reservoir and in-river fish habitat and river flow maintenance and enhancement uses, and uses in furtherance of the....Recovery Program)." With an appropriation date of October 16, 2002, this right is junior to water rights presently decreed for storage in the existing reservoir. The Permanent Water Supply and CRWCD pool will have equal priority for filling and share proportionately any shortages that may occur from time to time on account of drought, errors in operation, operational constraints on the Reservoir Enlargement, legal circumstances, or other causes. Any available water not released from the Permanent Water Supply prior to March 1 in any year will be carried over and available for possible use during the following augmentation period (July 1 – February 28). Once the Permanent Water Supply is put to beneficial use, the CRWCD will perfect its water right and convey it to the CWCB for instream flow purposes.

The remaining augmentation requirement will be met by leasing up to 2,000 AF/year from the CRWCD out of its 6,750-AF human use pool. This "Short-term Water Supply" will fill only after both the Permanent Water Supply and the balance of the CRWCD pool have obtained an actual or "paper" fill. However, any balance remaining in the Short-term Water Supply at the end of the augmentation period (July 1 – February 28) will be carried over and available for use during the succeeding augmentation period. The USBR, acting on behalf of the Recovery Program, will pay $50/AF, not to exceed $100,000/year during the initial lease term of 20 years. Under the terms of the lease, the Recovery Program would be required to pay only for water specifically requested by the Service, as described below, rather than a "take-or-pay" basis, which would require $100,000 to be paid every year. The Recovery Program would pay no OM&R on the leased water. At the end of the initial lease term, the Recovery Program, in consultation with the Service, would determine if renewing the lease was warranted and, if warranted, would negotiate a renewal with the CRWCD at the fair market value of water at that time, but no less than $50/AF/year.

The Short-term Water Supply would be secondary to the Permanent Water Supply and, as such, would be called for in roughly half of the years in which augmentation is needed, with an average annual leased volume of about 500 AF. On this basis, the average annual cost of the lease would be $25,000, but could range from $0–100,000 in any year. The CRWCD would retain the option to market any unreserved water from the Short-term Water Supply on an annual basis. The Service would notify the CRWCD of its intent to reserve water from the Short-term Water Supply for release later in the year in accordance with the following schedule:

1. On or before May 1 each year of the 20-year lease term, the Service may reserve 500 AF of the Short-term Water Supply or relinquish 2,000 AF to the CRWCD;

2. On or before June 1 of any year during which the Service reserves 500 AF pursuant to paragraph 1, the Service may reserve an additional 500 AF of the Short-term Water Supply or relinquish the remaining balance of 1,500 AF to the CRWCD;

3. On or before July 1 of any year during which the Service reserves a total of 1,000 AF pursuant to paragraphs 1 and 2, the Service may reserve the remaining balance of 1,000 AF of the Short-term Water Supply or relinquish that amount to the CRWCD.

4. In any year the Service fails to affirmatively reserve water pursuant to paragraphs 1, 2, and/or 3, the Service shall be considered to have relinquished the remaining balance of the Short-term Water Supply for the remainder of the augmentation period.

The decision points are based on hydrologic criteria which, if met, will allow the Service to forgo deliveries from the Short-term Water Supply in wetter-than-average years. Hydrologic criteria at Maybell for the three decision points (May 1, June 1, and July 1, respectively) are the volumes of April runoff (50% exceedance = 149,000 AF), April-May runoff (50% exceedance = 526,000 AF), and April-June runoff (70% exceedance = 713,000 AF). Conversely, failing to meet these criteria in drier-than-average years will allow the Service to reserve water from the Short-term Water Supply incrementally to respond to changing hydrologic conditions. However, to allow the Service greater flexibility in making decisions regarding use of the Short-term Water Supply, the lease contains no provisions with respect to hydrologic criteria. For example, failing to achieve the April runoff criterion would not necessarily indicate that augmentation from the Short-term Water Supply is needed, if April were colder and snowier than average, and the resultant increase in snowpack would likely produce greater volumes of runoff later in the spring.

Although the proposed action for base-flow augmentation differs somewhat from any of the 13 alternatives previously evaluated, it borrows features from several of them and, therefore, can be evaluated on that basis. The proposed action is as reliable in terms of water delivery as the other Elkhead-only alternatives, its capital costs are competitive with the least-cost alternatives, and its impacts to peak flows are comparable with the best performers among the structural options with respect to this evaluation criterion. Although its impacts to parks and water-related recreation at Elkhead Reservoir are higher than all but one alternative, there are no impacts at Steamboat Lake or Stagecoach Reservoir with this alternative, resulting in one of the best overall scores for this criterion among the structural options. Legal and institutional constraints would be similar to those of Alternative 6, one of the two best for this criterion. If points were awarded on this basis, the proposed action would score 23, placing it ahead of the other 11 structural alternatives, as well as both non-structural alternatives (Table 29). Although a variety of possible alternatives involving combinations of structural and non-structural options were not individually evaluated, it is unlikely that any combinations involving one or both non-structural options would perform as well as the proposed action, given the unreliability of non-structural options in meeting base-flow targets.

Operationally, base-flow augmentation will follow the protocol previously described, beginning on or after July 1 whenever flows at Maybell fall below the lower threshold (78 cfs). In drier years, if flows fall below 78 cfs prior to August 1, the augmentation rate will be reduced to 33 cfs to extend the available supply to 3 months vs. 2 months at 50 cfs (Figure 18). An additional amount (~5 cfs) will be released to offset transit losses assessed by the State Engineer for Water Division 6.

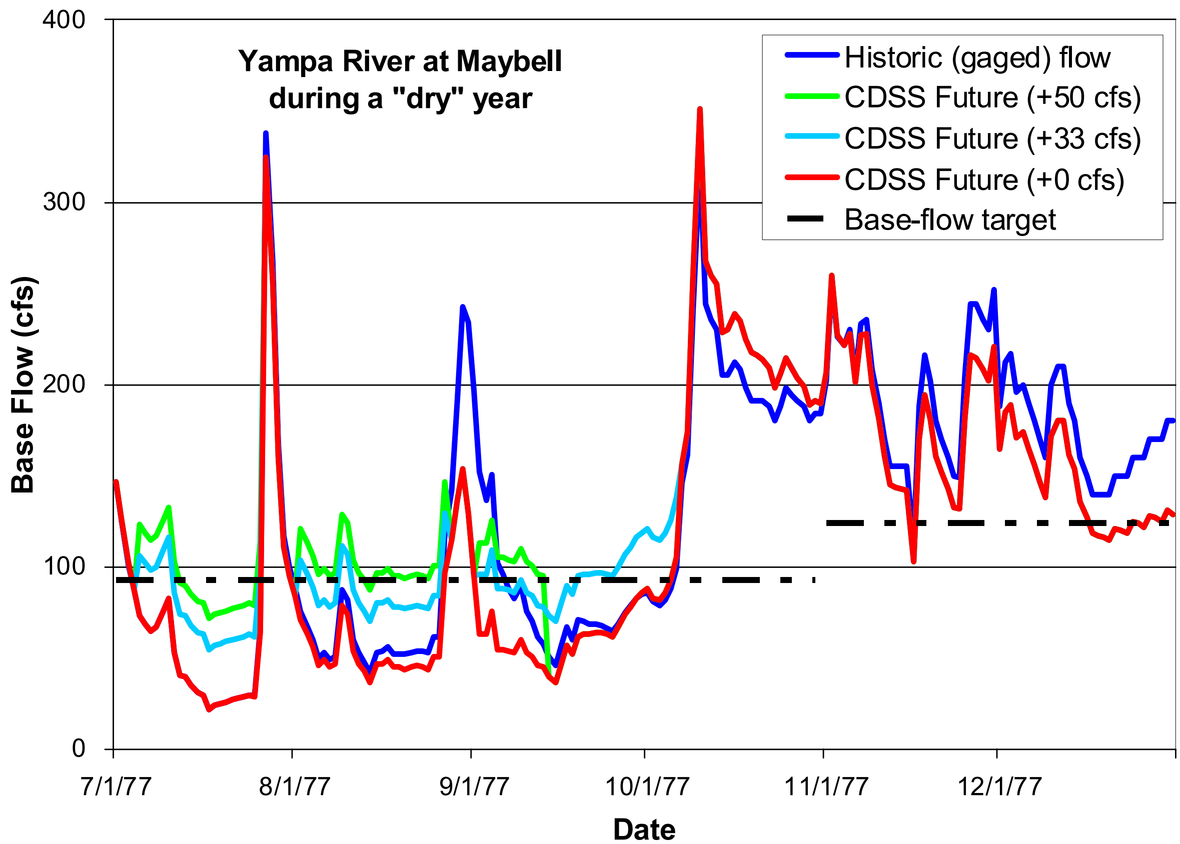


Figure 18. Base flow hydrographs for an extremely dry year (1977) under historic (■) and future augmented and unaugmented (■) conditions, where the duration of augmentation would have been supply-limited to 61 days at 50 cfs (■) but would not have been supply-limited at 33 cfs (■).

If river flows at Maybell remain above 78 cfs until after July 31, the augmentation rate will be 50 cfs, with up to ~8 cfs more to offset transit losses. At 33 cfs, the duration of augmentation would be about 3 months, whereas the duration at 50 cfs would be about 2 months. Augmentation would continue at the prescribed rate until augmented river flows reached the upper flow threshold (138 cfs) or until both the Permanent Water Supply and the reserved portion of the Short-term Water Supply are exhausted, at which time augmentation would cease. Augmentation would resume when river flows again fell below 78 cfs, as long as water remained available for this purpose (Figure 19).

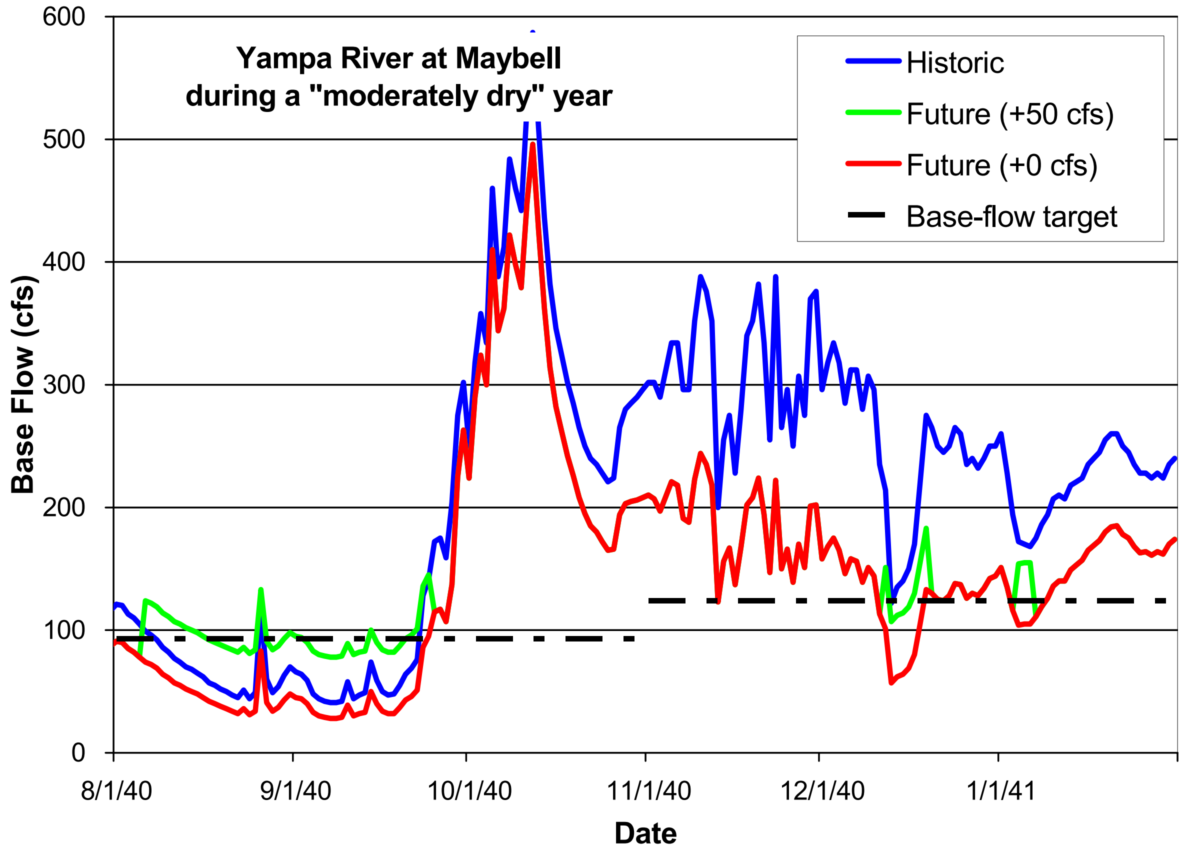


Figure 19. Base-flow hydrographs during a moderately dry year (1940–41), under historic (■) and future augmented (■) and unaugmented (■) conditions, where the duration of augmentation is not supply-limited at 50 cfs (both summer and winter augmentation is shown)

Reduce Negative Impacts of Nonnative Fishes

Background

Over 40 nonnative fish species currently occur in the Upper Colorado River Basin. These species can be numerically predominant in certain river reaches, including the critical habitat reach of the Yampa River downstream from Craig, Colorado. Negative interactions with certain warmwater nonnative fish species (particularly game fishes) have been identified as a factor contributing to the decline of native fish populations. Recovery goals for endangered humpback chub, bonytail, Colorado pikeminnow, and razorback sucker identified predation and competition by nonnative fishes as primary threats to continued existence or reestablishment of self-sustaining populations of these endangered fishes (USFWS 2002a-d).

The Yampa River in particular has experienced dramatic growth in nonnative fish populations, with a reciprocal decline in native fish populations (UCRRIP 2003). The nonnative species of greatest and most immediate concern are northern pike (*Esox lucius*), smallmouth bass (*Micropterus dolomieui*) and channel catfish (*Ictalurus punctatus*). All three species are believed to prey upon the smaller life stages of the endangered fishes and other native species, such as roundtail chub (*Gila robusta*), flannelmouth sucker (*Catostomus latipinnis*), and speckled dace (*Rhinichthys osculus*). These native species also serve as prey for the Colorado pikeminnow.

Originally stocked as a game fish in Elkhead Reservoir in 1977, northern pike accidentally became established in the Yampa River in the early 1980s by escaping from the reservoir and invading the Yampa River via Elkhead Creek, about 4 miles upstream from Craig, Colorado (Tyus and Beard 1990). Since then, northern pike have established a reproducing population in the Yampa River and have expanded their numbers and range in both the Yampa and Green rivers. Northern pike now occur throughout the Yampa River within critical habitat of the endangered fishes, as well as upstream from Craig, where seasonally flooded, vegetated backwaters and sloughs provide suitable habitat for spawning (Nesler 1995). Young-of-year northern pike feed on zooplankton and aquatic insects, shifting to a diet of fish and other vertebrates as they mature. Radio-telemetry and mark-recapture records indicate that the species uses flooded backwaters and sloughs in the Yampa River during spring runoff and that most individuals (78%) tend to remain within one-mile sections of river (Nesler 1995). Sexually mature northern pike are especially vulnerable to capture as they move from the main channel into off-channel spawning areas (Mann 1980; Nesler 1995). Many large adult northern pike move downstream from their spawning reaches into occupied critical habitat (Nesler 1995), where they compete with or prey upon endangered fishes (Wick et al. 1985; Tyus and Karp 1989; Tyus and Beard 1990; Nesler 1995), as well as roundtail chub, flannelmouth sucker and other native fishes (Tyus and Beard 1990; Martinez 1995; Nesler 1995).

The northern pike is an opportunistic top predator. Northern pike appear to select prey based on the size and abundance of the prey organisms more than the species of prey (Scott and Crossman 1973; Becker 1983; Raat 1988). Recent research even has documented northern pike predation upon subadult and young adult Colorado pikeminnow and razorback sucker in the Yampa and Green rivers (Hawkins 2004; Brunson and Christopherson 2004). Hawkins (2004) suggests that northern pike as small as 600 mm total length (TL) are capable of preying upon young Colorado pikeminnow (450–500 mm TL) that recruit into the Yampa River population. Although smallmouth bass are less capable of preying upon fishes of this size, their increasing abundance in the Yampa River and their capacity to compete with Colorado pikeminnow for smaller prey species make them a greater threat than previously thought (UCRRIP 2003).

Smallmouth bass are non-migratory, sight-feeding carnivores that prey on fish, crayfish, and aquatic insects (Scott and Crossman 1973; Carlander 1977; Becker 1983). This fish invaded the Yampa River in significant numbers when Elkhead Reservoir was first drawn down in 1992; they are now routinely collected in both the Yampa and Upper Green rivers (McAda et al. 1994). Prior to 1992, the species was captured only incidentally in riverine habitats. Impacts include suspected predation on young of native fishes (Hawkins and Nesler 1991) and competition with adults.

Channel catfish were first introduced into the Upper Colorado River Basin in 1892 (Tyus and Nikirk 1988) and are now considered common or abundant throughout much of the Upper Basin (Tyus et al. 1982; Nelson et al. 1995). This species is one of the most prolific predators in the Upper Colorado River Basin (Hawkins and Nesler 1991; Lentsch et al. 1996; Tyus and Saunders 1996). Channel catfish are found in low- to moderate-gradient rivers with sand, gravel, or boulder substrates. Most adult channel catfish are found in large, deep pools and runs during daylight, but move to riffles or shallow pools at night to feed. Young channel catfish congregate in riffles or shallow pools. Channel catfish spawn in late spring through early summer when water temperatures reach about 20–24°C. Adults seek dark secluded areas associated with cavities or cover to build their nests and spawn (Sigler and Miller 1963; McClane 1965; Pflieger 1975; Simpson and Wallace 1978). It has been demonstrated that spawning adults often migrate long distances in search of suitable spawning sites (Smith 1988; Gerhardt 1989; Smith and Hubert 1989; Gerhardt and Hubert 1990). However, recent radio-telemetry studies of channel catfish in the Yampa River have shown that these fish often remain in the same river reaches throughout the year (Irving and Karp 1995; Modde et al. 1999). Apparently, suitable spawning habitat is available locally in Yampa Canyon. Removal of channel catfish from the Yampa River is a high priority of the Recovery Program, especially in Yampa Canyon within DNM.

Hawkins and Nesler (1991) included channel catfish and northern pike in their ranking of nonnatives of greatest concern in the Colorado River Basin because of their documented or suspected negative interactions with native fishes, including predation or attempted predation on native fishes, and identified smallmouth bass as a species of increasing concern because of its increasing abundance, habitat preferences, and fish-eating habits. These nonnatives were specifically targeted for control in this plan because of their potential predatory or competitive effects on resident subadult and adult Colorado pikeminnow in the lower Yampa River upstream from Yampa Canyon, and similar effects (due primarily to channel catfish) on humpback chubs in Yampa Canyon. Moreover, control measures also are intended to stem expansion of these nonnative fish species into the Green River.

The recovery goals (USFWS 2002a-d) require that management actions to address threats posed by nonnative fishes be implemented in two steps: (1) develop management programs to identify the levels of management needed to minimize or remove the threat for selected species in selected river reaches (requirement for downlisting), and (2) implement identified levels of nonnative fish management (requirement for delisting). Nonnative fish management actions conducted by the Recovery Program are consistent with these requirements.

The Recovery Program has undertaken a variety of studies to determine appropriate levels of nonnative fish control needed to promote recovery of the endangered fishes, as well as the most effective means of reaching those levels. Preliminary study results indicate that the Yampa is extremely vulnerable to the impacts of nonnative fishes and, consequently, stands to benefit from an aggressive nonnative fish control program.

Nonnative Fish Management Policy

On February 4, 2004, the Recovery Program formally adopted a *Nonnative Fish Management Policy* (UCRRIP 2004) which states:

> *Management of nonnative fish populations is essential to achieve and maintain recovery of the endangered fishes.*
>
> *Nonnative fish management is one of many management actions necessary to achieve and maintain recovery of the endangered fishes, and failure to adequately manage nonnative fishes may nullify the positive effects of other Recovery Program actions associated with habitat management and restoration and endangered fish stocking.*
>
> *The overall goal of nonnative fish management is to attain and maintain fish communities where populations of the endangered and other native fish species can persist and thrive, and the recovery goals for the endangered fishes can be achieved.*
>
> *Management of nonnative fishes will be conducted as needed. Implementation of an effective nonnative fish management program is an adaptive process. As strategies are developed and implemented, they will be evaluated and revised based on results of research and monitoring.*
>
> *Because nonnative fish species targeted for management may have sportfish value to the angling public, the dual responsibilities of State and Federal fish and wildlife agencies to conserve listed and other native species while providing for recreational fishery opportunities will be considered in nonnative fish management strategies developed and implemented by the Recovery Program. This consideration will include consultation and approval from the State wildlife agencies prior to implementation of nonnative fish management actions.*
>
> *Agency and public understanding of the purpose and scope of nonnative fish management actions by the Recovery Program and its participating agencies is critical to the success of the effort. Recovery Program partners agree to support and actively participate in public communication and involvement.*

Nonnative Stocking Procedures

To help prevent competitive and predatory nonnative species from escaping into the Upper Colorado River system, the Service and the states of Colorado, Utah and Wyoming signed a Cooperative Agreement to implement *Procedures for Stocking Nonnative Fish Species in the Upper Colorado River Basin* (USFWS 1996). These “Nonnative Stocking Procedures” (NNSP) are consistent with the spirit of the Recovery Program, which directs that “stocking of nonnative species will be confined to areas where the absence of potential conflict with rare or endangered species can be demonstrated.” Implementation of the NNSP is intended to support recovery of the endangered fishes and to allow the Recovery Program to serve as the reasonable and prudent alternative for certain types of water development in the Upper Colorado River Basin by integrating management of recreational fisheries with ongoing recovery efforts.

The NNSP prohibit stocking any nonnative fish species, including trout, directly into critical habitat. Trout may be stocked into riverine habitats upstream from critical habitat, as well as into private floodplain ponds and reservoirs within the 50-year floodplain of the river. Before certain nonnative fishes can be stocked into these waters, however, they must be bermed to FEMA standards to prevent over-topping by frequent floods ($\geq$2% probability of occurrence) that would allow these fishes to escape to the river. Species are restricted to largemouth bass (*Micropterus salmoides*), bluegill (*Lepomis macrochirus*), black crappie (*Pomoxis nigromaculatus*) and triploid (sterile) grass carp (*Ctenopharyngodon idella*). Moreover, outlets of these waters, if any, also must be screened to prevent escapement of stocked fishes. The Recovery Program may install screens on existing ponds and reservoirs that already have active nonnative warmwater fisheries to prevent or reduce nonnatives from escaping. However, depending upon their location and connectivity with the river, new water storage projects in the Yampa River Basin intended to support warmwater sportfish, may need to consider nonnative fish control measures (e.g., berms, screening and/or stocking restrictions) in the project design and cost. State wildlife agency personnel will inspect screens and berms annually. If these measures fail to control escapement of nonnative fishes, future stocking into the affected waters will occur only after a case-by-case review.

The NNSP apply to both existing and new ponds and reservoirs. Similar restrictions apply to public waters within the 50-year floodplain, including mainstem reservoirs. In addition, fish may be stocked into public waters in accordance with lake management plans and stocking proposals previously approved or evaluated and accepted under the terms of the NNSP.

Aquatic Wildlife Management Plan

In its *Aquatic Wildlife Management Plan for the Yampa River Basin*, the Colorado Division of Wildlife (CDOW 1998) recommended the following control strategies/options for each of the three target species using Lentsch et al. (1996) and Tyus and Saunders (1996) as guidance, giving due consideration to maintaining local recreational fisheries for these valued sportfish, where possible. Lentsch et al. (1996) reviewed the distribution and biology of nonnative fishes in the Upper Basin; these authors and Tyus and Saunders (1996) also presented options for their control.

Upper Yampa River

- Assess predation impact of northern pike upstream from the Elk River confluence and upstream from Stagecoach Reservoir; eradicate northern pike as feasible. Encourage angler harvest as the primary method of northern pike control in Stagecoach Reservoir.

Middle Yampa River

- Manage primarily for conservation of native fish populations. Secondarily, manage for brown trout (*Salmo trutta*), rainbow trout (*Oncorhynchus mykiss*), Snake River cutthroat (*O. clarki* subspecies), and mountain whitefish (*Prosopium williamsoni*) fisheries, such that predation by large nonnative salmonids does not impact recruitment of native fishes.

- Develop black bass (i.e., smallmouth bass and largemouth bass) and northern pike fishing in off-channel ponds and reservoirs in accordance with provisions of the NNSP. Encourage local use of “Fishing is Fun” federal grant projects.

- Develop access/lease agreements with private landowners whose off-channel ponds or reservoirs are suitable under provisions of the NNSP to expand fishing opportunities for either coldwater or warmwater fish species.

- Reduce the abundance of northern pike and smallmouth bass in riverine habitats by capturing and translocating these fish to local waters suitable under provisions of the NNSP. Also reduce the abundance of white sucker (*Catostomus commersoni*) by lethal removal from the river, except as may be deemed necessary to serve as forage by larger game fishes.

Lower Little Snake River

- Emphasize management of the lower mainstem Little Snake River for populations of endangered and other native fishes.

Lower Yampa River

- Manage downstream from the Williams Fork confluence primarily for endangered and other native aquatic wildlife. Control the abundance of non-salmonid nonnative fishes as necessary to protect native fish populations and enhance recovery of endangered fishes.

- Remove northern pike, smallmouth bass, and channel catfish and translocate these fish to local waters suitable under provisions of the NNSP.

- Develop access/lease agreements with private landowners whose off-channel ponds or reservoirs are suitable under provisions of the NNSP to expand fishing opportunities for either coldwater or warmwater fish species.

Green River within Colorado

- Manage primarily for endangered and other native aquatic wildlife. Control the abundance of non-salmonid nonnative fishes as necessary to protect native fish populations and enhance recovery of endangered fishes.

Elkhead Reservoir — Lake Management Plan

Constructed in 1974, Elkhead Reservoir serves a water storage facility providing cooling water to Tri-State's Craig Power Plant and drinking water to the City of Craig. Elkhead Reservoir currently supports fisheries for northern pike, largemouth bass, smallmouth bass, black crappie, channel catfish, bluegill, and rainbow trout. Different species and sizes of trout have been stocked in the reservoir in the past, providing a limited coldwater sport fishery, but survival and growth of these fishes was poor. Currently, the CDOW stocks 10,000 catchable (10-inch) rainbow trout annually. Elkhead Reservoir is classified as an "A" water with respect to stocking trout that have been exposed to whirling disease (WD). "A" waters can be stocked only with trout that test negative for WD, as determined by a spore-count method.

Approximately 580 fingerling northern pike were stocked in the reservoir in 1977 to feed on the large population of suckers. An unknown number of these pike escaped to the Yampa River to establish the population that currently inhabits the river. Smallmouth bass were stocked in the reservoir sometime in the late 1970's or early 1980's, and also have established a population in the Yampa River. Prior to 1992, the capture of smallmouth bass in the Yampa River was an incidental occurrence and reproduction and recruitment to a riverine population was negligible. It is believed that the greatest escapement of smallmouth bass from the reservoir occurred during large reservoir draw-downs in 1992 and 1994. Currently, a large reproducing population of smallmouth bass inhabits the Yampa River, and the Recovery Program began removing these fish from the river in 2003 and relocating them to Elkhead Reservoir. Channel catfish were stocked in the reservoir in 1981, 1982, 1983, 1984, and 1985 and very few channel catfish currently inhabit the reservoir. Channel catfish were established in the Yampa River prior to the construction of Elkhead Reservoir, and it is unlikely that their escapement from the reservoir has had any measurable effect on the size of the river population. Largemouth bass were stocked in the reservoir in 1984 and 1985, and bluegill were stocked in 1986; there are no stocking records for smallmouth bass and black crappie. Other warmwater sportfish species in the reservoir have not established populations in the Yampa River although they, undoubtedly, also have escaped.

To minimize the escapement of fishes from Elkhead Reservoir, the City of Craig agreed to notify the CDOW of anticipated draw-down events. In response to such a notification in 2002, the CDOW constructed and maintained a fish weir below Elkhead dam using chicken wire fencing to block movements of fish downstream to the Yampa River. The weir was installed on July 18 and removed October 17. Releases of water in 2002 did not cause a severe draw-down of the reservoir, and no fish larger than minnows were observed in Elkhead Creek upstream from the weir.

The original 1994 Lake Management Plan (LMP) for Elkhead Reservoir called for managing the reservoir for largemouth and smallmouth bass fisheries through stocking with hatchery-reared largemouth bass and restrictive regulations. The current proposal by the CRWCD to enlarge Elkhead Reservoir includes installing a temporary screen on the existing outlet prior to drawing down the reservoir for construction and installing a permanent screen on the new outlet during construction. The purpose of screening the outlets is to prevent age-1 and larger life stages of most species from escaping from the reservoir through the outlets to the Yampa River via Elkhead Creek.

The cost of the temporary fish screen installed prior to drawing down the reservoir for construction will be borne by the Recovery Program and CRWCD in the same proportions as the balance of construction costs (20/47th to the Recovery Program and 27/47th to the CRWCD). The Recovery Program will pay the full cost of durable, rigid, metal screens with ¼-inch openings for both a 90-cfs (24-inch) outlet and 450-cfs (72-inch) outlet. A more detailed description of the proposed screening option can be found in Containing escapement from Elkhead Reservoir beginning on page 93.

The Elkhead LMP has been amended to provide for management of reservoir fisheries following the proposed enlargement. This plan will allow smallmouth bass that have been captured in the Yampa River and adjacent floodplain habitats to continue to be relocated to Elkhead Reservoir. Relocation will keep these valuable gamefish within the Yampa River basin and encourage their utilization by local anglers. Elkhead Reservoir is the only lake in the Yampa River Basin that already contains smallmouth bass and is capable of holding large numbers of smaller bass for growth to harvestable sizes. Harvesting smaller fishes will be encouraged by removing bag limits on fish shorter than 15 inches, whereas a bag limit of only two bass longer than 15 inches will provide anglers the opportunity to catch larger fish, while allowing these fish to exert predatory control on smaller fishes. All transplanted fish would be marked with Floy type tags or batch marks, such as fin clips. Monitoring during subsequent efforts to capture and remove more fish from the river would help determine if any tagged fish had escaped back to the Yampa River.

In addition, existing populations of black crappie and bluegill will be maintained using the statewide bag and possession limits of 10 black crappie and 20 bluegill. Hatchery-reared black crappie and bluegill will be stocked as needed to maintain viable populations for sport fishing. Stocking would occur in late summer or early autumn; no black crappie or bluegill would be stocked during spring runoff when the reservoir is spilling. Also, they would not be stocked near the dam. Periodically, fish populations will be sampled to evaluate if stocking and bag and possession limits are maintaining the desired quality of those sport fisheries.

After runoff in late June each year, 5,000 certified WD-free, catchable rainbow trout will be stocked to provide a summer trout fishery; in late September, an additional 5,000 trout will be stocked annually to provide an autumn and winter fishery. Hatchery-raised smallmouth bass will not be stocked into Elkhead Reservoir, and no further stocking of northern pike or channel catfish into Elkhead Reservoir will be permitted, regardless of source. Moreover, the CDOW will recommend to the Colorado Wildlife Commission that bag and possession limits on northern pike and channel catfish be removed at Elkhead Reservoir.

Proposed Control Actions for Nonnative Fishes in the Yampa River

Management of nonnative fish species will initially follow an experimental approach to develop effective strategies and identify the levels of management necessary to minimize or remove threats to the endangered fishes as identified in the recovery goals (USFWS 2002a-d). An annual data assessment will determine future nonnative fish management strategies, including possible changes to the list of target nonnative fish species, geographic scope of management areas, and methods employed. However, this adaptive process should not unduly delay timely and effective actions to minimize or remove the nonnative threat to the endangered fishes (UCRRIP 2004).

The Recovery Program currently is undertaking a variety of studies to determine appropriate levels of nonnative fish control needed to promote recovery of the endangered fishes, as well as the most effective means of reaching those levels. Preliminary study results indicate that the Yampa is extremely vulnerable to the impacts of nonnative fishes and, consequently, stands to benefit the most from an aggressive nonnative fish control program. A variety of measures are already underway in the Yampa River to reduce the impacts of nonnative fishes on the endangered fishes.

Recovery actions identified in the current revision of the RIPRAP (Green River Action Plan: Yampa and Little Snake Rivers) include activities to reduce the impacts of nonnative sportfish and other nonnative fishes on the endangered fishes. Because collection techniques and equipment are not discriminating, other nonnative species not specifically targeted for control, such as white sucker, may be taken fortuitously with the target species. These species will be removed, but not be translocated, except as needed to serve as forage for the translocated species.

Implementation of the Nonnative Stocking Procedures (NNSP)

The CDOW has stocked no warmwater fish in the Yampa Basin since 1994 and will continue to observe the agreement between the Service and the states of Colorado, Utah and Wyoming to implement the NNSP with respect to stocking nonnative fishes in Yampa Basin reservoirs and ponds. In accordance with the provisions of the NNSP, the CDOW requested and was granted a variance beginning in 2003 to stock smallmouth bass removed from the Yampa River into Elkhead Reservoir. A similar variance for northern pike and channel catfish was denied.

Non-lethal removal and translocation of northern pike and smallmouth bass

A key component of this effort is identification and acquisition of a sufficient number of suitable local translocation sites. To date, the only in-basin sites that have been identified to receive northern pike are five ponds (totaling about 15 surface acres) located at the Yampa State Wildlife Area (SWA) adjacent to the Yampa River west of Hayden, Colorado, and an oxbow at Loudy-Simpson Park, south of Craig, Colorado. However, because the SWA ponds may reconnect to the river during higher spring flows, they may be unsuitable for translocation of northern pike until after run-off subsides. These ponds are being used on an interim basis and may require additional measures, such as temporary screening or removal of northern pike prior to the following run-off period, to minimize potential return of these fish to the river. However, under higher flow conditions, northern pike likely would seek calmer waters out of the mainstream of the river, like that provided by the SWA ponds; therefore, their escapement from the ponds back to the river may not be significant.

Rio Blanco Lake, an off-channel reservoir on the White River downstream from Meeker, Colorado, also has been used as a receiving water for northern pike removed from the Yampa River. Other in-basin translocation sites are needed to accommodate nonlethal removal of northern pike. The first alternative probably would require developing access/lease agreements with private landowners and possibly involve implementing an incentive program with available funding to encourage voluntary participation by landowners. Elkhead Reservoir and Rio Blanco Lake have existing sport fisheries, including northern pike (Elkhead Reservoir also contains smallmouth bass and Rio Blanco Lake also contains channel catfish), and are large enough to accommodate future translocation needs. However, Elkhead Reservoir has been selected to receive smallmouth bass, but not northern pike. Although translocation to sites within the Yampa Basin are preferred, limited availability and capacity of suitable waters to received all the northern pike that may be removed from the Yampa River will require consideration of other options, including translocation of northern pike outside the Basin, lethal removal, and/or limiting the numbers of northern pike removed not to exceed the capacity of the available receiving waters. This issue will be addressed by the CDOW and Yampa Basin stakeholders.

From 1999 through 2002, biologists removed 1,478 northern pike from the Yampa River on behalf of the Recovery Program. Of these, 1,337 were translocated to other water bodies isolated from the river. Since 1999, northern pike have been removed from the Yampa River in Juniper Canyon, Maybell and Lily Park, below Craig, Colorado. Beginning in 2001, another crew has removed northern pike from backwaters and sloughs at the Yampa SWA and The Nature Conservancy's (TNC) Carpenter Ranch in the vicinity of Hayden, Colorado. Receiving waters included: SWA ponds, Rio Blanco Reservoir, and Loudy-Simpson Park (Table 31).

Beginning in 2003, the direction of the nonnative fish control program shifted to a more research-oriented approach. Fewer fish were translocated, while more fish were returned alive to the river. Most of the fish returned to the river were marked to allow for an assessment of nonnative fish populations and the effectiveness of the control program. Moreover, this program was expanded to include smallmouth bass, some of which were translocated to Elkhead Reservoir under a variance in the NNSP granted to Colorado by Utah, Wyoming and the Service. Official results of FY 2003 research have not been published, but preliminary results from Project 98A indicate that about 298 northern pike were captured, of which about 38 were translocated to the Yampa SWA and Loudy-Simpson ponds; the rest were returned to the river alive. In addition, during 2003, 294 smallmouth bass were translocated to Elkhead Reservoir.

Table 31. Numbers of northern pike, smallmouth bass and channel catfish captured upstream from Yampa Canyon, 1999–2003

Reach captured	Number of fish captured by reach and year										
	Project 98A [a] (northern pike)					Project 98b (northern pike)			Total pike	Project 125 [d]	
	1999	2000	2001	2002	2003	2001 [b]	2002 [c]	2003 [c]		SMB	CC [e]
Hayden	92	–	–	–	–	230	237	856	1,415	–	–
Little Yampa Canyon	–	–	–	–	–	–	–	–	–	1,407	–
Juniper Canyon	37	241	97	163	275	–	–	–	813	–	121
Maybell	29	150	110	99	120	–	–	–	508	–	154
Lily Park	6	84	61	40	52	–	–	–	243	–	97
Total captured	164	475	268	302	447	230	237	856	2,979	1,407	372

Disposition	Number of fish by disposition and year										
	Project 98A [a] (northern pike)					Project 98b (northern pike)			Total pike	Project 125 [d]	
	1999	2000	2001	2002	2003	2001 [b]	2002 [c]	2003 [c]		SMB	CC [e]
Translocated	80	350	268	288	38	186	165	539	1,914	294	–
Mortalities	5	10	–	12	–	4	30	17	78	3	–
Released/escaped	72	115	–	2	409	–	9	269	876	1,052	372
Research/education	7	–	–	–	–	40	33	31	111	58	–
Total handled	164	475	268	302	447	230	237	856	2,979	1,407	372

[a] Larval Fish Laboratory, Colorado State University, Fort Collins (Hawkins 1999, 2000, 2001, 2002, 2003a)
[b] USFWS, Colorado River Fishery Project, Grand Junction (McAda 2001)
[c] USFWS, Colorado River Fishery Project, Vernal (Modde 2002; Finney 2003)
[d] Smallmouth bass (SMB) and channel catfish (CC) captured in 2003 by the Larval Fish Laboratory (Hawkins 2003b)
[e] Includes 8 recaptures (fish captured, marked and released on a previous date)

Further development, implementation, and refinement of this translocation project will determine the level of northern pike removal necessary to minimize the threat of negative interactions with endangered and other native fishes. Measures of success of this project may include (1) decreasing abundance and capture indices for northern pike at habitat sites and over a specified period of time, (2) changes in length-frequency distribution of northern pike due to fewer large adult fish, (3) increased abundance and capture indices of native fish species in habitats sampled, (4) increased abundance of juvenile life stages of native fish species, and (5) increased recruitment of Colorado pikeminnow into the Yampa population at sizes of 350–450 mm total length.

In December 2003, Program Director's staff, Biology Committee members and other principal investigators met to discuss future direction of the nonnative fish control program. It had become apparent that a more aggressive strategy was necessary to control nonnatives species, particularly smallmouth bass, whose populations appear to be expanding to the detriment of small-bodied fishes. To this end, the Biology Committee agreed to expand control efforts with respect to northern pike and smallmouth bass within critical habitat, and northern pike upstream from critical habitat, the so-called "Hayden Reach." Removal of northern pike from the Hayden Reach is considered essential to serve as a buffer for any potential pike movement into critical habitat from populations upstream. In addition, it will allow biologists to determine to what extent such immigration may be occurring. Consideration also was given to extending northern pike control upstream to Lake Catamount. This proposal was deferred pending the outcome of the current studies to assess pike movement, which includes a tag-and-release study from Lake Catamount to Hayden.

Five projects are proposed for continuation or as new starts in FY 2004 (Table 32). These projects are scheduled continue through at least FY 2005, after which the Recovery Program may decide to terminate, continue, or modify them, as necessary and appropriate, based on FY 2004–05 results and the recommendations of the principal investigators.

Table 32. Nonnative fish control projects in the Yampa River in FY 2004–05

Target species	Treatment[a] and reach (in river miles) by project and target species				
	Project 98a	Project 98b	Project 98c	Project 110	Project 125
Northern pike	RT (45–140)	RT (140–178)	MR (178–208)	–	–
Smallmouth bass	–	MR (140–178)	MR (178–208)	LR (0–45)	RT (100–124) RT (51–56)
Channel catfish	–		–	LR (0–45)	–

[a] Key to treatments: RT – remove & translocate; MR – mark & release; LR – lethal removal

The following goals and objectives have been established to control northern pike and smallmouth bass that will be carried out concurrently within critical habitat beginning in 2004:

Northern pike (Project No. 98a)

Goal: Remove as many pike as possible from critical habitat and estimate the fraction of the population removed.

Objectives:

1. Obtain an estimate of the number of northern pike that reside in the 95-mile study reach in the Yampa River using a mark-recapture abundance estimator.

2. Remove a large portion of the estimated population of northern pike from the study reach during five removal passes.

3. Calculate the proportion of northern pike removed based on initial population size.

Smallmouth bass (Project No. 125)

Goal: Remove as many smallmouth bass as possible from a 12-mile treatment reach and a 5-mile concentration reach and estimate the fraction of the population removed from each reach.

Objectives:

1. Obtain an estimate of the number of smallmouth bass in the control and treatment reaches in Little Yampa Canyon and the 5-mile reach in Lily Park using a mark-recapture abundance estimator.

2. Remove a large portion of the estimated population of smallmouth bass from the 12-mile treatment reach in Little Yampa Canyon and the 5-mile concentration area in Lily Park.

3. Calculate the proportion of smallmouth bass pike removed from each study area based on initial population size and compare capture rates between control and treatment reaches.

4. Evaluate movement of tagged smallmouth bass from the control reach to ensure that immigration or emigration does not confound comparisons between control and treatment site.

The 95-mile-long northern pike study reach in the Yampa River extends from Craig, Colorado (RM 140) downstream to the top of Yampa Canyon (RM 45). This reach was expanded 20 miles (26%) from previous years from Milk Creek (RM 120) upstream to Craig. There are two smallmouth bass study reaches. One is located in Little Yampa Canyon between Round Bottom (RM 124) and near Government Bridge (RM 100), divided into a 12-mile control reach (RM 124–112) and a 12-mile treatment (removal) reach (RM 112–100). Another smallmouth bass 5-mile study reach extends from Cross Mountain Canyon (RM 56) downstream to the Little Snake River confluence (RM 51).

Sampling will occur between April and July, during runoff. Spring runoff sampling is preferred to other seasons because higher flows allow river access and navigation, and cool water temperatures allow easier and more successful transport of live fish. Northern pike and smallmouth bass are more susceptible to electrofishing when they occupy shallow shoreline and flooded off-channel habitats.

Three items have changed since 2003 sampling. The area of northern pike removal has increased 20 miles, smallmouth bass treatment and control reaches have doubled in length from 6 miles to 12 miles each, and almost double the number of removal passes will be attempted for each species. There will be six passes through the 95-mile study reach during sampling for northern pike. The first will be a river-wide marking pass, during which all pike will be captured, tagged, and released. Five additional removal passes will be made. Most effort during those passes will be focused in locations where pike were noted as the most abundant during the first sampling pass and where pike had high densities in previous years. Northern pike concentration areas typically contain few Colorado pikeminnow, so potentially harmful effects of repeated electrofishing will be reduced. Capture-recapture data from the first two sampling passes will be used to estimate abundance of pike in the study area, with this level of effort expected to achieve about a 70% removal of pike, assuming flows are sufficient for completion of the required number of sampling passes and that capture efficiency is relatively high (about 20%).

Smallmouth bass sampling will occur concurrent with pike sampling, focusing on two main areas described above. In Little Yampa Canyon, a total of 10 sampling passes will be completed, which includes six of those described for northern pike sampling, plus four additional passes. During the first pass, smallmouth bass will be marked and released in both control and treatment reaches. An additional nine removal sampling passes will be attempted in the treatment reach. In the control reach, smallmouth bass will be captured, tagged, and released on four sampling occasions, all of which will be done with pike sampling passes. Lily Park sampling for smallmouth bass will be done during pike sampling, with the first pass a mark and release pass followed by five removal passes.

Generally, fish will be captured by electrofishing both shorelines concurrently. Off-channel habitats such as backwaters and flooded tributaries will be sampled with block and shock techniques, seining, trammel nets, or fyke nets. Northern pike and smallmouth bass will be tagged with numbered Floy tags, and Passive Integrated Transponder (PIT) tags will be injected into the body cavities of Colorado pikeminnow per Recovery Program protocol.

Northern pike removed from the river will be translocated to Yampa SWA ponds and Loudy-Simpson pond as identified by CDOW. Smallmouth bass will be moved to Elkhead Reservoir. If CDOW prefers to move these fish to locations outside the Craig-Hayden area, fish will be transferred to CDOW staff in Craig for transport to other locations. Smallmouth bass may be provided to CDOW for trophic ecology studies, stable isotope analysis, and stomach analysis.

Removal of northern pike upstream from Craig (Project 98b) will follow a similar approach. This reach extends about 38 RM from Craig upstream to the US 40 bridge near Hayden (RM 178). Trap nets will be set in floodplain habitats along the Yampa River at The Nature Conservancy's Carpenter Ranch, Yampa State Wildlife Area (SWA) and additional sites as available. Sampling will be done for about 6–8 weeks while river flows are adequate to provide quiet-water habitat attractive to pike.

Preliminary efforts have shown that northern pike aggregations can be reduced quickly, with catch rates declining substantially after about 2 weeks of sampling in one location. Therefore, sampling would occur for about 2 weeks at each site, after which nets would be moved to another location. Two to four trap nets would be set at each site and emptied regularly during the sampling period. Because the number of fish collected in off-channel habitats is influenced markedly by the hydrograph and northern pike movement to spawning sites, data will be bracketed by temporal intervals and means compared among years.

Most of the Yampa River in the study area passes through private property; the Carpenter Ranch and Yampa SWA are the only locations where sampling currently is permitted. Floodplain habitat along the Yampa River in this reach is widespread, and the success of trapping northern pike will be greatly increased by obtaining access to additional habitat. Sampling duration will be reduced if permission to access additional suitable sampling sites cannot be obtained.

In addition to trap netting, the main channel of the Yampa River from the US 40 bridge near Hayden, Colorado, downstream to Craig will be sampled using hard-bottomed or inflatable electrofishing boats. The river channel will be sampled six times between April and June. The entire study area will be divided into 2-mile sections that will be sampled individually. On the first sampling pass, in agreement with CDOW, all northern pike will be tagged with Floy tags and released alive. On the next five sampling passes all northern pike will be removed. Any native fish captured will be identified to species, and total length (TL) and weight will be recorded. Each smallmouth bass captured will be tagged with a red Floy tag, its left pelvic fin also will be clipped, and it will be returned to the river alive. Data will be analyzed to establish a population estimate of northern pike, proportion and size structure of northern pike population that is removed, movement of northern pike and status of the smallmouth bass and native fish populations in the study reach. All northern pike captured during removal passes will be held alive, measured in TL, tagged with a numbered external tag, and transported to a stocking location that is agreed to by all parties to the NNSP.

Incidental mortalities will be refrigerated (when possible) and turned over to the CDOW. The relocation effort of northern pike will be closely coordinated with CDOW personnel, and all capture and length data on northern pike, smallmouth bass, and other species collected during the sampling effort will be provided to the CDOW and added to the Recovery Program database.

For the first time, nonnative fish investigations will be extended upstream from Hayden to Lake Catamount (RM 178–208), depending upon access. However, this project (98c) will not remove northern pike or other nonnative sportfish from the river. Its purpose is to determine population size, structure, and movement of northern pike in the study reach. The main channel of the Yampa River from the outlet of Lake Catamount to the US 40 bridge east of Hayden will be sampled using hard-bottomed or inflatable electrofishing boats. The river channel will be sampled three times during March and April. The entire study area will be divided into 2-mile intervals for sampling, fish processing and data collection strata. On all sampling passes all northern pike will be tagged with both PIT tags and Floy tags, TL and weight will be recorded, and fish will be returned to the river alive. Any native fish captured will be identified to species, and TL and weight will be recorded. Whenever possible, the right pelvic fin of each native fish will be clipped on the first pass to facilitate obtaining a population estimate through mark-and-recapture techniques. However, this effort will be abandoned if it requires substantial effort that detracts from the main objective.

PIT tags will be used to enable tagging juvenile life stages of northern pike when encountered, and reduce bias due to significant loss of Floy tags or other external tags. All smallmouth bass captured will be double marked with a white Floy tag and right pelvic fin clip, TL and weight will be recorded, and fish will be returned to the river alive. Data will be analyzed to estimate northern pike abundance, proportion, and size-structure of the northern pike population that could be removed, movement of northern pike, and status of the smallmouth bass and native fish populations in the study reach. Incidental mortalities will be refrigerated (when possible) and given to the CDOW. All capture and length data on northern pike, smallmouth bass, and other species collected during the sampling effort will be provided to the CDOW and added to the Recovery Program database.

Lethal removal of channel catfish and smallmouth bass from Yampa Canyon

Nonnative channel catfish have been recognized as the principal predator and competitor affecting humpback chub populations in the upper Colorado River basin. This effort began in 1998 as a research project (Project 88) to determine if channel catfish populations in Yampa Canyon could be depleted by harvesting. Yampa Canyon is within the boundaries of Dinosaur National Monument (DNM) and is subject to National Park Service regulations. During the study, which was completed in 1999, more than 4,400 catfish, weighing 2,700 pounds, were removed from Yampa Canyon. A variety of gear types and techniques were used, including fyke nets, hoop nets, trot lines, angling and electrofishing. Angling and electrofishing were the most effective techniques. Catfish and other nonnative fish captured during this project were removed from the river and killed. This pilot project found that the channel catfish population in Yampa Canyon can be depleted by harvesting, and catfish control in Yampa Canyon should continue (Modde and Fuller 2002). As a result of this study, the Recovery Program agreed to fund Project 110 beginning in 2001 to continue removing catfish from humpback chub critical habitat. During 2001 and 2002, this project removed more than 7,400 channel catfish, with an average length of 284 mm (11 inches). During the last day of each pass, catfish were transferred to the CDOW to be stocked into Kenney or Rio Blanco reservoirs (2003–2004). Due to the remoteness of Yampa Canyon, catfish were not otherwise translocated.

Recently, however, a highly prolific and mobile population of smallmouth bass has emerged as an even greater concern for endangered fishes in Yampa Canyon. Electrofishing catch rates of smallmouth bass have dramatically increased in the Yampa and Green Rivers since 2002. This increase in smallmouth bass abundance may exacerbate the negative impacts of nonnatives on the endangered fishes and confound other recovery actions. Concerns for humpback chub and Colorado pikeminnow susceptibility to smallmouth bass predation and competition were raised at the Recovery Program's nonnative fish control workshop in December 2003. During the workshop, smallmouth bass were considered to pose the greatest threat to endangered and other native fishes in the lower Yampa River, and the scope of work for this project in 2004 was expanded to include lethal removal of smallmouth bass from the same critical habitat reach concurrent with removal of channel catfish.

The purpose of this project is to develop an effective control program for smallmouth bass and channel catfish in Yampa Canyon. The goal is to sufficiently reduce the abundance of smallmouth bass and channel catfish to minimize predatory and competitive impacts on growth, recruitment, and survival of resident humpback chub and Colorado pikeminnow. The specific project objectives are:

1. Reduce the abundance of smallmouth bass and channel catfish in Yampa Canyon by capture and removal (lethal).

2. Compare the catch rates of smallmouth bass and channel catfish in (removal) reaches to determine the efficacy of removal efforts.

To allow for statistical comparisons of removal efficiency and to improve future removal efforts, the 46-mile study reach will be stratified into 10 contiguous reaches of approximately equal length. Stratification will be based on differences in geomorphic characteristics and logistic considerations.

Two inflatable boats (one per shoreline) will electrofish the entire study reach on at least three 4-day to 5-day trips per year. The size of the smallmouth bass population will be estimated using mark/recapture analysis. All smallmouth bass captured during the first pass of each year will be marked (right pectoral fin clip), measured (TL), weighed and returned to the river alive. Thereafter, all marked and re-captured smallmouth bass will be identified, measured, weighed, and removed from the river. Channel catfish population status will be determined by quantifying depletions and reductions in catch rates. All catfish will be measured, weighed, and removed from the river.

Channel catfish and smallmouth bass collected during the last day of each electrofishing trip will be transferred to CDOW personnel at Dinosaur, Colorado. These fish will be either translocated or retained for research purposes. This effort will be closely coordinated with CDOW personnel who will be responsible for tagging, hauling and releasing these fish into approved waters or for processing and disposal of specimens retained for research development.

Electrofishing becomes impractical during flows less than about 1,000 cfs. Thereafter, sampling will continue using lighter equipment and volunteer-assisted angling until flows fall below 300 cfs. Groups of 10–30 volunteers per trip (depending on availability) will remove smallmouth bass and catfish from half the study area during each 5-day trip. Therefore, two angling trips will be required to remove nonnatives from all 10 stratified reaches to complete one pass. Specific reaches sampled per trip will be determined randomly so that trip-specific effects will be distributed randomly.

Total numbers of smallmouth bass and channel catfish collected and catch per unit of effort per trip will be recorded for each reach and each gear type. Total length and weight data of the smallmouth bass and channel catfish removed will be used to determine the size structure of their populations. These data, in addition to the numbers of fish removed, will be used to estimate total biomass of smallmouth bass and channel catfish. A maximum likelihood depletion estimator (CAPTURE) will be used to calculate population sizes for each reach per year of the study to evaluate the effectiveness of removal efforts. Changes in length-frequency distribution of smallmouth bass and channel catfish removed will be analyzed statistically. Year-end analysis will summarize the biomass estimates and numbers of smallmouth bass and channel catfish removed from the Yampa River, assess differences between numbers and sizes removed among reaches, determine any changes in size structure of smallmouth bass and channel catfish populations associated with removal, and estimate the percent of these species removed.

<u>Removal of angler bag and possession limits in Colorado</u>

The Colorado Wildlife Commission approved removal of bag and possession limits for northern pike statewide, and channel catfish, largemouth bass, smallmouth bass, walleye (*Stizostedion vitreum*), green sunfish (*Lepomis cyanellus*), bluegill, black bullhead (*Ameiurus melas*) and black crappie in the Yampa and Green rivers in Colorado. The intent of this measure is to encourage anglers to harvest more nonnative sportfish. However, the measure does not require anglers to harvest them and, in some cases, anglers return sportfish to the river alive.

<u>Containing escapement from Elkhead Reservoir</u>

As previously described in this section, escapement of nonnative fishes from Elkhead Reservoir has occurred in the past, with the greatest escapement likely occurring during periodic reservoir draw-downs for maintenance. Laiho (2001) concluded that some form of fish separation will be needed at Elkhead Reservoir to reduce or curtail further escapement to the river. Without such measures, future escapement of nonnative fishes from Elkhead Reservoir is likely to confound ongoing efforts to control their populations in the Yampa River.

Prior to the drawing down Elkhead Reservoir to facilitate the proposed enlargement, nonnative fish currently residing in the reservoir must be effectively contained to prevent their escapement to the Yampa River. The existing reservoir outlet, located 31 feet below the normal (spillway crest) elevation, can evacuate only about 10,000 AF of the reservoir, leaving about 3,500 AF as a conservation pool during construction. The CRWCD has developed a proposal to contain nonnative fish within the conservation pool during this period. To prevent juveniles and larger life stages of nonnative fishes from escaping as the reservoir is drawn down to the conservation pool elevation, divers will install rigid, wedge-wire screens with ¼-inch openings on the existing outlet prior to drawing down the reservoir. Although the reservoir will be drawn down, there will be uncontrolled spills in the spring during construction, because the average yield of the Elkhead Creek basin exceeds the capacity of the reservoir; however, spills will be attenuated by the volume of water evacuated from the reservoir. Therefore, escapement of nonnative fish over the spillway should be less than under current operations that maintain reservoir elevations close to the spillway crest.

Laiho (2001) investigated a number of permanent structures and management options to prevent nonnative fishes from escaping Elkhead Reservoir. Structural options consisted of installing physical barriers or exclusion devices on the reservoir outlets and/or spillway, including (1) a 2.38-mm mesh net on both the primary outlet and spillway, (2) a 6.35-mm mesh net on both the primary outlet and spillway in combination with a 2.38-mm cylinder screen on the primary outlet, (3) fish graters/comminutors, (4) an enlarged primary outlet, (5) self-cleaning, rotating drum screens either above the spillway or downstream from the dam, and (6) a higher velocity net.

Laiho (2001) considered the first two (net) options to be the most feasible. He estimated costs of $900,000 for option 1 and $910,000 for option 2. However, these costs were based on rehabilitating Elkhead Dam without any increase in storage capacity. Increasing storage, with a concomitant increase in depth, would dictate a larger net and modifications to the screen design, thereby increasing costs to about $950,000 for option 1 and $1,250,000 for option 2 (Laiho 2001).

In addition, Laiho (2001) recommended the following "Reservoir Management Practices" that could be implemented in conjunction with structural measures to help prevent nonnative fishes from escaping from the reservoir:

> *Regulate reservoir levels during periods the service spillway does not have to be spilling to 1 foot (min) below the spillway sill in order to prevent wind tide or wave splash spills and to provide for a small amount of reservoir flow attenuation for minor rainfall events*
>
> *Reduce the frequency of surface spills and the escapement of small life forms by passing as much flow though the primary outlet as possible, especially during the post spawn period for warm water fish (May 1 through end of spring snowmelt runoff).*
>
> *Draw down reservoir more during the late summer through early spring period to make use of outlet capacity when it would be flowing at less than maximum capacity and to allow storing some spring runoff in reservoir that otherwise would flow over the spillway.*
>
> *Coordinate Elkhead Reservoir operations with the operations of other facilities and other basin practices which are intended to minimize the impact of non-native fish on the endangered fish (such as timing of releases, timing of unavoidable escapement, etc.).*

In February 2004, the Recovery Program adopted a proposal for screening Elkhead Reservoir during construction of the reservoir enlargement to control escapement of nonnative fish. This proposal calls for screening the controlled outlets and managing releases through the controlled outlets to minimize spillway flows. Although the spillway would not be screened with this proposal, anchors for securing a net-type barrier would be installed during construction of the reservoir enlargement, should such an exclusion device prove necessary in the future.

During construction, the controlled outlets of the new dam will be outfitted with durable metal screens made of wedge-wire or similar material with ¼-inch openings in their narrowest dimension. The dam will have two outlets: one 24-inch conduit controlled by an 18-inch jet flow gate with a design capacity of 90 cfs at the normal high water level (HWL) of 6,388 feet; one 72-inch conduit controlled by a 42-inch fixed cone valve with a design capacity of 450 cfs at normal HWL. The 72-inch outlet will emanate from a tower with three gated inlets—one 5-foot diameter bottom inlet, one 4-foot diameter intermediate inlet, and one 4-foot diameter upper inlet (Figure 20). At least two of these inlets would need to be opened to achieve the design capacity of 450 cfs. All three tower inlets could be used simultaneously; however, the overall capacity of the outlet would be restricted by the 42-inch fixed cone valve to 450 cfs at the normal HWL. The intermediate and upper inlets also may be used, as needed, for water quality mitigation (e.g., temperature and/or dissolved oxygen).

We expect that the 90-cfs outlet will be used principally to make routine contract deliveries from storage, including releases from the Permanent or Short-term water supplies for instream flow augmentation. The 72-inch conduit would be used to draw down the reservoir, if necessary, and in conjunction with the 24-inch conduit to attenuate flows over the unscreened spillway (Table 33). Controlled releases of unregulated inflows up to 540 cfs (450 + 90) will be made from the outlets during spring runoff. Once inflows exceed 540 cfs, controlled releases will continue at 540 cfs, with inflows in excess of 540 cfs flowing over the spillway. As runoff subsides, and the reservoir elevation recedes to the spillway crest elevation, to prevent further spills from occurring, controlled releases of unregulated inflows will continue. However, the reservoir will not be drawn down significantly below the spillway crest, except as needed by water users, including water released for instream flow augmentation. Therefore, occasional summer storms may cause some spills to occur. But these flows generally would be of small magnitude and duration. Once inflows fall below 90 cfs, use of the 72-inch outlet would no longer be necessary, and all discharges below 90 cfs could be made through the 24-inch outlet. This operational strategy alone will reduce the frequency and magnitude of spillway flows by about 75%, minimizing the opportunity for nonnative fish to escape over the unscreened spillway (Table 33).

Following years in which base-flow augmentation is required from Elkhead Reservoir, the reservoir elevation may be drawn down below the spillway crest elevation, further minimizing spills. The magnitude of any draw-downs will vary with the volume of water released, when it is released, and what, if any, portion of that volume is refilled prior to the ensuing spring runoff period. Water deliveries up to 7,000 acre-feet are expected in roughly half of the years to serve base-flow augmentation needs. However, releases of as much as 5,000 are more likely and, therefore, were used for this analysis. Inflows in excess of 540 cfs would fill the drawn-down reservoir until it reaches the spillway crest, after which the controlled outlets would continue to discharge 540 cfs, and inflows in excess of that amount would discharge from the uncontrolled spillway. Reservoir draw-downs of this magnitude would serve to further reduce the frequency of spillway flows below 200 cfs by another 25–38% (Table 33).

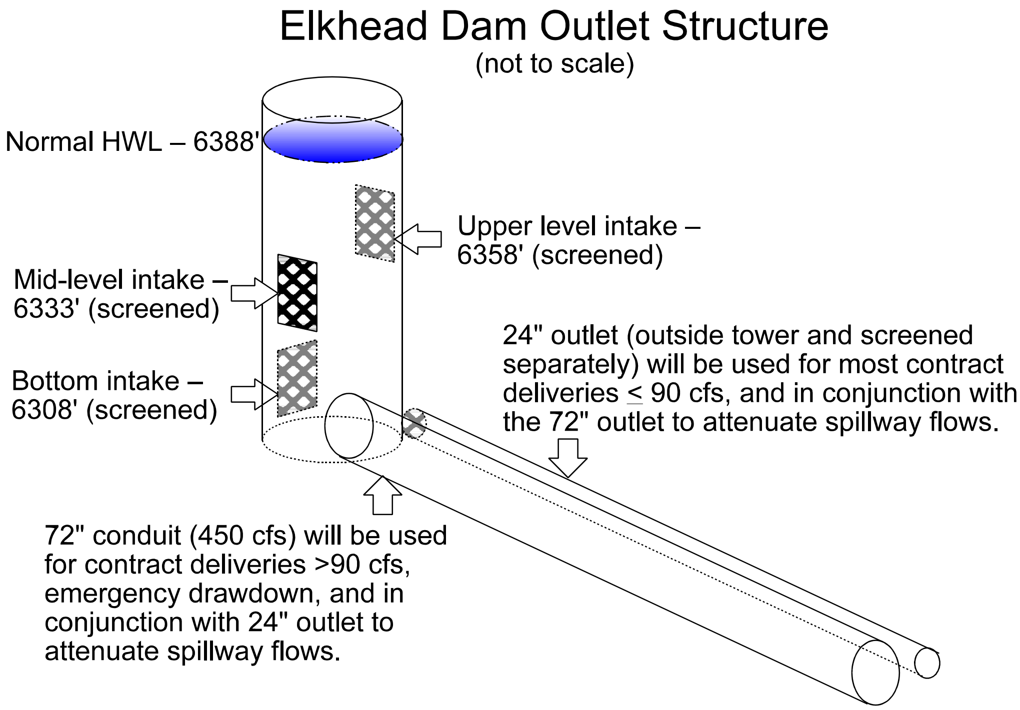


Figure 20. Schematic of proposed new outlet structure at Elkhead Dam, showing configuration of intakes and fish screens.

Table 33. Duration and magnitude of spillway flows based on bypassing unregulated inflows up to 540 cfs through the 72-inch (450 cfs) and 24-inch (90 cfs) outlets at Elkhead Reservoir

Flow (cfs)	Spillway depth[a] (inches)	Average[b] duration of spillway discharge (days/year)		
			w/ 540-cfs screened bypass	
		w/o bypass	w/o draw-down	w/draw-down[c]
>10	0.1	211[d]	24	15
>100	0.8	78	19	13
>200	1.7	60	16	12
>500	4.2	27	7	7
>1000	8.4	8	2	2

[a] Linearly extrapolated below 1,000 cfs from rating curve
[b] USGS Station 09246400 (period of record: 1996–2002)
[c] Reservoir draw-down due to releases of 5,000-AF from the Permanent Water Supply would store inflows in excess of 540 cfs up to the spillway crest elevation before spilling.
[d] Flows ≤10 cfs likely are due to outlet leakage or dam seepage, rather than spillway flows.

All three tower inlets and the 24-inch conduit will be screened during construction to preclude escapement of adult and subadult nonnative fishes from the reservoir. Although the spillway will not be screened, anchors for a net-type barrier will be installed during construction of the dam, so that such a barrier could be easily installed in the future, if necessary (Table 34).

Table 34. Estimated cost of temporary screens and permanent screening options at Elkhead Res.

Description	Temporary screens	Permanent screen options		
		90 cfs	90 cfs + (1 × 450 cfs)	90 cfs + (3 × 450 cfs)
Marine construction	$9,600	–	–	–
Mounting frames	$900	–	–	–
Small flat screens	$6,000	–	–	–
Repair existing gates	$6,000	–	–	–
Anchors for barrier net	–	$33,750	$33,750	$33,750
Large flat screens (450-cfs outlet) [a]	–	–	$75,000	$145,000
Cylinder screens (90-cfs outlet)	–	$90,000	$90,000	$90,000
Backwash systems	–	$50,000	$100,000	$100,000
Up-size 14" line to 24"	–	$24,000	$24,000	$24,000
Subtotal	$22,500	$197,750	$322,750	$392,750
Design engineering (5%)	$1,125	$9,888	$16,138	$19,638
Contractor G&A and profit (15%)	$3,375	$29,663	$48,413	$58,913
Mobilization (15%)	$3,375	$29,663	$48,413	$58,913
Construction engineering (8%)	$1,800	$15,820	$25,820	$31,420
Contingency (15%)	$3,375	$29,663	$48,413	$58,913
Project management (10%)	$2,250	$19,775	$32,275	$39,275
Total	$37,800	$332,220	$542,220	$659,820

[a] Cylinder screens may be used instead of flat screens; cost to be determined.
Source: URS Engineering 4-2-2003 preliminary design report

The Colorado State Engineer's Office has expressed concern that if all controlled outlets were screened, there would be no means for flows to bypass these structures in an emergency that required the reservoir to be drained expeditiously. The issue is that if the screens were to become fouled, thereby reducing outlet design capacities, an emergency evacuation of the reservoir could be prolonged at potential risk to public safety. Using all three gated inlets together may mitigate this potential impact, in whole or in part. However, some other means of removing or bypassing the screens may be required by the State Engineer to ensure that design discharge of the outlets is not compromised. We expect that such extraordinary measures would be required only if screen fouling is so severe as to prevent using the full capacity of the outlets in an emergency.

The cost of temporary screens will be borne proportionately between the CRWCD and Recovery Program, following the same *pro rata* formula used for other construction elements (27/47th to the CRWCD, or about $21,715, and 20/47th to the Recovery Program or about $16,085). The cost of permanent screens will be borne entirely by the Recovery Program.

The cost of the permanent screens includes up-sizing the smaller outlet tube from 14 inches to 24 inches to accommodate higher flows (up to 90 cfs) and installing cylinder screens on the smaller outlet. If flat screens are used for this purpose, the cost may be reduced. Several options were considered for the 450-cfs outlet: not screening any of the three tower gates, screening only the bottom tower gate, or screening all three tower gates. At a minimum, the bottom tower gate should be screened, because this gate would be used in emergency situations to rapidly draw down the reservoir, likely releasing large numbers of nonnative fishes, if the outlet were unscreened. Moreover, screening the bottom gate allows for its routine use in attenuating spillway flows, as described above. It is uncertain for what purpose(s) and with what frequency the intermediate and upper tower gates would be used. Therefore, consideration was given to initially installing only the necessary attachment hardware so that screens could be easily installed in the future. However, the cost savings of this option are insignificant relative to the potentially greater cost of retrofitting these gates once the reservoir is full, and does not take into account unforeseen operational consequences if releases from these gates must be delayed for screen installation. Therefore, all three gates will likely be screened during construction of the tower.

Although the cost of this screening option is less than the estimated $1M cost of a net-type fish barrier across both the outlets and spillway, the principal reasons for rejecting a net-type barrier at this time were its high replacement cost and potential failure in the face of high spring flows. A 6.35-mm net was installed at Highline Lake in the Grand Valley in 1999. This 363-foot-long × 19-foot-deep net, made of high-molecular weight polyethylene material, has proven to be effective, with relatively little maintenance beyond annual cleaning. To date, annual maintenance costs have ranged from about $2,200 to $4,800 (Foreman 2001, 2002, 2003a). However, the net is scheduled for replacement in 2005, at an estimated cost of $100K (Foreman 2003b).

A similar net at Elkhead Reservoir would need to be at least 80 feet deep, more than four times the depth of the Highline net, and its estimated replacement cost would be close to $500K, roughly half the cost of the initial installation (Laiho 2001). Furthermore, the Elkhead net may need to be replaced more frequently than the net at Highline Lake. Spillway flows at Highline Lake are relatively infrequent and smaller in magnitude and duration than at Elkhead. Floating debris carried by higher inflows to Elkhead Reservoir could foul or damage the net, causing it to fail. However, nonnative fish escapement over the new spillway will be monitored, and if the Recovery Program determines that escapement of problematic species is at levels that thwart recovery efforts, a net barrier or other fish exclusion device would be installed on the spillway.

Information and Education

To be effective and to maintain public understanding and support, it will be critical to initiate an active and widespread information and education (I&E) effort. Public relations will be critical to the success of this project. Project managers will assist Recovery Program staff, CDOW, and Yampa River Basin Partnership in developing and implementing an effective I&E program on nonnative removal projects.

Restore Habitat (Habitat Development and Maintenance)

This recovery element includes several different, unrelated actions designed to promote recovery of the endangered fishes:

1. Acquire/enhance floodplain habitats
2. Restore/maintain native fish passage at diversion structures
3. Evaluate/remediate entrainment by diversion structures

Acquire and enhance floodplain habitats

Prior to construction of Flaming Gorge Dam, high spring flows inundated floodplain habitats along the Green River with greater frequency, magnitude and duration than that which occurs under contemporary regulated flow conditions. Floodplain depressions that fill with water during high flows entrain larval fishes and serve as excellent nurseries for the endangered fishes. Mortality of larvae is extremely high, and only a small fraction of the drifting larvae are entrained. However, mortality rates decline as fish grow larger and fitter. As larvae emerge from spawning beds in the main river channel, they drift downstream with the current until they are entrained into quiet, shallow and relatively warm backwaters and floodplain depressions, where they find refuge from predation and a readily available food supply. The proximity of larval entrainment sites to spawning sites is an important factor in their survival, as the number of surviving larvae continues to decline with distance from spawning sites (Valdez and Nelson 2004). Under favorable conditions found in floodplain depressions, young-of-the-year fish can grow faster during the summer and achieve a better condition factor, making them better able to avoid predation and survive harsh winter conditions in their first year of life. However, many of these depressions are now isolated from the main river channel under all but the wettest hydrologic conditions.

The Recovery Program's floodplain program (USDI 1998) is intended to provide suitable nursery habitats for the endangered fishes by acquiring, in fee or by easement, suitable properties within the floodplain of the Green River, among other rivers, and enhancing these properties for the benefit of the endangered fishes. Inducing inundation by releasing large volumes of water from Flaming Gorge is either not practicable due to the hydraulic constraints of dam operations or sociologically unacceptable due to potential impacts to life and property (USDI 1998). Although unregulated flows from the Yampa River provide volume and a more natural shape to the Green River hydrograph, additional measures are needed to create and/or enhance floodplain habitats that serve as nurseries for the endangered fishes.

Artificial and/or natural levees prevent the river from connecting with floodplain areas; breaching levees allows water to enter these depressions at lower peak flows. Some of these areas are located on public land. But some of the best sites are on private land, requiring the consent and cooperation of the landowner(s). The Recovery Program has entered into agreements with and/or acquired rights from willing landowners to protect and enhance floodplain habitat to benefit the endangered fishes (USDI 1998). To date, 1,008 acres of floodplain habitat have been acquired from private landowners in fee or by easement in the Green River subbasin (Table 35).

Table 35. Floodplain habitat acquired in the Green River subbasin

Property name	Acres	RM	Purpose
Thunder Ranch	455	305	Razorback sucker larvae
IMC	12	302.5	Razorback sucker/Colorado pikeminnow adults
Richens	33	288	Razorback sucker/Colorado pikeminnow adults
Slaugh, C.M.	21	288	Razorback sucker/Colorado pikeminnow adults
Slaugh, M.D.	24	288	Razorback sucker/Colorado pikeminnow adults
Lamb	463	240	Razorback sucker/Colorado pikeminnow adults

In addition, 610 acres of floodplain habitat on public property (BLM and Ouray NWR) have been restored and/or protected (Table 36). Where applicable, restoration consisted of breaching levees to allow floodplain depressions to flood at lower spring flows. Pre-breach flows required to overtop site levees ranged from 12,900 cfs to 26,500 cfs (median 21,500 cfs; mean 20,500 cfs). After breaching, these sites were inundated at flows ranging from 10,000 cfs to 16,000 cfs. Flows of 13,000 cfs or greater occur at Jensen, Utah, in 2 out of 3 years, post-1963 hydrology.

Table 36. Public lands restored and/or protected in the Green River subbasin

Site name	Acres	Breach (feet)	Post-breach connection flow
Bonanza Bridge	23	350	13,000 cfs in 3/97 and 6/98 Upstream breaches in 4/00 at 13,000 cfs
Horseshoe Bend	17	1000	13,000 cfs in 10/97; 11,000 cfs in 6/98
Stirrup	20	20	13,000 cfs in 3/97 and 6/98
Baeser Bend	38	20	14,000 cfs in 10/97; 13,000 cfs in 5/98
Above Brennan	41	20–40	13,000 cfs in 10/97; 10,000 cfs in 5/98 (Existing inlet floods at 12,900 cfs) Upstream breaches 4/2000 at 13,000 cfs
Johnson J-4	20	200	13,000 cfs in 3/98; 10,000 cfs in 5/98
Leota L-7/7a	59	350 600	15,000 cfs, 20,000 cfs in 3/98; 12,500 cfs, 15,000 cfs in 11/98
Old Charlie Diked	56	100	13,000 cfs in 3/97; 11,000 cfs in 6/98
Old Charlie Wash	336	none	~14,000–16,000 cfs

Internal levees that separated Johnson units J-1 to J-4 have been breached or removed, resulting in an additional 146 floodable acres. Leota units L-1 to L-10 have also been connected, resulting in an additional 1,016 floodable acres (FLO Engineering 1997; Tetra Tech 1999).

With respect to future research on the Green River, Valdez and Nelson (2004) state:

> *Research on floodplains should continue with a focus to better understand important parameters including, but not limited to: hatching and emergence success at razorback sucker spawning bars, total numbers of drifting larvae, numbers of larvae entrained in floodplains, survival rate in floodplains and mainstem, time spent by fish in floodplains, growth of fish in floodplains and mainstem, suitable fish densities in floodplains, and number of fish recruiting.*

The Recovery Program proposes to conduct additional research on the relationship between flows and floodplain habitats beginning in 2004 (see Monitoring Populations and Habitat on page 103).

Restore/maintain native fish passage at diversion structures

The Program has undertaken several studies to determine whether existing diversion structures on the Yampa River within critical habitat impede upstream migration of endangered fishes. Modde et al. (1999) specifically examined the Maybell and Patrick Sweeney diversions in 1996 and 1997. They found that Colorado pikeminnow migrated upstream from their spawning sites on the descending limb of the spring hydrograph when water depths and velocities allowed them to move freely across these structures. These long-distance migrations occurred only immediately before and immediately after spawning. Their movements during the remainder of the year were not constrained by artificial barriers any more than they were by natural barriers, such as Cross Mountain Canyon. Therefore, no remedial action is required to facilitate fish passage at these diversion structures as configured in 1997.

However, new diversion structures constructed within critical habitat could affect fish passage. New structures, in this case, includes reconstruction of or modifications to existing structures such that they impede fish migration. For example, with an increase in the overall height of a structure or its downstream slope (with or without an increase in height), fish may no longer be able to navigate it at lower flows. Depending upon the elevation and vertical drop of a structure, it may impose a barrier on fish passage even at higher flows. If flow is spread evenly across a flat concrete weir, regardless of height or drop, the depth at any one point may not be sufficient to permit passage, whereas a notched weir, which concentrates low flows and increases water depth at the notch, may permit passage.

Pursuant to Section II.A.1.c. of the FY 2004 Green River Action Plan: Yampa and Little Snake Rivers, the Program has developed guidelines with regard to minimum water depth and maximum water velocity and vertical drop for construction of any new/modified diversions and other structures in critical habitat on the Yampa River to facilitate fish passage and to minimize impacts inherent to their routine maintenance. Guidelines will describe specific parameters for fish passage, such as minimum depth and maximum slope/rise and velocity. The incremental construction cost, if any, will be borne by the Recovery Program if structures are for parties diverting water on or before January 22, 1988, regardless of whether such structures allow the parties to deplete more water than they had historically. They would, however, be subject to a depletion charge for any new depletions. If structures are intended for water users who began depleting water after January 22, 1988, the incremental costs of passage would have to be borne by the project proponents.

Evaluate/remediate entrainment by diversion structures

Endangered fish may be entrained by, or otherwise enter, existing water diversion canals, resulting in the loss (i.e., incidental take) of these individuals. Larval life stages are most susceptible to entrainment. However, endangered fishes are not known to spawn upstream from Yampa Canyon. Therefore, we do not expect larval fish to be entrained, since all major water diversions on the Yampa River are located upstream from Yampa Canyon. Moreover, only adult/subadult Colorado pikeminnow occur in significant numbers upstream from Yampa Canyon, so there would be little, if any, impact to razorback sucker, humpback chub and bonytail. However, adult/subadult Colorado pikeminnow which occupy the reach downstream from Craig could enter canals within this reach and become trapped or stranded. In November 2002, the Service initiated a native fish retrieval project in the Grand Valley; native fish were collected from pools remaining in the irrigation canals of the Grand Valley Irrigation Company (GVIC) and Grand Valley Project (GVP) following cessation of irrigation. These fish were collected by electrofishing and returned to the river alive. Although screens were installed on the GVIC canal inlet to exclude fish from entering the canal, low-water conditions in 2002 prevented the screen from being used during most of the irrigation season. In addition to salvaging fish, this project was intended to ascertain whether and to what extent fish are entering these canals. A similar effort was carried out in 2003 at the GVIC canal and will be again in 2004 to evaluate the effectiveness of the screen after it has been used for an entire irrigation season. No salvage work will be carried out at the GVP until after fish passage is installed on the diversion.

A similar project is proposed for the Maybell Canal on the Yampa River. With the consent of the canal owners and at the expense of the Program, field crews will retrieve native fishes from the irrigation canal shortly after it is drained at the end of the irrigation season. Any fish that remain in the canal will congregate in low spots where water is retained temporarily until it evaporates or seeps into groundwater. Field crews, whose composition will be determined by the Program, will determine whether and to what extent Colorado pikeminnow and/or other native species enter the canal and, if necessary, retrieve these fish and release them to the river alive. These investigations will serve the dual purpose of evaluating, as well as minimizing, potential incidental take due to entrainment. Fish salvage would be carried out annually, unless initial investigations establish that entrainment is not occurring or that incidental take from all causes is occurring at levels below those expected.

Manage Genetic Diversity/Augment or Restore Populations

Maintaining the genetic integrity of wild and captive-reared endangered fishes is important to their recovery and to preventing irreversible losses of genetic diversity. The Recovery Program developed the following genetic management goals: (1) prevent immediate extinction; (2) conserve genetic diversity through recovery efforts that will establish viable wild stocks by removing or significantly reducing factors that caused the population declines; (3) maintain the genetic diversity of captive-reared fish; and (4) produce genetically diverse fish for augmentation efforts (Czapla 1999). However, supplemental stocking with endangered fish propagated from captive brood stocks is not intended to replace natural reproduction and recruitment.

In 1999, the CDOW developed a plan to stock bonytail in the Yampa and Green rivers in Colorado. This stocking plan was revised in 2001 (CDOW 2001). Restoring bonytail through stocking above Lodore Canyon on the Green River and within the lower reaches of the Yampa is a high priority for the CDOW. Stocking began in 2000, with a total of 23,000 juvenile bonytail stocked to date in the

Green River near Brown's Park, Colorado, and in the Yampa River near its confluence with the Green River at Echo Park. Both sites are within Dinosaur National Monument (DNM), and stocking is carried out by the CDOW with the cooperation of the National Park Service (NPS). The State of Utah stocks razorback sucker to the Green River below Split Mountain to supplement the Middle Green/Yampa population. This activity also is a high priority for the Recovery Program.

The presence of stocked hatchery fish can provide an inaccurate picture of the size and health of the wild population. Therefore, fish stocked into the Yampa and Green rivers will be marked to allow the size of the wild population to be differentiated from the size of the stocked population. While stocked fish contribute to the size of the adult population, the overall health of a specific population depends upon successful natural reproduction as indicated by increased numbers of young-of-the year fish and corresponding increases in the adult population due to recruitment.

Monitor Populations and Habitat

Final recovery goals have been published for the four Colorado River endangered fish species (USFWS 2002a-d). They include both population and habitat criteria considered necessary for recovery. Monitoring endangered fish populations, as well as those habitats essential to their recovery, is necessary to determine when populations have recovered to the extent that they may be downlisted to threatened status or delisted (i.e., removed from the list of threatened and endangered species). Conversely, if populations of these species decline, additional recovery actions may be needed, or existing actions may need to be modified following an adaptive management process.

The importance of monitoring cannot be overstated. Although this element does not contribute directly to the recovery of the endangered fishes, it bridges all of the other recovery elements by evaluating their performance, both directly and indirectly, to assess their contributions to recovery and provide future direction for recovery actions using an adaptive management process.

Monitoring also will provide the Service with information relevant to criteria selected to reinitiate formal Section 7 consultation on this proposed action. For example, by monitoring consumptive water use, the CWCB will determine the average annual rate of depletions for comparison with the anticipated increase in depletions on which the original consultation was based. This information will be used in conjunction with actual stream flow data to assess the impacts of those depletions on peak flows, including their secondary impacts on sediment transport and floodplain inundation. Modeling will help ascertain whether anticipated beneficial effects of flow augmentation on base flows have been realized, and also will serve to inform an adaptive management process to determine if the augmentation protocol should be modified in response to actual stream flow data.

Separate performance criteria for each of the proposed recovery actions will measure their effectiveness in achieving short-term objectives (e.g., reduction in nonnative fish populations), as well as their long-term contribution to the recovery of the endangered fishes. For example, populations of nonnative fishes will be monitored to ascertain the effectiveness of nonnative fish management activities. Declining nonnative fish populations in the river would provide direct evidence that these activities are achieving their short-term objectives, and provide indirect evidence of potential long-term benefits of this recovery action to the endangered fishes and other native species by reducing competition with and predation by nonnative species. However, corresponding changes in endangered fish populations (i.e., increased abundance, expanding range, evidence of spawning and recruitment, etc.) would be required to confirm the anticipated beneficial effects of all recovery actions. However, attributing recovery to any specific action(s) will be difficult.

Monitoring endangered fish populations

The Recovery Program will monitor adult Colorado pikeminnow, razorback sucker and humpback chub populations to ascertain the status of these populations (e.g., numerical abundance, age-class structure, evidence of recruitment), using standardized protocols. Larval sampling will determine whether and to what extent these populations are spawning. Survival of stocked fish also will be assessed. Endangered fish population data will be collected fortuitously during nonnative fish management activities; conversely, the status of nonnative fish populations also can be monitored in conjunction with endangered fish population surveys to make the most efficient use of the Program's limited resources (Table 37).

Table 37. Projects related to population monitoring in the Yampa and Green rivers, 2003-2004

Project No: Title	Reach (RM)	Effort
22f: Yampa River and Green River larval Colorado pikeminnow and larval razorback sucker collections	Yampa: 0 (mouth) Green: 319–248	June–August 2003 and 2004; plankton nets, seines, light traps
98a: Yampa River northern pike translocation	Yampa: 120–46	April–June 2003 and 2004; electrofishing, trammel and fyke nets, seines
98b: Upper Yampa River northern pike, smallmouth bass, channel catfish translocation	Yampa: Upstream from Craig	April–June 2003; trap nets and electrofishing
109: Middle Green River northern pike removal	Green: 335–246	April–June 2003 and 2004; electrofishing, trammel and fyke nets
110: Lower Yampa River channel catfish removal	Yampa: 46–0	June–September 2003; electrofishing and angling
123: Green River nonnative fish removal	Green: 318–132	June–August 2003 and 2004; fyke nets
125: Middle Yampa River smallmouth bass and channel catfish translocation	Yampa: 120–45	April–June 2003 and 2004; electrofishing
128a: Middle Green River Colorado pikeminnow population estimate	Yampa: 117–46 Green: 334–246 White: 104–0	April–June 2003; electrofishing, 3–4 passes
128b: Lower Green River Colorado pikeminnow population estimate	246–0	April–June 2003; electrofishing, 3–4 passes
129: Desolation/Gray canyons humpback chub population estimate	184–145	June–July 2003 and 2004; electrofishing, 3 passes
133: Yampa Canyon humpback chub population estimate	47–0	May–June 2003 and 2004 (electrofishing and angling); September–October 2003 and 2004 (seines, trap nets, electrofishing)

Monitoring nonnative/native fish populations

Nonnative fish populations will be monitored during management activities for these species (Table 32), as well as in conjunction with monitoring endangered fish populations (Table 37). A decline in numbers of nonnatives fishes can be considered presumptive evidence of a benefit to the endangered fishes; however, to confirm that nonnative fish management activities have, in fact, achieved the desired benefits for native species, it will be necessary to examine populations of the endangered fishes, and/or surrogate native species, such as roundtail chub and flannelmouth sucker, which suffer similar impacts due to competition with and predation by nonnative species. An increase in their overall abundance, especially younger, smaller life stages, would be indicative of reproduction, larval survival, and potential recruitment into the adult populations, thereby allowing endangered fish populations to become self-sustaining. Native fish populations also could provide a significant prey base for Colorado pikeminnow, as nonnative fish populations are expected to decline in response to management activities.

Monitoring Habitat

Habitat consists not only of bedforms, such as spawning bars, floodplain depressions and backwaters, but also the stream flows that create and maintain them and their dynamic, flow-related habitat features, such as riffles, eddies, pools, etc. Peak flows will be monitored to assess whether the impacts of depletions and water storage exceed predicted levels. If so, the Service may need to reinitiate consultation to evaluate these unanticipated impacts. In addition, sediment transport will be evaluated to determine the validity of predicted flow-transport relationships. If peak-flow impacts are equal to or less than predicted, but their effect on sediment transport is greater than expected, the Service may need to reinitiate consultation.

Monitoring flow

Flow recommendations for the Green River at Jensen, Utah, are predicated on certain hydrologic assumptions with respect to flows in both the Green River upstream from Flaming Gorge Dam and the Yampa River. If impacts to Yampa River peak flows are greater than expected, the proposed modification of Flaming Gorge Dam operations may not be sufficient to achieve the desired flows. Failure to meet these recommendations could require the USBR to reinitiate consultation for Flaming Gorge Dam, require the Service to reinitiate consultation on this management plan or both.

The assumptions grounding the base-flow augmentation strategy will be tested. The augmentation protocol described on page 77 is not intended to precisely meet the flow recommendations. Rather, it is intended to meet the spirit of those recommendations. In some instances it will exceed them, while in others it will fall short of them. The base-flow augmentation strategy recognizes that flow targets cannot be met with the available water supply in the driest 10% of years. However, the expectation is that augmentation will reduce the long-term average frequency, magnitude and duration of “transgressions” of flow targets to historical levels as required by the flow recommendations (Modde et al. 1999) in the remaining 90% of the years. If the augmentation protocol fails to achieve the flow recommendations in this context, the protocol itself may be modified, following an adaptive management process, or other means (e.g., forbearance agreements) may be necessary to ensure that flow targets are met in their historical context. Moreover, failure to achieve these long-term objectives may require the Service to reinitiate consultation.

Monitoring sediment transport

Alluvial processes are critical to creating and maintaining physical habitats needed for the recovery of the endangered fishes. The Recovery Program awarded Argonne National Laboratory a contract to determine the most urgent priorities for geomorphic research. LaGory et al. (2003) followed an approach similar to a Delphi process. Workshops in December 2002 and February 2003 provided a forum for experts in fluvial geomorphology and fishery biology to discuss the attributes to consider in determining research priorities and reach consensus on assigning scores to these attributes. In this manner, LaGory et al. (2003) identified the habitats and river reaches that are most important for each of the four endangered fish species. They then looked at the scientific literature currently available, both published and unpublished, to determine where data gaps existed. Filling these data gaps will be the primary goal of future geomorphic research.

Based on these identified priorities, the Recovery Program will initiate an investigation in 2004 to study underlying geomorphic processes relevant to the formation and maintenance of backwater habitats in both the Colorado and Green rivers. These reaches and habitats are important for larval and juvenile life stages of the endangered fishes. However, these processes are relatively poorly understood, particularly with regard to the effects of peak-flow magnitude and duration, sediment deposition and erosion, base-flow magnitude and variability, and antecedent conditions on habitat availability and conditions. Knowledge of sediment dynamics in important river reaches is critical to understanding the effects of flow regimes on endangered fish habitats. The following research project developed for the Green River subbasin consists of two separate elements (A & B):

A. Study connected backwaters in the following Green River reaches:
   (1) Split Mountain Canyon to Desolation Canyon (focus on Ouray, Utah, area)
   (2) Labyrinth and Stillwater canyons
B. Install suspended sediment gages at the following USGS stream flow gages:
   (1) Green River at Jensen, Utah (09261000)
   (2) Green River at Green River, Utah (09315000)
   (3) Yampa River at Deerlodge Park, Colorado (09260050)

Topographic measurements of selected backwaters and adjacent exposed sandbars in each of the study reaches would be made using standard survey techniques (e.g., total station) annually during the summer base-flow period. These measurements would be used to develop a three-dimensional model for each habitat that predicted the effect of flow magnitude and variability on backwater surface area, depth, and volume during the base-flow period of the survey year. Existing stream gages in each study reach would be used to measure stream flow during the study. Sediment gages established at existing stream gages would be used to measure suspended sediment load in critical reaches of the Green River during the study. Data on daily suspended sediment load will provide information needed for, among other things: (1) an understanding of sediment import and export balance; (2) the effects of flow regime on habitat maintenance; (3) the relationship between sediment load and flow, including base and peak flows; (4) the effects of antecedent conditions on sediment transport; and (5) the effect of peak-flow duration on sediment transport rates. Data collected by sediment gages will help resolve many of the key uncertainties associated with existing flow recommendations.

Other monitoring

Tamarisk (*Tamarix* sp.), an aggressive, exotic, deciduous conifer, has displaced native riparian vegetation throughout the Southwestern United States and exacerbated surface water losses through transpiration. Once established, it is extremely difficult to control. State and local governments, federal agencies and private interest groups have taken an active role in trying to control this invasive species. Although tamarisk has not been identified as one of the threat factors affecting the endangered fishes of the Colorado River Basin, it potentially could pose a threat if, because of altered hydrologic regimes, it becomes established on mid-channel bars that currently serve as spawning sites or otherwise degrades essential habitats for the endangered fishes. For this reason, the Recovery Program and the Service support the work of the Tamarisk Coalition and other agencies actively involved in the tamarisk control effort. Tamarisk already is established in DNM, and the NPS is concerned that it will become more widespread. To further support this effort, the Recovery Program will monitor spawning sites and other essential habitats to ensure that tamarisk does not adversely impact them. Such monitoring will occur routinely in conjunction with other management activities, such as monitoring endangered fish populations and nonnative fish control.

ENVIRONMENTAL ASSESSMENT

INTRODUCTION

The National Environmental Policy Act (NEPA) requires federal agencies to fully disclose the impacts of their proposed actions on the human environment. Section 202 of the NEPA established the Council on Environmental Quality (CEQ) which subsequently adopted regulations to implement the provisions of the NEPA. These regulations can be found in the Code of Federal Regulations (40 CFR Parts 1500–1508). Subsection (§) 1507.3 requires federal agencies to adopt specific procedures to implement these regulations. The CEQ allows each agency latitude as to how the agency implements the various statutory requirements of the NEPA. With regard to preparing an environmental assessment (EA), §1501.3 defers to these procedures to allow federal agencies to determine when an EA is required. The Department of the Interior adopted procedures that state:

> *An EA will be prepared for all actions, except those covered by a categorical exclusion, those covered sufficiently by an earlier environmental document, or those actions for which a decision has already been made to prepare an EIS. The purpose of an EA is to allow the responsible official to determine whether to prepare an EIS or a FONSI.* (Departmental Manual: 516 DM 3.2)

The CEQ regulations require federal agencies to reduce excessive paperwork and delays by, among other things, using the scoping process to identify significant issues and de-emphasize insignificant issues (40 CFR 1501.7), briefly discussing issues other than significant ones (40 CFR 1502.2(b)), incorporating information by reference to other documents (40 CFR 1502.21), combining environmental documents with other documents (40 CFR 1506.4), categorically excluding actions which have insignificant individual or cumulative impacts (40 CFR 1508.4), and using a finding of no significant impact when an action not otherwise excluded will not significantly affect the human environment (40 CFR 1508.13). This EA adheres to these CEQ requirements, as appropriate.

Part 516 DM 2.3 of the Departmental Manual (69 FR 10866; March 8, 2004) defines a categorical exclusion as:

> *...a group of actions that would have no significant individual or cumulative effect on the quality of the human environment and, for which in the absence of extraordinary circumstances, neither an environmental assessment nor an environmental impact statement is required.*

Chapter 8 of the Departmental Manual (516 DM 8.5; revised May 27, 2004) deals with categorical exclusions for specific activities carried out by the U.S. Fish and Wildlife Service, including the following actions relevant to this management plan:

A. <u>General</u>

> *(2) Personnel training, environmental interpretation, public safety efforts, and other educational activities, which do not involve new construction or major additions to existing facilities.*

B. <u>Resource Management</u>. *Prior to carrying out* [the following] *actions, the Service should coordinate with affected Federal agencies and State, tribal, and local governments.*

(1) Research, inventory, and information collection activities directly related to the conservation of fish and wildlife resources which involve negligible animal mortality or habitat destruction, no introduction of contaminants, or no introduction of organisms not indigenous to the affected ecosystem.

(6) The reintroduction or supplementation (e.g., stocking) of native, formerly native, or established species into suitable habitat within their historic or established range, where no or negligible environmental disturbances are anticipated.

(8) Consultation and technical assistance activities directly related to the conservation of fish and wildlife resources.

Recovery actions under the Yampa Management Plan that meet the above criteria for categorical exclusion are information and education, nonnative fish management research, habitat research and monitoring, fish population monitoring, stocking endangered fishes, and consultation and technical assistance activities (but not necessarily those federal actions for which consultation or technical assistance is provided). Moreover, activities related to acquisition, restoration, and management of flooded bottomland habitats are covered under an existing EA (USDI 1998). The future potential impacts of other recovery actions, such as restoring endangered fish passage and reducing impacts of maintaining diversion structures, and reducing or eliminating entrainment of endangered fishes at diversion structures, have not been addressed in this EA or elsewhere, because their site-specific impacts cannot be fully evaluated until their location(s) have been identified and specific action(s) described. Separate NEPA document(s) will be prepared, if necessary, for any such action(s).

The Service issued a preliminary draft management plan in October 2001. Pursuant to 40 CFR 1501.7, on November 27–29, 2001, the Service held scoping meetings at three venues within the Yampa River Basin to identify significant issues of concern to the affected public to be addressed through the NEPA process. A summary of oral comments received at these public meetings can be found in Appendix E. The Service subsequently issued a Notice of Availability (NOA) in July 2003 (68 FR 44808; July 30, 2003) to announce its publication of a revised draft management plan and draft EA, and held another round of public meetings in August 2003 at the same venues as the November 2001 meetings. Copies of the NOA and written comments received on the draft plan and EA can be found in Appendix F. The management plan was revised, as appropriate, based on the comments received.

Pursuant to 40 CFR 1506.4, this EA has been combined with the Yampa Management Plan. To minimize redundancy with the management plan, much of the background information and descriptions of alternatives, as well as any relevant analyses of impacts, are incorporated into this EA by reference to appropriate sections of the management plan (40 CFR 1502.21). Hydrologic impacts not evaluated elsewhere in the management plan, including the cumulative impacts of depletions, were identified and evaluated separately (Appendix G).

PURPOSE AND NEED

The Purpose and Need for the proposed action can be found on page 1 of the Management Plan.

AFFECTED ENVIRONMENT

Geography and topography

The Yampa River Basin covers most of Routt and Moffat counties and small portions of Garfield and Rio Blanco counties in Colorado, as well as southwestern Carbon County and southeastern Sweetwater County in Wyoming. Situated principally within portions of three physiographic provinces, the Southern Rocky Mountains, Wyoming Basin, and Colorado Plateau (Fenneman and Johnson 1946), the diverse landforms of the Yampa Basin include steep mountain slopes, high plateaus, rolling hills, incised sandstone canyons, broad alluvial valleys and floodplains. The Yampa Basin is bounded by the Continental Divide on the east and north, the White River Plateau (locally known as the Flattops) along the southern hydrologic divide with the White River Basin, and the hydrologic divide with the Green River Basin along its northwestern flank (see Figure 1 on page 4 of the Management Plan). Elevations range from 12,180 feet (Mount Zirkel) in the Sierra Madre Range to about 5,080 feet at the confluence of the Yampa and Green rivers at Echo Park within Dinosaur National Monument.

Climate

The Yampa River Basin is characterized by cool, dry summers and cold winters. Local climatic conditions in the Basin vary with elevation. Average July temperatures range from ~62°F at Steamboat Springs to ~73°F at Dinosaur, and average January temperatures range from ~15°F at Steamboat Springs to ~21°F at Dinosaur (Yampa Valley Partners 2002). Summer high temperatures above 90°F are rare, while winter low temperatures occasionally dip to -40°F to -50°F. Maybell holds the Colorado record low temperature of -61°F. The frost-free period ranges from 60–120 consecutive days, depending upon elevation, generally from mid-May through late September (Burns & McDonnell 1999).

Precipitation follows a similar pattern, with annual averages ranging from more than 50 inches at the highest elevations of the Sierra Madre Range to less than 9 inches in the lower reaches of the Little Snake River drainage (Andrews 1978). Rainfall can be sporadic and locally intense. Snow accounts for a significant percentage of total precipitation throughout the Basin, though snowpack contributes a greater percentage at higher elevations (Yampa Valley Partners 2002). May produces the highest average rainfall (1.7 inches), while March produces the most snowfall (15 inches). September produces the smallest average rainfall (1.13 inches), while February is the driest of the winter months (10 inches of snow). Sustained winds as high as 30–40 miles per hour may occur during the winter, causing snow scour and drifting (Burns & McDonnell 1999). Dry windy conditions during the spring can cause the snowpack to erode through sublimation.

Geology and soils

The headwaters of the Yampa and Little Snake rivers originate in the Sierra Madre Range of the Southern Rocky Mountains province. This region is underlain by relatively erosion-resistant pre-Cambrian igneous granite, gneiss and schist and meta-sedimentary strata. The central portion of the Yampa Valley lies within the Wyoming Basin, characterized by erodible Tertiary and Cretaceous sedimentary formations. Between Steamboat and Craig, these formations are dominated by the Mesa Verde Group and Mancos Shale. At Craig, Mancos Shale creates the valley floor with Mesa Verde sandstones and shales being expressing in the hills north and south of the river. Downstream from Craig, the Yampa River enters the Brown's Park Formation, consisting of Tertiary crossbedded sandstones and siltstones, before slicing through Cross Mountain, a small, north-south faulted anticline. Below Cross Mountain, the river encounters the Yampa Plateau rising at the eastern end of the Uinta Uplift. The river carves a sinuous course of embedded meanders through the Weber Sandstone of this Miocene-Pliocene uplift, creating the Yampa Canyon (Chronic 1980).

The Little Snake River follows a similar course from the Sierra Madre range through the more erodible intermediate strata of the Mesa Verde Group, Steele Shale and Brown's Park Formation before joining the Yampa River just upstream from Yampa Canyon. Sixty-percent of the sediment delivered to Yampa Canyon is generated in the reach of the Little Snake River below Dixon, Wyoming. Other sedimentary formations in this reach include loosely cemented, interbedded sandstones, siltstones and mudstones of the Wasatch and Green River formations; the Washakie Formation of sandstone, siltstone, mudstone and conglomerate; and the Bridger Formation, which ranges from shale to sandstone. These relatively young, erodible formations are found in the far western portion of the Little Snake River basin, where Paleozoic sedimentary strata, primarily limestone, sandstone and siltstone, are exposed. Shales are more common in Cretaceous formations, while mudstones dominate Tertiary strata. Sparse vegetation, low rainfall and readily erodible deposits in this region contribute to its high sediment yield (Hawkins and O'Brien 2001).

Hydrology and geomorphology

The Yampa River is considered to have the most natural hydrograph of any river of its size in the Upper Colorado River Basin. Relative to other basins, its natural flows have not been significantly altered by large, mainstem reservoirs or diversions. Owing to the semi-arid regional climate and orographic distribution of precipitation, most of the annual yield of the Yampa River Basin is derived from snowmelt at higher elevations. This results in average peak flows (~10,000 cfs at Maybell) that are two orders of magnitude higher than average base flows (~100 cfs). The highest recorded peak flows (~24,000 cfs) are more than four orders of magnitude higher than the lowest recorded base flows (~2 cfs). So, extreme flow variations routinely occur both inter-annually and intra-annually. A more comprehensive discussion of hydrology can be found in the management plan under **Setting** beginning on page 3.

Channel slope and substrate also vary widely, from steep, swift, turbulent, bedrock-, boulder- and cobble-lined headwater tributaries through a series of alternating long, alluvial reaches and short, bedrock-confined reaches. Alluvial reaches are characterized by slower-flowing, braided and meandering channels through gravel/cobble substrates, bounded by alluvial terraces that frequently flood at higher flows. At Cross Mountain Canyon (RM 58–55), the river descends steeply to another alluvial reach before beginning its final descent through Yampa Canyon (RM 45–0) to the Green River. Between Cross Mountain and Yampa Canyon, the Little Snake River (RM 50) contributes 77% of the average annual sediment load to the Yampa River (O'Brien 1987), while providing only 27% of average water volume. High spring flows are important for transporting this sediment through Yampa Canyon to the Green River and beyond. O'Brien (1987) concluded that the sediment budget of the Yampa Canyon is roughly in long-term equilibrium. However, he also stated:

> *The effect of reducing the discharge in the Little Snake* [River] *will be to reduce the sediment load in the canyon. Concomitantly, reducing the water supply in the Yampa River upstream of the confluence with the Little Snake River will have the effect of limiting the river's ability to transport the sediment load in the canyon.*

Significant amounts of sediment are generated due to regional geology. Sand Wash and Muddy Creek, two principal tributaries to the Little Snake River, produce the largest amounts of sediment. Sand Wash is underlain predominantly by the Bridger Formation, which produces mostly sand-sized sediments. Muddy Creek and Powder Wash drain the Green and Wasatch Formations, which yield finer sediments. Sand Creek drains the Washakie Formation (Hawkins and O'Brien 2001).

In addition to its sediment-transport function, the natural hydrograph of the Yampa River provides a natural shape to the hydrograph of the Green River downstream from the confluence. Since its completion in October 1962, Flaming Gorge Dam, located on the Green River 68 RM upstream from its confluence with the Yampa, has significantly reduced peak flows while increasing base flows. Sediment load at Jensen, Utah, has been reduced 54% since Flaming Gorge Dam was completed, because the reservoir acts as a sediment trap for the Green River, which contributed 3.6 million tons of the sediment per year prior to 1962 (Andrews 1986). However, Andrews (1986) also concluded that, since 1962, an equilibrium between sediment supply and transport has existed in the Green River, from the Yampa River downstream to Jensen. He attributes this to the location of Flaming Gorge Dam just 68 RM upstream from a significant source of sediment. Further discussion of geomorphological processes can be found in Appendix G (Evaluation of Peak-flow Impacts).

Water Quality

Generally, water quality in the Yampa River Basin is considered excellent. Headwaters originate in high alpine forests of the Flat Tops and Mount Zirkel wilderness areas. The upper basin has relatively pristine water quality typical of high-elevation, coldwater streams, and certain stream segments have been designated as "Outstanding Waters," which must be maintained and protected at their existing water quality. Headwater reaches are typical of the Rocky Mountain region, where snowmelt produces neutral to slightly acidic pH and relatively low alkalinity. The Colorado Water Quality Control Commission (WQCC) designated uses for various stream segments in the basin to include: Aquatic life coldwater (Class 1); Aquatic-life warmwater (Classes 1 and 2); Recreation (Classes 1a, 1b, and 2); Water-supply; and Agriculture. The WQCC designated as "Use Protected" several stream segments that do not consistently meet water-quality standards or that are subject to significant existing point-source discharges. All other stream segments in the watershed are reviewable under the State's antidegradation regulations (Montgomery Watson Harza 2002).

Water temperatures in the Yampa River and its tributaries vary seasonally and diurnally, as well as with elevation and stream flow. Harmonic mean annual temperatures vary inversely with elevation, with cold mean temperatures typical of headwater reaches versus the warmer mean temperatures of lower reaches. The amplitude of variation between seasonal high and low temperatures also varies inversely with elevation. That is, the range of annual temperature extremes is greater at lower elevations which also experience a wider range of ambient air temperatures throughout the year (Wentz and Steele 1980). In 1975–76, Wentz and Steele (1980) found that summer water temperatures exceeded 20°C, the upper limit for coldwater biota, at 9 of 82 water quality sample sites located throughout the Yampa River Basin in Colorado and Wyoming. Observed summer temperatures ranged from 9°C to 25.5°C, with no sites exceeding 30°C, the upper limit for warmwater biota. They observed the highest temperatures in areas where flows were extremely low. They concluded that water temperatures greater than 20°C were due to natural causes, and water temperatures in both the Yampa and Little Snake rivers had not changed significantly since 1951 (Wentz and Steele 1980).

Dissolved oxygen (DO) varies with elevation, temperature, and salinity, among other factors. It also is influenced by natural physical and biological instream processes, such as flow, aeration, photosynthesis, respiration, and decay of organic material, as well as the effects of human activities, such as inflows of pollutants from point and nonpoint sources. Levels of DO may show seasonal, as well as diurnal variation, typically in response to changes in physical and/or biological variables (Montgomery Watson Harza 2002). For example, during daylight hours, photosynthesis may drive DO higher, whereas at night respiration may drive DO lower. Dissolved oxygen ranged from 44 to 162% saturation, with values greater than 100% saturation at 57 of 81 sites sampled by Wentz and Steele (1980). Occasionally, concentrations of DO lower than water-quality standards have been observed in certain stream segments in the Yampa Basin. Wentz and Steele (1980) found DO was below coldwater aquatic-life standards (6.0 mg/L) at only three sites and below warmwater aquatic-life standards (5.0 mg/L) at two of those sites. Occasional low DO concentrations have also been observed on the Yampa River downstream from Stagecoach Reservoir, as well as on the Yampa River at Steamboat Springs. A recent study by the City of Steamboat Springs concluded that DO levels fluctuate seasonally in response to flows and water levels; DO typically is greater that 10.0 mg/L in spring and decreases steadily as flows decrease and temperatures rise. The USGS also found that diurnal fluctuations in DO may be due, in part, to algal photosynthesis and respiration (Montgomery Watson Harza 2002).

Low levels of DO also have been reported as a chronic problem in Stagecoach Reservoir. The Colorado Water Quality Control Division (WQCD) found significant blooms of a blue-green alga, *Aphanizomenon* sp., in 1996. Dissolved oxygen concentrations typically were less than 6.0 mg/L, the coldwater aquatic-life standard. Total phosphorus concentrations and secchi disk measurements suggest that Stagecoach Reservoir is eutrophic. Total phosphorus ranged from 0.031 mg/L in the epilimnion to 0.14 mg/L in the hypolimnion (Montgomery Watson Harza 2002).

The WQCD also observed moderate algal blooms of *Aphanizomenon* sp. and *Gloetrichia* sp. in Steamboat Lake in 1996. Although DO concentrations in the epilimnion were greater than 6.0 mg/L, concentrations were less than 0.7mg/L below 7 meters in depth. Chlorophyll *a* concentrations and secchi disk measurements indicate that Steamboat Lake may be mesotrophic, whereas total phosphorus concentrations suggest the lake is eutrophic (Montgomery Watson Harza 2002).

In the Yampa River Basin, pH generally ranges from 6 to 9. At higher elevations, lower pH values occasionally result from snowmelt that produces runoff extremely low in alkalinity (low buffering capacity). In other cases, it may indicate acid drainage from historic mining activities, such as in the Oak Creek drain (Montgomery Watson Harza 2002). A pH at least 5.0 is capable of sustaining amphibian life, while trout mortality decreases as pH increases. However, pH values greater than 9.0 are considered adverse to aquatic life, especially fish, and exceed Colorado water-quality standards (Yampa Valley Partners 2002).

At Maybell, measured pH values have increased from about 7.6 in the 1950s and 1960s to about 8.3 in the 1980s and 1990s. Chafin (2002) compared water-quality data collected from the Yampa River near Maybell during 1950–1974 with data collected during 1975–1999 to determine if this trend is real or simply an artifact of changes in measurement procedures (Table 38).

Table 38. Comparison of water-quality data (median values) between two 25-year periods

Water-quality parameter (units)	EPA [a]	Chafin (2002) data		
		1950–74	1975–99[b]	% change
Specific conductance (µS/cm)	–	469	530	13.0%
pH (-$\log_{10}$[H^+ concentration])	6.5–8.5	7.7	8.2	6.5%
Alkalinity (mg/L as $CaCO_3$)	–	138	137	-0.7%
Dissolved solids, sum of constituents (mg/L)	250	287	317	10.5%
Dissolved solids, total load (tons/day)	–	280	371	32.5%
Calcium (mg/L)	–	38	41	7.9%
Magnesium (mg/L)	–	16	20	25.0%
Sodium (mg/L)	–	36	39	8.3%
Potassium (mg/L)	–	2.5	2.5	0.0%
Chloride (mg/L)	250	18	14	-22.2%
Sulfate (mg/L)	250	72	110	52.8%
Fluoride (mg/L)	2.0	0.3	0.2	-33.3%
Silica (mg/L)	–	10	6.9	-31.0%
Nitrate [b] (mg/L as N)	10	0.23	0.06	-73.9%

[a] Secondary Drinking Water Regulations (except Nitrate = Primary Drinking Water Standards)
[b] Later period for nitrate concentrations is 1975–1994

These two periods represent the 25 years immediately preceding and the 25 years immediately following 1975, the year that onsite pH measurements began. Prior to 1975, samples were collected in the field and brought back to the laboratory for analysis. Chafin (2002) concluded that the earlier technique produced erroneously lower pH values probably due to respiration by microorganisms in laboratory samples. If pH had been measured onsite, respiration would not have been a factor. Therefore, the apparent increase in pH likely was caused mostly by changing to the more accurate, onsite methodology.

Specific conductance and dissolved solids concentration were significantly greater during the latter 1975–1999 period. Calcium, magnesium, sodium and sulfate concentrations also were significantly greater during this period, whereas chloride, fluoride and silica were significantly less than during the 1950–1974 period. Alkalinity and potassium concentration were not significantly different between these periods (Chafin 2002).

However, water quality in the Yampa River Basin generally is very good, with upper and lower basins receiving favorable ratings from the EPA's Index of Watershed Indicators (Yampa Valley Partners 2002). Ames (1977) concluded that the Yampa is a "clean healthy river" because it supports a highly diverse and complex aquatic community (as cited in Montgomery Watson Harza 2002). Wentz and Steele (1980) found that 57% (35) of the 61 sites they successfully sampled were "clean" based on their analysis of the diversity of genera of benthic macroinvertebrates (Figure 21). They calculated diversity indices for each of the 61 sample sites from which data were recovered, based on the formula presented by Slack et al. (1973):

$$\bar{d} = -\sum_{i=1}^{t} (n_i / n) \log_2 (n_i / n)$$

where: $\bar{d}$ = diversity index;
n = total number of individuals in all taxa;
n_i = number of individuals in each taxon i; and
t = number of taxa.

Diversity indices less than 1.0 are considered indicative of heavy pollution; indices from 1.0 to 3.0 indicate moderate pollution; and indices greater than 3.0 indicate clean, unpolluted water quality. Although Wentz and Steele (1980) observed diversity indices less than 1.0 at two sites, these were likely due to extreme flow conditions, rather than strictly water-quality limitations. At one site, low flow (0.1 cfs) probably exacerbated its higher temperature (23°C) and conductivity (1,100µS/cm). At the other site, high, turbulent flow may account for the absence of certain bottom-dwelling taxa. Disregarding the latter anomaly, Wentz and Steele (1980) found that diversity indices (Figure 22), the number of genera, numbers of individuals and biomass all tended to decrease downstream.

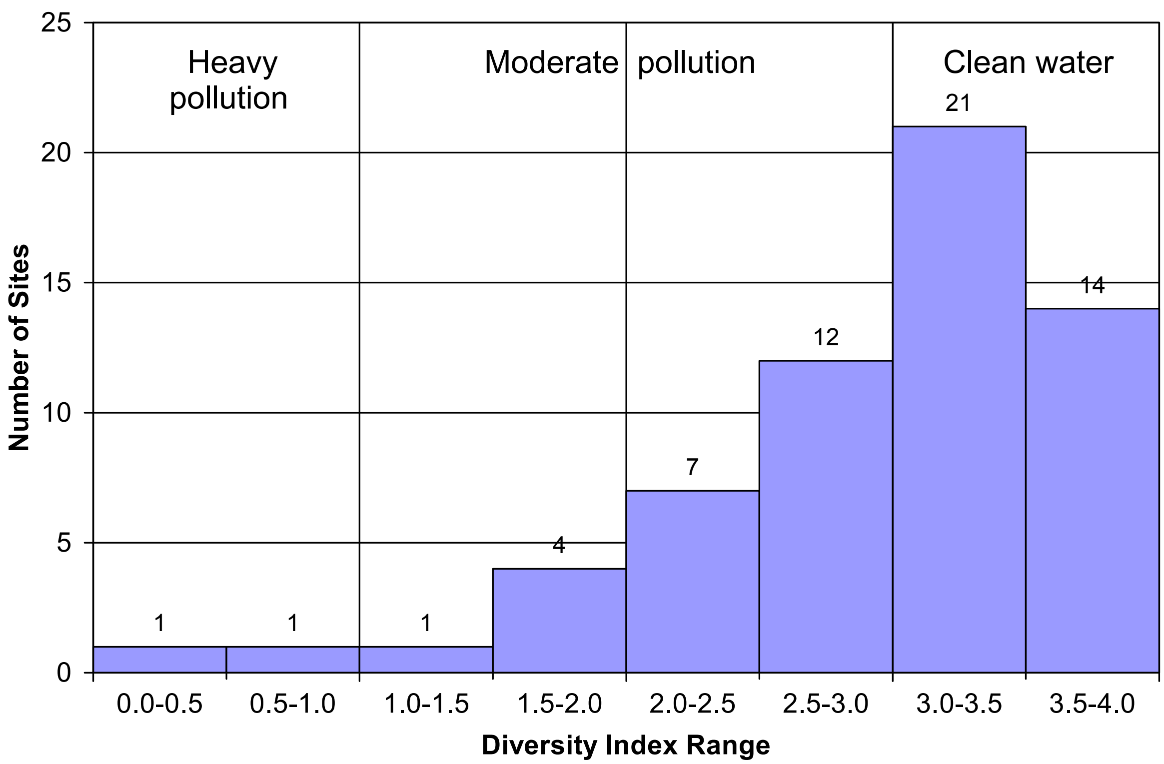


Figure 21. Diversity indices of benthic macroinvertebrates as indicators of water quality: Number of sample sites in each range of indices (adapted from Wentz and Steele 1980)

Although this finding is somewhat different from those of other investigators (Ames 1977; Canton and Ward 1977; as cited in Wentz and Steele 1980), it is not unexpected, as conductivity (Figure 23) and temperature tend to increase, and oxygenation tends to decrease from upper to lower reaches. Moreover, the finer, more readily mobilized sediments typical of lower reaches are less conducive to colonization by a variety of macroinvertebrate taxa.

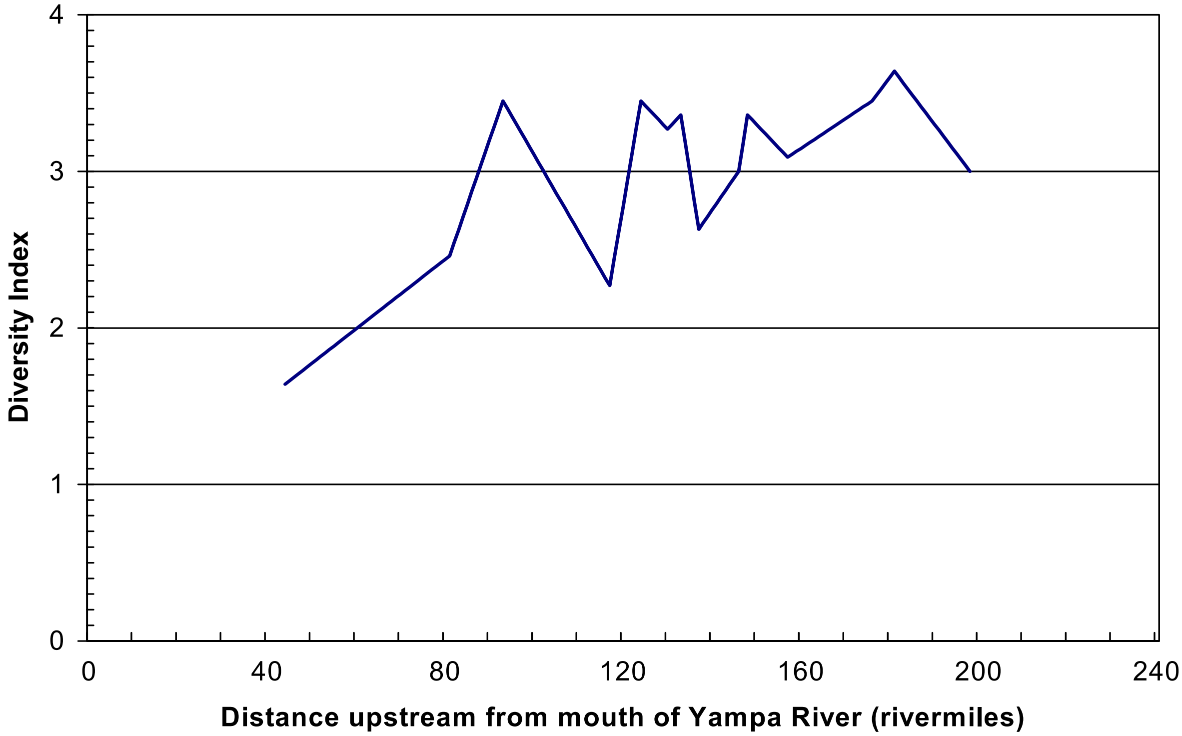


Figure 22. Diversity indices of benthic macroinvertebrates as a function of distance upstream from the mouth of the Yampa River (adapted from Wentz and Steele 1980).

Wentz and Steele (1980) found that although specific conductance in the Little Snake River had not changed significantly since 1951, there had been a 14% increase in conductance in the Yampa River during the same period, which they attributed to increased agricultural and municipal use of water. Specific conductance provides an indirect means of measuring concentrations of major inorganic cations, such as calcium, magnesium, sodium, and potassium, and anions — bicarbonate, sulfate, chloride, fluoride and silicates. But concentrations of individual ions may vary from site to site, due to the geological heterogeneity of the basin, as well as seasonally due to both natural causes and anthropogenic factors, such as irrigation. Specific conductance increases downstream, as water accumulates dissolved solids from both point and non-point sources. These solutes may be diluted, but are not eliminated from the river. Wentz and Steele (1980) found that specific conductance increased from 100 microsiemens per centimeter (µS/cm) or less in headwater reaches to more than 300 µS/cm within 20 miles downstream, which they attributed to irrigation. Farther downstream, specific conductance stabilized, apparently because inputs of solutes were balanced by dilution from tributary inflows upstream from the Little Snake River. However, the specific conductance of the Little Snake River is more than twice that of the Yampa upstream from its confluence with the Little Snake, resulting in a 40% increase in conductance in the Yampa River downstream from their confluence (Figure 23). A slight increase in specific conductance observed in the Yampa River from the Little Snake River downstream to the Green River probably was due to evaporation, as evident from a net loss of 18 cfs through this reach (Wentz and Steele 1980).

Specific conductance generally varies inversely with flow. Conductance typically declines in spring, as high flows from snowmelt dilute solutes to a greater extent than do lower base flows later in the year. At Steamboat Springs, Wentz and Steele (1980) observed a high inverse correlation between specific conductance and Yampa River flows above 136 cfs; however, they did not observe a similar relationship at flows below 136 cfs (Figure 24).

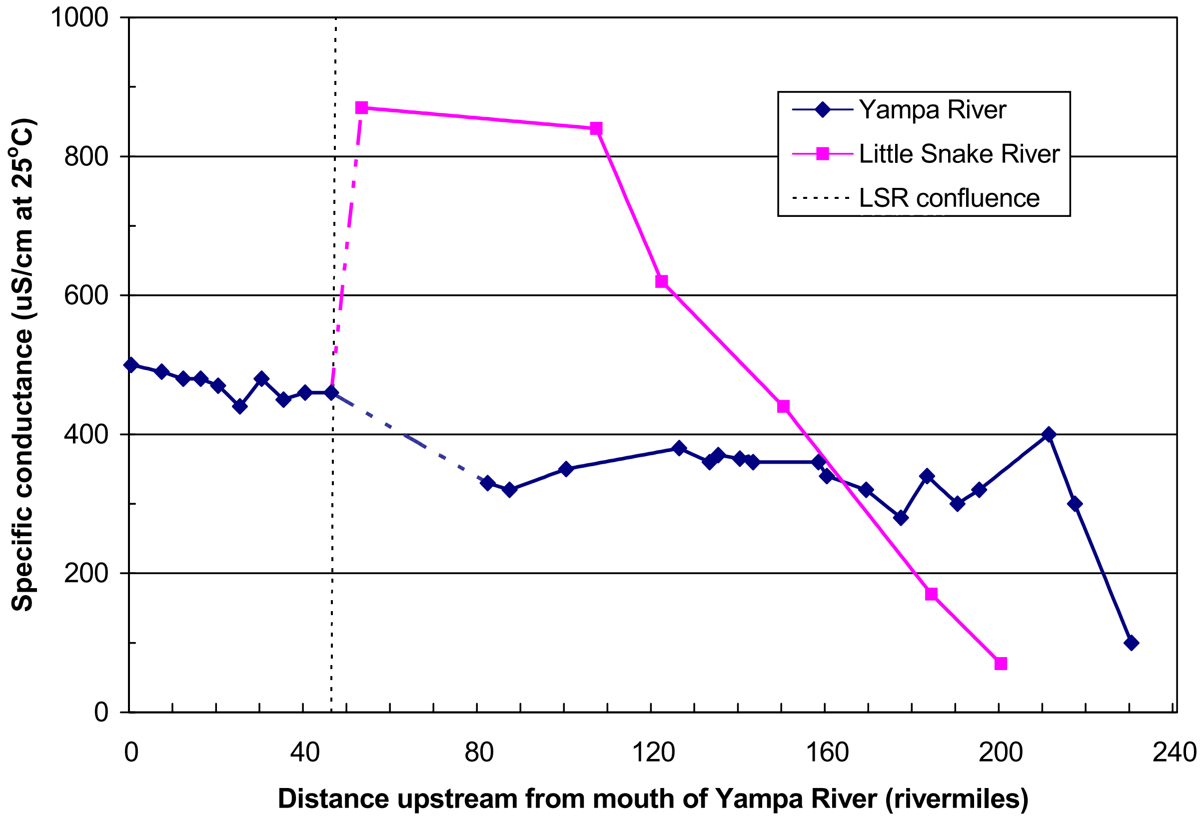


Figure 23. Specific conductance in the Yampa and Little Snake rivers, Colorado and Wyoming, August-September 1975 and August 1976 (adapted from Wentz and Steele 1980)

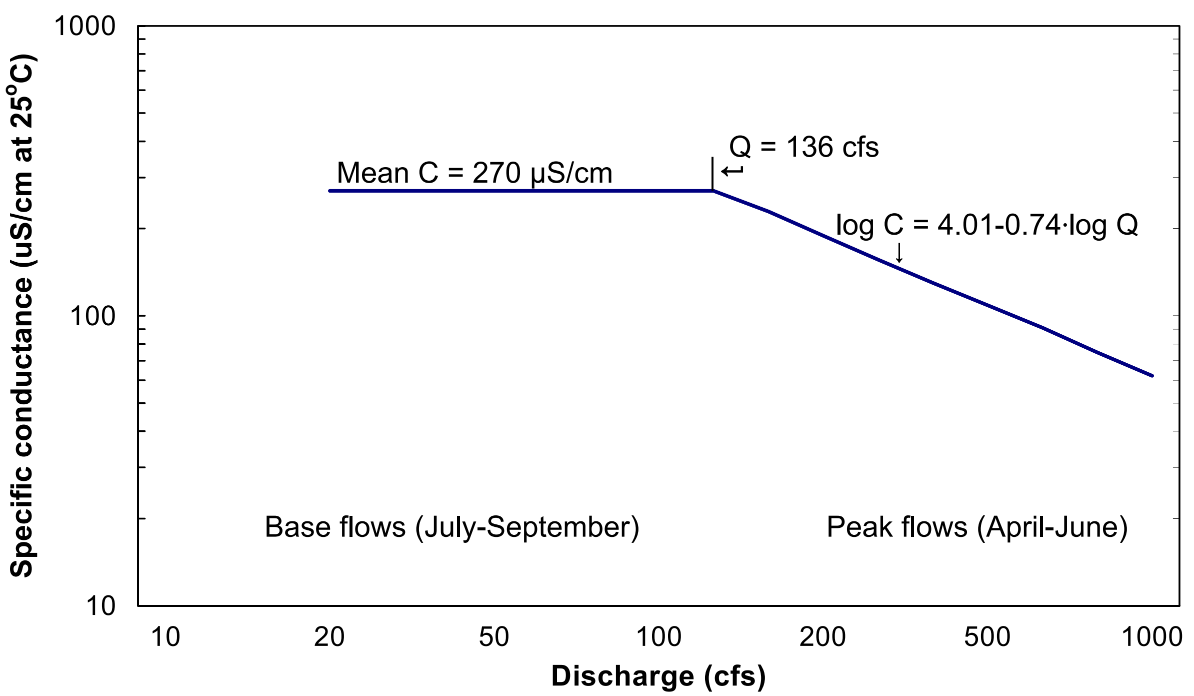


Figure 24. Specific conductance (C) vs. flow (Q), Yampa River at Steamboat Springs during base-flow and peak-flow conditions, April-September 1977 (adapted from Wentz and Steele 1980)

In Elkhead Creek, fluctuations in specific conductance appear to be moderated by Elkhead Reservoir. Kuhn et al. (2003) found that specific conductance in Elkhead Creek upstream from the reservoir (110–960 μS/cm) varied to a greater extent than it did in the creek downstream from the dam (120–560 μS/cm), which they attributed to the reservoir mixing base flows higher in dissolved solids with spring flows containing lower levels of dissolved solids. They also observed that specific conductance in the creek was greater below the dam than above the reservoir at the onset of runoff, approximately equal during peak runoff, and lower below the dam following runoff. At the onset of runoff, water containing higher levels of dissolved solids initially was flushed from the reservoir until the reservoir was in balance with spring inflows. Following runoff, as flows decreased and dissolved solids in Elkhead Creek upstream from the reservoir increased, water that had been stored during spring peak flows, containing lower concentrations of dissolved solids, continued to discharge from the reservoir (Kuhn et al. 2003).

Intra-annual variation in major-ion concentrations and total dissolved solids (TDS) in Elkhead Creek appeared to be consistent from year to year both above and below the reservoir. Seasonal patterns in major-ion concentrations were evident and mirrored seasonal patterns in specific conductance. As with specific conductance, variability in the concentrations of most major ions was greater above the reservoir (TDS ~70–640 mg/L, sum of constituents) than below the dam (~75–330 mg/L). Ninety percent of the observed TDS values in the creek above the reservoir were between 100 and 430 mg/L. These differences were evident throughout the year except during spring runoff, when major-ion concentrations in Elkhead Creek were about the same both upstream and downstream from the reservoir (Kuhn et al. 2003).

At Maybell, TDS averaged 170 mg/L (126–286 mg/L) from 1941 through 1993. During the same 53-year period, TDS in the Green River downstream from Flaming Gorge Dam averaged 430 mg/L (327–571 mg/L) with somewhat higher levels since Flaming Gorge Dam was completed in 1962 (484 mg/L) than before (373 mg/L). At Green River, Utah, TDS in the Green River averaged 451 mg/L (366–616 mg/L) also with somewhat higher values since 1962 (476 mg/L) than before (435 mg/L). However, the Yampa River also exhibited higher average TDS since 1962 (185 mg/L) than before (149 mg/L), so TDS increases could be due to other factors in both rivers, possibly in addition to the effects of Flaming Gorge Dam in the Green River. Two major factors may have contributed to these increases: (1) addition of salts from water use, principally irrigation, and (2) consumption or depletion of water, including evaporation from reservoirs (USDI 1995).

Concentrations of TDS may serve as a measure of water quality, with lower TDS values generally indicative of higher water quality. Sources of TDS may be natural as well as anthropogenic. TDS levels may be elevated due to natural mineralization or erosional processes. These natural processes may or may not be exacerbated by human activities, such as mining, agriculture and urbanization, that expose soils and mineral deposits and accelerate leaching, erosion, and weathering of minerals. Point-source pollution is another potential cause of elevated TDS concentrations, which have been reported from several locations in the basin, including Oak Creek upstream from its confluence with the Yampa River and Trout Creek, and may be associated with mining activities in these areas (Montgomery Watson Harza 2002).

During wetter years, salt concentrations generally are low due to higher dilution factors, while total annual salt loads (tons/year) are higher than in drier years, largely due to higher volumes of water in wet years (USDI 1995). The 24-year (1951–74) average dissolved solids load of the Yampa River was estimated to be roughly 450,000 tons/year or about 5% of the average annual load of dissolved solids for the Upper Colorado River Basin (Wentz and Steele 1980). Several of the major inorganic ions typical of Colorado waters include sulfates, selenium, iron and manganese.

Sulfates are widely distributed in nature and may occur naturally in waters at concentrations above ambient water quality standards. Oxidation of pyrites may contribute to high levels of sulfate where outcrops containing pyrites are exposed to weathering and in mine drainage. Occasional elevated sulfate levels, including levels exceeding water quality standards, have been noted in Elkhead Creek, Yampa River below Craig, Morapos Creek near Hamilton, Yampa River near Maybell, and Little Snake River downstream from the Colorado-Wyoming border (Montgomery Watson Harza 2002).

Selenium, an element that occurs naturally in soils, bio-accumulates in some organisms, causes birth defects in waterfowl at chronic levels, and can be acutely toxic at higher concentrations. Elevated concentrations of selenium have been found in the Yampa Basin at several Colorado locations including the Yampa River above Phippsburg, Elkhead Creek above Long Gulch, Fortification Creek, Good Spring Creek, Milk Creek, the Yampa River near Maybell, and the Little Snake River below the Colorado-Wyoming state line (Montgomery Watson Harza 2002). However, Wentz and Steele (1980) found selenium in exceedance of water quality standards at only one of the 82 sites they sampled (Table 39). The USGS currently is evaluating selenium in the Yampa Basin.

Table 39. Number of sites failing to meet water-quality standards for certain constituents [a]

Inorganic Constituents	Water-supply standard		Aquatic-life standard		Agricultural standard	
	Dissolved	Total	Dissolved	Total	Dissolved	Total
pH	3	–	3	–	–	–
Dissolved oxygen	–	–	3	–	–	–
Cadmium	0	0	0	2 [b]	0	0
Copper	0	0	1	3	1	1
Iron	3	33	2	13	–	–
Lead	0	1 [c]	1	1 [c]	0	0
Manganese	12	23	0	0	7	8
Mercury	0	0	7	18	0	0
Nickel	–	–	0	0	0	0
Selenium	1	1	1	1	1	1
Zinc	0	0	0 [d]	0 [d]	0	0

[a] Adapted from Wentz and Steele (1980); see Table 40 for Water Quality Standards.
[b] Only two sites exceeded 10 µg/L, the minimum detection limit; however, the aquatic-life standard is 0.4 µg/L.
[c] Only one site exceeded 100 µg/L, the minimum detection limit; however, the water-supply standard is 50 µg/L, and the aquatic-life standard is 4 µg/L.
[d] One site may have exceeded the aquatic-life standard (50 µg/L); however, analytical problems prevented confirmation.

Iron and manganese often occur in relatively high concentrations in Colorado streams and generally result from naturally occurring mineralization. Elevated levels of iron and manganese also may be indicative of runoff from mining operations (Montgomery Watson Harza 2002). Several smaller tributaries of the Yampa River have exhibited elevated levels of iron, manganese and mercury in the past (Table 39). During a 1975 basin-wide reconnaissance, Wentz and Steele (1980) found that 33 sample sites had levels of total iron that exceeded water-quality standards for domestic water supply, and 23 sites had levels of total manganese in excess of these standards. Thirteen sites also exceeded the aquatic-life standard for total iron, and 18 sites exceeded the aquatic-life standard for total mercury. Natural sulfide mineralization is the likely source of iron and manganese in Hahn's Peak drainages, whereas surface coal mining within the drainages of Grassy, Fish, Foidel and Middle creeks may account for elevated levels of these minerals (Wentz and Steele 1980).

Total mercury levels in excess of aquatic life standards were found in Oak Creek and Sage Creek, as well as Fish and Foidel creeks. Mining appears to be responsible for higher levels of mercury at all but the Sage Creek site, which is located downstream from the Hayden Station. Higher levels of mercury may have occurred at Sage Creek because the creek was highly acidic, and mercury is more soluble under acidic conditions. During their basinwide reconnaissance, only the Sage Creek site exhibited an abnormally low value of pH (2.1), which Wentz and Steele (1980) attributed to blowdown water from the smokestacks at the Hayden Station entering the creek. This appears to have been an acute, rather than chronic, condition in Sage Creek. Another exacerbating factor is that several of the streams that exhibited elevated levels of iron, manganese and mercury also had extremely low flows during the period of the reconnaissance (August-September 1975).

Compounds of nitrogen and phosphorus are considered major nutrients because of the role they play in plant growth. Nutrients can enter lakes and streams from natural sources, such as atmospheric deposition, precipitation, erosion and natural biochemical processes. In addition, anthropogenic sources, such as urban runoff, domestic and industrial wastewater, livestock waste and erosion caused by development, contribute to the aquatic nutrient load. Nutrient enrichment can promote unwanted growth of algae in lakes and streams, resulting in eutrophication (Kuhn et al. 2003).

With a few notable exceptions, however, nutrient enrichment does not appear to be problematic in the Yampa River Basin. Several areas exhibiting nutrient enrichment appear to have resulted from over-fertilization. Stinking Gulch contained 3.0 mg/L dissolved nitrogen (as N), probably due to contamination from an area of oil and gas development upstream. The addition of phosphorus to the cooling towers at Hayden Station to inhibit corrosion and scaling is the likely cause of elevated levels of dissolved phosphorus (0.17 mg/L as P) in Sage Creek (Wentz and Steele 1980).

Stream Classification and Water Quality Standards for the Yampa River Basin (CDPHE 2003) can be found in Appendix H and have been excerpted for specific river reaches in Table 40.

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Table 40. Stream classifications and water quality standards for certain reaches of the Yampa River and certain tributaries (page 1 of 2)

Gage/Location	Stream segment[a]	Designation[b]	Stream Classification	Numeric standards[c]: Physical and Biological		Inorganic (mg/L)		Metals (µg/L)			
Yampa, above Stagecoach	2a	–	Aq life cold 1	DO	6.0 mg/L	NH_3 (ac)	TVS	As (ac)	50[d]	Pb (ac)	TVS
Yampa, below Stagecoach	2a	–	Recreation 1	DO (sp)	7.0 mg/L	NH_3 (ch)	0.02	Cd (ac)	TVS[e]	Pb (ch)	TVS
Yampa, Steamboat Springs	2a	–	Water supply	pH	6.5–9.0	Cl_2 (ac)	0.019	Cd (ch)	TVS	Hg (ch)	0.01(tot)
Yampa, below Elk River	2a	–	Agriculture	F Coli	200/100ml	Cl_2 (ch)	0.011	CrIII (ac)	50[d]	Ni (ac)	TVS
Elk River, Clark	3	–				CN	0.005	CrVI (ac)	TVS	Ni (ch)	TVS
Elk River, Milner	3	–				S	0.002	CrVI (ch)	TVS	Se (ac)	TVS
Elkhead Creek	14	–				B	0.75	Cu (ac)	TVS	Se (ch)	TVS
Little Snake, Slater	18	–				NO_2	0.05	Cu (ch)	TVS	Ag (ac)	TVS
						NO_3	10	Fe (ch)	300	Ag (ch)	TVS[e]
						Cl	250	Fe (ch)	1000[d]	Zn (ac)	TVS
						SO_4	250	Mn (ch)	50	Zn (ch)	TVS
Yampa, Craig	L1	–	Aq life cold 1	DO	6.0 mg/L	NH_3 (ac)	TVS	As (ac)	50[d]	Pb (ac)	TVS
			Recreation 1a	DO (sp)	7.0 mg/L	NH_3 (ch)	0.02	Cd (ac)	TVS[e]	Pb (ch)	TVS
			Water supply	pH	6.5–9.0	Cl_2 (ac)	0.019	Cd (ch)	TVS	Hg (ch)	0.01(tot)
			Agriculture	F Coli	200/100ml	Cl_2 (ch)	0.011	CrIII (ac)	50[d]	Ni (ac)	TVS
				E. coli	126/100ml	CN	0.005	CrVI (ac)	TVS	Ni (ch)	TVS
						S	0.002	CrVI (ch)	TVS	Se (ac)	TVS
						B	0.75	Cu (ac)	TVS	Se (ch)	TVS
						NO_2	0.05	Cu (ch)	TVS	Ag (ac)	TVS
						NO_3	10	Fe (ch)	300[f]	Ag (ch)	TVS[e]
						Cl	250	Fe (ch)	1000[d]	Zn (ac)	TVS
						SO_4	250[f]	Mn (ch)	50[f]	Zn (ch)	TVS

[a] From Classifications and Numeric Standards for Upper Colorado River Basin and North Platte River, Regulation No. 33 (CDPHE 2003)
L = Classifications and Numeric Standards for Lower Colorado River Basin, Regulation No. 37 (CDPHE 2003)
[b] OW = Outstanding Waters; UP = Use-protected; – None
[c] All values are dissolved, unless otherwise noted (see footnote d); (sp) = spawning; (ac) = acute; (ch) = chronic; TVS = Table Value Standard
[d] Total recoverable; otherwise dissolved (see footnote c)
[e] Numeric standard for trout waters
[f] Where actual water supply use exists, Fe, Mn and SO_4 standards are the less restrictive of these values or existing quality as of January 1, 2000

Table 40. Stream classifications and water quality standards for certain reaches of the Yampa River and certain tributaries (page 2 of 2)

Gage/Location	Stream segment [a]	Designation [b]	Stream Classification	Numeric standards [c]: Physical and Biological		Inorganic (mg/L)		Metals (µg/L)			
Yampa, Maybell	L2	–	Aq life warm 1	DO	5.0 mg/L	NH_3 (ac)	TVS	As (ac)	50 [d]	Pb (ac)	TVS
			Recreation 1a	pH	6.5–9.0	NH_3 (ch)	0.06	Cd (ac)	TVS	Pb (ch)	TVS
			Water supply	F Coli	200/100ml	Cl_2 (ac)	0.019	Cd (ch)	TVS	Hg (ch)	0.01(tot)
			Agriculture	*E. coli*	126/100ml	Cl_2 (ch)	0.011	CrIII (ac)	50 [d]	Ni (ac)	TVS
						CN	0.005	CrVI (ac)	TVS	Ni (ch)	TVS
Yampa, Deerlodge Park						S	0.002	CrVI (ch)	TVS	Se (ac)	TVS
						B	0.75	Cu (ac)	TVS	Se (ch)	TVS
						NO_2	0.05	Cu (ch)	TVS	Ag (ac)	TVS
						NO_3	10	Fe (ch)	300 [f]	Ag (ch)	TVS [e]
						Cl	250	Fe (ch)	1000 [d]	Zn (ac)	TVS
						SO_4	250 [f]	Mn (ch)	50 [f]	Zn (ch)	TVS
Little Snake, Lily Park	L16	–	Aq life warm 2	DO	5.0 mg/L	NH_3 (ac)	TVS	As (ac)	100 [d]	Mn (ch)	TVS
			Recreation 1a	pH	6.5–9.0	NH_3 (ch)	0.06	Cd (ac)	TVS	Hg (ch)	0.01(tot)
			Agriculture	F Coli	200/100ml	Cl_2 (ac)	0.019	Cd (ch)	TVS	Ni (ac)	TVS
				E. coli	126/100ml	Cl_2 (ch)	0.011	CrIII (ac)	TVS	Ni (ch)	TVS
						CN	0.005	CrVI (ac)	TVS	Se (ac)	TVS
						S	0.002	CrVI (ch)	TVS	Se (ch)	TVS
						B	0.75	Cu (ac)	TVS	Ag (ac)	TVS
						NO_2	0.05	Cu (ch)	TVS	Ag (ch)	TVS [e]
								Fe (ch)	1100 [d]	Zn (ac)	TVS
								Pb (ac)	TVS	Zn (ch)	TVS
								Pb (ch)	TVS		

[a] From Classifications and Numeric Standards for Upper Colorado River Basin and North Platte River, Regulation No. 33 (CDPHE 2003)
L = Classifications and Numeric Standards for Lower Colorado River Basin, Regulation No. 37 (CDPHE 2003)
[b] Designation: OW = Outstanding Waters; UP = Use-protected; – None
[c] All values are dissolved, unless otherwise noted (see footnote d); (sp) = spawning; (ac) = acute; (ch) = chronic; TVS = Table Value Standard
[d] Total recoverable; otherwise dissolved (see footnote c)
[e] Numeric standard for trout waters
[f] Where actual water supply use exists, Fe, Mn and SO_4 standards are the less restrictive of these values or existing quality as of January 1, 2000

There are only a few point-source discharges to the Yampa River, principally from municipal wastewater treatment facilities. Since 1993, municipal wastewater discharges basin-wide have increased 10% from roughly 3.7 to 4.1 million gallons per day (mgd), with Steamboat Springs contributing 61–63% of the total wastewater discharge (2.26–2.57 mgd), an increase of almost 14% (Yampa Valley Partners 2002; Table 41).

During the same period, per capita output of wastewater declined by about the same percentages (14% in Routt County and 10% basin-wide). The two-fold difference in per capita output between Routt and Moffat counties can be attributed to the large number of visitors and seasonal residents who visit Steamboat Springs each year. These non-residents are not counted toward the resident population, but their contribution to wastewater production is apparent.

Table 41. Wastewater discharge (mgd) in the Yampa Basin during three recent periods [a]

	Municipality	1991–1993	1994–1997	1998–2002	Change
Routt County	Yampa	0.06	0.04	0.03	-50.0%
	Phippsburg	0.03	0.03	0.01	-66.7%
	Oak Creek	0.23	0.21	0.28	21.7%
	Steamboat Springs	2.26	2.43	2.57	13.7%
	Milner	0.01	0.02	0.01	0.0%
	Hayden	0.18	0.25	0.18	0.0%
	Total Routt County	2.77	2.98	3.08	11.2%
Moffat County (Craig)		0.94	1.12	1.00	6.4%
Total		3.71	4.1	4.08	10.0%
Number of residents (Routt)		15,208 [b]	16,889 [c]	19,690 [d]	29.5%
Number of residents (Moffat)		11,724 [b]	13,159 [c]	13,194 [d]	12.5%
Number of residents (Total)		26,932 [b]	29,908 [c]	32,884 [d]	22.1%
Routt per capita discharge (gpd)		182	176	156	-14.1%
Moffat per capita discharge (gpd)		80	85	76	-5.5%
Total per capita discharge (gpd)		138	137	124	-9.9%

[a] Source: Yampa Valley Partners 2002
[b] 1992 estimate, linearly interpolated between 1990 and 2000 census data
[c] 1995 estimate, linearly interpolated between 1990 and 2000 census data
[d] 2000 census data

Chafin (2002) measured the highest pH in the Yampa River (9.20) above the Elk River confluence, about 1.8 miles downstream from the Steamboat Springs wastewater treatment plant outfall, where he concluded that nutrient enrichment caused photosynthesis by algae to dominate. The effects of photosynthesis were still dominant 16 miles downstream near Hayden, although they appeared to be attenuated by re-aeration and diluted by cleaner water from the Elk River. About 37 miles farther downstream and 6 miles below the outfall of the Craig wastewater treatment plant, pH again rose in apparent response to nutrient enrichment (Chafin 2002).

The only occurrence of nutrient enrichment that Wentz and Steele (1980) attributed, at least in part, to municipal wastewater was on Oak Creek, which contained 0.63 mg/L of dissolved nitrogen. In addition, effluent from the Oak Creek drain contributed 0.81 mg/L of dissolved nitrogen and 14 mg/L of dissolved organic carbon to Oak Creek downstream from the drain. However, nitrogen concentrations near the confluence of Oak Creek with the Yampa River decreased to approximately the same levels as those observed upstream from the Town of Oak Creek, whereas organic carbon concentrations did not decrease significantly until after dilution by the Yampa River (Wentz and Steele 1980).

Kuhn et al. (2003) found that nutrient levels generally were low in Elkhead Creek both above and below Elkhead Reservoir, with no statistically significant difference between these two stations. Moreover, year-to-year variation in the concentrations of major nutrients also was insignificant. However, within-year concentrations did vary seasonally. Nutrient concentrations at both stations usually were lowest from July through February and highest during snowmelt, from March through June (Kuhn et al. 2003).

Fecal coliforms are any of several genera of bacteria belonging to the family Enterobacteriaceae. Excrement from mammals, including humans, is the most common source of fecal coliforms in water. Presence of these organisms is indicative of contamination associated with wastewater or animal grazing. In the Yampa River Basin, likely sources are effluent from municipal wastewater treatment facilities and domestic septic systems or grazing animals, such as deer, elk and cattle. Elevated coliform levels have been detected in several locations in the basin, including Lost Dog Creek above mouth near Clark, Little Bear Creek near Craig, Morapos Creek near Hamilton, Johnson Gulch, Little Snake River downstream from the Colorado-Wyoming border, and the Yampa River at Deerlodge Park (Montgomery Watson Harza 2002).

In Elkhead Creek, median levels of fecal coliforms detected above and below Elkhead Reservoir were 46 colonies/100 ml and 35 colonies/100 ml, respectively. These levels are well below the applicable water-quality standard of 200 colonies/100 ml. Likewise, median levels of *Escherichia coli*, a human pathogen, were 21 colonies/100 ml and 31 colonies/100 ml above and below the reservoir, which are also well below the water-quality standard of 126 colonies/100 ml. The maximum number of coliforms and *E. coli* detected (100 colonies/100 ml and 83 colonies/100 ml, respectively) also were below water-quality standards (Kuhn et al. 2003).

Air quality

Although air quality in the Yampa River Basin is generally good, there are several air quality issues of note: Environmental Protection Agency (EPA) 1993 designation of Steamboat Springs as a moderate non-attainment area under the National Ambient Air Quality Standards (NAAQS) for 24-hour PM-10 concentrations; and EPA 1996 citation of Hayden Station for violations of the Clean Air Act due to its emissions of particulate matter, sulfur dioxide (SO_2) and nitrogen oxides (NO_x).

PM-10 is a measure of particulate matter between 2.5 and 10 µm in diameter. Local sources of PM-10 include dust from street sanding and unpaved roads, and smoke from burning wood and coal. These microscopic particles can remain air-borne indefinitely, cause respiratory problems, visibility impairment, and climate changes, and damage soil and vegetation (Yampa Valley Partners 2002). The NAAQS maximum 24-hour PM-10 is 150 $\mu g/m^3$ and the average annual PM-10 is 50 $\mu g/m^3$. The 24-hour PM-10 may not be exceeded more than three times during any consecutive 3-year period. Steamboat Springs had exceeded 150 $\mu g/m^3$ on several occasions prior to 1997, with a maximum 3-year average exceedance of 2.31 in 1991. During the same period (1991–2000), Steamboat Springs had not exceeded the average annual PM-10. Moreover, it had not exceeded the 24-hour PM-10 since 1996 and, in 2001, the City of Steamboat Springs, Routt County and State of Colorado filed requested that EPA redesignate the city as a PM-10 attainment area (CDPHE 2001).

The U.S. Forest Service (USFS) concluded that visibility in the Mount Zirkel Wilderness Area may have been impaired, and that impairment was due, in part, to the Craig and Hayden power stations. The Mount Zirkel Visibility Study, funded by the owners of Craig and Hayden stations, and jointly managed by the owners, USFS, and State of Colorado, was completed in 1996. Under the terms of a 1996 settlement, Public Service Company (now Xcel Energy) agreed to install air pollution controls on its Hayden Station to remove more than 20,000 tons per year of air pollutants that had adversely impacted air quality and make progress toward reducing acid precipitation in the Mount Zirkel Wilderness Area. Controls were installed in 1999 which should reduce SO_2 emissions by 85%, and NO_x emissions by 50% (DOJ 1996; Ely 1999).

Vegetation

The Yampa River Basin has floristic similarities to the Northern Rocky Mountains Physiographic Province in the Park (i.e., Sierra Madre) Range north of Steamboat Springs and to the Colorado Plateau/Uinta Mountains Province in the Williams Fork Mountains southeast of Craig. However, most of the basin is more closely related to the flora of the Wyoming Basin Province (Kittel and Lederer 1993). Its wide range in elevation, and varied terrain, soils and climate contribute to the ecological diversity of the Yampa River Basin. Upland plant communities vary with elevation, slope, aspect, soils and hydrology, and range from alpine tundra at the highest elevations through spruce-fir subalpine forests and mesic ponderosa pine montane forests to more xeric piñon-juniper woodlands, oak scrub and sagebrush steppe, with drought-tolerant grasses, forbs and succulents at lower elevations.

During a 2-year study, Kittel and Lederer (1993) identified 38 distinct riparian plant associations along intact, relatively undisturbed reaches of perennial rivers and streams throughout the Yampa River Basin in Colorado, which they classified into the eight broad categories (Table 42).

The first three categories represent tree-dominated plant associations. Evergreen Forests include several different associations of coniferous species, principally subalpine fir (*Abies lasiocarpa*), Engelmann spruce (*Picea engelmannii*), and Colorado blue spruce (*P. pungens*), with a shrub layer consisting predominantly of thinleaf alder (*Alnus incana* ssp. *tenuifolia*) or black twinberry (*Lonicera involucrata*), and a variety of willows (*Salix boothii*, *S. drummondiana*, *S. geyeriana*, *S. lasiandra* var. *caudata*, *S. monticola*, and *S. wolfii*), especially along stream margins and other areas with hydric soils. Similarly, the herbaceous component includes hydric species, including bluejoint reedgrass (*Calamagrostis canadensis*), sedges (e.g., *Carex rostrata*, *C. aquatilis*), rushes (*Juncus* spp.), bulrush (*Scirpus americanus*) and meadow horsetail (*Equisetum arvense*), as well as mesic forbs, such as monkshood (*Aconitum columbianum*), mountain bluebell (*Mertensia ciliata*) and western sweet cicely (*Osmorhiza depauperata*). These cool, moist associations are found only in the upper reaches of the Yampa River Basin between 7,200 and 9,400 feet elevation. Similar hydric associations consisting of exclusively herbaceous vegetation, predominantly aquatic sedge (*C. aquatilis*) and creeping spikerush (*Eleocharis palustris*), and/or planeleaf willow (*S. planifolia* var. *monica*) also can be found in moist soils typically above 7,000 feet (Table 42).

Mixed Deciduous-Evergreen Forests are represented by a single plant association, which consists of a canopy of narrowleaf cottonwood (*Populus angustifolia*), with scattered to co-dominant occurrences of Colorado blue spruce, and a dense understory of red osier dogwood (*Cornus sericea*). This association generally occurs at lower elevations than those of Evergreen Forest associations. Its distribution in the Yampa River Basin overlaps the elevations of several Deciduous Forest associations that lack a coniferous component. Mesic forbs, such as cutleaf coneflower (*Rudbeckia laciniata*), baneberry (*Actaea rubra*), false solomon-seal (*Smilacina stellata*), Richardson geranium (*Geranium richardsoni*), dandelion (*Taraxacum officinale*) and western sweet cicely, dominate the undergrowth. Adjacent riparian vegetation consists of thinleaf alder/mesic forb and Pacific willow/mesic graminoid shrublands. Adjacent uplands vary from Gambel's oak (*Quercus gambelii*) and serviceberry (*Amelanchier alnifolia*) shrublands on drier slopes, to aspen (*Populus tremuloides*) woodlands, subalpine fir-Engelmann spruce and Douglas fir (*Pseudotsuga menziesii*) forests on north-facing slopes, shaded ravines and other areas having cooler, moister micro-climates.

Table 42. Undisturbed riparian plant associations of the Yampa River Basin in Colorado (page 1 of 2)

Plant Associations (Kittel and Lederer 1993)	Elevation of occurrence (feet above MSL)				
	6000	7000	8000	9000	10000
Evergreen Forests					
Engelmann spruce-subalpine fir/thinleaf alder					
Engelmann spruce-subalpine fir/black twinberry					
Colorado blue spruce/thinleaf alder					
Mixed Deciduous-Evergreen Forests					
Narrowleaf cottonwood-Colorado blue spruce/ thinleaf alder-red osier dogwood					
Deciduous Forests					
Narrowleaf cottonwood-box elder/red osier dogwood					
Narrowleaf cottonwood/thinleaf alder					
Narrowleaf cottonwood/serviceberry					
Narrowleaf cottonwood/red osier dogwood					
Narrowleaf cottonwood/coyote willow					
Rio Grande cottonwood/skunkbush					
Tall-stature Willow Shrublands					
Booth's willow/mesic forb					
Booth's willow/beaked sedge					
Drummond's willow/Canadian reedgrass					
Coyote willow/mesic graminoid					
Geyer's willow/beaked sedge					
Pacific willow/mesic graminoid					
Rocky Mountain willow/aquatic sedge					

Table 42. Undisturbed riparian plant associations of the Yampa River Basin in Colorado (page 2 of 2)

Plant Associations (Kittel and Lederer 1993)	Elevation of occurrence (feet above MSL)					
		6000	7000	8000	9000	10000
Low-stature Willow Shrublands						
Planeleaf willow/aquatic sedge						
Wolf's willow/mesic forb						
Non-willow Shrublands						
Thinleaf alder-red osier dogwood						
Thinleaf alder-Geyer willow						
Thinleaf alder/mesic forbs						
Skunkbush						
Silver buffaloberry/giant wildrye						
Herbaceous Plant Associations						
Aquatic sedge						
Beaked sedge						
Nebraska sedge						
Desert saltgrass meadow						
Creeping spikerush						
Povertyweed						
Baltic rush						
Scratchgrass						
Bulrush						
Alkali bulrush						
Miscellaneous Plant Associations						
Boxelder/bare ground (disturbance association)						
Slimstem reedgrass						
Rubber rabbitbrush						
Common scouring rush						

Five of the six Deciduous Forest associations also are dominated by narrowleaf cottonwood, with the remaining association, found only at the lowest elevations in the basin, dominated by Rio Grande cottonwood (*P. deltoides* ssp. *wislizenii*). Between 6,500 and 7,500 feet elevation, where narrowleaf cottonwoods predominate, understory vegetation consists of box elder (*Acer negundo*), red osier dogwood, river hawthorn (*Crataegus rivularis*), thinleaf alder, serviceberry, and willows. Dominant vegetation on adjacent uplands varies from Douglas fir forests and aspen woodlands at higher elevations to Gambel's oak scrub and big sagebrush shrublands at lower elevations, dependent on local micro-climatic conditions and soils. Kittel et al. (1999) consider the box elder-narrowleaf cottonwood/red osier dogwood riparian forest near Hayden to be the finest example of this globally rare plant community in North America, calling it the "crown jewel" of the Yampa River Basin.

Below 5,700 feet, where Rio Grande cottonwoods predominate, the understory is composed mainly of skunkbush (*Rhus trilobata*) with lesser amounts of red osier dogwood, spreading rabbitbrush (*Chrysothamnus linifolius*), snowberry (*Symphoricarpos* spp.) and coyote willow (*Salix exigua*). Adjacent uplands are vegetated with piñon-juniper woodlands (*Pinus edulis*, *Juniperus utahensis*) and greasewood (*Sacrobatus vermiculatus*) scrub.

Kittel and Lederer (1993) also identified nine different willow-based plant associations, divided into two categories, Tall-stature and Low-stature Willow Shrublands. Low willows, predominantly planeleaf willow and Wolf's willow (*Salix wolfii*), occur at higher elevations, whereas tall-stature willows generally occur at intermediate elevations, with Booth's willow (*S. boothii*) and Rocky Mountain willow (*S. monticola*) predominant, and lower elevations, where coyote willow, Geyer's willow (*S. geyeriana*) and Pacific willow (*S. lasiandra* var. *caudata*) predominate. Some of the largest and best examples of Booth's/mesic forb shrublands in Colorado occur along the South Fork and main stem of Slater Creek in the headwaters of the Little Snake River (Kittel et al. 1999).

Five Non-willow Shrubland associations are similar in composition to several of the Deciduous Forest associations, but without a cottonwood canopy. Dominant species include thinleaf alder, red osier dogwood, Geyer's willow, skunkbush and silver buffaloberry (*Shepherdia argentea*). These associations principally occur at elevations below 8,500 feet, whereas riparian wetlands dominated by herbaceous vegetation range widely throughout the basin. However, with the exception of the aquatic sedge and creeping spikerush associations previously described, most herbaceous wetland plant associations identified by Kittel and Lederer (1993) also occur below 8,500 feet elevation.

Fisher et al. (1983) conducted a more intensive survey of the Yampa and Green river riparian corridors in Dinosaur National Monument for the National Park Service. They classified upland plant communities as Blackbrush, Grassland, Piñon-Juniper, Mormon Tea, Rabbitbrush, Sagebrush and Shrub, or combinations of these, based on dominant species. Similarly, they classified riparian zone vegetation, where distinct, as Boxelder, Cottonwood, Squawbush (i.e., skunkbush), Tamarisk, and Willow. They also differentiated "floodzone" vegetation from other riparian plant communities. Floodzone vegetation, which consisted predominantly of annuals and flood-tolerant perennials, as well as seedlings of less flood-tolerant riparian species such as cottonwoods and tamarisk, was patchy and did not form continuous communities. Patches of dominant flora, such as horsetails (*Equisetum*), licorice (*Glyccyrrhiza*), dogbane (*Apocynum*), milkweed (*Asclepias*), smartweed (*Polygonum*), and sedges (*Carex*), were used to delineate these areas (Table 43).

Periodic flooding has a significant and direct impact on riparian and floodzone vegetation. Changes in species composition and dominance, as well as vegetation growth-form, density, coverage, and diversity are evident at or near the high water line. Inundation and scouring are the principal effects of flooding on vegetation. Inundation is a function of water depth, and scouring is a function of water velocity. Because both depth and velocity increase with discharge, their effects on vegetation cannot always be readily differentiated (Fisher et al. 1983).

Whereas prolonged inundation can inhibit establishment of flood-intolerant species, it can provide suitable conditions for establishment of ephemeral, flood-tolerant plant communities. The primary effect of inundation on vegetation is to limit the length of the growing season, favoring fast-growing annuals and flood-tolerant perennials. However, scouring can remove even the floodzone deposits that are seasonally vegetated with flood-tolerant species. Shear stress and abrasion by entrained sediment also can damage these plants.

Flood-tolerant species have developed adaptions to the rigorous conditions of flooding. Smartweed (*Polygonum amphibium*) can begin growth as a submergent and develop into a terrestrial plant as flood flows recede. Willows and tamarisk develop foliage while their stems are still submerged. They also are capable of withstanding abrasion and shear stress from scouring. Confined to the upper floodzone and less rigorous hydraulic regime of side channels, young cottonwoods appear to be less resistant to scouring than willows or tamarisk (Fisher et al. 1983).

Fisher et al. (1983) also found that most floodzone vegetation consisted of perennial plants capable of vegetative reproduction. Roots or rhizomes of these species may persist in the substrate from which new growth can sprout once suitable hydrologic conditions resume. Dominant flora that exhibit these characteristics include horsetail, aquatic sedge, spikerush, rush, licorice, hemp dogbane, milkweed, smartweed, povertyweed, and bur-sage. Although many grasses share similar characteristics, generally they were not found far below the high water line (Fisher et al. 1983).

Clean substrates that result from scouring also provide suitable conditions for seedlings of willows, cottonwoods and tamarisk. Once established, willows and tamarisk develop extensive root systems that stabilize the substrate and mitigate the effects of scouring. Above the substrate, vegetation further reduces scouring by slowing the water and enabling the deposition of entrained sediment. Fisher et al. (1983) estimate that recruitment of tamarisk stems occurs in pulses rather than at a constant rate. They noted that one such pulse in stem recruitment occurred in 1978, following a year with unusually low water conditions, possibly due to root-sprouting stimulated by low-water or the failure of seedlings produced in 1976 to be removed by high flows the following spring.

They also suggest that both unusually high and unusually low flow conditions are critical to sexual reproduction of willows, cottonwoods and tamarisk. This is especially true for cottonwoods, which disperse their seed during the spring flood. Seeds deposited on suitable moist substrates germinate as flows recede, but seedlings may be scoured away by subsequent floods. Higher flows, in particular, create suitable conditions for germination on higher terraces, where seedlings would be safe from all but the highest spring flows in subsequent years. This process is likely the source of cottonwoods at Anderson Hole, Haystack Rock and other locations along the Yampa River. Willows seem to follow a similar strategy and distribution (Fisher et al. 1983).

Table 43. Riparian plant species found in Dinosaur National Monument (page 1 of 2)[a]

Group	Plant species	Anderson Hole	Tepee Rapids	Haystack Rock	Big Joe Rapids	Mather Hole	Laddie Park	Boxelder Park	Stateline[b]	Compromise[b]
Sedges and rushes	Meadow horsetail (*Equisetum arvense*)			□	□	□	○	○		
	Common scouring rush (*E. hyemale*)		○	□	○	□	○	○		
	Smooth scouring rush (*E. laevigatum*)		○	□	○	□			○	○
	Aquatic sedge (*Carex aquatilis*)		○		○	□	□	□		
	Spikerush (*Eleocharis* sp.)		□		○	○	○	○		
	Creeping spikerush (*E. palustris*)									○
	Rush (*Juncus* sp.)				○	○	○			
	Toad rush (*J. bufonius*)					○				
Grasses	Desert wheatgrass (*Agropyron desertorum*)						○			
	False quackgrass (*A. pseudorepens*)									○
	Western wheatgrass (*A. smithii*)		○	○		○	○	○	○	○
	Quackgrass (*A. repens*)	○								
	Slender wheatgrass (*A. trachycaulum*)		○	○			○			
	Redtop bentgrass (*Agrostis alba*)					○	○			
	Saltgrass (*Distichlis stricta*)	○		○	○	□	○	○		
	Canada wildrye (*Elymus canadensis*)							○	○	○
	Indian ricegrass (*Oryzopsis hymenoides*)						○		○	
	Witchgrass (*Panicum* sp.)					○				
	Kentucky bluegrass (*Poa pratensis*)					○				
	Prairie cordgrass (*Spartina pectinata*)					□	○		○	
	Sand dropseed (*Sporobolus cryptandrus*)	○				○	○	○		
	Needle-and-thread grass (*Stipa comata*)						○			
Forbs	Pigweed (*Amaranthus palmeri*)					○				
	Dogbane (*Apocynum cannabinum* var. *glaberrinum*)		□		□	□	□	□	○	○
	Aster (*Aster hesperinus* var. *hesperinus*)					○				
	Goosefoot (*Chenopodium fremontii*)					○				
	Goosefoot (*C. glaucum*)						○	○		
	Slimleaf goosefoot (*C. leptophylum*)					○				
	Hairy goldaster (*Chrysopsis villosa*)	○		○		○	○	○	○	
	Wild buckwheat (*Eriogonum* sp.)	○								
	Ridgeseed spurge (*Euphorbia glytosperma*)						○			
	Bur-sage (*Franseria discolor*)	○	○			○	○			
	American licorice (*Glycyrrhiza lepidota*)		□	□	○		□			○
	Cudweed (*Gnaphalium palustre*)				○		○			

[a] Key to symbols: ○ = present; □ = dominant (adapted from Fisher et al. 1983)
[b] Green River sites in Whirlpool Canyon downstream from the Yampa River.

Table 43. Riparian plant species found in Dinosaur National Monument (page 2 of 2) [a]

Group	Plant species	Anderson Hole	Tepee Rapids	Haystack Rock	Big Joe Rapids	Mather Hole	Laddie Park	Boxelder Park	Stateline [b]	Compromise [b]
Forbs (continued)	Gumweed (*Grindelia squarrosa* var. *squarrosa*)					○	○			
	Broom snakeweed (*Gymnosperma glutinosa*)					○	○			○
	Povertyweed (*Iva axillaris*)	□		○	○	○	○	○	○	○
	Pepperweed (*Lepidium medium* var. *pubescens*)						○			
	Black medic (*Medicago lupilina*)					○	○			
	Alfalfa (*M. sativa*)				○	○				
	Yellow sweetclover (*Melilotus officinalis*)		○							
	Field mint (*Mentha arvensis*)					○				
	Evening primrose (*Oenothera* sp.)				○					
	Desert four o'clock (*Oxybaphus lanceolatus*)					○				
	Rippleseed plantain (*Plantago major*)					○				
	Smartweed (*Polygonum amphibium*)			○	□	○				
	Curlytop knotweed (*P. lapathifolium*)					○				
	Cinquefoil (*Potentilla anserina* var. *anserina*)		○	○		○	○			
	Rose (*Rosa* sp.)			○						
	Dock (*Rumex* sp.)					○				
	Golden dock (*R. fueginus*)						○	○		
	Tumbleweed (*Salsola kali*)						○	○		
	Spiny sowthistle (*Sonchus asper*)					○				
	Flannel mullein (*Verbascum thapsus*)					○				
	Cocklebur (*Xanthium* sp.)		○	○						
	Canada cocklebur (*X. strumarium* var. *canadense*)					○				
	Italian cocklebur (*X. italicum*)					○			○	○
Trees and shrubs	Boxelder (*Acer negundo*)					○			○	○
	White sagebrush (*Artemisia ludoviciana*)					○	○	○		
	Big sagebrush (*A. tridentata*)	□						○		
	Rubber rabbitbrush (*Chrysothamnus nauseosus*)						○		○	
	Douglas rabbitbrush (*C. viscidiflorus* ssp. *linifolius*)						○	○		
	Utah juniper (*Juniperus utahensis*)								○	
	Cottonwood (*Populus* sp.)	○			□	○	○	○	○	
	Rio Grande cottonwood (*P. wislizenii*)			□		○				○
	Skunkbush (*Rhus trilobata*)	□		○	□	○				
	Coyote willow (*Salix exigua*)		□	□	○	○	○			○
	Tamarisk (*Tamarix pentandra*)			□	□	□	□	□	□	□

[a] Key to symbols: ○ = present; □ = dominant (adapted from Fisher et al. 1983)
[b] Green River sites in Whirlpool Canyon downstream from the Yampa River.

Wildlife

Partial lists of major wildlife species typically associated with each of these macrohabitats are tabulated in Tables 44-46. These lists are not all-inclusive, but include significant species (e.g., common species, species with commercial and/or recreational value, threatened, endangered and sensitive species). These include resident and migratory/transient species. Resident species may occur in more than more major habitat type, usually in association with seasonal use patterns (e.g., breeding, calving, winter range, etc.) In addition to vegetation types, wildlife may prefer habitats with specialized physical characteristics (e.g., cliffs, rock outcrops, talus slopes, etc.) or utilize anthropogenic landforms and structures (e.g., stock tanks, croplands, irrigated pasture, and human habitations). Some species, such as coyotes, mule deer and black-billed magpies, are widespread generalists, occupying many different habitat types, year-round or seasonally. Others, such as the pine marten and white-tailed ptarmigan, are more specialized and occupy a narrower range of habitats. Some species may utilize multiple habitats, but over a narrow geographic range. For example, Canada lynx utilize willow thickets (wetlands) adjacent to or interspersed within their preferred spruce-fir forest habitat, whereas beaver are found in similar wetland habitats throughout a wider range of adjacent upland habitats from desert to forest. Migratory species, such as elk and mule deer utilize higher-elevation habitats in summer and lower-elevation habitats in winter.

Big game mammals include mule deer, elk (wapiti), moose, bighorn sheep, pronghorn antelope, black bear and mountain lion; furbearers include coyote, red fox, bobcat, mustelids, beaver and muskrat; and small game include squirrels, prairie dogs, marmot, rabbits and hares. Ducks and geese, upland game birds, such as pheasant, quail, grouse, turkey, and dove, and agricultural pests, such as crow and starling, also are harvested.

In 2001, the Rocky Mountain Bird Observatory (RMBO 2002) initiated a two-year project to inventory the birds of Dinosaur National Monument (DNM) in northwestern Colorado and northeastern Utah. Initial work involved a series of breeding bird transects in each of five primary habitats (sage shrubland, semidesert shrubland, piñon-juniper, mixed conifer, and low-elevation riparian). In 2001, work was completed in piñon-juniper and low-elevation riparian habitats.

For low-elevation riparian habitat, 63 one-mile line transects were surveyed by raft on the Yampa and Green rivers; line transects totaling 15 kilometers in length were surveyed on foot in riparian habitat that could not be adequately sampled from the river. For river transects, observers recorded all birds seen and/or heard and the perpendicular distance to each bird from the center of the river. For riparian transects surveyed on foot, observers visited areas with large patches of riparian habitat (Deerlodge Park, Gates of Lodore, Echo Park, Pool Creek, Cub Creek, Green River Campground, Rainbow Park, Jones Creek, Harding Hole, and Laddie Park), and surveyed line transects from 300 to 5000 meters in length, recording all birds seen and/or heard and the perpendicular distance to each bird from the transect line (RMBO 2002).

In the two habitat types, 3988 individual birds of 86 species were recorded on the transects. In piñon-juniper, 2050 individual birds of 70 species were recorded. The most numerous species were the black-throated gray warbler (n = 377), gray flycatcher (n = 204), spotted towhee (n = 179), chipping sparrow (n = 153), mourning dove (n = 96), and blue-gray gnatcatcher (n = 89). In low-elevation riparian, 1938 individual birds of 59 species were recorded; the species with the highest counts were violet-green swallow (n = 417), yellow warbler (n = 238), lazuli bunting (n = 215), white-throated swift (n = 155), spotted towhee (n = 102), and spotted sandpiper (n = 77). Notable species observed in DNM, but not detected on transects included American white pelican, doublecrested cormorant, ring-billed gull, rock dove, western screech-owl, great horned owl, burrowing owl, common nighthawk, common poorwill, willow flycatcher, eastern kingbird, steller's jay, blackpoll warbler and American goldfinch (RMBO 2002).

Most other avian species are protected under one or more federal and/or state statutes, including the Endangered Species Act, Bald and Golden Eagle Protection Act, and Migratory Bird Treaty Act. Game animals for which Colorado,Wyoming or Utah require a license are so designated with the letter "G" under each state's Status, while the letter "M" under "US" Status denotes that a Migratory Bird Hunting and Conservation Stamp (Duck Stamp) or other federal permit/license is required (CDOW 2002a,b; UDWR 2003b; WFGD 2002a). Other classifications include endangered (E), threatened (T), proposed as threatened (PT), candidate (C), and Colorado species of special concern (SC)(CDOW 2002c). In Wyoming, six native species status categories are recognized; three, SC1–SC3, are considered to be high priorities for conservation attention (Fertig and Beauvais 1999). Utah classifies species of special concern as species whose populations have substantially decreased (P) or have limited distribution (D) due to restricted or specialized habitats. "P/D" denotes species that meet both criteria (UDWR 2003a).

Table 44. Partial list of mammals known or likely to occur in the Yampa River Basin

Mammals	Status[a]				Preferred habitat(s)
	US	CO	WY	UT	
Dwarf shrew	–	–	SC3	–	Rocky areas within grasslands, woodlands, forests, alpine tundra
Long-eared myotis	–	–	SC2	–	Coniferous forests; roost in caves, buildings or mines near water
Fringed myotis	–	–	SC2	D	Caves, mines, and buildings, most often in desert, woodland areas.
Brazilian free-tailed bat	–	–	–	P/D	Caves and buildings
Spotted bat	C2	–	SC2	P	Deserts–coniferous forests; roost/hibernate in caves, rock crevices
Townsend's big-eared bat	–	–	SC2	P/D	Coniferous forests, desert shrubland; roost in mines or caves
Nuttall's cottontail rabbit	–	G	G	G	Brushy areas along stream courses or dry washes above 6,000 feet from desert areas up to the lower slopes of the mountains
White-tailed jackrabbit	–	G	G	G[b]	Mountains, foothills and valleys; generally occurs in open areas
Snowshoe hare	–	G	G	G	Coniferous forests, with aspen, willow, alder in higher mountains
Pika	–	–	–	D	Alpine and subalpine talus and rockpiles
Porcupine	–	–	–	–	Coniferous/mixed forest areas, riparian areas, deserts, shrublands
13-lined ground squirrel	–	–	–	D	Foothills of the Bighorn Mountains and the Bighorn Basin
Yellow-bellied marmot	–	G	G[b]	G	Meadows and rockpiles near forested areas
White-tailed prairie dog	–	G	G[b]	G	Plains, short-grass prairie
Beaver	–	G	G	G	Permanent slow moving streams, ponds, small lakes and reservoirs
Muskrat	–	G	G	G[b]	Marshes; ponds; shallow, slow-moving streams, vegetated areas
Mule deer	–	G	G	G	Wide ranging: open deserts to high mountains to urban areas
Wapiti (Elk)	–	G	G	G	Plains' edge to high mountains; meadows, forests and grasslands
Moose	–	G	G	G	Forested areas near lakes, streams or wetlands
Bighorn sheep	–	G	G	G	Steep, rugged terrain dominated by grass, low shrubs, rock cover
Pronghorn antelope	–	G	G	G	Grasslands, semidesert shrublands, mountain parks, western basins
Mountain lion	–	G	G	G	Canyons and mountainous areas with brush, woodlands or forests
Bobcat	–	G	G	G	Deserts; brushy, wooded areas; foothills, canyons, mesas, plateaus
Canada lynx	T	E	–	P/D	Dense coniferous forests ≥8,000' near bogs, thickets, rocky areas
Black bear	–	G	G	G	Large forested areas, woodland or brush
Coyote	–	G	G	G[b]	Open deserts, grasslands, forests, urban settings, and other habitats
Red fox	–	G	G	G[b]	Riparian woodland, wetlands, forest-edge, open/semi-open habitat
Swift fox	–	SC	SC3	–	Shortgrass prairie
Raccoon	–	G	G	G[b]	Riparian, urban; commonly found in wooded areas near water
Ringtail	–	–	–	D	Rocky deserts, wooded foothills, canyons, mesas near water
Striped skunk	–	G	–	G[b]	Open areas, especially grasslands and meadows, urban settings
Long-tailed weasel	–	–	G	G	Occurs in many types of habitat, brushy areas, near forest edges
American (pine) marten	–	–	G	D	Forested areas, high remote mountainous areas
American mink	–	–	G	G	Ponds, wetlands, riparian areas near forests in mountainous areas
River otter	–	E	–	P/D	Riparian; along creeks and major river drainages
Badger	–	G	G	G	Grasslands, plains, deserts, shrublands in mountain parks/valleys
Black-footed ferret	E	E	SC1	E	Grasslands in plains, mountain parks/valleys

[a] See page 135 for status codes
[b] May be taken without a permit/license
Sources: CDOW 1993, 2002a–c; Fertig and Beauvais 1999; UDWR 2003a,b; WFGD 2002

Table 45. Partial list of birds known or likely to occur in the Yampa River Basin (1 of 3 pages)

Birds	Status[a] US	CO	WY	UT	Preferred habitat(s) and breeding status (B)
Clark's grebe	–	–	SC4	–	Wetlands–open water (B)
American white pelican	–	–	–	–	Wetlands–open water: shallow lakes, marshes, rivers (B)
Great blue heron	–	–	–	–	Wetlands–open water: shorelines of lakes, marshes rivers (B)
Canada goose	M	G	G	G	Wetlands–open water: lakes, rivers, marshes, reservoirs (B)
Green-winged teal	M	G	G	G	Wetlands–open water: near woodlands, grasslands and fields (B)
Mallard	M	G	G	G	Wetlands–open water: fields near wetlands, parks, ponds (B)
Northern pintail	M	G	G	G	Wetlands–open water (B)
Gadwall	M	G	G	G	Wetlands–open water: ponds, lakes and marshes (B)
American wigeon	M	G	G	G	Wetlands–open water: near grasslands and fields (B)
Ring-necked duck	M	G	G	G	Wetlands–open water: lakes, rivers, marshes (B)
Lesser scaup	M	G	G	G	Wetlands–open water (B)
Common merganzer	M	G	G	G	Wetlands–open water (B)
Turkey vulture	–	–	–	–	Forested and open habitats; roost in trees near or over water (B)
Golden eagle	–	–	–	–	Nest on cliffs, large trees in open country, mountainous areas (B)
Bald eagle	T	T	SC2	T	Riparian forests along large rivers, lakes, reservoirs (B)
Northern harrier	–	–	–	–	Grasslands, marshes, fields (B)
Northern goshawk	C2	–	SC4	P	Woodlands/mature mountain forest–riparian habitats (B)
Sharp-shinned hawk	–	–	–	–	Woodlands and forests (B)
Red-tailed hawk	–	–	–	–	Open country, with scattered trees or other elevated perches (B)
Cooper's hawk	–	–	–	–	Woodlands and riparian areas (B)
Swainson's hawk	–	–	–	P	Primarily in shrub and grassland habitats at mid-elevations(B)
Ferruginous hawk	–	–	–	T	Grasslands/shrub-steppe, woodland edges, farmlands, desert (B)
Rough-legged hawk	–	–	–	–	Grasslands, fields, marshes, sagebrush, tundra, open forests (B)
Merlin	–	–	SC3	–	Coniferous forests, open woodlands, marshes, deserts, fields
Peregrine falcon	–	SC	SC3	E	Canyons, sheer rock cliffs near water (B)
American kestrel	–	–	–	–	Open habitats, prairies, deserts, wooded streams, farmlands (B)
American coot	M	G	G	G	Wetlands–open water: ponds, lakes and marshes (B)
Sora	M	G	G	G	Wetland-open water: freshwater wetlands and wet fields (B)
Greater sandhill crane	M	SC	G	G	Mudflats, wet meadows and agricultural areas; parks with grassy hummocks and water; ponds lined with willows or aspens (B)
White-tailed ptarmigan	–	G	G	G	Spruce-willow subalpine timberline areas; alpine tundra (B)
Mtn. sharp-tailed grouse	–	G	G	G	Bunch-grass foothill areas interspersed with deciduous shrubs (B)
Sage grouse	–	G	G	P/D	Successional-scrub areas; riparian habitats, grasslands (B)
Blue grouse	–	G	G	G	Woodlands, subalpine meadows; prefer open stands of conifers or aspen with brush understory; dense fir at high elevations (B)
Merriam's turkey	–	G	G	G	Coniferous forests, forest openings, forest/grassland edges (B)
Killdeer	–	–	–	–	Fields, pastures and riparian areas (B)
Mountain plover	PT	SC	–	P/D	Shortgrass prairie, overgrazed tallgrass and fallow fields; prairie grasslands, arid plains and fields, sagebrush, shrub-steppe (B)
Spotted sandpiper	M	–	–	–	Rocky shoreline and marshy habitats (B)
Long-billed curlew	M	–	SC1	P/D	Short grass with bare ground; rangelands and pastures
Common snipe	M	G	G	G	Wetlands–open water (B)
Wilson's phalarope	M	–	–	–	Wetlands–open water (B)
Mourning dove	M	G	G	G	Prefer open fields, forest edges created by modern agriculture (B)
Yellow-billed cuckoo	C	–	SC2	T	Woodlands, open riparian multi-story deciduous woodland (B)

[a] See page 135 for status codes

Table 45. Partial list of birds known or likely to occur in the Yampa River Basin (2 of 3 pages)

Birds	Status[a]				Preferred habitat(s) and breeding status (B)
	US	CO	WY	UT	
Great horned owl	–	–	–	–	Almost any habitat, except arctic and alpine environments (B)
Burrowing owl	–	T	SC4	P	Breed in grassland regions; open grasslands, mountain parks, well-drained steppes, deserts, prairies, agricultural lands (B)
Mexican spotted owl	T	T	–	T	Lower elevation forests, mostly in deep, incised, rocky canyons
Common nighthawk	–	–	–	–	Open habitats: grasslands, fields, open forests (B)
White-throated swift	–	–	–	–	Rocky cliffs and canyons in mountainous areas (B)
Broad-tailed hummingbird	–	–	–	–	Woodlands, riparian or adjacent habitats, in both lower valleys and higher elevations (B); streamside habitats near meadows
Belted kingfisher	–	–	–	–	Wetland-open water: riparian habitats near streams, lakes (B)
Lewis' woodpecker	–	–	–	P/D	Tall trees, often dead or blackened by fire (B)
Downy woodpecker	–	–	–	–	Forests, riparian woodlands, parks, and suburbs (B)
Hairy woodpecker	–	–	–	–	Deciduous or coniferous forests, woodlands, and orchards; in the southwestern US, it is found mainly in mountainous areas (B)
Three-toed woodpecker	–	–	–	D	Woodlands (B)
Northern flicker	–	–	–	–	Open forest areas, often nesting in cavities of dead trees (B)
Gray flycatcher	–	–	–	–	Predominantly piñon-juniper, sagebrush and desert shrublands (B)
SW willow flycatcher	E	E	–	E	Riparian, successional-shrub habitats outside Yampa River Basin
Say's phoebe	–	–	–	–	Open woodlands, farmland, or savannahs (B)
Western kingbird	–	–	–	–	Trees, bushes and other raised areas, such as buildings (B); open and semi-open habitats, such as deserts and grasslands
Horned lark	–	–	–	–	Grasslands (B); open deserts, alpine meadows
Violet-green swallow	–	–	–	–	From lowland valleys to mountain peaks, typically breeds in mid-elevation aspen forests (B)
Cliff swallow	–	–	–	–	Bridges, buildings, culverts, cliffs (B); normally found in lowlands, but occasionally in mountainous regions up to 8,500 feet elevation
Barn swallow	–	–	–	–	Barns and other buildings, bridges, cliffs (B); open habitats
Gray jay	–	–	–	–	Woodland regions (B); boreal and subalpine coniferous forests
Piñon jay	–	–	–	–	Successional-scrub regions (B)
Western scrub-jay	–	–	SC3	–	Successional-scrub regions (B); scrub oak, piñon-juniper forests
Clark's nutcracker	–	–	–	–	Woodlands (B)
Black-billed magpie	–	G	N[b]	G[b]	Widespread: Valleys and foothills (B)
American crow	–	G	N[b]	G[b]	Open woodland areas (B); agricultural areas, towns
Common raven	–	–	–	–	Nests primarity on cliffs or in trees (B); mountainous areas
Black-capped chickadee	–	–	–	–	Variety of habitats, including mixed deciduous/coniferous woodlands (B), willow thickets, clearings, and parks
Mountain chickadee	–	–	–	–	Woodland regions (B); coniferous and mixed montane woodlands
Juniper titmouse	–	–	–	–	Successional-scrub regions (B); piñon-juniper woodlands
Bushtit	–	–	–	–	Successional-scrub regions (B); piñon-juniper woodlands
Rock wren	–	–	–	–	Talus slopes, scrublands, or dry washes (B); arid and semi-arid habitats from low deserts to high mountains
Canyon wren	–	–	–	–	Cliffs, steep canyons, and rock outcrops (B); manmade structures
Bewick's wren	–	–	–	–	Successional-scrub regions (B)
House wren	–	–	–	–	Successional-scrub regions (B); open and semi-open areas
American dipper	–	–	–	–	Mountainous areas near lakes and streams (B)
Ruby-crowned kinglet	–	–	–	–	Spruce-fir forests (B), lower parks, woodlands during winter
Blue-gray gnatcatcher	–	–	–	–	Variety of forest habitats (B); piñon-juniper woodlands

[a] See page 135 for status codes.
[b] May be taken without a permit/license

Table 45. Partial list of birds known or likely to occur in the Yampa River Basin (3 of 3 pages)

Birds	Status[a]				Preferred habitat(s) and breeding status (B)
	US	CO	WY	UT	
Mountain bluebird	–	–	–	–	High mountain valleys, meadows, forest edges, rangelands higher than 5,000 feet (B); cleared forests and human-dominated areas
Townsend's solitaire	–	–	–	–	Woodlands (B)
Hermit thrush	–	–	–	–	Woodlands, forests and riparian habitats (B)
American robin	–	–	–	–	Urban/suburban areas; woodlands, scrublands, wetlands, fields (B)
Northern mockingbird	–	–	–	–	Open areas with scattered trees, farmlands, second growth areas, and residential neighborhoods, all at low elevation (B)
Sage thrasher	–	–	–	–	Greasewood, sagebrush communities in low elevation deserts (B)
Cedar waxwing	–	–	–	–	Nests in small trees (B)
Loggerhead shrike	–	–	–	–	Thick brush, shrubs, or small trees in open areas (B); grasslands, pastures, desert scrub habitats, open woodlands, other open areas
European starling	–	G	G[b]	G[b]	Urban areas, farmlands, other disturbed or non-native habitats (B)
Black-throated gray warbler	–	–	–		Dry oak chaparral, piñon-juniper, coniferous and open mixed woodlands with a brushy understory (B)
Blackpoll warbler					Forests, woodlands, and riparian areas (B)
Yellow warbler	–	–	–	–	Woodlands, scrublands, agricultural and riparian areas (B)
Common yellowthroat	–	–	–	P	Marshes, riparian areas, brushy pastures, fallow fields (B)
Wilson's warbler	–	–	–	–	Successional-scrub regions (B)
Western tanager	–	–	–	–	Woodlands, coniferous forests (B); parks, open areas, streamsides
Black-headed grosbeak	–	–	–	–	Open woodlands, forest edges (B); lowland valleys, mountains, submontane shrublands, riparian woodlands, aspen woodlands
Blue grosbeak	–	–	–	P/D	Successional-scrub regions (B); habitats with scattered trees, riparian woodlands, scrubland or woodland edges
Lazuli bunting	–	–	–	–	Successional-scrub regions (B); arid brushy canyons
Spotted towhee	–	–	–	–	Thickets, brush, and other areas of dense shrubby growth (B)
Chipping sparrow	–	–	–	–	Open forests, forest edges, and riparian habitats (B)
Brewer's sparrow	–	–	–	–	Successional-scrub regions (B)
Sage sparrow	–	–	–	–	Successional-scrub regions (B); grassland and desert habitats
Vesper sparrow	–	–	–	–	Dry grasslands and sagebrush
Bobolink	–	–	–	P/D	Grasslands (B); successional-scrub, wet meadows and irrigated agricultural areas (primarily pasture and hay fields)
Western meadowlark	–	–	–	–	Grasslands (B); cultivated fields, meadows, prairies, mountain meadows up to 12,000 feet elevation
Red-winged blackbird	–	–	N[b]	N[b]	Marshes (B); agricultural fields, brushy areas near water
Yellow-headed blackbird	–	–	N[b]	N[b]	Prairie wetlands, wet mountain meadows, lowland marshes (B)
Brewer's blackbird	–	–	N[b]	N[b]	Fields, agricultural lands, parks, and other open areas; nest in trees near water (B)
Common grackle	–	–	–	–	Open or semi-open habitats with scattered trees; urban/suburban areas, farms, orchards, and other human-modified habitats (B)
Brown-headed cowbird	–	–	N[b]	N[b]	Grasslands, fields, pastures, orchards, coniferous and deciduous woodlands, forest edges, brushy thickets, suburban areas (B)
Bullock's oriole	–	–	–	–	Open woodlands, brushy areas, riparian zones; nest in trees (B)
Scott's oriole	–	–	SC3	–	Successional-scrub regions (B)
Cassin's finch	–	–	–	–	Woodlands (B)
House finch	–	–	–	–	Urban areas (B); both native and human-altered habitats
Pine siskin	–	–	–	–	Woodland, coniferous forests (B)
American goldfinch	–	–	–	–	Successional-scrub regions (B)

[a] See page 135 for status codes.

[b] May be taken without a permit/license

(CDOW 2002a–c; Fertig and Beauvais 1999; Sauer et al. 2001; UDWR 2003a,b; WDGF 2003)

Table 46. Partial list of amphibians and reptiles known or likely to occur in the Yampa Basin

Amphibians	Status[a]				Preferred habitat(s)
	US	CO	WY	UT	
Boreal (western) toad	C,S	E	–	P	Moist/wet areas of foothills and mountains: subalpine meadows, aspen and spruce-fir forests, riparian habitats
Great Basin spadefoot toad	–	–	–	–	Variety of habitats, from sagebrush to spruce-fir forests
Woodhouse's toad	–	–	–	–	Variety of habitats, preferring areas with deep soft soils where burrowing is not difficult
Bullfrog	–	G	G[b]	–	Near water its entire life, dispersing only during wet weather
Northern leopard frog	S	SC	G[b]	–	Variety of water habitats near cattails and other aquatic vegetation; forages relatively far from water
Western chorus frog	–	–	–	–	Marshes, grasslands, agricultural lands, forests near water
Wood frog	S	–	–	–	Disjunct population; 8,000-10,000 feet in north-central Colorado and south-central Wyoming
Tiger salamander	–	G	G[b]	–	Variety of habitats near water
Reptiles					
Snapping turtle	–	G	G[b]	–	Aquatic areas
Western whiptail	–	–	–	–	Extreme western Colorado below 6,000 feet elevation
Plateau striped whiptail	–	–	–	–	Mountainous wooded areas, lower elev. riparian woodlands
Common sagebrush lizard	–	–	–	–	Sagebrush, piñon-juniper woodlands, open forests
Eastern collared lizard	–	–	–	–	Rocky areas with sparse vegetation
Greater short-horned lizard	–	–	–	–	Open areas in habitats from grasslands to high mountains
Northern plateau lizard (Eastern fence lizard)	–	–	G[b]	–	Great variety of habitat: plains, shrublands, farmlands, forests; crevices or underground during cold periods
Ornate tree lizard	–	–	–	–	Variety of habitats ranging from deserts to lower edges of the spruce-fir zone; prefers areas along rivers and streams
Side-blotched lizard	–	–	–	–	Semi-arid and arid areas with sandy or rocky soil containing scattered brush or trees
Common gartersnake	–	–	–	–	Moist areas
Terrestrial gartersnake	–	–	–	–	Variety of habitats, including aquatic
Eastern racer	–	–	–	–	Open areas in meadows, fields, woodlands
Gopher snake	–	–	–	–	Numerous habitats, from lowlands to high mountains
Western hognose snake	–	–	–	–	Below 6,000 feet elevation in eastern Colorado; recently found in Moffat County, Colorado
Milksnake	–	–	–	P	Variety of habitats
Nightsnake	–	–	–	–	Arid and semi-arid desert flats, plains, and woodlands; prefer areas with rocky and sandy soils
Smooth greensnake	–	–	–	P/D	Grassy areas and meadows; prefers moist areas
Striped whipsnake	–	–	–	–	Variety of habitats; found most often near streams
Midget faded rattlesnake	–	–	–	P/D	Primarily found on the ground, will occasionally climb into trees and shrubs; uses mammal burrows, crevices, or caves
Western (prairie) rattlesnake	–	G	G[b]	–	Prairies and deserts to open mountain forests; primarily a ground dweller, will occasionally climb trees and shrubs

[a] See page 135 for status codes.
[b] May be taken without a permit/license
(CDOW 2002a–c; Colorado Herpetological Society 2002; Fertig and Beauvais 1999; UDWR 2003a,b; WGFD 2003)

Fisheries

The Yampa River and its tributaries offer diverse aquatic habitats from cold, clear, high-gradient headwater streams with boulder and bedrock substrates, to warmer, slower-moving, sediment-laden lower reaches, characterized by sand, gravel and cobble substrates and deeply incised canyons. Transitional between these extremes the Yampa River is a meandering stream, alternating between topographically confined reaches and broader alluvial valleys with complex channels (braided channels, oxbows, backwaters and sloughs) lined with cottonwoods and willows and fringed by riparian wetlands, pasture, irrigated cropland (mostly hayfields) and undeveloped rangeland. Its highly variable flow regime also influences composition of fish fauna, especially in lower reaches where seasonally low flows and warmer temperatures limit the distribution of cold-water species, such as trout and whitefish.

Native Colorado River cutthroat trout (*Oncorhynchus clarki pleuriticus*) can be found in smaller, high-gradient headwater tributaries, whereas nonnative brown and rainbow trout fare better in mainstream habitats upstream from Hayden, Colorado. Occasionally, trout have been found downstream below Craig, but only during cooler seasons. Conversely, native warm-water species, such as Colorado pikeminnow, generally do not occur upstream from Craig, whereas other native species, such as flannelmouth and bluehead sucker, speckled dace and roundtail chub, can be found upstream in transitional reaches, as well. Humpback chub have more specialized habitat requirements, confining them to lower, canyon-bound reaches.

Lakes and reservoirs support sport fisheries for bass, northern pike and trout. Smallmouth bass and northern pike have established populations in the Yampa River, as well. Channel catfish also are locally abundant in the river. The section entitled Reduce Negative Impacts of Nonnative Fishes beginning on page 79 provides a detailed description of measures being taken to minimize the effects on native fishes due to predation and competition by nonnative fishes.

Table 47 lists fish species that occur in the Lower Yampa River Basin. Reaches of the Yampa and Little Snake rivers that have been surveyed are listed numerically on the right side of Table 45: (1) Yampa Canyon; (2) Lower Little Snake River; (3) Lily Park; (4) Sunbeam-Maybell; (5) Juniper Springs; and (6) Craig-Hayden (Carlson 1979; Hawkins et al. 2001; Nesler 1995). Native species are grouped separately from nonnative species. Species status codes include endangered (E), threatened (T), Colorado species of special concern (SC), Utah conservation species (CS), game (G) and nongame (N) fishes. Certain nongame species may be taken with a valid state fishing license, while other live, nongame fish may not be used (as bait) or possessed, as footnoted in Table 47 (CDOW 2002a–c; Fertig & Beauvais 1999; UDWR 2003a, b; WGFD 2003). A dash (–) indicates a species has no special Federal status or does not occur in that state or river reach.

Holden and Stahlnaker (1975a) collected 22 species of fish from the Yampa River. They found flannelmouth and bluehead suckers, speckled dace, roundtail chubs and redside shiners to be the most abundant, with the lower section exhibiting the greatest diversity. Rainbow, brown and cutthroat trout and mountain whitefish were found in lower Yampa Canyon primarily during fall, winter and early spring. Given that these species were not found in the upper canyon, they likely migrated upstream from the Green River during these cooler seasons. Largemouth bass, bluegill and walleye found in the lower canyon also were likely migrants from the Green River system. Rainbow and brown trout found at Juniper Springs and Craig were likely stocked fish (Holden and Stahlnaker 1975a). Holden and Stahlnaker (1975b) also found creek chub to be common in Yampa Canyon, while mottled sculpin rarely occurred there.

Table 47. Fishes known to occur in the Yampa River system

Native species	Species status [a]				Species occurrence by reach [a]					
	US	CO	WY	UT	1	2	3	4	5	6
Colorado River cutthroat	–	SC	G	CS	–	–	–	–	–	–
Mountain whitefish	–	G	G	G	☐	–	–	–	☐	☐
Utah chub	–	N [b]	N [c]	N	☐	–	–	–	–	–
Humpback chub	E	T	–	E	●	○	–	–	–	–
Bonytail	E	E	–	E	⊕	–	–	–	–	–
Roundtail chub	–	SC	N	T	☐	☐	☐	☐	☐	☐
Colorado pikeminnow	E	T	–	E	○,♂♀	○	○	○	○	○
Speckled dace	–	G	N [c]	N	☐	☐	☐	☐	☐	☐
Bluehead sucker	–	SC	N	P	☐	☐	☐	☐	☐	☐
Flannelmouth sucker	–	SC	N	P	☐	☐	☐	☐	☐	☐
Mountain sucker	–	SC	N	N	–	–	–	–	–	–
Razorback sucker	E	E	–	E	♂♀	–	–	–	–	–
Mottled sculpin	–	N [b]	N	N	☐	☐	–	–	–	☐
Nonnative species										
Rainbow trout	–	G	G	G	☐	–	–	–	☐	☐
Brown trout	–	G	G	G	☐	–	–	–	–	☐
Nonnative cutthroat	–	G	G	G	☐	–	–	–	–	–
Northern pike	–	G	G	G	☐	–	☐	☐	☐	☐
Common carp	–	N [b]	N [c]	N [b]	☐	☐	☐	☐	☐	☐
Creek chub	–	N [b]	N [c]	N	☐	☐	–	–	–	–
Fathead minnow	–	N [b]	N [c]	N	☐	☐	☐	☐	☐	–
Red shiner	–	N [b]	N [c]	N	–	☐	–	–	–	–
Redside shiner	–	N [b]	N [c]	N	☐	☐	☐	☐	☐	☐
Sand shiner	–	N [b]	N [c]	N	–	☐	–	–	–	–
White sucker	–	N [b]	N [c]	N	☐	☐	☐	☐	☐	☐
Black bullhead	–	G	G	G	☐	☐	☐	–	–	–
Channel catfish	–	G	G	G	☐	–	☐	☐	☐	–
Plains killifish	–	N [b]	N [c]	N	–	☐	–	–	–	–
Green sunfish	–	G	G	G	☐	–	☐	–	–	–
Bluegill	–	G	G	G	☐	–	–	–	–	–
Black crappie	–	G	G	G	–	–	–	–	☐	–
Smallmouth bass	–	G	G	G	☐	–	–	–	☐	☐
Largemouth bass	–	G	G	G	☐	–	–	–	–	–
Walleye	–	G	G	G	☐	–	–	–	–	–

[a] See text for status codes and reach definitions.
[b] Nongame species that may be taken with a license
[c] Use or possession of live bait fish prohibited in Little Snake River drainage of Wyoming
☐ One or more life stages present
● All life stages present
○ Adults and/or subadults present
⊕ Stocked 200mm fish
♂♀ Spawning

In their 1986–1989 survey of the Yampa and Green rivers in DNM, Karp and Tyus (1990) found flannelmouth and bluehead suckers to be abundant in all four reaches sampled (Yampa, Lodore, Whirlpool and Split Mountain canyons), while roundtail chub was more common in Yampa Canyon than elsewhere. Common carp and channel catfish were the most abundant nonnative species in all reaches but Lodore Canyon, where trout were most abundant. Also noteworthy was the presence, though rare, of northern pike in Yampa Canyon, not found in earlier collections.

Carlson (1979) found that the numbers of native suckers and chubs declined from downstream to upstream, whereas nonnative suckers increased. He also cited reports of several sucker hybrids—flannelmouth sucker × white sucker; bluehead sucker × white sucker; and flannelmouth sucker × razorback sucker—as well as speckled dace × redside shiner. Mountain whitefish and rainbow trout also were more abundant upstream from Craig, whereas channel catfish did not occur upstream from Maybell. Carlson (1979) found no smallmouth bass or northern pike in the Yampa River, although these species are known to be locally abundant in the river today (Nesler 1995).

Hawkins et al, (2001) found that 72% of the fish community in the Little Snake River consisted of native species, with flannelmouth sucker, bluehead sucker, roundtail chub and speckled dace most abundant. Species composition did not change significantly among seasons or sites they sampled. They also found that Colorado pikeminnow and humpback chub used the lower 10 miles of the Little Snake River in spring and early summer, when temperatures in the Little Snake River were warmer than those in the Yampa River; but they retreated back to the Yampa by August as flows began to wane and temperatures in the Yampa River were becoming warmer than those in the Little Snake River. The presence of humpback chub in June and July suggest that they may be spawning in the Little Snake River. However, larval *Gila* could not be identified to species, so Hawkins et al. (2001) were unable to confirm that humpback had spawned there.

Hawkins et al. (2001) speculated that native species dominated the fish community of the Little Snake River because of its extremely variable hydrograph and its associated physical and chemical characteristics, such as water temperature, water quality and sediment transport. In 1995, maximum peak flows were 165 times greater than the lowest base flows. Hawkins et al. (2001) suggest that such extreme variation is typical for the Little Snake River, regardless of the volume of runoff. All reaches were dewatered at the lowest flows, but was especially apparent in the sandy and braided middle reach. Under low-water conditions, scattered pools provide refugia in the lower and upper reaches; these pools are connected by surface flows too shallow to allow fish to move freely between them. Shallow, widely dispersed flows also produced larger diurnal temperature variations than observed in the Yampa River, which together with other physical factors may create conditions that initially attract humpback chub and Colorado pikeminnow to the Little Snake River in spring and later cause them to abandon the Little Snake in summer.

Threatened and endangered species

On September 11, 2000, the Fish and Wildlife Service provided a list of threatened and endangered species that potentially could be affected by the proposed action (Appendix I). Species include those which may occur in the Yampa Basin, the action area, as well as those which may occur within the floodplain of the Green River downstream from the Yampa River, outside the action area but potentially affected by the proposed action. Subsequent to the date of the original species list, three noteworthy events have occurred: On July 6, 1999 the bald eagle was proposed for delisting (64 FR 36454); on July 25, 2001, the yellow-billed cuckoo became a candidate for listing (66 FR 38611; USFWS 2001a); and on September 9, 2003, the proposal to list the mountain plover as threatened was withdrawn (68 FR 53083; USFWS 2003a).

Federal listed, proposed and candidate species

Common name	Scientific name	Status	Federal Reg.
Bald eagle	*Haliaeetus leucocephalus*	Threatened	32 FR 4001
Mexican spotted owl	*Strix occidentalis lucida*	Threatened	58 FR 14248
Southwestern willow flycatcher	*Empidonax traillii extimus*	Endangered	60 FR 10693
Mountain plover	*Charadrius montanus*	Withdrawn	68 FR 53083
Humpback chub	*Gila cypha*	Endangered	32 FR 4001
Bonytail	*Gila elegans*	Endangered	45 FR 27710
Colorado pikeminnow	*Ptychocheilus lucius*	Endangered	32 FR 4001
Razorback sucker	*Xyrauchen texanus*	Endangered	56 FR 54957
Black-footed ferret	*Mustela nigripes*	Endangered	32 FR 4001
Canada lynx	*Lynx canadensis*	Threatened	65 FR 16052
Ute ladies'-tresses orchid	*Spiranthes diluvialis*	Threatened	57 FR 2048
Yellow-billed cuckoo	*Coccyzus americanus*	Candidate	66 FR 38611
Boreal toad	*Bufo boreas boreas*	Candidate	60 FR 15281

Bald eagle (*Haliaeetus leucocephalus*)

On July 12, 1995, the Fish and Wildlife Service reclassified the bald eagle from endangered to threatened in 43 of the 48 conterminous states. It also remains threatened in Michigan, Minnesota, Wisconsin, Oregon, Washington, where it previously had been so classified (60 FR 36000). The bald eagle had been listed as endangered south of the 40th parallel on March 11, 1967 (32 FR 4001) under the Endangered Species Protection Act of 1966 (16 U.S.C. 668aa–668cc). On February 14, 1978, protection for the bald eagle was expanded to include the entire lower 48 states (43 FR 6233).

Following World War II, populations of the bald eagle were adversely impacted by the widespread use of organochlorine pesticides, such as DDT, that induced reproductive failure due to egg-shell thinning. On December 31, 1972, DDT was banned from use in the United States. Other potential threat factors include destruction or degradation of habitat, electrocution on powerlines, collisions with motor vehicles, poaching and poisoning. Poisoning may occur directly when bald eagles ingest poisoned bait intended for other animals, such as coyotes, or indirectly when they ingest prey contaminated with pesticides, lead shot, or other toxic substances (USFWS 1995a).

Bald eagles are closely tied to water throughout their life history. They rarely nest farther than 2 miles from water. Nests 6–9 feet in diameter and 3 feet thick typically are constructed in large, sturdy trees along shorelines in relatively remote areas; cliffs or rock outcrops may be selected for nest sites where suitable trees are not available. Prey consists predominantly of fish, waterfowl and small mammals. Carrion may be locally and/or seasonally important, particularly in winter. Winter communal roost sites typically consist of large trees in sheltered groves near open water. Their reliance on large trees close to water makes bald eagles particularly vulnerable to the effects of water-development projects (USFWS 1995a).

Bald eagles can be seen roosting in cottonwoods along the riparian corridor of the Yampa River in winter (Young 2000). Bald eagle nesting has been confirmed in southeastern Utah, western Colorado and south-central Wyoming (Sauer et al. 2001). In the Yampa River Basin, three pairs are known to nest along the Little Snake River, and two pairs have been documented nesting along the Yampa (Jerry Craig, pers. comm.).

Mexican spotted owl (*Strix occidentalis lucida*)

The Mexican spotted owl was listed as a threatened species throughout its entire range on March 16, 1993, without critical habitat (58 FR 14248; USFWS 1993). On February 1, 2001, critical habitat for this species was designated on 4.6 million acres of federal land (66 FR 8530; USFWS 2001b). However, there are no units of critical habitat in the Yampa River Basin. Records indicate that Mexican spotted owls may occur as far north as the Book Cliffs in northeastern Utah; however, the most significant extant population in Utah resides in the vicinity of Zion National Park. Few owls have been reported recently in Colorado, most of which were found in the San Juan Mountains in southwestern Colorado and along the Front Range in central Colorado as far north as the Denver area (USFWS 1993). In northwestern Colorado, the only known locality for Mexican spotted owls is in DNM, where one or two breeding pairs may nest (Jerry Craig, pers. comm.).

Southwestern willow flycatcher (*Empidonax traillii extimus*)

The Southwestern willow flycatcher was listed as endangered on February 27, 1995 (60 FR 10694) without critical habitat. This species breeds from southern California through Arizona to western New Mexico, southwestern Colorado and southern Utah, including the Lower Green River Basin (USFWS 1995b). Critical habitat was designated for this species on July 22, 1997 (62 FR 39129) in Arizona, California and New Mexico (USFWS 1997). However, no critical habitat was designated in Colorado, Utah or Wyoming. *E. t. extimus* is not known to breed or otherwise inhabit the Yampa River Basin. Another subspecies of willow flycatcher, *Empidonax traillii adastus*, found in the Yampa Basin breeds from western Colorado through the Great Basin to eastern California. However, this subspecies is not considered threatened or endangered (USFWS 1995b).

Humpback chub (*Gila cypha*)

See species description beginning on page 12 of the Management Plan.

Bonytail (*G. elegans*)

See species description beginning on page 14 of the Management Plan.

Colorado pikeminnow (formerly Colorado squawfish, *Ptychocheilus lucius*)

See species description beginning on page 15 of the Management Plan.

Razorback sucker (*Xyrauchen texanus*)

See species description beginning on page 16 of the Management Plan.

Black-footed ferret (*Mustela nigripes*)

The black-footed ferret was listed as endangered on March 11, 1967, without critical habitat (32 FR 4001). This slim-bodied member of the weasel family once ranged throughout the Great Plains, mountain basins and semi-arid grasslands of west-central North America from Mexico to Canada, inhabiting grasslands, steppe and shrub-steppe in association with prairie dogs, its principal prey. This secretive animal is rarely seen, except at night. It remains underground in prairie dog burrows during the day and in winter when it is less active (NatureServe Explorer 2002).

As a result of prairie dog and predator control programs the species has been extirpated from virtually all of its former range, including Canada. A remnant population was found near Meeteetse, Wyoming; however, this population succumbed to canine distemper, and remaining survivors were captured for propagation in captivity. Black-footed ferrets possibly have been extirpated from Colorado and New Mexico, as well as Texas, Nebraska and Montana, and are presumed to be extirpated from Oklahoma, Kansas, Alberta and Saskatchewan (NatureServe Explorer 2002). Recent reports of wild black-footed ferrets in Utah, Colorado and New Mexico are unconfirmed.

Captive-reared ferrets have been reintroduced to sites in Wyoming, South Dakota, Montana, and Arizona. Recently, to establish a nonessential experimental population of black-footed ferrets in northeastern Utah and northwestern Colorado, ferrets were reintroduced to the Coyote Basin in Utah and land managed by the Bureau of Land Management (BLM), north of Maybell (USFWS 1998).

Canada lynx (*Lynx canadensis*)

The Service listed the contiguous United States Distinct Population Segment (DPS) of the Canada lynx as threatened on March 24, 2000 (65 FR 16052). This DPS occurs in forested portions of 13 of the lower 48 states, including Colorado and Utah. It is considered part of a larger metapopulation, whose core is located in the northern boreal forests of central Canada. In the contiguous western states, the lynx is associated with the subalpine coniferous forest (USFWS 2000).

In 1999, the CDOW initiated a program to reintroduce Canada lynx in southwestern Colorado with lynx captured in Alaska and Canada. Since May 2002, the CDOW has tracked 63 of 129 lynx released in Colorado to date. Lynx are found mainly from New Mexico north to Gunnison, with a few lynx ranging north to the I-70 corridor. A few lynx are known to have dispersed north of I-70 (CDOW 2003a). However, no lynx are known to occur in the Yampa River Basin. Nevertheless, continued dispersal of this species could result in lynx re-inhabiting the action area.

Ute ladies'-tresses (*Spiranthes diluvialis*)

Spiranthes diluvialis was listed as a threatened species on January 17, 1992 (57 FR 2048). This perennial, terrestrial riparian orchid, can be identified by its cluster of 3–15 small white- or ivory-colored flowers in a spike atop the stem, 8–20 inches tall, that typically bloom from late July through August, occasionally through September (USFWS 1992). Long, narrow leaves near the base of the stem become progressively shorter going up the stem. Endemic to moist soils in mesic or wet meadows near springs, lakes or perennial streams, Ute ladies'-tresses is an early to intermediate successional species and depends largely on natural flood disturbance to maintain suitable habitat. Its continued survival is threatened by human modification of its riparian habitat (e.g., dams, flood control, urbanization, and stream channelization), as well as over-utilization by orchid collectors (USFWS 1992; Sipes 2002). Intentional introduction or invasion of exotic plant species and indiscriminate use of herbicides and/or other chemicals may adversely affect *S. diluvialis*. Excessive livestock grazing is believed to be detrimental; however, mild to moderate grazing may be beneficial (NatureServe Explorer 2002; USFWS 1992).

At the time of its listing as threatened in 1992, populations were known only from the Colorado Front Range; the Green River drainage in eastern Utah, including Brown's Park and Dinosaur National Monument (DNM); and in the eastern Great Basin in western Utah and adjacent Nevada (USFWS 1992). Since then, populations also have been discovered in Wyoming, Montana, Nebraska and Idaho. The Nevada population has not been relocated, and several historic populations in Colorado and Utah are presumed extirpated (NatureServe Explorer 2002). Although there are no known populations within the Yampa River Basin, the species does occur along the Green River in DNM downstream from the Yampa River.

Its low numbers and restricted habitat make the species vulnerable to natural or anthropogenic disturbances. Smaller, scattered populations, particularly those in DNM and Capitol Reef National Park, may not be large enough to ensure their long-term survival. Extinction of individual populations due to local catastrophic events (e.g., fires, floods) also is possible (USFWS 1992). However, the occurrence of numerous, geographically distinct, populations may provide some security for the species from such localized events.

Yellow-billed cuckoo (*Coccyzus americanus*)

On February 9, 1998, the Service received a petition from the Southwest Center for Biological Diversity on behalf of 22 groups to list the yellow-billed cuckoo as endangered with critical habitat. On July 25, 2001, the Service issued its 12-month finding, concluding that although the petitioned action is warranted, it is precluded by work on other species having higher priorities for listing (USFWS 2001b).

The yellow-billed cuckoo is a medium-sized bird, 12 inches long, weighing about 2 ounces. It is one of six species of the family Cuculidae that breed in the United States, only two of which — the yellow-billed cuckoo and greater roadrunner — breed west of the Continental Divide (USFWS 2001b). Historically, the species was widespread and locally common in California and Arizona; locally common in New Mexico, Oregon and Washington; uncommon in scattered drainages in western Colorado, western Wyoming, Idaho, Nevada and Utah; and probably uncommon and very local in British Columbia. Among the states west of the Rocky Mountains, Arizona probably has the largest remaining population (168 pairs and 80 single birds located in 1999). However, the population appears to be substantially less than previous estimates (846 pairs located in the lower

Colorado River and five major tributaries in 1976). Surveys by the NPS in southwest Colorado, from 1988 through 1995, located no yellow-billed cuckoos. Only one bird was found during a survey of 242 miles of riparian habitat along six rivers in west-central Colorado. In Utah, where the species was historically uncommon to rare, breeding was reported at Ouray National Wildlife Refuge, along the Green River, in 1992 and Matheson Wetland Preserve, near Moab, in 1994. The status and trends of this species in Wyoming are unknown (USFWS 2001b). The Colorado Breeding Bird Atlas (Kingery 1999) reported nesting in the Yampa River Basin in Routt County, east of Craig, Colorado. Andrew and Righter (1992) also reported sighting a non-resident cuckoo near Craig.

The species requires large tracts of riparian habitat for breeding, and habitat losses are believed to be largely responsible for its decline. Principal causes of habitat loss are conversion to agriculture and other uses, dams and flow management, channelization and livestock grazing (USFWS 2001b).

Boreal toad (*Bufo boreas boreas*)

On September 30, 1993, the Service received a petition from the Biodiversity Legal Foundation to list the western boreal toad as endangered with critical habitat. On March 23, 1995, the Service issued its 12-month finding, which concluded that although the petitioned action is warranted, it is precluded by work on other species having higher priorities for listing (USFWS 1995c).

Boreal toads were once common at higher elevations (7,500–12,000 feet) throughout Colorado and in the Sierra Madre, Medicine Bow and southern Laramie Mountains of eastern Wyoming. They were found in only three localities at the southern extent of their range in the San Juan Mountains of northern New Mexico. These three populations have since been extirpated. Boreal toads were absent from 83% of the sites in Colorado and Wyoming where they historically were found, although recent surveys found several previously undocumented locations. Most of the species' habitat is located on state and national forests, as well as other public lands administered by the BLM, NPS and USBR (USFWS 1995c). Within the Yampa River Basin, the most likely localities of boreal toad populations are in the vicinity of reservoirs, natural lakes, beaver ponds and wetlands at higher elevations along the eastern boundary of the Basin. Boreal toads are known to breed in the littoral zone along the margins of Steamboat Lake (CDOW 2002b).

Destruction or adverse modification of habitat may contribute to the continued decline of the species. However, local land management activities probably did not cause its range-wide decline. The species' decline was likely due to infection by the bacterium *Aeromonas hydrophila*, exacerbated by adverse environmental stressors, such as pollution, acid precipitation, or increased ultra-violet radiation. Native and nonnative competitors and predators probably have a minor impact (USFWS 1995c). Chytrid fungus, linked to the decline of amphibians in Australia and Central America , has been confirmed in a boreal toad population west of Denver (CDOW 2002b).

Because the southern Rocky Mountain population of boreal toads is geographically isolated from the population in western Wyoming and northeastern Utah, the southern Rocky Mountain population can be listed as a distinct vertebrate population segment (USFWS 1995c). The species is listed as endangered by the State of Colorado (CDOW 2002b) and is considered a Species of Special Concern by the State of Utah because the boreal toad "has experienced a substantial decrease in population, distribution and/or habitat availability" (UDWR 2003). The boreal toad is not listed by the State of Wyoming (Fertig and Beauvais 1999).

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Socioeconomic environment

Between 1970 and 2000, the human population in northwest Colorado grew 151%, with Routt County growing almost three-fold and Moffat County growing slightly more than two-fold during that period (Table 48, Figure 25). Between 2000 and 2020, this region is projected to grow another 40% (Yampa Valley Partners 2002). Patterns of population growth also are reflected in the composition of the workforce. Between 1970 and 2000, the number of jobs in the two counties grew more than four-fold (six-fold in Routt County). In 1970, the number jobs in agriculture, services, wholesale and retail trade, and government were roughly equal (18–22% of all jobs). Since then, however, the number of jobs in agriculture grew only 27%, while jobs in construction and services grew more than ten-fold and more than seven-fold, respectively (Table 49, Figure 26). Therefore, by 2000 Services accounted for 38% of all jobs, and agriculture had fallen to 7% of the job market (Figure 27). This shift can be attributed to the growth of the ski industry during this period and the correspondingly disproportionate growth in and around Steamboat Springs, Routt County.

Job growth in mining (three-fold) and transportation and utilities (four-fold) also is significant. Energy-related industries (electric power plants, coal mining, oil and gas production) also provide a substantial income to the Yampa Valley, especially Moffat County where they provide more than a third of the total income. Hayden Station and Craig Station, coal-fired thermo-electric generators, are the largest employers in the utilities sector in the Yampa Basin. Natural resource industries (utilities, coal, oil and gas) provide 69% of the tax revenue in Moffat County. Coal is the principal mineral mined in the Yampa Basin. Colowyo and Trapper coal mines in Moffat County south of Craig produce 25% of the total coal production in Colorado. Deserado Mine just south of Moffat County in Rio Blanco County also provides employment to Moffat County residents (Moffat County Department of Natural Resources 2001). Coal mines in Routt County include Twentymile Mine, south of Hayden, and several mines near Oak Creek.

With average annual wages of almost $61,000, mining produces far more income, per capita, than any other economic sector. Transportation and utilities rank second at almost $48,000 per annum. Services, by far, produce the greatest total annual income of any sector ($218M), while providing a modest per capita annual income of $22,000 compared with jobs in construction and government, which earn about $35,000 (Table 50).

Between 1992 and 1997, total value of agricultural products in Routt and Moffat counties declined 3% to $41.8M, while the value produced per acre of agricultural land rose 9% to $26.93 (Yampa Valley Partners 2002). Although only 7% of the workforce is employed in agriculture and related industries, preservation of the rural character and agrarian lifestyle in the Yampa Valley is considered a high priority (Yampa Valley Partners 2002).

Table 48. Human population in Routt and Moffat Counties, Colorado, 1970–2020

Year	Population			Change since 1970 (%)			10-year change (%)		
	Routt	Moffat	Total	Routt	Moffat	Total	Routt	Moffat	Total
1970	6,592	6,525	13,117	–	–	–	–	–	–
1980	13,404	13,133	26,537	103%	101%	102%	103%	101%	102%
1990	14,088	11,357	25,445	114%	74%	94%	5%	-14%	-4%
2000	19,690	13,184	32,874	199%	102%	151%	40%	16%	29%
2010	*24,645*	*14,565*	*39,210*	*274%*	*123%*	*199%*	*25%*	*10%*	*19%*
2020	*29,786*	*16,373*	*46,159*	*352%*	*151%*	*252%*	*21%*	*12%*	*18%*

Source: Colorado Department of Local Affairs (1970–2000 based on U.S. Census Data; 2010–2020 forecasts [*italics*] based on preliminary 2001 estimates)

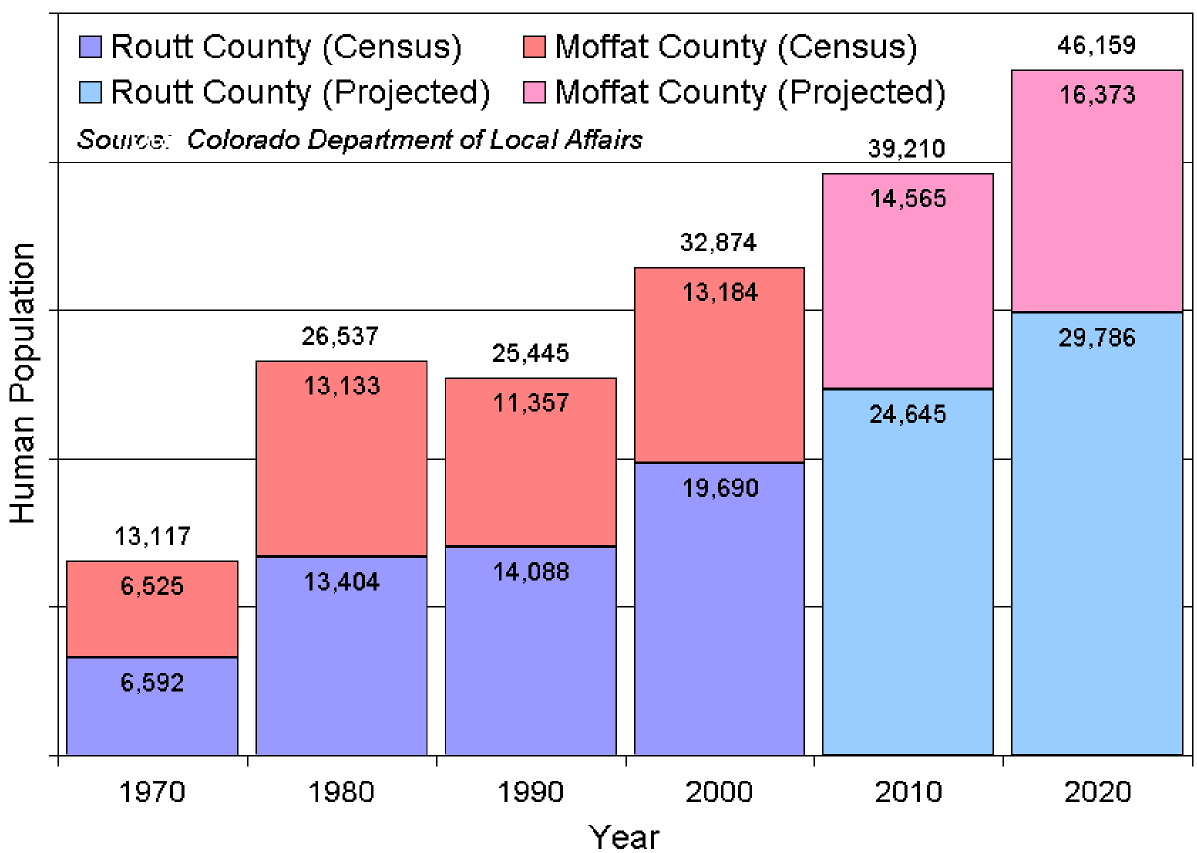


Figure 25. Human population in Routt and Moffat counties, Colorado, 1970–2000 (U.S. Census) and 2010–2020 (Colorado Department of Local Affairs forecast)

Table 49. Changes in workforce size and composition by sector in Routt and Moffat counties, Colorado, between 1970 and 2000

Sector	Number of jobs in 1970				Number of jobs in 2000				1970–2000	
	Routt	Moffat	Total	%Total	Routt	Moffat	Total	%Total	Δ jobs	Δ%
Agriculture	660	678	1,338	22%	925	776	1,701	7%	363	27%
Mining	123	216	339	6%	518	540	1,058	4%	719	212%
Manufacturing	53	103	156	3%	264	114	378	1%	222	142%
Transportation & Utilities	163	164	327	5%	799	526	1,325	5%	998	305%
Wholesale/retail trade	575	561	1,136	19%	3,782	1,593	5,375	21%	4,239	373%
Services	826	504	1,330	22%	7,671	2,182	9,853	38%	8,523	641%
Construction	185	151	336	6%	3,124	352	3,476	13%	3,140	935%
Government	550	539	1,089	18%	1,673	1,266	2,939	11%	1,850	170%
Totals	3,135	2,916	6,051	100%	18,756	7,349	26,105	100%	20,054	331%

Table 50. Labor income by sector in Routt and Moffat counties, Colorado, between 1970 and 2000

Sector	Income in 1970 ($M)				Income in 2000 ($M)				1970–2000	
	Routt	Moffat	Total	%Total	Routt	Moffat	Total	%Total	∆ $M	∆%
Agriculture	$10.55	$9.06	$19.61	13%	$1.49	$1.87	$3.36	0.5%	($16.25)	-83%
Mining	$10.74	$9.27	$20.01	13%	$32.01	$32.41	$64.42	9%	$44.41	222%
Manufacturing	$1.50	$2.46	$3.96	3%	$6.41	$2.25	$8.66	1%	$4.70	119%
Transportation & Utilities	$7.72	$9.93	$17.65	11%	$31.14	$32.18	$63.33	9%	$45.67	259%
Wholesale/retail trade	$13.76	$14.86	$28.61	19%	$78.39	$31.10	$109.49	16%	$80.87	283%
Services	$16.67	$9.13	$25.80	17%	$181.21	$36.75	$217.96	32%	$192.16	745%
Construction	$7.39	$4.22	$11.61	8%	$112.05	$8.56	$120.60	17%	$108.99	939%
Government	$14.50	$12.79	$27.29	18%	$55.02	$46.45	$101.47	15%	$74.18	272%
Totals	$82.83	$71.72	$154.55	100%	$497.71	$191.56	$689.27	100%	$534.72	346%

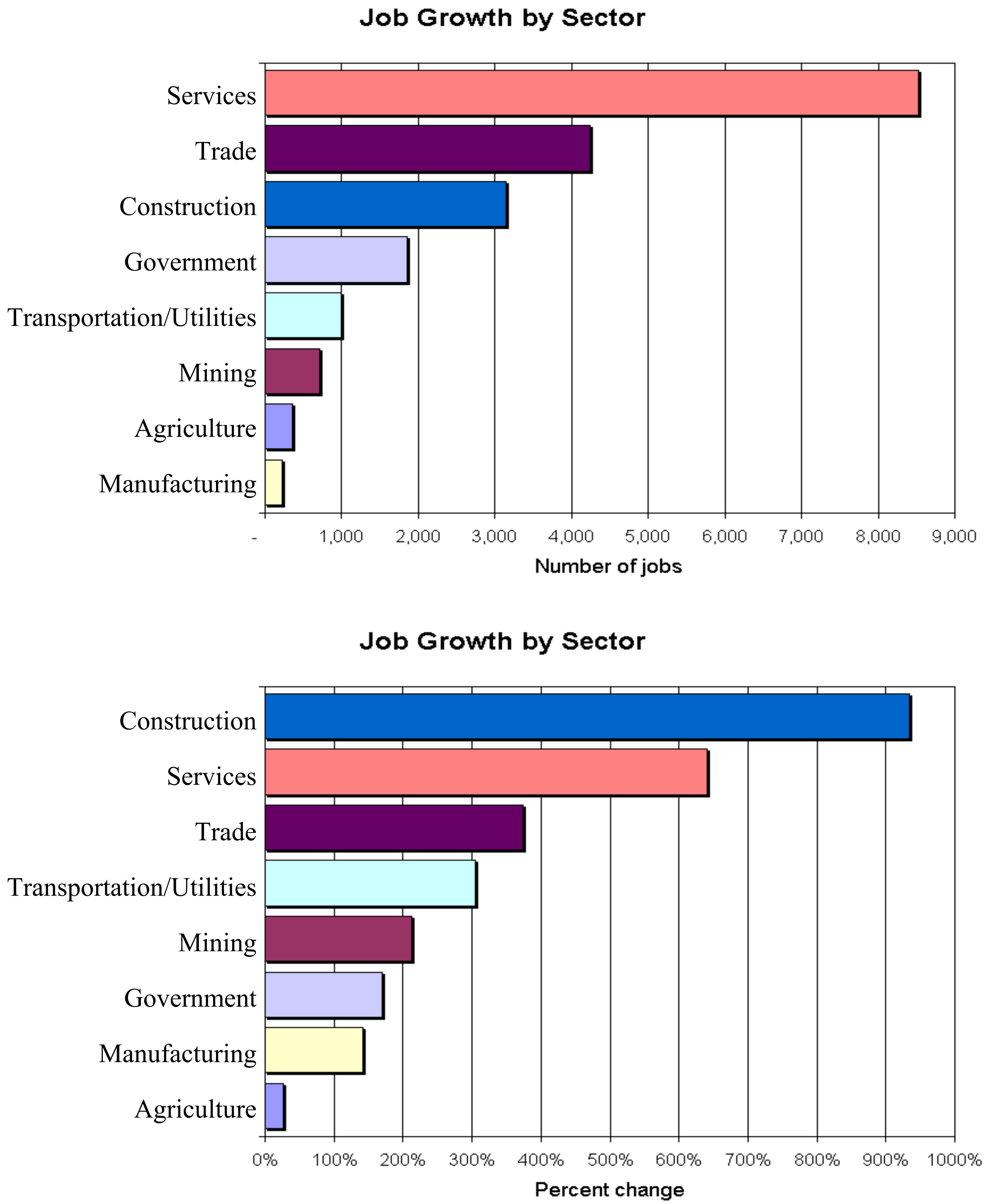
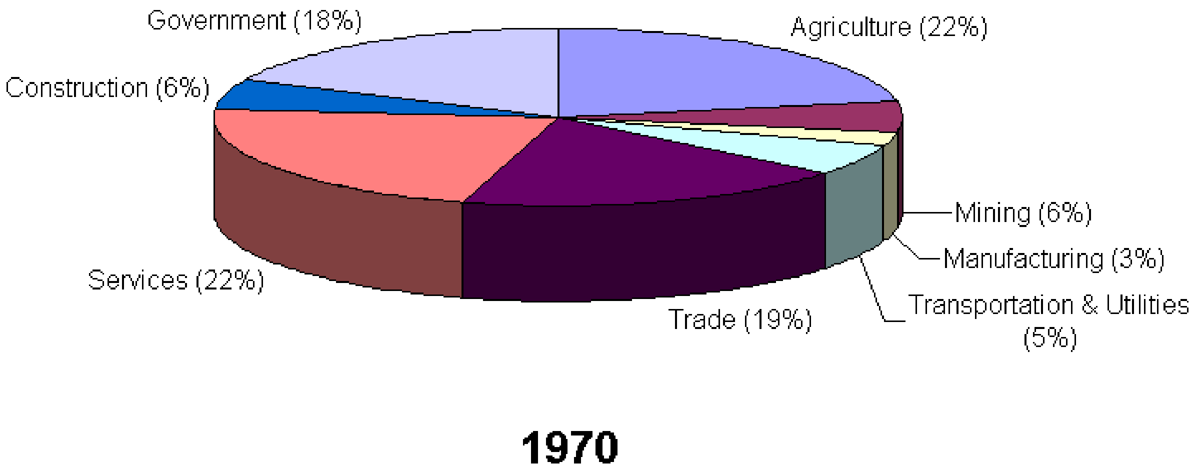


Figure 26. Increase in the number of jobs and percent change by economic sector in Routt and Moffat counties, Colorado, between 1970 and 2000



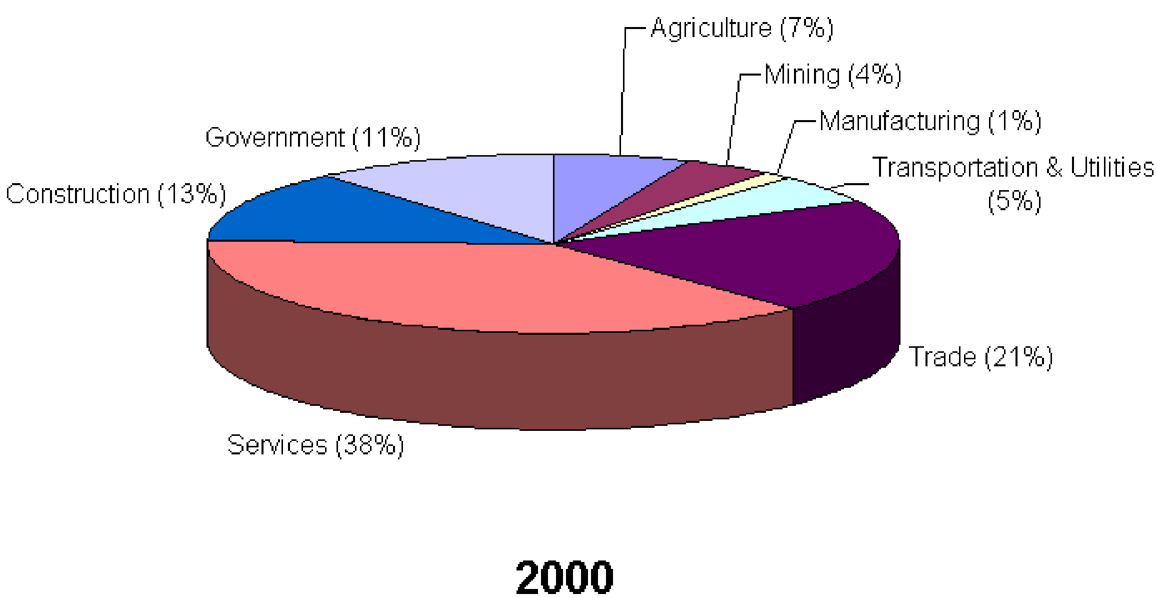


Figure 27. Change in employment by different economic sectors in Routt and Moffat counties, Colorado, between 1970 (6,051 jobs) and 2000 (26,105 jobs)

According to the Colorado Department of Agriculture, Agricultural Statistics Service (1997), 53% of lands in Moffat and Routt counties is under federal ownership, more than two-thirds of which is under the Bureau of Land Management (Table 51). State lands represent another 6% of the area, consisting largely of state parks, state wildlife areas, and lands held in trust by the State Land Board. The remaining 41% of the area includes mostly private lands, as well as public lands used for local government buildings, parks, schools, etc. Agriculture accounts for about 34% of total land use (82% of private lands) in the Yampa Basin. These do not include state and federal lands on which grazing leases are held. Between 1992 and 1997, total agricultural land and cropland both declined by 11%; however, during the same period, irrigated cropland increased 21% (Yampa Valley Partners 2002). Lands under irrigation (80,000 acres) represent less than 2% of the total land area or roughly 5% of the agricultural acreage.

Table 51. Land ownership and land use in Routt and Moffat counties, Colorado, 1997

Land ownership/land use	Land Area (acres)			%Total
	Routt Co.	Moffat Co.	Total	
Public lands (total)	740,243	1,931,216	2,671,458	58.7%
Federal lands (subtotal)	670,007	1,733,326	2,403,332	52.8%
Bureau of Land Management	84,958	1,527,188	1,612,146	35.4%
National Park Service [a]	–	152,613	152,613	3.4%
U.S. Forest Service	585,049	41,579	626,628	13.8%
U.S. Fish and Wildlife Service [b]	–	11,945	11,945	0.3%
State lands (subtotal)	70,236	197,890	268,126	5.9%
Other lands (total)	771,463	1,112,195	1,883,658	41.4%
Agricultural land (subtotal)	521,000	1,031,000	1,552,000	34.1%
Cropland (including pasture)	102,000	104,000	206,000	4.5%
Irrigated cropland	50,000	30,000	80,000	1.8%
Balance of agricultural land	419,000	927,000	1,346,000	29.5%
Balance of other lands (subtotal)	250,463	81,195	331,658	7.3%
GRAND TOTAL	1,511,706	3,043,410	4,555,116	100%

[a] Dinosaur National Monument, a significant portion of which is outside the Yampa Basin
[b] Brown's Park National Wildlife Refuge, all of which is outside the Yampa Basin
Source: Colorado Department of Agriculture, Colorado Agricultural Statistics Service (1997)

Livestock grazing (primarily cattle and sheep) and production of hay are the principal agricultural activities. Some wheat and barley also are produced (Table 52). In terms of value, livestock represents 85% of agricultural product sales, based on data from 1992 and 1997 (Yampa Valley Partners 2002).

Table 52. Agricultural production in the Yampa River Basin, 2001 [a]

	Colorado [b]								Wyoming [c]					
	Routt County			Moffat County			Totals		Carbon County			Sweetwater County		
Crop (units)	Acres	Prod.	Rank	Acres	Prod.	Rank	Acres	Prod.	Acres	Prod.	Rank	Acres	Prod.	Rank
Barley (bu)	1,000	25,000	12	300	7,500	18	1,300	32,500	NR	NR	18	NR	NR	12
Oats (bu)	–	–	–	600	23,000	21	600	23,000	NR	NR	19	NR	NR	11
Wheat, spring (bu)	1,500	32,000	12	900	15,000	17	2,400	47,000	–	–	–	–	–	–
Wheat, winter (bu)	5,700	115,000	25	12,600	222,000	21	18,300	337,000	NR	NR	8	–	–	–
Hay, alfalfa (tons)	12,500	12,100	40	25,500	33,400	29	38,000	45,500	5,000	10,000	–	12,000	18,000	–
Hay, other (tons)	36,000	56,000	3	22,000	39,500	21	58,000	95,500	82,000	96,000	–	9,000	10,000	–
All hay (tons)	48,500	68,100	–	47,500	72,900	–	96,000	141,000	87,000	106,000	6	21,000	28,000	20
All cattle & calves (head)[d]		25,000	25	–	27,000	24	–	52,000	–	90,000	4	–	18,000	22
All sheep & lambs (head)[d]		NR	NR	–	NR	NR	–	NR	–	13,000	9	–	10,000	11

[a] Wyoming counties include large areas outside the Yampa River Basin.
[b] Source: Colorado Agricultural Statistics 2002 (preliminary 2001 data, ranked among 63 Colorado counties); NR = not reported.
[c] Source: Wyoming Agricultural Statistics 2002 (preliminary 2001 data, ranked among 24 Wyoming counties); NR = not reported.
[d] January 1, 2002 inventory

Outdoor recreation is a significant leisure activity for the citizens of the Yampa Valley, as well as for visitors from outside the basin. Downhill skiing is the dominant form of recreation in terms of both visitor-days and revenue. Steamboat Springs ski resort draws about one million visitors each year from all over the world, roughly 9% of the annual skier visits in Colorado and almost 2% of the annual skier visits nationally (Yampa Valley Partners 2002).

On nearby Routt National Forest, ski touring, snowshoeing and snowmobiling are popular winter activities, as well. The National Forest also offers opportunities for hiking, camping, backpacking, mountain biking, horseback riding, wildlife viewing, photography, hunting, fishing and motorized travel (USFS 2003). Hunting and fishing on both public and private lands contribute significantly to the local economy, as well as to the custom and culture of the Yampa Valley. Guided hunting and fishing trips are enjoyed by people from outside the Yampa Valley, as well.

Annual visitation at Colorado State Parks (Steamboat Lake, Pearl Lake, Stagecoach Reservoir and Yampa River/Elkhead Reservoir) and Dinosaur National Monument (DNM) has hovered around a million people since 1993 (Yampa Valley Partners 2002). In addition to the activities previously mentioned, state parks also offer opportunities for water-based recreation, such as motor boating, water skiing, sailing, rafting, kayaking, and swimming. DNM provides challenging whitewater experiences, by permit, as well as opportunities for hiking, backpacking and motor touring. Much of DNM's backcountry is inaccessible except on foot or afloat.

ENVIRONMENTAL CONSEQUENCES

Hydrology and geomorphology

Eleven gages and one other location (below Elk River) were selected to represent a variety of river reaches (Table 53). Flows below the Elk River confluence were synthesized by adding Yampa River flows at Steamboat Springs to Elk River flows near Milner. The magnitude of depletions upstream from each gage was determined roughly in proportion to the area of its watershed within each Water District, weighted toward downstream reaches, because there typically is more arable land at lower elevations. These depletions were converted to average monthly flows in cfs, which were subtracted from current average monthly river flows to generate an estimate of future river flows. Each future monthly river flow was compared against its corresponding current monthly flow to determine the percentage reduction in flows. These changes were then color-coded as follows:

Increased	Reduced 0–2%	Reduced 2–5%
Reduced 5–10%	Reduced 10–20%	Reduced >20%

Depletions from the Yampa River and its tributaries in Colorado upstream from the Little Snake River are expected to increase as much as 30,000 AF/year by 2045. Depletions from the Little Snake River in Colorado and Wyoming are expected to increase up to 23,500 AF/year during the same period. These depletions represent roughly 2.6% of the current average annual yield of the Yampa River upstream from the Little Snake River and about 5.5% of the current average annual yield of the Little Snake River at Lily Park. The total expected increase in depletions represents almost 3.4% of the average annual yield at Deerlodge Park. However, because neither depletions nor flows are distributed evenly throughout the year, impacts would be proportionately greater during the post-runoff, base-flow period than during peak-flow periods (Table 53).

Generally, impacts of depletions are cumulative, with reductions in flow increasing downstream. Without augmentation, flow reductions upstream from the Elk River confluence would not be greater than 5% in any month. Conversely, reductions greater than 10% may occur frequently during base-flow months downstream from Craig, Colorado. Table 53 also includes estimated future flows with base-flow augmentation from each of three different sources: Stagecoach Reservoir, Steamboat Lake and Elkhead Reservoir. During certain months, reservoirs that store water during off-peak periods may further reduce base flows. Therefore, the Stagecoach alternative reduces flows in the Yampa River upstream from the Elk River confluence more than 10% during several base-flow months, whereas the Elkhead alternative results in reductions greater than 10% from Elkhead Creek under similar conditions. Moreover, augmentation would ameliorate the impacts of depletions only within those stream reaches downstream from the augmentation water source (e.g., releases from Stagecoach Reservoir would not influence Elk River flows). The higher the water source is located in the basin, the longer the reach that would potentially benefit from it. However, the benefits of augmentation are most apparent immediately downstream from each source and diminish as both native flows and depletions increase farther downstream (Table 53). With greater distances between the point of release and point of delivery, more water would likely be lost in transit. For this assessment, however, transit losses representing one-sixth (16.67%) of the total volume of water released were assessed from the point of release, regardless of the source.

Table 53. Impacts of depletions on stream flows without and with augmentation (page 1 of 2)

Gage/Location	Estimated future increase in average monthly depletions (AF) above gage/location											
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Yampa, abv. Stagecoach	138	118	104	130	119	138	118	116	124	181	149	118
Yampa, blw. Stagecoach	138	118	104	130	119	138	118	116	124	181	149	118
Yampa, Steamboat Spgs.	323	275	244	304	279	323	275	270	289	422	347	274
Elk River, Clark	46	39	35	43	40	46	39	39	41	60	50	39
Elk River, Milner	138	118	104	130	119	138	118	116	124	181	149	118
Yampa, blw. Elk River	461	393	348	434	398	461	393	385	413	603	496	392
Elkhead Creek	48	27	35	43	38	42	42	50	59	61	60	44
Yampa, Craig	1499	1215	1212	1288	1241	1402	1279	1410	1712	1990	1805	1548
Yampa, Maybell	1975	1481	1561	1715	1620	1824	1697	1909	2299	2596	2406	1992
Little Snake, Slater	0	0	0	0	0	0	0	0	0	0	0	0
Little Snake, Lily Park	1432	934	1013	1087	1013	1169	1224	2040	3291	3776	3301	2149
Yampa, Deerlodge Park	4023	2944	3139	3397	3207	3586	3511	4569	6246	7036	6368	4740

Gage/Location	Current average monthly stream flows (cfs) without augmentation											
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Yampa, abv. Stagecoach	52	53	44	42	43	63	113	122	115	101	74	52
Yampa, blw. Stagecoach	67	62	53	51	52	65	132	157	131	99	82	63
Yampa, Steamboat Spgs.	135	127	105	101	103	168	653	1723	1790	362	151	110
Elk River, Clark	82	68	63	57	56	71	282	1171	1369	458	131	83
Elk River, Milner	142	110	92	88	91	168	729	2093	2165	668	165	113
Yampa, blw. Elk River	277	237	197	189	194	336	1382	3816	3955	1030	316	223
Elkhead Creek	11	13	12	14	16	78	376	647	144	14	7	8
Yampa, Craig	321	305	239	234	290	777	2343	4836	3977	966	266	232
Yampa, Maybell	239	353	297	279	334	716	2597	6233	5477	1382	380	246
Little Snake, Slater	39	36	32	32	33	51	263	1077	932	159	39	29
Little Snake, Lily Park	115	122	99	92	124	380	1067	2559	1967	299	69	55
Yampa, Deerlodge Park	576	606	446	435	566	1463	3729	8246	6796	1591	497	375

Gage/Location	Predicted average monthly stream flows (cfs) in the future without augmentation											
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Yampa, abv. Stagecoach	50	51	42	40	41	61	111	120	113	98	71	50
Yampa, blw. Stagecoach	65	60	51	49	50	63	130	155	129	96	80	61
Yampa, Steamboat Spgs.	130	122	101	96	98	163	648	1718	1785	355	145	105
Elk River, Clark	81	67	62	56	55	69	281	1170	1368	456	129	82
Elk River, Milner	140	108	90	86	89	166	727	2091	2163	665	163	111
Yampa, blw. Elk River	270	230	191	182	188	328	1375	3808	3947	1020	308	217
Elkhead Creek	10	13	11	13	15	77	375	646	143	13	6	7
Yampa, Craig	297	283	219	212	270	754	2322	4812	3949	933	236	207
Yampa, Maybell	207	326	272	250	308	685	2568	6202	5439	1339	340	214
Little Snake, Slater	39	36	32	32	33	51	263	1077	932	159	39	29
Little Snake, Lily Park	83	93	72	62	96	348	1038	2526	1930	258	29	22
Yampa, Deerlodge Park	509	549	391	373	509	1397	3669	8180	6714	1503	413	307

Key to color coding: (Percent reduction)

0–2%	2–5%	5–10%	10–20%
>20%	Increased	0–2% during runoff months	

Table 53. Impacts of depletions on stream flows without and with augmentation (page 2 of 2)

Gage/Location	Predicted future average monthly stream flows (cfs) augmented from Stagecoach Res.											
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Yampa, abv. Stagecoach	50	51	42	40	41	61	111	120	113	98	71	50
Yampa, blw. Stagecoach	66	58	51	49	48	58	127	153	129	97	84	68
Yampa, Steamboat Spgs.	131	120	100	96	96	158	646	1716	1785	356	150	113
Elk River, Clark	81	67	62	56	55	69	281	1170	1368	456	129	82
Elk River, Milner	140	108	90	86	89	166	727	2091	2163	665	163	111
Yampa, blw. Elk River	271	228	191	182	185	323	1372	3808	3947	1022	312	224
Elkhead Creek	10	13	11	13	15	77	375	646	143	13	6	7
Yampa, Craig	298	282	219	212	267	748	2320	4812	3949	935	240	214
Yampa, Maybell	208	325	271	250	305	680	2566	6202	5439	1341	344	221
Little Snake, Slater	39	36	32	32	33	51	263	1077	932	159	39	29
Little Snake, Lily Park	83	93	72	62	96	348	1038	2526	1930	258	29	22
Yampa, Deerlodge Park	510	547	390	373	507	1393	3666	8180	6714	1505	417	314

Gage/Location	Predicted future average monthly stream flows (cfs) augmented from Steamboat Lake											
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Yampa, abv. Stagecoach	50	51	42	40	41	61	111	120	113	98	71	50
Yampa, blw. Stagecoach	65	60	51	49	50	63	130	155	129	96	80	61
Yampa, Steamboat Spgs.	130	122	101	96	98	163	648	1718	1785	355	145	105
Elk River, Clark	82	68	63	57	55	69	279	1155	1366	457	134	89
Elk River, Milner	141	109	91	87	90	165	725	2076	2163	666	167	119
Yampa, blw. Elk River	271	231	192	183	188	328	1374	3793	3947	1022	312	224
Elkhead Creek	10	13	11	13	15	77	375	646	143	13	6	7
Yampa, Craig	298	284	220	213	270	753	2320	4797	3949	935	240	214
Yampa, Maybell	208	328	273	251	308	685	2568	6189	5439	1341	344	221
Little Snake, Slater	39	36	32	32	33	51	263	1077	932	159	39	29
Little Snake, Lily Park	83	93	72	62	96	348	1038	2526	1930	258	29	22
Yampa, Deerlodge Park	510	550	392	374	510	1397	3669	8164	6714	1505	417	314

Gage/Location	Predicted future average monthly stream flows (cfs) augmented from Elkhead Reservoir											
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Yampa, abv. Stagecoach	50	51	42	40	41	61	111	120	113	98	71	50
Yampa, blw. Stagecoach	65	60	51	49	50	63	130	155	129	96	80	61
Yampa, Steamboat Spgs.	130	122	101	96	98	163	648	1718	1785	355	145	105
Elk River, Clark	81	67	62	56	55	69	281	1170	1368	456	129	82
Elk River, Milner	140	108	90	86	89	166	727	2091	2163	665	163	111
Yampa, blw. Elk River	270	230	191	182	188	328	1375	3808	3947	1020	308	217
Elkhead Creek	11	13	10	12	12	72	371	646	143	14	11	15
Yampa, Craig	298	284	218	211	267	748	2317	4812	3949	935	240	214
Yampa, Maybell	208	327	271	249	305	680	2566	6202	5439	1341	344	221
Little Snake, Slater	39	36	32	32	33	51	263	1077	932	159	39	29
Little Snake, Lily Park	83	93	72	62	96	348	1038	2526	1930	258	29	22
Yampa, Deerlodge Park	510	549	390	371	507	1393	3666	8180	6714	1505	417	314

Key to color coding: (Percent reduction)

- White: 0–2%
- Yellow: 2–5%
- Light orange: 5–10%
- Orange: 10–20%
- Dark orange: >20%
- Green: Increased
- Gray: 0–2% during runoff months

Based on computer simulations of projected future depletions of water for human use, as well as reservoir storage to serve human needs and base-flow augmentation, average peak flows will be reduced less than 2% at Maybell and at Deerlodge Park relative to historic peak flows. Average peak-flow reductions are somewhat greater (2±%) in the Little Snake River at Lily Park than in the Yampa River mainstem, because the Little Snake provides only 28% of the average annual yield of the Yampa and, therefore, depletions from the Little Snake are proportionately larger. Under the driest hydrologic conditions modeled, future depletions would reduce peak flows more relative to peak flows under historic demand conditions (~14% and ~8% at Lily Park and Deerlodge Park, respectively) than under average or wetter hydrologic conditions, although absolute reductions in peak flows would be smaller under the driest conditions. However, these computer simulations indicate that reductions would not be significant in terms of the ability of peak flows to deliver and remove sediment from the Yampa River, particularly to and through Yampa Canyon (Appendix G).

A dependable, firm augmentation water supply would provide flow augmentation from mid-summer through late winter to emulate historic base-flow conditions in all but the driest years, when it would partially satisfy the deficits of stream flow targets in their historical context. The proposed augmentation strategy will satisfy the flow recommendations for minimum base flows developed by the Fish and Wildlife Service. Specific peak-flow recommendations have not been developed, but it appears that implementation of this management plan would result in only minimum impacts to peak flows (Table 28).

However, none of the augmentation scenarios would benefit the Little Snake River, which would experience the largest flow percentage reductions during the base-flow period. Flow reductions in the Little Snake River at Lily Park may exceed 50% in August and September, while flows from October through February may be reduced by 23–33%. The magnitude of these reductions is due to the extremely low base flows typical of the Little Snake River under current conditions. Currently, average monthly base flows in the Little Snake at Lily Park range from 55 cfs in September to 124 cfs in February. However, there have been occasional, protracted periods of little or no surface water flow at Lily Park in the past, although subsurface alluvial flow may play a role in freshening remnant pools that provide refugia for native fishes under such dry conditions.

Less than 20% of current depletions from the Little Snake River occur downstream from the Town of Baggs, Wyoming, and almost 80% of new depletions in Wyoming are expected to occur upstream from Baggs. Therefore, future depletions likely will follow roughly the same distribution as that observed currently. However, their effects will likely be felt throughout much of the reach downstream from Baggs. Depletions are not expected to increase in Colorado Water District 54. Therefore, no impacts on Little Snake River flows near Slater, Colorado, are expected (Table 53).

Water quality

As observed by Wentz and Steele (1980), reductions in base flows alone will not necessarily result in higher levels of specific conductance (Figure 24). However, increasing discharges of municipal wastewater and urban runoff due to projected human population growth in the Yampa Valley, decreasing stream flows due to projected future depletions of water, or a combination of both factors could impact water quality. In its *Yampa Valley Water Demand Study*, BBC (1998) projected resident human populations of 40,200–49,500 in Routt County and to 22,300–27,500 in Moffat County by 2045 under moderate-growth and high-growth scenarios. These projections represent increases over the 2000 census of 104–151% in Routt County, 69–108% in Moffat County, and 90–134% overall (Table 54).

Table 54. Estimation of potential future wastewater load under alternative growth scenarios

	Routt County			Moffat County			Totals		
	2000 [a]	2045 [b]		2000 [a]	2045 [b]		2000 [a]	2045 [b]	
		Low	High		Low	High		Low	High
Population	19,690	40,200	49,500	13,194	22,300	27,500	32,884	62,500	77,000
Per capita gpd [c]	156	136	136	76	66	66	124	111	111
Discharge (mgd)	3.07	5.46	6.72	1.00	1.47	1.82	4.07	6.93	8.54

[a] 2000 census data
[b] 2045 population estimates taken from *Yampa Valley Water Demand Study* (BBC 1998)
[c] Gallons per day derived from Table 41 (2045 reduced 13% for water conservation measures)

Because most of the growth is expected to occur in Steamboat Springs and Craig, wastewater loads for these two municipalities should increase proportionately, assuming that growth in resident populations is proportional to growth in non-resident populations (i.e., seasonal residents and visitors). However, if growth in resident populations exceeds growth in non-resident populations, per capita wastewater output would decline, producing lower-than-projected total wastewater loads.

Moreover, water conservation measures for residential and commercial toilets, showers and faucets, mandated by the National Energy Policy Act of 1992, are expected to further reduce both municipal water consumption and wastewater loads. Colorado's Statewide Water Supply Initiative estimates that implementing these water conservation measures will reduce overall municipal water demand 6% by the year 2030. BBC (1998) estimated that 70% of residential water use is non-consumptive (i.e., returns to the river as municipal wastewater). For this analysis, we reduced overall municipal water demand 9% by linearly extrapolating the estimated 2000–2030 reduction through 2045, and divided 9% by 0.7 to estimate the reduction in the non-consumptive portion of overall water demand (i.e., wastewater load). This produced an estimated reduction in 2000 per capita wastewater loads of about 13% by 2045. Nevertheless, because of the projected increases in human populations, by 2045 wastewater output can be expected to increase 78–119% in Routt County and 47–82% in Moffat County (Table 54), with most of that growth likely to occur in Steamboat Springs and Craig.

Point sources of pollution are relatively easy to identify, monitor and control, whereas specific nonpoint sources are not as readily identified and, therefore, are more difficult to monitor or control. Nonpoint sources include surface runoff from mine tailings, paved surfaces and disturbed areas, as well as groundwater contaminated by leaking or inadequate septic systems or irrigation return flows. Nonpoint-source constituents most commonly found in the Yampa Basin include sediment, salinity, nutrients, bacteria and heavy metals. Urban areas can contribute all of these constituents, whereas undeveloped land typically contributes only sediment. Nonpoint-source pollution would likely increase if land were further disturbed by agricultural activities or urban development. Land development for agricultural, residential, commercial or industrial purposes potentially can have significant cumulative impacts on water quality. However, "best management practices" or BMPs have been in common usage in both agricultural and urban areas to control erosion and reduce water pollution. Similar techniques have been applied to mining operations to reduce leaching and erosion of tailings and to silviculture and road construction to control erosion. Continued application of BMPs should serve to mitigate these impacts. These pollution abatement techniques must be site-specific basis to adjust to different soils, geology and topography, and to the nature and extent of the disturbance (Montgomery Watson Harza 2002).

No significant changes in agricultural practices are expected. Irrigated agriculture is not expected to experience significant growth in the foreseeable future, at least in terms of new depletions. However, if irrigation practices were modified, such as by converting from predominantly flood irrigation to sprinkler irrigation, both depletions and return flows from agriculture could be reduced. As a result, levels of fertilizers, pesticides and soil salts entering the river potentially could decline, as less leaching of soil contaminants occurs under sprinkler irrigation than under flood irrigation. Nevertheless, water conserved by modifying irrigation practices could be used to irrigate additional lands that previously had not been irrigated. Moreover, sprinklers could irrigate certain lands that are unsuitable for flood-irrigation due to elevation or topography. Irrigation of lands previously undeveloped, fallow, or cultivated with dry crops initially could increase the rate at which salts and other contaminants are leached from soils. However, because of the historic widespread use of flood irrigation, most of the acreage currently under irrigation is found on floodplain terraces in close proximity to the river. If new lands were brought under sprinkler irrigation, they could be, and likely would be, more distant from the river, thereby attenuating the impacts of contaminants in return flows. Moreover, higher efficiencies of sprinkler irrigation systems would minimize the volumes of new return flows. Therefore, TDS levels may decline or remain relatively unchanged overall or increase locally only where new lands are brought under irrigation.

In addition, hydrologic modifications, such as reservoir storage, reservoir releases, and water diversions, can impact water quality. Water quality impacts directly related to such hydrologic modifications include changes in nutrient concentrations, dissolved oxygen, temperature and turbidity (Montgomery Watson Harza 2002). Reductions in flow also can exacerbate the effects of other point sources and nonpoint sources of pollution. The latter effects would be most pronounced during periods of low stream flow.

Average Yampa River base flows are expected to decline 2–5% at Steamboat and 5–10% at Craig by 2045. Although these reductions are not significant, water quality could deteriorate because of higher wastewater loads combined with lower base flows. However, the human population in the Yampa River Basin is expected to grow 90–134% by 2045, whether or not this management plan is implemented. In addition, municipal wastewater treatment facilities would need to be upgraded or expanded to handle the additional wastewater loads. To continue to comply with ambient water quality standards, Colorado may require these modified facilities to treat their effluent to a higher standard under the terms of any new or amended National Pollutant Discharge Elimination System (NPDES) permits for these facilities.

Moreover, the stream-flow augmentation proposal in this plan would mitigate water quality impacts to base flows downstream from Craig. Releases from Elkhead Reservoir would have higher water quality than concurrent inflows from Elkhead Creek, because water released from the reservoir would be characteristic of the higher-quality spring flows that filled the reservoir (Kuhn et al. 2003). Of the three structural augmentation sources, only Stagecoach Reservoir could mitigate impacts immediately downstream from the Steamboat Springs wastewater outfall. Non-structural measures, such as water conservation, supply-interruption contracts, and instream flow water rights, would be progressive — meaning they would likely produce an incremental increase in stream flows from upstream to downstream reaches, thereby providing a proportionately smaller benefit to upper reaches than to lower reaches.

Air quality

Growth in the human population and concomitant increases in vehicular traffic and smoke from furnaces and fireplaces may degrade air quality. Fugitive dust from building and road construction also can be expected to increase in response to residential population growth and commercial and industrial development. Fugitive dust from surface coal mining and aggregate mining also could increase, if these activities are expanded in the future. Increased tourism could exacerbate air quality degradation due to higher volumes of vehicular traffic producing emissions exhaust gases and dust from winter highway sanding. However, improvements in vehicle emissions, seasonal restrictions on wood-burning, and implementation of palliative dust-control measures could mitigate these effects. Moreover, these effects would be expected with or without the proposed action.

The largest increase in depletions in the Yampa River Basin during the next 40+ years is expected to occur in the industrial sector, specifically thermo-electric power generation. Additional units at the coal-fired Craig and Hayden stations could increase airborne emissions from these point sources. However, installation of emission controls and rigorous enforcement of the NAAQS for PM-10, SO_2 and NO_x at these facilities could reduce or prevent any significant deterioration of air quality due to power plant emissions.

Vegetation

Impacts to vegetation could result from the proposed reservoir enlargement, as well as from potential changes in the hydrologic regime due to reductions in peak-flow frequencies, magnitudes and/or durations. Hydrologic data (Appendix G) suggest that the latter impacts will be relatively minor compared to historic conditions. Acreage under irrigation is not expected to increase in the foreseeable future. Therefore, losses of wetland habitats due to their conversion to agricultural uses is not expected to be significant. However, adoption of more efficient irrigation practices locally could reduce return flows, some of which nourish existing wetlands and riparian habitats.

Impacts to upland vegetation would be restricted to the dam construction area and footprint of an the enlarged Elkhead Reservoir pool. Native vegetation within the upland portion of the project area is dominated by Wyoming big sagebrush (*Artemisia wyomingensis*), needle-and-thread grass, Indian ricegrass, antelope bitterbrush (*Purshia tridentata*) and mountain snowberry (*Symphoricarpus oreophilus*). No other impacts to upland vegetation are expected from this or other management elements described in this document (USACE 2004).

Roughly 57 acres of palustrine emergent and scrub-shrub wetlands occur within the Elkhead project area. These wetlands are dominated by Baltic rush (*Juncus balticus*), broad-leaf cattail (*Typha latifoli*), coyote willow and small-winged sedge (*Carex microptera*), with intrusions or local populations of small-fruit bulrush (*Scirpus microcarpus*), bluejoint reedgrass, beaked sedge (*Carex rostrata*), Nebraska sedge (*Carex nebrascensis*) and other wetland species in smaller amounts. The project would fill or inundate approximately 37 acres of wetlands that currently exist at the margins and delta of the existing reservoir, at the base of the existing dam embankment, and adjacent to the existing County Road 29 embankment (USACE 2004; see Appendix J: Figures 4 and 5).

The CRWCD provided the Corps with a wetland mitigation plan to mitigate unavoidable impacts. Four separate mitigation sites covering 42 acres (Appendix J: Figure 6) have been proposed:

1. Place cross-channel sheet-pile check dams on Elkhead Creek above the new elevation of the operational pool to collect sediment and accelerate development of a new delta; native plant materials present in the area are expected to revegetate the site naturally (Appendix J: Figures 6a and 6b);

2. Excavate and place salvaged hydric soils from Brown Gulch on an island created by the new operational pool elevation; native plant materials present in the salvaged soils are expected to revegetate the site naturally (Appendix J: Figure 6c);

3. Create wetlands at the new mouth of Brown Gulch by berming and backfilling with salvaged hydric soils; native plant materials present in the salvaged soils are expected to revegetate the site naturally (Appendix J: Figure 6d);

4. Placing hydric soils salvaged on-site in Mud Gulch; native plant materials present in the salvaged soils are expected to revegetate the site naturally (Appendix J: Figure 6e).

The CRWCD proposes to monitor the mitigation sites and collect data regarding the presence of hydric soils, hydrophytic vegetation and hydrologic conditions. Prior to the Corps issuing a Clean Water Act § 404 permit for the project, the Corps will require the CRWCD to provide site-specific mitigation and monitoring plans (USACE 2004).

The Corps will prepare a separate NEPA document for the proposed 12,000-AF enlargement of Elkhead Reservoir. This document also will describe in greater detail the site-specific impacts of the project, alternatives to the proposed action, and proposed mitigation to address these impacts.

Changes in cover and species composition of riparian vegetation have been reported in response to stream-flow regulation. The research of Fisher et al. (1983) was intended to predict the potential effects to riparian vegetation along the Yampa River due to flow regulation by a large mainstem dam and reservoir. Their approach was to study analogous river systems, specifically the Green River downstream from Flaming Gorge Dam, and the response of these systems to flow regulation in order to predict changes in vegetation likely to occur within the Yampa River riparian corridor under similar circumstances. However, Lodore and Whirlpool canyons on the Green River differ from one another and from Yampa Canyon in terms of their geology, orientation, width, depth, sinuosity and gradient. These physical characteristics, in turn, can affect local microclimates (e.g., temperature, humidity, wind, and insolation), substrates (e.g., nature and size of sediment deposits), flow velocity, water chemistry and other habitat variables that influence how riparian vegetation responds to anthropogenic changes in the flow regime (Fisher et al. 1983).

The two principal hydrologic consequences of flow regulation by dams are attenuation of peak flows (i.e., reduction in mean flow maxima) due to water storage in reservoirs on the peak of the annual hydrograph, and an increase in mean flow minima during the base-flow period due to releases of water from storage. Another consequence is the loss of sediment from the system due to its entrapment within reservoir impoundments. Loss of sediment, in turn, can reduce turbidity, and increase water clarity and light penetration which, combined with reduced frequency, magnitude and duration of scouring flows, can promote growth of algae and submergent, vascular vegetation (Fisher et al. 1983).

Downward migration of both riparian and upland plant species is one consequence of significant, long-term reductions in peak flows, as evident from the encroachment of boxelder, juniper and rabbitbrush into the pre-dam floodzone of the Green River downstream from Flaming Gorge Dam. The Yampa would likely exhibit a similar response under comparable hydrologic conditions. Along the shoreline of the Colorado River downstream from Glen Canyon Dam, tamarisk was the principal post-dam invader. However, after initially invading the Green River below Flaming Gorge Dam, tamarisk stands do not appear to be expanding; in fact, in Lodore Canyon, Fisher et al. (1983) found that most tamarisk, though nearly 20 years old, were small and decadent. Tamarisk were more vigorous along the Green River just above its confluence with the Yampa River, where the stream gradient is not as steep (Fisher et al. 1983).

Another effect of reducing mean flow maxima is the decline or loss of sexual (i.e., seedling) reproduction and recruitment by large woody riparian species, such as boxelder and cottonwood. Inundation of upper floodplain terraces helps prepare a seedbed for these tree species. Floods of equal or greater magnitude are so infrequent that these terraces are relatively invulnerable to subsequent scouring floods, allowing seedlings to become established before the next major flood. Riparian tree populations on upper floodplain terraces may decline, in part, if seedling reproduction is reduced due to attenuated peak flows downstream from dams. When seedling production and recruitment is insufficient to replace old, decadent stands of woody vegetation, these stands will decline. Along the Green River between Flaming Gorge Dam and the Yampa River confluence, Fisher et al. (1983) observed that boxelder was the only woody riparian species of which they found seedlings. Below the Yampa, cottonwood and tamarisk seedlings were limited to the floodzone area periodically inundated by unregulated inflows from the Yampa.

There are few cottonwoods of intermediate age-classes along the Yampa River, which Fisher et al. (1983) attribute to the infrequency of high flood flows. Loss of high flows, effectively could eliminate what little age-class diversity exists along the Yampa and encourage the downward migration of upland species such as skunkbush, sagebrush and Mormon tea into the floodzone. Vegetative propagation of herbaceous plants, such as sedges, reeds, horsetails, licorice and dogbane also can result if the frequency of high-water years is reduced. Perennial grasses, in addition to these species, were the principal invaders of the Green River shoreline in Lodore Canyon following construction of Flaming Gorge Dam (Fisher et al. 1983).

Although the proposed action does not include any new, large, mainstem reservoirs on the Yampa River as envisioned by Fisher et al. (1983), their findings and conclusions have some relevance to current and foreseeable future hydrologic conditions on the Yampa River. Under the proposed action, future depletions are expected to reduce Yampa River mean flow maxima by 1.3% at Maybell and 4.4% at Deerlodge Park relative to historic (baseline) conditions. Mean flow maxima would be reduced 10% on the Little Snake River at Lily Park and 2.7% on the Green River at Jensen compared to historic conditions. Under extremely wet hydrologic conditions (≤10% exceedance), percentages of peak-flow reductions would be significantly less (0.5%, 6.7%, 2.4%, and 1.6% at Maybell, Lily Park, Deerlodge Park and Jensen, respectively) than during the driest conditions (1.3%, 14.2%, 7.6%, and 4.0% at Maybell, Lily Park, Deerlodge Park and Jensen, respectively). Floodplain terraces are inundated most often during these wetter conditions; therefore, these relatively infrequent events, rather than average conditions, play the most critical role in ensuring successful reproduction and recruitment of woody riparian species.

By comparison, since 1963 when Flaming Gorge Dam was completed, median flow maxima in the Green River have been reduced 63% at Greendale, 33% at Jensen and 27% at the town of Green River. Even under the wettest conditions, peak flows have been reduced 61%, 32% and 24%, respectively, at these same locations (Muth et al. 2000). The stream-flow gage at Greendale is located immediately downstream from Flaming Gorge Dam and, therefore, peak flows are directly affected by releases from the dam. Reductions in peak flows at Jensen are moderated by inflows from the Yampa, whereas inflows from the White, Duchesne and Price rivers also serve to moderate reductions at the Green River, Utah, gage.

Under proposed flow recommendations for the Green River at Jensen, depending upon hydrology, releases from Flaming Gorge Dam should be sufficient to inundate floodplain habitats in 4 of 10 years with a magnitude of at least 18,600 cfs for at least 2 weeks (Muth et al. 2000). Prior to 1963, flows of this magnitude and duration occurred in 2 out of 3 years on average, whereas after 1963 they occurred only once in 8 years on average. Therefore, flows of this magnitude and duration occurring 4 in 10 years would represent a significant improvement over post-1963 conditions, though not as good as pre-1963. These recommendations were made with the foreknowledge that depletions from the Yampa River would further reduce peak flows and may require that releases from Flaming Gorge be adjusted to offset depletions and achieve flow recommendations at Jensen.

Although the purpose of these flow recommendations is to provide habitat for endangered fishes downstream from Flaming Gorge Dam, they also are expected to maintain the vigor and diversity of riparian vegetation dependent upon periodic inundation by high spring flood flows. However, releases from Flaming Gorge, as noted earlier, cannot mitigate for the impacts of depletions on the mainstem of the Yampa River, including the Yampa River riparian corridor. Nevertheless, depletions from the Yampa River should not have significant impacts on riparian vegetation, because highest spring flows would be reduced no more than 2.4% relative to current conditions.

Riparian habitats throughout the western United States have been severely impacted by invasive plants, such as tamarisk. Tamarisk has a deep root system (up to 100 feet) that allows it to thrive even under drought conditions, creating impenetrable thickets that encroach on rivers and streams. Its leaves excrete salt, producing a salty residue in its leaf litter that inhibits growth of other plant species, enabling it to aggressively displace native vegetation, such as cottonwoods and willows. Tamarisk provides poor wildlife habitat, increases fire hazards, restricts access to waterways, and generally consumes more water than does the native riparian and upland vegetation it displaces (CWCB 2003).

The CWCB (2003) estimates that tamarisk and another invasive nonnative species, Russian olive (*Elaeagnus angustifolius*), have displaced roughly 57,000 acres of native habitat statewide, only one-third of which previously consisted of cottonwood, willow and other riparian species, and two-thirds of which previously was occupied by upland vegetation, such as sagebrush and rabbitbrush. Invasion of streamside upland habitats by tamarisk and Russian olive potentially impacts water consumption to a greater extent than displacement of a comparable acreage of riparian vegetation, because although tamarisk and Russian olive consume one acre-foot more water per acre than native riparian species, such as cottonwood and willow, they consume four acre-feet more water per acre than do native upland grasses and shrubs.

Therefore, the CWCB (2003) estimates that these phreatophytes use about 171,000 AF more water per year than the native vegetation they displaced. Estimates of future expansion by these two species range from 90,000 acres (1% annual expansion) to 200,000 acres (2.5% annual expansion) statewide during the next 50 years (CWCB 2003), using an additional 270,000–600,000 AF of water per year, or enough to satisfy the needs of almost 1.2 million to more than 2.6 million people. These estimates assume that no control measures would be implemented to reduce the areal extent of tamarisk and Russian olive. However, the State of Colorado and other western states consider controlling these species to be a high priority. Moreover, bills are pending before both houses of the U.S. Congress for tamarisk control legislation. The Senate version, known as the Tamarisk Control and Riparian Restoration Act (S. 1236), would provide grants to western states (up to $20M total in 2004 to Arizona, California, Colorado, Idaho, Montana, New Mexico, Nevada, Oklahoma, Texas, Utah, and Wyoming) for tamarisk research, control, and revegetation of riparian habitats.

CWCB (2003) estimates about 546 acres of tamarisk and 143 acres of Russian olive have invaded riparian and adjacent upland habitats in Routt and Moffat counties, with most of the acreage of both species (685 acres) in Moffat County. These species could occupy more than 2,400 acres in these two counties in 50 years if they expanded by 2.5% per year. Using the same formula for the differential in water consumption, these two species currently deplete roughly 2,800 AF more water than the native vegetation they displaced from the Yampa Basin in Colorado, with the potential in 50 years to deplete 7,200 AF more water than would an identical acreage of native vegetation. Although its prodigious water consumption poses a significant impact, tamarisk presents a variety of other environmental impacts, including:

- Extensive degradation of riparian habitat and loss of biodiversity;
- Little nutritional value for wildlife and livestock, and restricts their access to water.
- Increased frequency and intensity of wildfires due to leaf litter; wildfires tend to kill native cottonwood and willows but not tamarisk.
- Stabilization of streambanks, bars, islands, causing channel narrowing, increased flooding, and other changes in stream morphology that can impact habitat for endangered fish.
- Restricted recreational access to streams (e.g., boating, fishing, hunting, bird watching).

Tamarisk is capable of colonizing and stabilizing mid-channel bars and islands when water levels are low. Once established, these plants can withstand higher flows that otherwise would drown and/or scour tamarisk seedlings. Therefore, frequent, high, scouring flows are needed to prevent tamarisk from becoming established on these areas, that may provide spawning sites for endangered fishes. Although the magnitude of peak flows will be reduced slightly from historic conditions, the estimated reduction of the highest peak flows is not expected to be significant and their frequency should not be affected. Therefore, the proposed action is not expected to promote invasion of tamarisk in Yampa Canyon or elsewhere along the mainstem of the Yampa River. Encroachment by tamarisk, as well as native woody species, could occur along the Little Snake River if peak flows were reduced for extended periods sufficient to allow woody vegetation to become established. However, the large, highly variable sediment loads of the Little Snake River may retard further encroachment by alternately smothering and scouring seedlings.

Nevertheless, the status of invasive species, tamarisk in particular, will be monitored, and control measures will be implemented as necessary and appropriate to minimize or reduce the areal extent of the invasive plant. Although the Recovery Program has not identified tamarisk as a risk factor for the four listed fish species, the Recovery Program supports the goals of the Tamarisk Coalition. Tamarisk control potentially could benefit the endangered fish species by reducing "non-beneficial" water consumption, particularly during base-flow periods. Although water consumption by tamarisk and Russian olive in the Yampa Basin currently does not represent a significant percentage of depletions, it could become significant in the future if their expansion is not monitored and controlled. Moreover, encroachment by tamarisk onto mid-channel bars and gravel islands used as spawning habitats during higher flows could adversely impact the endangered fishes.

The Recovery Program can contribute to this effort by educating its participants and principal investigators on the impacts of invasive plant species, particularly tamarisk, and providing a means by which tamarisk can be monitored during the course of other recovery actions, such as managing nonnative fish populations or monitoring endangered fish populations and habitat. Of particular interest to the Recovery Program would be any evidence of encroachment by tamarisk onto mid-channel bars and gravel islands that provide spawning sites for endangered fishes. Due to the complexity and intensity of recovery actions, any fortuitous tamarisk monitoring necessarily would be incidental to the objectives of those recovery actions. Recovery Program participants and principal investigators would report any significant findings to the Tamarisk Coalition, State of Colorado, the affected counties and/or federal land management agencies, such as the NPS or BLM, as appropriate. These entities would be responsible for carrying out any actions, as they deem necessary and appropriate, to eradicate local stands of tamarisk or control its further expansion.

Wildlife

Localized impacts to wildlife due to reservoir enlargement also will be addressed in a separate, site-specific NEPA document (USACE 2004). These impacts would be restricted principally to the area of the reservoir enlargement. During construction, the reservoir pool would be drawn down about 30 feet, reducing the surface area of water available for waterfowl. Shorebirds and wading birds may benefit initially as the reservoir is drawn down, making potential prey organisms available as new mudflats are exposed. More mobile aquatic prey species may concentrate in the shallow water along the margins of the shrinking reservoir, where they also would be available to predators. Eventually, any prey left stranded and uneaten would dessicate or decompose.

Similarly, piscivorous species, such as osprey, may benefit from the initial concentration of prey within the smaller conservation pool. Eventually, these species also would benefit from the enlarged reservoir, once prey populations have reestablished their pre-construction densities. In the interim, piscine prey will be reduced through predation, competition and other potential environmental stressors, such as hypoxia resulting from algal blooms or decomposition of organic matter. When the reservoir fills, both during and after the construction period, reservoir fish population densities will decline initially, and fewer fish will be available to piscivorous predators.

Mammals that live or forage along the margins of the existing reservoir will be displaced during construction. Larger, mobile species and habitat-generalists with large home ranges would be better able to adapt than smaller, less mobile species with more fastidious habitat requirements. Large mammals, such as deer and elk, likely would continue to use the drawn-down reservoir. However, lack of vegetative cover likely will deny smaller mammals access to the water unless herbaceous vegetation rapidly invades the newly exposed substrate. Displaced individuals may die if forage is inadequate to sustain them or they are exposed to increased competition or predation.

Riparian habitat along the margins of the existing reservoir initially would be dessicated as the reservoir is drawn down and eventually would be inundated by the enlarged reservoir. Smaller mammals and reptiles that manage to survive along the margins of the existing reservoir during construction may be drowned or displaced as the reservoir fills following construction. However, the net loss of riparian habitat along the reservoir would be temporary, and new riparian habitat would become established along the margins of the enlarged reservoir and recolonized by the same or similar wildlife species. Losses of wetlands and the wildlife they support downstream from the dam and upstream from the existing reservoir will be mitigated in-kind (see **Vegetation** beginning on page 166).

Wildlife dependent on riparian and wetland habitats along the Yampa River and its tributaries would be impacted only to the extent these habitats are impacted by the proposed action. Impacts to these habitats due to depletions are not expected to be significant. Widespread agricultural conversion from flood irrigation to sprinkler irrigation or from agricultural use to non-agricultural use could significantly reduce the volume of return flows upon which certain wetland habitats rely. However, such conversions are not anticipated nor are they elements of the proposed action.

Piscivorous species may experience an initial decline in the availability of prey due to nonnative fish management activities. Eventually, nonnative fish will be replaced as prey by native fishes whose populations expand in response to reduced competition and predation by nonnative fishes. Moreover, numerous nonnative fishes that are not the specific targets of management activities will remain in the river and continue to be available as prey for wildlife.

Fisheries

The proposed action would result in both beneficial and adverse impacts to riverine fisheries. Nonnative sport fisheries in the Yampa River would be adversely affected by proposed nonnative fish management actions intended to benefit endangered species and other native fishes. Northern pike and smallmouth bass populations in the Yampa River are expected to decline in response to these management actions. However, because these fishes would be translocated to other water bodies, such as the SWA ponds, Loudy-Simpson pond and Elkhead Reservoir, they will continue to be available for local anglers to harvest.

Reduced competition with and predation by nonnative species due to nonnative fish management activities should benefit all native fishes within not only those river reaches undergoing such treatment, but also other (non-treatment) reaches into which nonnative fishes otherwise might have dispersed from treatment reaches. Certain management actions, conducted upstream from critical habitat but intended to reduce the number of nonnative fishes dispersing downstream into critical habitat, would benefit native fishes within the upstream treatment reaches, as well. Furthermore, native and nonnative coldwater sportfish, such as Colorado River cutthroat, rainbow trout and brown trout, would benefit from removal of northern pike from reaches they currently share with these competitive and predatory fish. Because some native species are long-lived and may take several years to reach sexual maturity, a positive response by native fish populations, especially endangered fishes, may not be immediately evident. However, depletion of nonnative fish populations and consequent expansion of populations of more common, faster maturing, native fishes would provide indirect evidence of a beneficial effect on other native species.

In addition, stream-flow augmentation during typically dry periods would benefit native fisheries downstream from Elkhead Creek by providing minimum base flows to freshen pools and maintain riffles that provide an invertebrate prey base for many native fish species. Although average base flows would be reduced an annual average of 6.6% by depletions (3~13% in any base-flow month), base-flow augmentation would increase the minimum flow from that which occurred historically.

Reductions in base flows of 2–5% due to future depletions should not adversely affect native and nonnative coldwater fisheries in the Yampa River upstream from Elkhead Creek, the Elk River, and other significant tributaries. However, if new dams and reservoirs were built on smaller tributaries, fisheries immediately downstream from the dams could be adversely affected by disadvantageous changes in both water quantity and water quality. These impacts would be mitigated on a case-by-case basis, and appropriate NEPA documentation would be prepared for any project for which a federal action (e.g., CWA §404 permit, USFS/BLM special use permit, or FERC license) is required.

Future depletions could reduce base flows in the Little Snake River at Lily Park an average of 31% relative to current (baseline) flow conditions. The magnitude of potential base-flow reductions is due largely to extremely low baseline flow conditions, typical of the Little Snake River. Excluding the peak-flow months of April through June and transition months of March and July, flows at Lily Park average just 89 cfs and range from monthly averages of 57 cfs in September to 137 cfs in February. Future depletions could reduce average base flows by 27 cfs. However, releases from the Little Snake Supplemental Irrigation Supply Project, which is considered part of the baseline for this assessment but is not reflected in the historic gage data, may serve to partially mitigate these impacts by providing water to serve the needs of agriculture during periods of low stream flow. Nevertheless, the Recovery Program will continue to monitor the Little Snake River to ensure that native fish populations continue to thrive in the face of further depletions.

Threatened and endangered species

The proposed action consists of several different elements, some of which may adversely affect threatened and endangered species and some that are not likely to adversely impact these species. Certain action elements may be generally beneficial to one or more species, but neutral or potentially adverse to others. For example, reservoirs may provide habitat for bald eagles, but operation of these reservoirs may be potentially adverse to the endangered fishes due to impacts on peak-flows and escapement of nonnative fishes. Table 55 provides a summary of these effects.

Table 55. Summary of probable impacts[a] on threatened and endangered species and critical habitat

Proposed action	Bald eagle	Mexican spotted owl	SW willow flycatcher	Humpback chub	Bonytail	Colorado pikeminnow	Razorback sucker	Black-footed ferret	Canada lynx	Ute ladies-tresses orchid	Yellow-billed cuckoo [c]	Boreal toad [c]
Reservoir storage [b]	+	–	○	●	●	●	●	○	–	○	○	○
Depletions	○	–	○	●	●	●	●	○	–	○	○	○
Flow augmentation	○	–	–	+	+	+	+	–	–	–	–	–
Nonnative fish control	○	–	–	+	+	+	+	–	–	–	–	–
Habitat enhancement	○	–	○	+	+	+	+	–	–	–	–	–
Fish passage	–	–	–	–	–	+	–	–	–	–	–	–
Entrainment prevention	–	–	–	–	–	+	–	–	–	–	–	–
Stocking	–	–	–	–	+	–	+	–	–	–	–	–
Monitoring	–	–	–	○	○	○	○	–	–	–	–	–

[a] Key to probable impacts: "–" = no effect; "+" = beneficial effect;"○" = not likely to adversely affect; "●" = may adversely affect
[b] Excluding water stored and released to augment stream flows (addressed separately).
[c] Candidate species

The proposed action is expected to have no effect on the Mexican spotted owl, black-footed ferret, or Canada lynx. Although Mexican spotted owls inhabit portions of Dinosaur National Monument, the proposed action will not impact upon their woodland habitat nor reduce their prey base of small mammals. The black-footed ferret was recently reintroduced into Moffat County. Found exclusively in upland semi-arid shortgrass habitats in association with their prairie dog prey, the black-footed ferret does not rely upon riverine or riparian habitats that may be affected by the proposed action. The Canada lynx typically is found in spruce-fir boreal forests at higher elevations. Although it utilizes riparian habitats, such as willow thickets, its principal habitat is located above the likely area of influence of the proposed action.

The bald eagle, southwestern willow flycatcher, Ute ladies'-tresses, yellow-billed cuckoo and boreal toad may occur within the area affected by the proposed action; however, for reasons discussed below, the proposed action is not likely to adversely affect these species. Nevertheless, the proposed action may adversely affect the endangered humpback chub, bonytail, Colorado pikeminnow and razorback sucker.

Bald eagle

The bald eagle generally is found in close proximity to water. It principally uses the Yampa River in winter, although several breeding pairs also may utilize the river in spring and summer. Impacts on stream flows due to water depletions are greatest July through October, when fewer eagles are present. Depletion effects on flows from late summer through winter will be augmented with water stored in Elkhead Reservoir, if necessary, to the extent water is available for that purpose. Because the bald eagle's preferred prey are fish and waterfowl, base-flow augmentation should support its prey base and potentially provide more open water in winter (i.e., less ice cover) for foraging. Moreover, no adverse impacts are expected to the riparian forest that eagles use for roosting.

A reduction in nonnative competitive and predatory fishes could cause a short-term reduction in forage available to the bald eagle. However, native fish populations are expected to increase as predation and competition by nonnative fishes decrease. Moreover, alternative prey are readily available, including other nonnative fishes, such as white sucker and carp, small mammals, birds and carrion. Therefore, we do not expect any adverse effect to bald eagles due to proposed nonnative fish management activities.

Southwestern willow flycatcher

Although a related subspecies, *Empidonax traillii adastus*, occurs in northwestern Colorado, *E. t. extimus* does not occur in the Yampa River Basin. The nearest population of this subspecies occurs downstream from Green River, Utah. Flow fluctuations in Green River downstream from the Yampa River due to the proposed action would be well buffered by inflows from the Upper Green River (upstream from the Yampa), as well as the Duchesne, White, Price and San Rafael rivers, downstream from the Yampa. Therefore, the proposed action should have no adverse impact on the southwestern willow flycatcher.

Humpback chub, bonytail, Colorado pikeminnow, and razorback sucker

Current depletions have reduced both peak flows and base flows in the Yampa River. Projected future depletions will further reduce flows, but are expected to have proportionately greater impact on base flows. For this reason, base-flow augmentation is a key element of the proposed action. However, the objective of base-flow augmentation is to emulate historic flow conditions and satisfy the Service's 1999 flow recommendations (Modde et al. 1999). It will not restore base flows to those that would have occurred in the absence of depletions.

Peak flows are considered equally, if not more, important to the species' recovery. Peak flows shape the channel and transport sediment to build and maintain nursery habitats for Colorado pikeminnow and razorback sucker downstream in the Green River. Although peak flows in the Yampa and Little Snake rivers are expected to be reduced somewhat due to depletions of water for current and foreseeable future human needs, computer analyses indicate that sediment transport and the downstream functions it serves will remain in balance (i.e., sediment supply ~ sediment transport). Moreover, Green River flow recommendations at Jensen, Utah, are predicated on releases from Flaming Gorge Dam to coincide with and reinforce peak flows of the Yampa River. These recommendations were made with the assumption that water development in the Yampa River Basin would continue, using the same information as was used in developing the Yampa management plan. On this basis, the Service believes that the Green River flow recommendations can be met in spite of future depletions from the Yampa River.

Other management plan actions also are intended specifically to offset the adverse impact of depletions and assist in the recovery of the four endangered Colorado River fish species. Nonnative fish management activities, if successful, should reduce populations of competitive and predatory species, potentially benefitting all native fish species, including the endangered fishes. Drawing down Elkhead Reservoir prior to construction and spring flows through the reservoir basin during construction could release large numbers of nonnative fishes to the Yampa River. The Service and CDOW have agreed to work cooperatively in conjunction with the CRWCD and Yampa River Basin Partnership to ensure that adequate measures are taken to fully contain nonnative fishes resident in Elkhead Reservoir prior to the initiation of reservoir draw-down to preclude escapement of nonnative fishes to the river (CDOW 2003b; USFWS 2003b). Specific control measures are described under Containing escapement from Elkhead Reservoir beginning on page 93. These include the potential incorporation of a permanent fish barrier on the Elkhead Dam outlet and/or spillway. If needed, the Recovery Program will select and fund construction of a fish barrier at Elkhead.

Potential entrainment of or entry by endangered fishes, predominantly Colorado pikeminnow, into diversion canals will be evaluated, and remedial measures will be undertaken, if necessary. Such measures could include installation and operation of fish screens on larger diversions or annual retrieval and release operations, similar to the proposed evaluation program. Populations of the endangered fishes also will be monitored periodically to determine their status and trends, and management actions may be modified, if necessary, to promote recovery of these species.

Ute ladies'-tresses

This threatened orchid is found in Dinosaur National Monument along the Green River downstream from its confluence with the Yampa River. It also occurs in Brown's Park, along the Green River upstream from the Yampa (USFWS 1992). Its reliance on moist soils make it potentially vulnerable to stream-flow modification. However, base-flow reductions due to depletions from the Yampa River Basin can be offset by releases from Flaming Gorge Dam as specified in Muth et al. (2000). Base-flow augmentation in the Yampa River also would partially offset any reductions in base flows due to depletions. Peak flows in the Green River are highly modified by the operation of Flaming Gorge Dam. The shape of the hydrograph downstream from the Yampa River confluence is dictated to a large extent by flows from the Yampa. The Service's biological opinion for the operation of Flaming Gorge Dam (USFWS 1992) acknowledges that *Spiranthes diluvialis* found in the Brown's Park area "is not expected to be affected" by revised operations of the dam. Moreover, the Green River flow recommendations report (Muth et al. 2000) assumes that flow targets downstream from the Yampa River confluence can be met in spite of expected water development to meet future demand in the Yampa Basin. These flow recommendations are intended to provide floodplain inundation at a certain frequency, magnitude and duration to benefit the endangered fishes resident in the Green River. Periodic inundation also should provide favorable conditions for *S. diluvialis*. Therefore, the proposed action should have no significant adverse impact on this threatened plant.

Yellow-billed cuckoo

Yellow-billed cuckoos have been documented in the Yampa River Basin (Andrews and Righter 1992; Kingery 1999). The cottonwood riparian forest along the middle reaches of the Yampa River appear to provide suitable nesting habitat for the cuckoo. The proposed action is not likely to have an adverse impact this forest, which is stable and relatively secure. Conversion to agricultural uses also is unlikely. Therefore, the proposed action is not likely to affect the yellow-billed cuckoo.

Boreal toad

The boreal toad historically occurred in wetlands and subalpine forests above 7,500 feet elevation. Its decline has been attributed largely to factors other than habitat destruction or degradation. Boreal toads are known to inhabit the littoral zone and moist margins of Steamboat Lake. The proposed action would eliminate Steamboat Lake as an augmentation water source, reducing fluctuations in water surface elevations that could adversely impact on boreal toads. Most of the water (21,364 AF) in Steamboat Lake is held for recreation and instream flow use. The 3,300 AF currently adjudicated for instream flow could be released to meet other instream flow purposes. Use of the only other reservoir account (5,000 AF) in Steamboat Lake is not expected to increase significantly in the future, as this account serves as an emergency water supply.

Boreal toads are not known to occur at Elkhead Reservoir, nor does Elkhead Reservoir provide suitable habitat for this species. Moreover, large water development projects in the headwater habitat of the boreal toad are unlikely, because there is inadequate yield to support such projects. Therefore, the proposed action is not likely to have any adverse effect on the boreal toad.

Socioeconomic environment

The proposed action is predicated on realistic projections of population growth and economic development in the Yampa River Basin over the next 40+ years. Increments of depletions in Colorado and Wyoming were adopted to serve the projected water needs of the human population. The proposed action is to provide offsetting measures to minimize the impacts of those depletions on the four listed fishes and, in so doing, neither promote nor constrain foreseeable growth and development. Certain assumptions were made with regard to how depletions would be allocated between economic sectors; however, the proposed action places no restrictions on how water is actually allocated within the identified increments of depletions. So, the proposed action would not influence development in any one sector at the expense of any other(s).

The proposed action in and of itself will not result in any changes in land ownership nor place any restrictions on its use. However, the proposed action does not relieve land owners/managers from compliance with all applicable State and Federal regulations, including the Endangered Species Act (ESA). More than half of the land in the Yampa River Basin is under Federal ownership. Federal agencies are mandated by the ESA to conserve threatened and endangered species and, in that context, they are required to consider threatened and endangered species in making decisions regarding management of lands under their control. Private actions for which a Federal permit or license is required would still need to comply with ESA requirements, as well, regardless of the proposed action.

Certain measures may be required in the future to reduce or eliminate take of the endangered fishes. These measures may include installing and operating fish screens on diversion inlets to prevent fish from entering canals, or providing fish passage over diversion dams, as necessary. The Recovery Program would bear any incremental costs of these facilities and provide annual funds sufficient to maintain them. Therefore, economic and operational impacts to water users should be minimal.

The increments of future depletions described in the management plan assume no additional acreage will be brought under irrigation in Colorado and a modest expansion of irrigated acreage in Wyoming. These assumptions are based on information developed in consultation with Yampa Basin water users, the Colorado Water Conservation Board and the Wyoming State Engineer's Office. Base-flow augmentation and other recovery actions within the management plan are intended to offset the impacts of depletions, so that those depletions may continue in compliance with the ESA. Future water development within these defined increments is considered to be an impact of the proposed action under this management plan. Moreover, this management plan does not preclude water development in excess of these defined depletion increments. However, depletions in excess of those considered in a PBO consultation would likely require the Service to reinitiate formal intra-Service consultation under Section 7 of the ESA to evaluate their impacts.

Potential long-term impacts to water-related recreation at each of three reservoirs and state parks have been previously discussed in detail (see Impacts to parks and water-related recreation beginning on page 56). Short-term impacts due to the proposed enlargement of Elkhead Reservoir will be described in a separate, site-specific NEPA document for that project. Potential impacts to sport fisheries have been described in the management plan under **Reduce Negative Impacts of Nonnative Fishes** beginning on page 79. This program currently is experimental and, for the purposes of the NEPA, categorically excluded from this impact assessment However, once this program is no longer considered experimental, it will be necessary to prepare a separate NEPA document to address its impacts.

Cumulative impacts

The CEQ regulations (40 CFR 1500–1508) implementing the procedural provisions of the NEPA, as amended (42 U.S.C. 4321 *et seq*.), define cumulative effects as:

> *...the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions* (40 CFR 1508.7).

Cumulative effects analysis must consider the proposed action(s) together with those other actions to determine if there is a synergistic or antagonistic relationship between these actions and to what extent that relationship may exacerbate the impacts of the proposed action(s). Cumulative effects may be simply additive, or linear, in nature or may be more complex, or nonlinear. For example, evaporative losses from reservoirs and consumptive uses of water are different "uses" of water, but share similar effects (i.e., reduction in stream flows), which are additive in nature. Conversely, predation/competition by nonnative fishes may be exacerbated by reductions in stream flows (from all causes), because lower flows result in less available habitat, over-crowding (exposing native species to greater predation and competition), and environmental stress (e.g., higher temperatures and/or lower DO). The relationship between these stressors is more difficult to quantify. However, "nonlinear" effects are not necessarily unpredictable. For example, the relationship between stream flow and sediment transport is nonlinear, but predictable and easily quantified.

The CEQ developed guidelines for cumulative effects analysis (CEQ 1997) which state:

> *If cause-and-effect relationships cannot be quantified, or if quantification is not needed to adequately characterize the consequences of each alternative, qualitative evaluation procedures can be used.*

Certain effects, though additive, also serve to mask the effects of the proposed action. For example, releases from Stagecoach Reservoir for hydropower production and other purposes may mask the effects of releases for instream flow augmentation. In the case of Steamboat Lake, however, releases for instream flow augmentation combined with releases for other purposes may exceed the threshold for reservoir draw-down established by Parks, whereas releases for instream flow augmentation alone may not.

Cumulative effects due to synergistic or antagonistic interactions between different elements of the proposed action and alternatives to the proposed action have been addressed elsewhere in this EA. This section is intended to address the cumulative effects of the proposed action with other actions beyond the scope of this document, such as water quality impacts due to hazardous materials spills or development of coal bed methane.

Petrochemical spills have occurred in the past, and likely will occur in the future. Past events have involved tanker truck accidents in which petrochemicals entered a waterway. Such spills are potentially lethal to aquatic organisms. Combined with a reduction is stream flows, the effects of spills could be exacerbated or ameliorated. Locally, the impact could be more severe, because less flow would not dilute or flush the toxic material from the local area as readily as higher flows. Conversely, if less material is flushed downstream, spill containment and clean-up would be facilitated, potentially resulting in lesser impacts downstream.

Petrochemical pipelines also cross the Yampa River and its tributaries. A leak or rupture of such a pipeline could have similar effects as those of a tanker spill, but could be more devastating due to potentially greater volumes of spills. Like tanker spills, pipeline incidents would have potentially greater local impacts and potentially smaller impacts downstream if flows were reduced. However, the impact of any spill incident would be influenced to a greater extent by its seasonality, due to the high seasonal variability of flows, and the timeliness and effectiveness of the emergency response.

Coal trains also pose a potential threat to water quality. In many locations within the Yampa Valley the railroad runs parallel to the river in close proximity, increasing the likelihood that a railway accident could dump coal into the river. Recent derailments of coal trains along both the Colorado and Gunnison rivers have provided evidence of that risk. However, coal is perceived as presenting a lesser threat than petrochemicals; although coal contains toxic materials, they leach from coal at a much lower rate, so toxic concentrations of these substances may not be achieved at higher flows. Nevertheless, over time such leachates potentially could impact aquatic life locally, particularly during periods of lower flow and higher temperatures. Moreover, because coal is not readily flushed from the aquatic environment, it may pose a greater risk of chronic exposure to aquatic organisms.

Coal bed methane (CBM) is a form of natural gas found in coal seams, frequently saturated with water, where the methane is held under pressure by the water. Although CBM has properties similar to those of natural gas produced by conventional means, its production differs from that of other sources. CBM extraction involves pumping water from the coal seam aquifer to relieve the pressure that holds the gas, allowing it to escape from the coal seam (Keith et al. 2003).

CBM can be found throughout the United States where there are deposits of coal. The largest of these is the Powder River Basin in northeastern Wyoming and southeastern Montana. Within the Upper Colorado River Basin, such deposits occur in the Greater Green River Basin of Wyoming, Colorado and Utah; the Uinta-Piceance Basin in Colorado and Utah; and the San Juan Basin in Colorado and New Mexico. Of these, only the Greater Green River Basin lies within the action area.

CBM extraction actually produces more water than it consumes. The quality of such "produced water" varies from near-potable to highly saline. In Montana, some produced water has been put to beneficial use, including domestic water supply, livestock watering and irrigation. Contaminants that typically are associated with produced water in southeastern Montana include the cations calcium, magnesium and sodium, and the anions chloride, sulfate and bicarbonate (Schafer 2001).

Historically, in Colorado, CBM-produced water generally has not been of sufficient quality for any beneficial use; only recently has the quality of produced water in Colorado been deemed suitable for limited beneficial uses. For example, in the Raton Basin of southeastern Colorado, about 5 mgd of groundwater is extracted from CBM wells. Approximately 30% of this amount (1.5 mgd) is discharged to natural streams under discharge permits issued by the Colorado Water Quality Control Division. However, because most of the produced water is of lesser quality, about 40% of this water (2 mgd) is discharged to evaporation pits and another 30% (1.5 mgd) is injected into a different aquifer (Wolfe and Graham 2004).

The Raton and San Juan basins appear to have the greatest potential of CBM development in Colorado. There is relatively little potential for CBM development in the Greater Green River Basin in Colorado or Wyoming. However, there are producing CBM wells in the Little Snake River Basin in Wyoming. Produced water from these wells is discharged to unlined off-channel ponds, from which some water may seep back into the water table, and possibly into adjacent streams or washes.

The Wyoming Department of Environmental Quality, Water Quality Division, established a permit program for produced water, including a General Permit for CBM applications within the structural Powder River Basin. This permit provides coverage to point-source discharges of CBM produced water to unlined "off-channel containment units" as long as certain criteria are met. Off-channel containment units, for purposes of this permit, are constructed ponds, pits or reservoirs sited on upland areas, outside of natural drainages and alluvial deposits associated with these natural drainages. The produced water must be contained in the unit and may not be discharged into other surface waters of the state (WDEQ 2002). Although the General Permit is specific to the Powder River Basin, similar provisions are included for individual CBM permits in other basins.

In addition to seepage, breaching or overtopping of off-channel containment pond embankments by locally intense storm events also pose a risk to water quality. Impacts to water quality are of concern not only for aquatic life, but for domestic water supplies (both surface and groundwater) and agriculture. Waters whose specific conductance (SC) is less than 3,000 µS/cm are considered to be most suitable for irrigation. Irrigating alfalfa with more saline water (SC = 8,600 µS/cm) reduced yield by 50%, whereas irrigating with less saline water (SC = 2,700 µS/cm) reduced yield less than 5%. However, with careful management and crop selection, water with SC as high as 7,500 µS/cm has been used successfully for irrigation. CBM produced waters in Montana generally have SC of 2,000 µS/cm or less (Schafer 2001).

Nevertheless, soil permeability can be affected by high levels of sodium, as expressed by the sodium adsorption ratio (SAR), which is a function of the milliequivalent sodium ion concentration divided by the square root of milliequivalent calcium plus magnesium ion concentrations. In general, higher SAR levels reduce soil permeability to a greater extent. However, the reduction in permeability due to the SAR decreases as a function of SC (Figure 28). For example, at SC = 700 µS/cm, the upper "tolerable" limit of SAR is 12; at SC = 2,000 µS/cm, the upper SAR limit is 30 (Schafer 2001). According to Schafer (2001): *Irrigation waters with moderate salinity or permeability hazard can be used for short duration without adverse effects. Prolonged use of these waters may require special management techniques*. Produced water from the Scotty Lake Coal Bed Natural Gas (CBNG) Pilot Project in northeastern Sweetwater County, Wyoming, with SC = 1,750 µS/cm and SAR = 42.9 (Anderson Environmental Consulting 2004), would be considered to pose a severe permeability hazard (Figure 28) and, without dilution, would not be suitable for irrigating crops.

Produced water from the Scotty Lake CBNG project also exceeds ambient water quality standards for chloride, sulfate, iron and manganese in the Little Snake River (Anderson Environmental Consulting 2004; CDPHE 2003). We would expect produced water from CBM wells within the Little Snake River Basin to exhibit similar properties. Evaporation from containment ponds also will concentrate salts and, at higher concentrations, may form salt precipitates along their margins. If such a containment were to leak or be breached, highly saline water could adversely impact surface-water quality. Therefore, it is imperative to prevent inferior-quality produced water from entering any surface or ground water with a hydrologic connection to the Little Snake River or its tributaries. Rigorous enforcement of standard CBM permit conditions to prevent surface water contamination should be protective of aquatic life. Lining containment units to reduce seepage would be more protective of water quality. Nevertheless, open water in containment units with high concentrations of salt can present an attractive nuisance to migratory waterfowl and other wildlife. The most protective measures would be treating CBM-produced water prior to surface disposal or reinjecting it to groundwater, as long as aquifers into which water is injected are neither shallow nor tributary to surface waters, and these aquifers are not used for domestic or agricultural purposes.

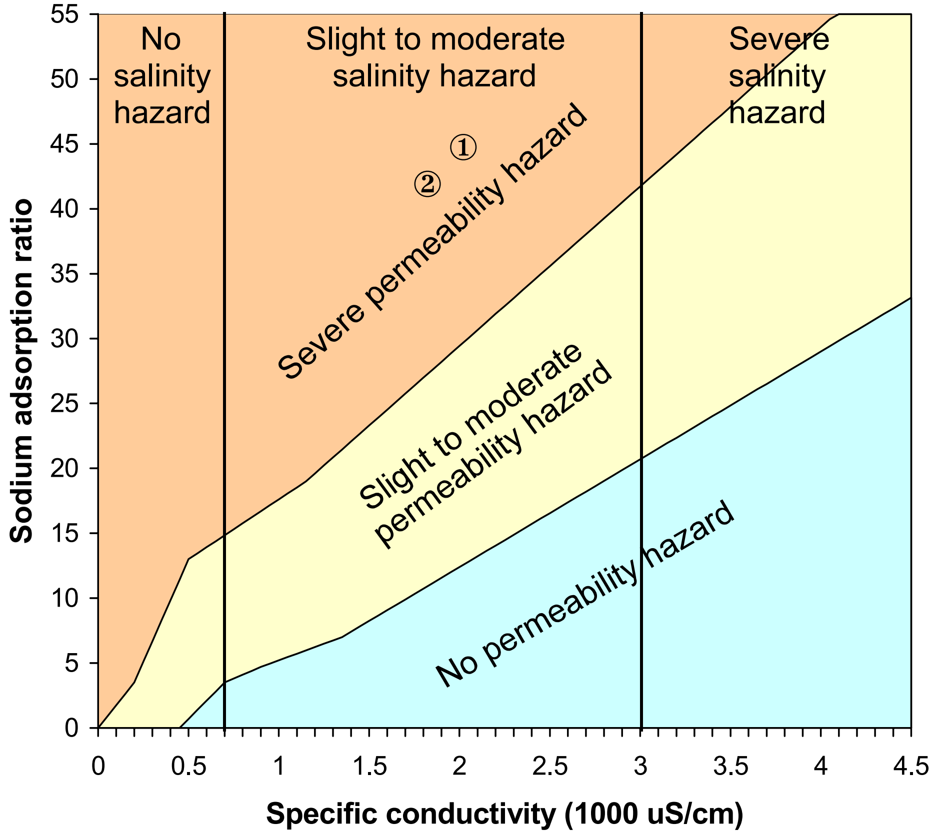


Figure 28. Salinity/soil permeability hazards as functions of specific conductance and sodium adsorption ratio in irrigation water, with reference to produced water from ① Powder River Basin and ② Scotty Lake CBNG (adapted from Schafer 2001)

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