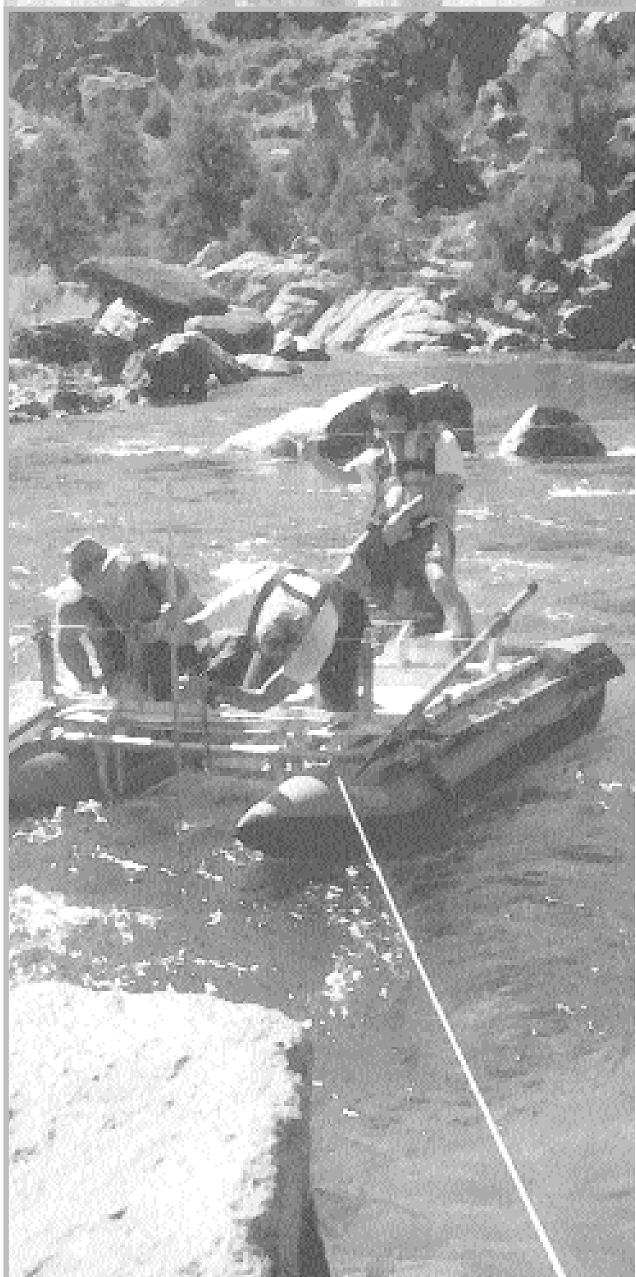
Arkansas River Water Needs Assessment



Section 6. Recreation Assessment

By:

Bruce DiGennaro, EDAW*
Dave Taliaferro, Bureau of Land Management

* Under contract to the Colorado Division of Parks and Outdoor Recreation and the U.S. Department of the Interior, Bureau of Land Management

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Preface

Each section of the *Arkansas River Water Needs Assessment* contains information that may be useful for a variety of purposes. However, each section is just a part of the overall *Arkansas River Water Needs Assessment* and the information contained therein should not be taken out of context or considered in isolation. Decisions regarding riverflows and reservoir levels should consider the findings of the assessment as a whole, while also recognizing that such decisions are limited by the necessity to supply water for domestic, agricultural, and other uses in the basin consistent with existing water rights held by water users. A summary of the entire assessment can be found in Section 1 of this report.

Acknowledgments

This assessment could not have been completed without an extensive amount of coordination and cooperation among the participating agencies. The following individuals participated in interagency workgroups throughout the assessment and are recognized for the significant amount of time and resources they invested in conducting various studies and documenting the findings in this report:

Water Workgroup: Bill Carey (Bureau of Land Management), John Gierard (formerly Bureau of Reclamation, now Western Area Power Administration), Dan Muller (Bureau of Land Management), Roy Smith (Bureau of Land Management), Steve Swanson (Bureau of Land Management), and Steve Witte (Colorado Division of Water Resources).

Biological Workgroup: Clay Bridges (Bureau of Land Management, retired), Mark Elkins (Colorado Division of Wildlife), Dave Gilbert (Bureau of Land Management), Doug Krieger (Colorado Division of Wildlife), Greg Policky (Colorado Division of Wildlife), and Rich Roline (Bureau of Reclamation).

Recreation Workgroup: Mike French (Colorado Division of Parks and Outdoor Recreation), Steve Reese (Colorado Division of Parks and Outdoor Recreation, retired), Mike Sugaski (U.S. Forest Service), and Dave Taliaferro (Bureau of Land Management).

Editorial and Graphics Workgroup: Linda Hill (Bureau of Land Management) and Jennifer Kapus (Bureau of Land Management).

The assessment team was guided throughout the process by a management advisory group, which was established through a formal memorandum of understanding. The members of this group are recognized for being responsive to the study team's needs and providing helpful advice, on numerous occasions, regarding controversial issues that arose during the study: Levi Deike (Bureau of Land Management), Dave Giger (Colorado Division of Parks and Outdoor Recreation), Alice Johns (Bureau of Reclamation), Dan McAuliffe (Colorado Department of Natural Resources), and Donnie Sparks (Bureau of Land Management).

During the assessment process, the services of several individuals were acquired through contracts and an interagency agreement. The timely deliverables, extraordinary assistance, and dedication to the assessment of these individuals under these formal arrangements were extremely appreciated. Kip Bossong (U.S. Geological Survey) compiled and analyzed a large amount of historic data, which significantly aided the streamflow analyses in this report. Bruce DiGennaro (formerly EDAW) provided a wealth of insight and strategy towards completing the recreation user surveys and assessment. Teresa Rice (formerly University of Colorado Natural Resource Law Center) completed an enormous amount of research on water uses and institutions. Both Bruce and Teresa wrote reports that are of such quality they could stand alone as exhaustive treatments of their respective assignments.

Certain individuals who were responsible for initiating preliminary discussions and studies leading to this assessment deserve special thanks for their vision and support. They include: Mac Berta (Bureau of Land Management, retired), Jim Fogg (Bureau of Land Management), Jack Garner (Bureau of Reclamation), Larry MacDonnell (formerly University of Colorado Natural Resource Law Center), Steve Norris (Colorado Division of Wildlife), Don Prichard (Bureau of Land Management), Donnie Sparks (Bureau of Land Management), Steve Vandas (U.S. Geological Survey), and Pete Zwaneveld (Bureau of Land Management).

Several individuals provided the team with helpful insight and reviews of documents. In particular, we acknowledge the following individuals for their commitment to participating in meetings and providing review comments:

Legal and Institutional Analysis Advisory Group: Carl Genova (Southeastern Colorado Water Conservancy District), Denzel Goodwin (Upper Arkansas River Water Conservation District), Alan Hamel (Pueblo Board of Water Works), Steven Kastner (Colorado Division of Water Resources), Phil Saletta (Colorado Springs Utilities), and Tom Simpson (Southeastern Colorado Water Conservancy District).

Biology, Hydrology, and Recreation Peer Reviewers: Mark Butler (U.S. Fish and Wildlife Service), Paul Flack (Colorado Division of Parks and Outdoor Recreation), Bill Hagdorn (Bureau of Land Management), Mike Lewis (U.S. Geological Survey), Rich Niemeyer (National Park Service), Scott Schuler (U.S. Forest Service), and Jay Thompson (Bureau of Land Management).

Advisor on Reservoir Operations: Tom Gibbens (Bureau of Reclamation, retired).

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Section 6. Recreation Assessment

In 1993, the U.S. Bureau of Land Management, in cooperation with Colorado's Department of Natural Resources (Division of Water Resources, Division of Wildlife, and Division of Parks and Outdoor Recreation), the U.S. Forest Service, and the U.S. Bureau of Reclamation (BOR) initiated a Water Needs Assessment for the Upper Arkansas River and its associated reservoirs. The following report describes studies and analyses conducted as a part of this assessment to determine water needs for recreation.

The study area includes the Arkansas River from Leadville to Pueblo and four associated storage reservoirs; Turquoise Lake, Twin Lakes, Clear Creek Reservoir, and Pueblo Reservoir (Figure 6-1). This area supports a wide variety of water-based recreation activities. Many of these activities, particularly fishing, white-water boating, and reservoir boating are directly affected by water management in the basin, which determines riverflows and lake levels.

The purpose of this section of the report is to document water needs for fishing and boating activities on the Arkansas River and its associated storage reservoirs. The report provides an evaluation of both river- and lake-oriented recreation, focusing primarily on evaluating water needs for fishing and boating activities. Other recreation activities that occur in the study area, such as sightseeing and camping, are less directly influenced by water levels and therefore were not evaluated. For the purposes of this section, water needs are defined primarily through the development of user preference curves. Rather than providing absolute binary functions, these curves indicate degrees of acceptability associated with various water conditions. Threshold values have also been developed to indicate acceptable and optimal conditions for each major activity.

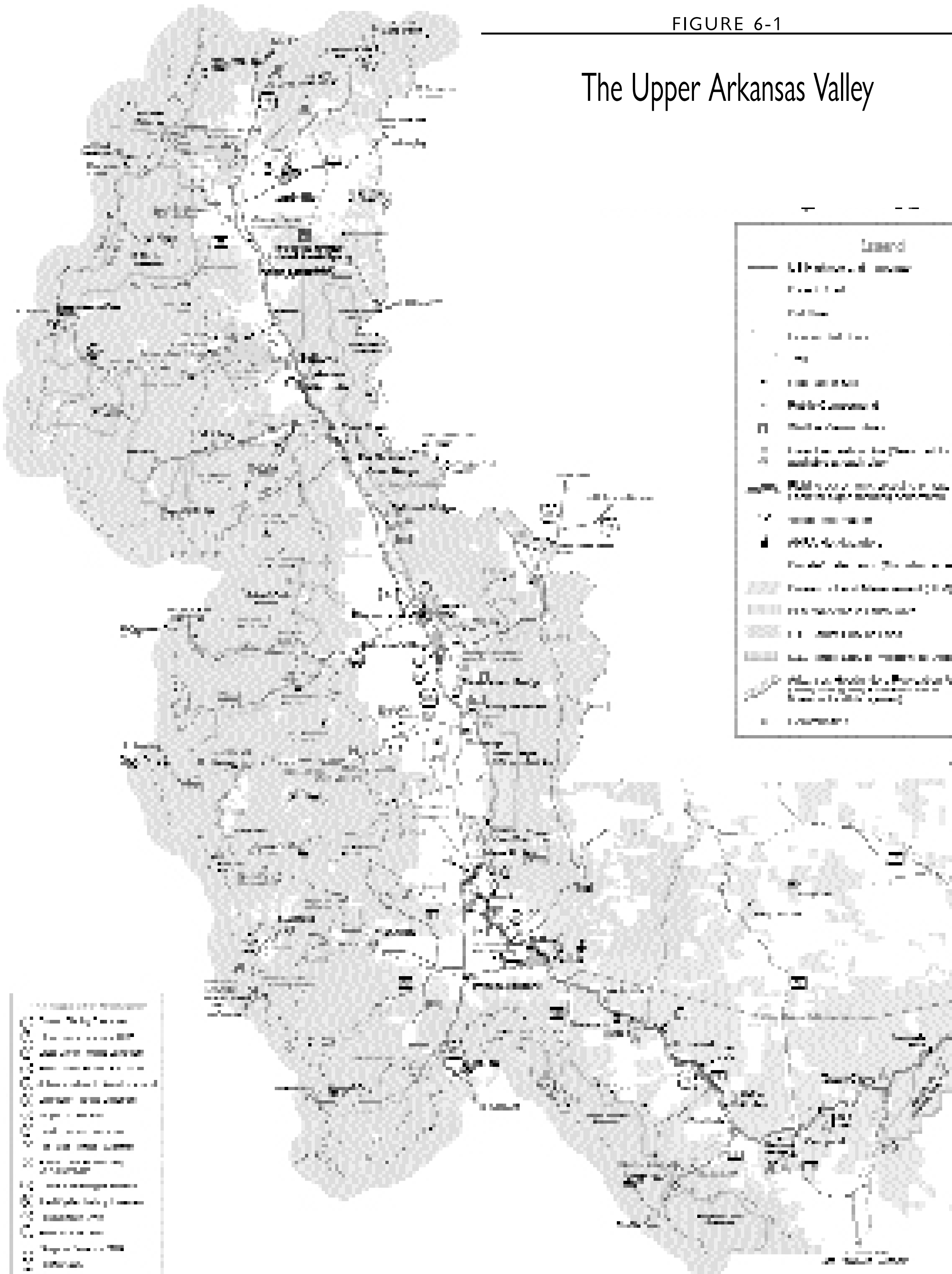
The recreation water needs presented herein are based on: 1) an analysis of the physical characteristics of the river and reservoirs in relation to water levels; 2) an assessment of use patterns in relation to various flow conditions (based upon the Wellsville gage) and reservoir levels; and 3) results from several user surveys conducted between 1991 and 1995. Each of these data sources are compared and contrasted to develop the most accurate depiction of flow needs possible. The data includes responses from experienced users, casual users, private boaters, commercial boaters, and anglers of all types for six sections of the river, as well as for Twin Lakes, Turquoise Lake, and Pueblo Reservoirs. Some limited data were also collected for Clear Creek Reservoir because, even though it is not a Fryingpan-Arkansas Project reservoir, its operations are included within this study.

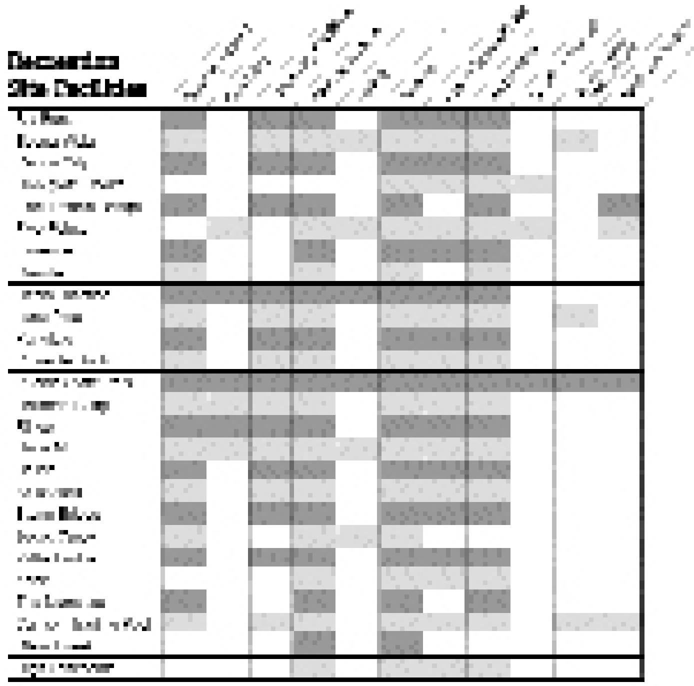
The relationship between water levels and recreation opportunities is highly complex, particularly when there is a diversity of users such as in the upper Arkansas Basin. Water levels can influence a variety of factors important to recreation, including, shoreline access, navigability, safety, fishing success, white-water dynamics, and ultimately, the overall quality of the recreation experience. In addition, each recreation activity may have slightly different needs. What is good for one user may be bad for another. In some cases, water levels (particularly at the extremes) may influence actual recreation decisions. However, recreation decisions are also typically influenced by numerous other factors, including weather, the time of year, family summer vacations, and the availability of other substitute opportunities.

Preferences for specific water levels are generally derived from experience. Users who recreate in the area frequently, and thus are exposed to a variety

FIGURE 6-1

The Upper Arkansas Valley




Recreation
Site Facilities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of different water levels, will tend to have stronger and more well-defined preferences. Users who have only experienced one or two flow levels have less information from which to derive a preference (i.e., little to compare the experience to). Skill level, which is typically related to experience, also tends to play a strong role in defining tolerance levels and preferences. For example, highly skilled boaters often desire difficult, challenging conditions, while less skilled boaters prefer calmer, safer, less threatening conditions.

Recreation Setting

The Arkansas River Basin in Colorado is one of the nation's outstanding recreation areas. The area's natural resources attract millions of recreation visitors each year and offer abundant and outstanding opportunities for fishing, rafting, kayaking, picnicking, hiking, camping, mountain biking, and sightseeing. In addition to river-oriented opportunities, Clear Creek, Turquoise, Twin, and Pueblo Reservoirs provide a wide variety of flat-water recreation opportunities, including fishing, power boating, sailing, water skiing, and sailboarding.

Recreation use within the study area is considerable and has increased significantly over the past 7 years (see Table 6-1). In 1990, the Arkansas River supported an estimated 339,000 recreation users. In 1996, an estimated 590,000 visitors used the river for recreation, an increase of 251,000 users or 74 percent over 1990 use levels. The Arkansas River is the most popular river in the U.S. for white-water boating. Demand for lake recreation opportunities has also increased, but at a slower rate. In 1990, Lake Pueblo State Park supported an estimated 1,096,000 visitors. By 1996, this had increased to over 1,543,000 visitors, an increase of approximately 447,000 visitors or 41 percent over 1990 use levels. These use estimates are based on user counts conducted by the Colorado Division of Parks and Outdoor Recreation. According to the USDA Forest Service, in 1996, there were 50,000 visitors for camping at Turquoise Reservoir and 27,000 visitors for camping at Twin Lakes Reservoir.

Recreation activities within the study area contribute significantly to the region's economy. Survey data regarding recreational spending within the area suggest that in 1996 direct expenditures associated with recreation activities on the Arkansas River contributed over $23 million to the region's economy. Using a standard accepted economic multiplier of 2.56 (source: Colorado Visitor Expenditures Study), these expenditures equate to a total economic impact of nearly $60 million for river-oriented activities. Fees associated with just the 76,000 camping visitors at Turquoise and Twin Lakes Reservoirs contributed $235,133 to the region's economy. Using the economic multiplier, these partial expenditures equate to an economic impact of over $600,000. Economic contributions to the region from Pueblo Reservoir are estimated, using the same economic multiplier, at $34 million. In total, those recreation activities

TABLE 6-1

Trends in Annual Visitor Use (in thousands)

	1990	1991	1992	1993	1994	1995	1996
Arkansas River Recreation Area	339	402	472	518	557	545	590
Lake Pueblo State Park	1,096	1,092	1,337	1,378	1,522	1,621	1,543*

Source: Colorado Division of Parks and Outdoor Recreation

* After 1996, there is an upward trend at Lake Pueblo State Park, with annual vistor use estimates ranging from 1.7 to over 2 million from 1997-1999.

associated with the river and the reservoirs contributed nearly $95 million to the region's economy.

Generally, recreation activity within the study area is greatest between the months of April and September, with peak use occurring in June, July, and August. Table 6-2 provides the monthly use estimates for the Arkansas River and the reservoirs in the study area for 1996. Of the 590,000 users visiting the Arkansas River in 1996, about 69 percent visited the river during the months of June, July, and August. Of the 1,543,000 visitors to Lake Pueblo State Park in 1996, about 57 percent visited the lake during the months of June, July, and August. Of the 76,000 visitors to Turquoise and Twin Lakes Reservoirs during 1996, 94 percent visited the lakes during the months of June, July, and August. The visitor numbers for Clear Creek Reservoir are for anglers only. Substantial ice fishing use occurs at the upper reservoirs during the winter months (see Table 6-2).

Recreation Management

In recognition of the river corridor's outstanding recreation values, the Arkansas Headwaters Recreation Area (AHRA) was established in October 1989. Recreation management activities and resource management activities within the AHRA are directed through a cooperative effort between the U.S. Bureau of Land Management (BLM), USDA Forest Service (USFS), Colorado Division of Parks and Outdoor Recreation (CDPOR), and Colorado Division of Wildlife (CDOW). Portions of the "Pine Creek" and "Numbers" sections of the AHRA also involve cooperative management between the USFS, BLM, and CDPOR. Recreation facilities at Turquoise and Twin Lakes are managed

TABLE 6-2

1996 Monthly Visitor Use

	Arkansas River	Clear Creek Reservoir*	Turquoise Lake Reservoir*	Twin Lakes Reservoir*	Pueblo Lake Reservoir
January	7,965	796	191	138	48,174
February	7,247	796	191	138	50,428
March	14,379	796	191	138	72,541
April	19,145	796	191	138	97,499
May	54,833	1,114	631	1,066	241,062
June	115,854	2,304	8,896	3,727	361,472
July	176,133	3,134	19,198	10,737	283,385
August	112,699	2,676	18,823	9,917	238,465
September	34,572	1,920	725	149	36,087
October	27,271	796	191	138	40,975
November	9,451	796	191	138	27,453
December	10,643	796	191	138	45,291
Total	590,192	16,720	49,610	26,562	1,542,832

* Numbers for October through April are estimates only; they are not from actual counts.

Sources: Arkansas Headwaters Recreation Area, USDA Forest Service, Lake Pueblo State Park, and Colorado Division of Wildlife by the USFS. The CDOW manages recreation access at Clear Creek Reservoir and the CDPOR manages recreation at Lake Pueblo. The CDOW also has acquired and manages several easements across private lands within the river corridor for the primary purpose of providing for improved angler access. The CDOW is responsible for all facets of wildlife management within the study area, including special regulations on two sections of the river and fish stocking programs.

Approximately 60 percent of the river corridor is in private ownership, while the remaining forty percent is on Federal and State public lands. Almost all of the properties surrounding Turquoise and Twin Lakes are national forest land managed by the USFS. Lake Pueblo is surrounded primarily by State lands managed by CDPOR as Lake Pueblo State Park.

Commercial recreation activities within the AHRA are regulated through special 5-year concession agreements. As of May 1996, a total of 94 permits were in place, covering white-water boating, float fishing, walk and wade fishing, shuttles, and video and still photography. A total of 63 white-water boating outfitters are permitted to operate on the river. Permit revenues in fiscal year 95 totaled more than $410,000, and in fiscal year 96 totaled over $499,000.

Management of the Arkansas Headwaters Recreation Area is guided by the Arkansas River Recreation Management Plan developed by the BLM and CDPOR with input from a 22-member advisory committee representing a wide array of varying user groups, agencies, and other concerns. Implementation of this plan involves a continuing effort by those that developed the plan through a designated Citizen Task Force. This Citizen Task Force represents anglers, private boaters, environmental concerns, commercial boaters, landowners/cattlemen, the Upper Arkansas Area Council of Governments, and water users.

Key management issues dealt with in the plan include development of additional public access and facilities, public safety (including work with the Colorado Department of Transportation to develop better and safer highway access to recreation facilities), natural resource monitoring and management, carrying capacities for white-water boating, rationing plans for commercial outfitting uses, education and interpretation, and law enforcement. Recreation management costs are funded almost entirely through user fees, including both access/parking fees and commercial permit fees.

Management of Turquoise and Twin Lake recreation areas is guided by the San Isabel National Forest Land Management Plan. These two reservoirs are managed mainly for fishing, camping, picnicking, and boating. Clear Creek Reservoir is managed by the City of Pueblo's Board of Public Water Works in partnership with the CDOW. The reservoir is managed mainly for fishing and boating, as well as for some limited camping. Pueblo Reservoir is operated by the Bureau of Reclamation (BOR) in partnership with the CDPOR and CDOW. Recreation use of Pueblo Lake State Park is guided by the Lake Pueblo State Park Management Plan.

River Recreation

The physical characteristics of the Arkansas River vary considerably from Leadville to Pueblo (about 150 miles). These different physical settings provide for different recreation opportunities in terms of access, activities, and experiences. Table 6-3 briefly describes each of the primary river segments and lists the identified management focus for each segment, as defined in the Arkansas River Recreation Management Plan. Table 6-4 briefly illustrates the established carrying capacities by river segment, season, and launch window, as defined in the Arkansas River Recreation Management Plan.

Recreation activity on the Arkansas River varies from year to year. Recent use estimates developed by the CDPOR and CDOW indicate that approximately 50 percent of river use is for

TABLE 6-3

River Segment Descriptions and Water-Based Recreation Values

Segment	Description	Recreation Values
1. Leadville to Buena Vista	The upper reaches of this segment provide fairly quiet, calm waters. Below Granite, the river changes dramatically as it flows into a narrow canyon culminating at Pine Creek rapids (Class V-VI). Below Pine Creek, the river offers kayakers and rafters technically challenging waters (Class III-V) all the way to Buena Vista, especially in the popular "Numbers" section. Fishing is very good in this upper segment, especially between Kobe Access Site down to the Granite Gorge. Recreational gold panning is popular in this segment.	~ Angling ~ Boating (technical white-water kayaking; no commercial boating above Granite)
2. Buena Vista to Salida	This segment of the river receives the most intense recreation use focused especially on the popular "Browns Canyon" section. Browns Canyon offers outstanding fishing, camping, and picnicking, as well as challenging white-water boating opportunities (Class II-IV). Below Browns Canyon, the valley widens as the river passes through the Big Bend section. This area offers prime trout fishing opportunities and includes numerous access easements across private lands to access points on public lands.	~ Wildlife observing ~ Angling ~ Boating (white water rafting/kayaking, quiet-water boating, float fishing)
3. Salida to Vallie Bridge	Deep pools, rock banks, and gravel bars are common in this segment of the river, making it particularly attractive and enjoyable for anglers. The segment also contains a number of intermediate white-water rapids. Angling access in this area is provided by many access easements across private lands and numerous public recreation sites.	~ Wildlife observing ~ Angling ~ Boating (some sections offer white-water rafting, quiet water boating, float fishing)
4. Vallie Bridge to Parkdale	The river drops sharply in this segment with numerous white-water sections of the river. This segment is intensively used by anglers and white-water boaters (Class III-IV). Viewing bighorn sheep is very popular at many locations in this segment. Recreational gold panning is popular in this segment as well. Numerous public recreation access points and sites are in this segment.	~ Wildlife observing ~ Angling ~ Boating (white water rafting/kayaking with some quiet water boating and float fishing)
5. Parkdale to Cañon City	This segment of the river is dominated by the more than 1000-foot-deep Royal Gorge. The river is used extensively for white-water boating. Sightseeing is very popular, especially from the Royal Gorge City Park.	~ Angling ~ Boating (technical white-water rafting/kayaking) ~ Sightseeing
6. Cañon City to Pueblo Reservoir	Below Cañon City, the river changes into a quiet, meandering, Great Plains-type river. A wide ribbon of cottonwood and willow trees creates an important riparian/wetland zone for wildlife. Some angling and canoeing occur in this segment, but it receives much less recreation use than the other river segments. The river offers excellent wildlife viewing and quiet-water float fishing opportunities.	~ Wildlife observing ~ Angling ~ Boating (mostly canoeing and float fishing)

Source: Arkansas Headwaters Recreation Area

TABLE 6-4

Carrying Capacities by Season and Segment

Segment	Primary Use	Location: From-To	Capacities (Boats Per Day) Private	Capacities (Boats Per Day) Commercial	Seasons	Windows
1A	Fisheries rehabilitation	Leadville-Granite	10	0	Year-round	None
1B	Private boating	Granite-RR Bridge	350	30	5/15 - Labor Day	Rafts launch 8:30 a.m.-11:00 a.m.
			[200]	[10]	[Labor Day - 5/14]	[same]
1C	Mixed boating	RR Bridge-Buena Vista	150	150	5/15 - 8/14	None
			[100]	[50]	[8/15 - 5/14]	
2A	Commercial boating	Buena Vista-Big Bend	150	450	5/15 - Labor Day	None
			[100]	[50]	[Labor Day - 5/14]	
2B	Multiple use recreation	Big Bend-Salida	150	150	5/15 - 8/14	Comm. off river by 5:00 p.m.
			[30]	[10]	[8/15 - 5/14]	[same]
3	Fishing	Salida-Vallie Bridge	150	150	5/15 - 7/14	Comm. off river by 5:00 p.m.
			[30]	[10]	[7/15 - 5/14]	[same]
4A	Multiple use recreation	Vallie Bridge-Texas Creek	100	150	5/15 - 8/14	Comm. off river by 5:00 p.m.
			[30]	[10]	[8/15 - 5/14]	[same]
4B	Multiple use recreation	Texas Creek-Parkdale	150	300	5/15 - Labor Day	Comm. off river by 5:00 p.m.
			[30]	[30]	[Labor Day - 5/14]	[same]
5	Technical white-water boating and fishing	Parkdale-Cañon City	150	150	5/15 - Labor Day	None
			[75]	[30]	[Labor Day - 5/14]	[same]
6	Specialty quiet-water w/fishing	Cañon City-Pueblo Reservoir	35	35	Year-round	None

Notes: Riverwide commercial launch window is 8:30 a.m. to 3:30 p.m.; [ ] designates off-season;
Float fishing trips must occur within carrying capacity trips.
Source: Arkansas Headwaters Recreation Area

boating activity, 30 percent is for sightseeing, between 5 and 16 percent is for fishing, 5 percent is for picnicking, and 3 percent is for camping. Of these uses, the two primary activities that are most directly affected by changes in riverflow are angling and boating. The range of river angling use presented above represents different estimates calculated by CDPOR and CDOW (as described under "Angling").

Angling

The Arkansas River offers excellent angling opportunities along its entire length and is well-known for its outstanding brown trout fishery. Opportunities for wade fly angling are particularly good in segments 1, 2, and 3, due to a predominance of shallow water habitat and easy public access. Float fishing is popular in segments 2, 3, 4, and 6. Bait and lure angling are particularly popular in segment 4. Both brown and rainbow trout catches in the river average 10 to 12 inches, but there is the possibility of an occasional trophy catch.

The majority of the anglers on the river are fly fishing anglers. Results from a 1995 CDOW creel census indicate that 54 percent of the anglers were fly fishing, 28 percent were lure fishing, and 18 percent were bait fishing. While the vast majority of the angling is "walk and wade," a number of users also "float fish" on the river. Both commercial walk and wade and commercial float fishing outfitters operate on the river. Statistics maintained by CDPOR indicate that a total of 3,109 commercial clients engaged in float fishing on the river in 1996. Throughout the remainder of this report, the lure and bait fishing narratives, tables, and charts will be combined.

Total annual angling use of the river is difficult to estimate due to the length of the river, multiple access points, and different counting techniques employed by CDOW and CDPOR. Statistics compiled by the Arkansas Headwaters Recreation Area and CDOW indicate that somewhere between 23,753 and 67,973 anglers visited the upper Arkansas River in 1995. Table 6-5 presents monthly angling use estimates developed by the Arkansas Headwaters Recreation Area for 1995. Table 6-6 presents angling use estimates prepared by CDOW for that same year (by geographic river reach).

Angler use estimates presented in Table 6-5 are based on year-round daily counts conducted during routine field patrols for approximately 125 miles of the river from the Cañon City area up to the Kobe Access Site. Daily counts have been extrapolated to account for areas and times not observed.

TABLE 6-5

Arkansas Headwaters Recreation Area River Angling Use Estimates - 1995

Month of Field Count	Anglers Counted
January	439
February	630
March	1,595
April	1,478
May	2,433
June	979
July	2,859
August	3,984
September	3,294
October	4,547
November	863
December	652
Annual Total	23,753

Source: Arkansas Headwaters Recreation Area

Use estimates presented in Table 6-6 are based on creel survey data collected by CDOW from April through September 1995. Angling use on private property was assumed to be 25 percent of that on public lands. Use within individual river segments was also expanded by 25 percent to estimate annual angler use. Table 6-6 displays those areas where surveys were conducted; the river reach where that creel area data was extrapolated to; what part of the reach is publicly or privately owned; and the estimated anglers in those reaches. Figure 6-2 displays the location of the 1995 creel surveys. This data represents approximately 100 river miles from Parkdale upriver to the Kobe Bridge.

Differences between the estimates shown in Tables 6-5 and 6-6 are due to the different sampling methodologies employed by the Arkansas Headwaters Recreation Area and CDOW, including different sampling locations and sampling times and different extrapolation techniques. While no attempt has been made to calculate the error functions associated with these two estimates, it is likely that the margin of error for both estimates is relatively large. This is

TABLE 6-6

Colorado Division of Wildlife Arkansas River Angling Use Estimates - 1995

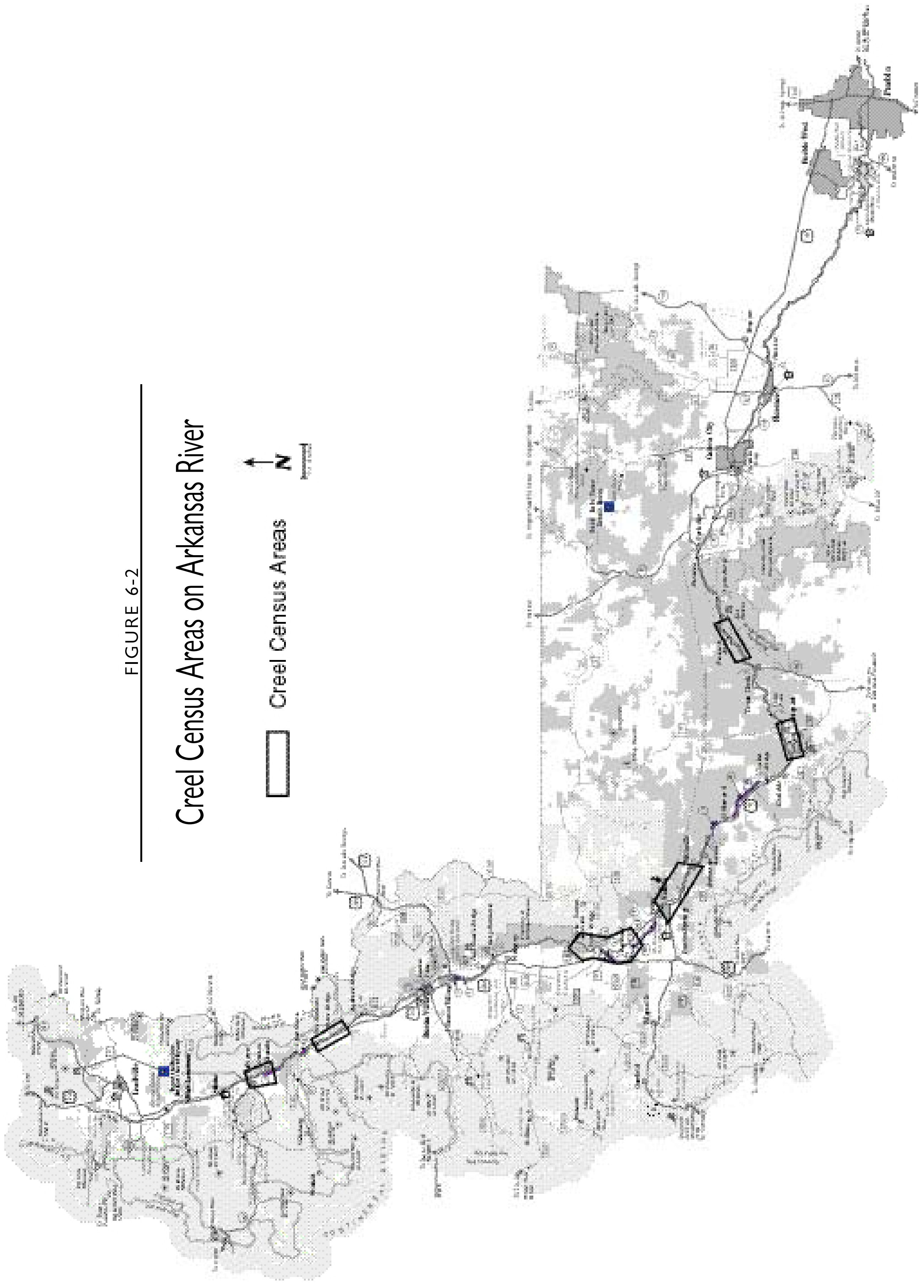
		Public			Private (Note: private anglers/mile are 25 percent of public anglers/mile)			
Creel census area name and miles	Extrapolated river reach and miles	Anglers per mile	Miles	Total anglers	Anglers per mile	Miles	Total anglers	Total anglers
Floodplain to Pinnacle Rock (3.0 miles)	Parkdale - Texas Creek (13.3 miles)	786	13.3	10,454	0	0	0	10,454
Lone Pine to Big Cottonwood Crk (3.0 miles)	Texas Crk - Lazy J (12.0 miles)	1,550	4.8	7,440	388	7.2	2,794	10,234
	Lazy J - Upper Howard Brdg (8.3 miles)	1,550	3.1	4,805	388	5.2	2,018	6,823
Badger Crk to Stockyard Bridge (6.4 miles)	Howard Brdg - Stockyard Brdg (11.4 miles)	792	5.2	4,118	198	6.2	1,228	5,346
County Road 166 to Big Bend (2.0 miles)	Stockyard Brdg - Stone Brdg (10.9 miles)	702	7.8	5,476	175	3.1	543	6,019
	Stone Brdg - Ruby Mtn (11.2 miles)	702	10.2	7,160	175	1.0	175	7,335
	Ruby Mtn - Hwy 285 Brdg (6.0 miles)	702	1.8	1,264	175	4.2	735	1,999
Railroad Bridge to Otero Bridge (3.1 miles)	Hwy 285 Brdg - Otero Brdg (9.0 miles)	256	6.2	1,587	64	2.8	179	1,766
Granite Gorge to Chaffee/Lake County Line (1.0 mile)	Otero Brdg - Granite Brdg (7.8 miles)	256	5.0	1,280	64	2.8	179	1,459
	Granite Brdg - Kobe Brdg (6.0 miles)	1,343	2.0	2,686	336	4.0	1,344	4,030
	Totals	–	59.4	46,270	–	36.5	9,195	55,465
	Total Annual Anglers							67,973*

Source: Colorado Division of Wildlife

* Extrapolated by 25 percent to include the remaining river miles not covered by the creel census.

FIGURE 6-2

Creel Census Areas on Arkansas River



common for extrapolations that attempt to estimate annual recreation use over a large geographic area that is influenced by many uncontrolled variables such as weather. Combined, the two estimates provide a general range of estimated angling use on the river.

White-Water Boating

The upper Arkansas River is one of the most popular white-water boating rivers in the United States. The river offers a broad variety of boating experiences from easy Class I (beginner) to challenging Class V-VI (experts only), and boasts several nationally recognized white-water boating sections including the Numbers, Browns Canyon, and Royal Gorge. Few other rivers in the country offer the combination of diversity and accessibility available along the Arkansas River.

White-water boating use on the river includes both private and commercial users. Commercial rafting activities are focused in three segments of the river: Browns Canyon (segment 2); Pinnacle Rock (segment 4); and Royal Gorge (segment 5). Over 60 commercial outfitters are permitted to operate on the river. Private boating (rafting and kayaking) is also concentrated in these three segments, but is common in other areas, particularly Numbers (segment 1). White-water boating opportunities (particularly commercial opportunities) attract large numbers of visitors to the Arkansas River. Figures 6-3, 6-4, and 6-5 provide maps of the river corridor.

Boating use of the river has increased significantly (approximately 34 percent) over the past 5 years with over 287,000 boaters estimated for all of 1996. The river is heavily used by commercial white-water companies that offer full-day and half-day trips on various sections of the river. This commercial use dominates the white-water boating activity, accounting for over 90 percent of the total boating activities on the river (see Table 6-7).

Reservoir Recreation

At the upper end of the Arkansas River Basin, Turquoise Reservoir, Twin Lakes, and Clear Creek Reservoirs provide shoreline and boat angling opportunities in a scenic, high-altitude mountain setting. Total recreation use at these upper reservoirs is shown in Tables 6-1 and 6-2. Maps of Turquoise and Twin Lakes and their existing

TABLE 6-7

River Boating Use 1991-1997 (May through September)

Year	Commercial Clients	Private Individuals	Total Boaters
1991	157,862	18,569	176,431
1992	181,716	15,948	197,664
1993	185,123	22,871	207,994
1994	201,040	22,890	223,930
1995	199,109	22,487	221,596
1996	228,153	23,115	251,268
1997	235,931	21,287	257,218

Source: Arkansas Headwaters Recreation Area

FIGURE 6-3

Upper Section-Upper Arkansas River Basin

FIGURE 6-4

Middle Section-Upper Arkansas River Basin

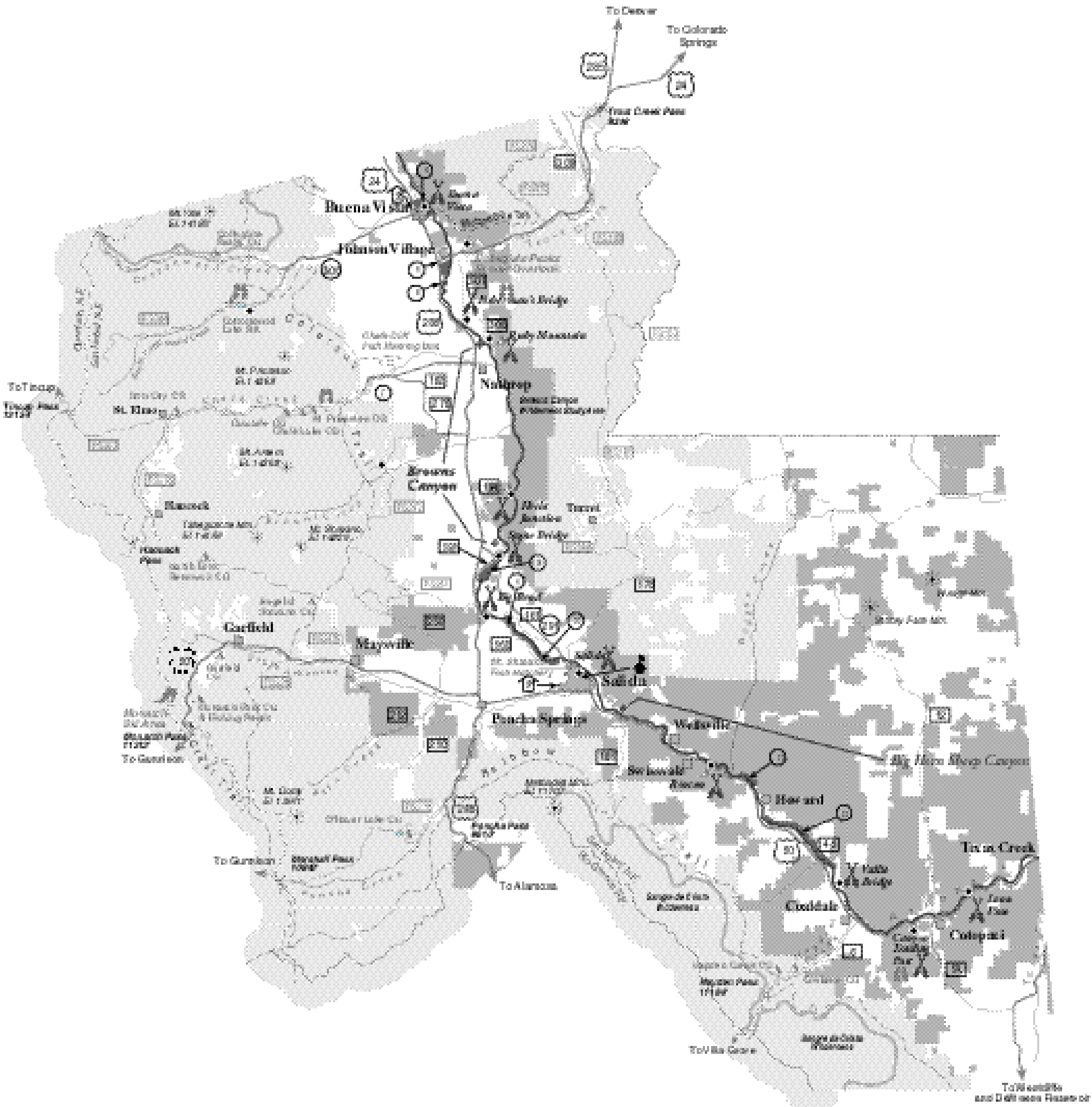
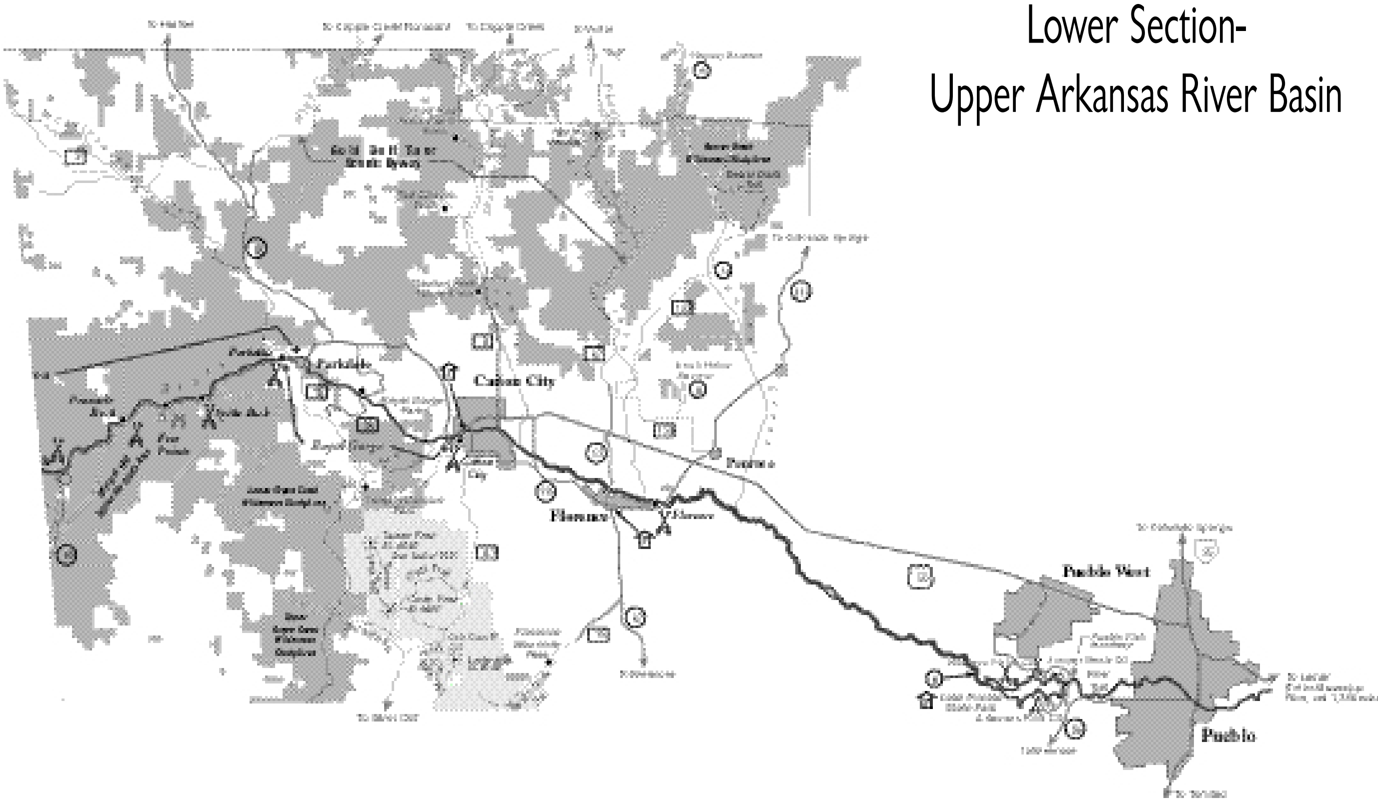


FIGURE 6-5



recreation facilities are shown in Figures 6-6 and 6-7. Table 6-8 describes the recreation values that exist at the basin reservoirs.

At the downstream end of the study area, Pueblo Reservoir offers opportunities for more intensive water sports and a wide range of boating activities. Pueblo Reservoir also offers opportunities for warm- and cold-water fishing. A map of Lake Pueblo State Park and its associated recreation areas is shown in Figure 6-8. Lake Pueblo State Park is one of the heaviest used State Parks in Colorado, accommodating 1.7 million visitors a year. Total recreation use at Lake Pueblo State Park for 1990-1996 is shown in Table 6-1.

Angling

The four upper basin reservoirs offer excellent angling opportunities. They are known for the variety of fish species that reside there. Lake trout and rainbow trout are the most caught species at Turquoise and Twin Lakes Reservoirs, while rainbow trout comprise the majority of the anglers' catches at Clear Creek Reservoir. Eighty percent of angling is from shore, while 20 percent occurs from a boat. At Pueblo Reservoir, smallmouth bass and walleye are the most caught species. Approximately 30 percent of Pueblo Reservoir visitors are anglers, the majority fishing from boats (57 percent). CDOW and CDPOR angling use estimates are shown in Table 6-9. The majority of angling use occurs in June, July, and August at these waters; however, use does take place the remainder of the year as well (e.g., ice fishing at the upper reservoirs and open-water fishing throughout the year at Pueblo Reservoir).

Boating

Boating takes place on all four reservoirs. Boating on the upper three reservoirs is mainly tied to boat angling, sailing, and pleasure power boating. Boating on Pueblo Reservoir includes power boating, boating for water skiing, personal watercraft operation, sailboating, sailboarding, and general pleasure boating.

FIGURE 6-6

Turquoise Lake

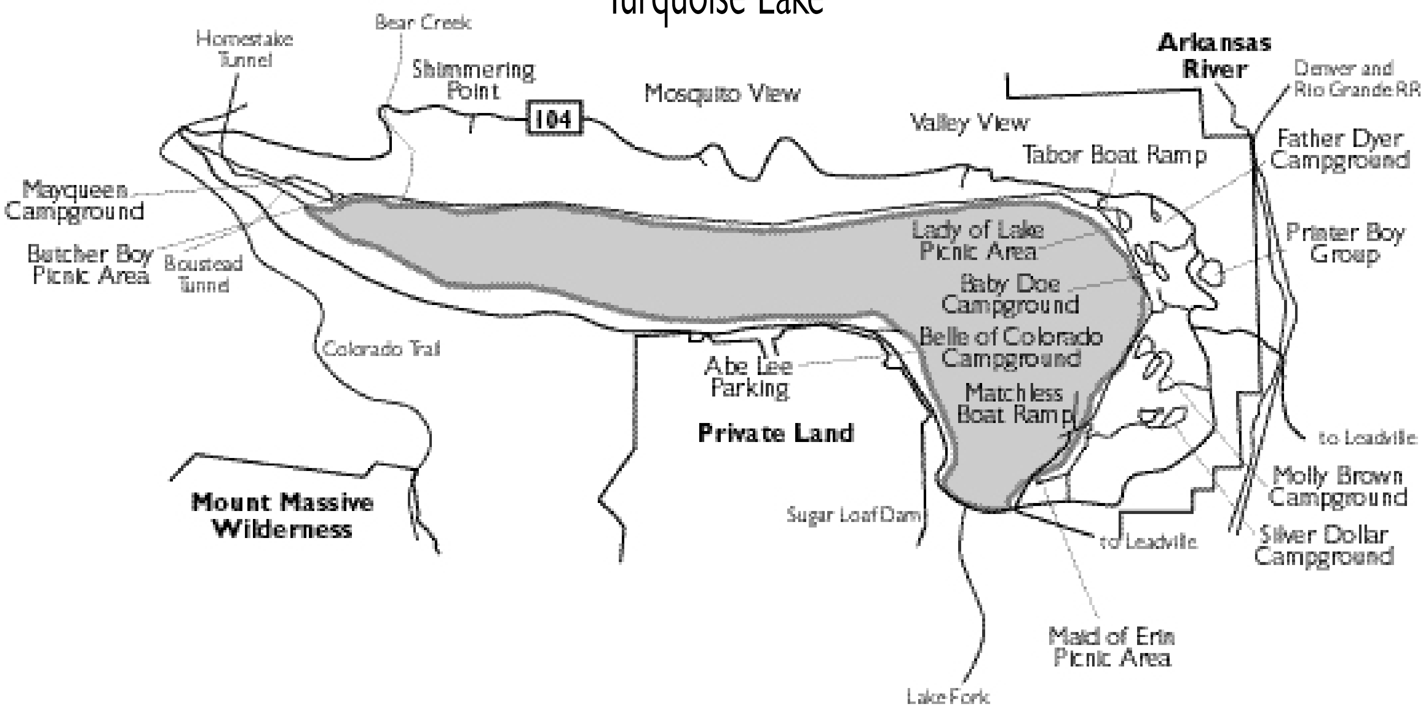


FIGURE 6-7

Twin Lakes

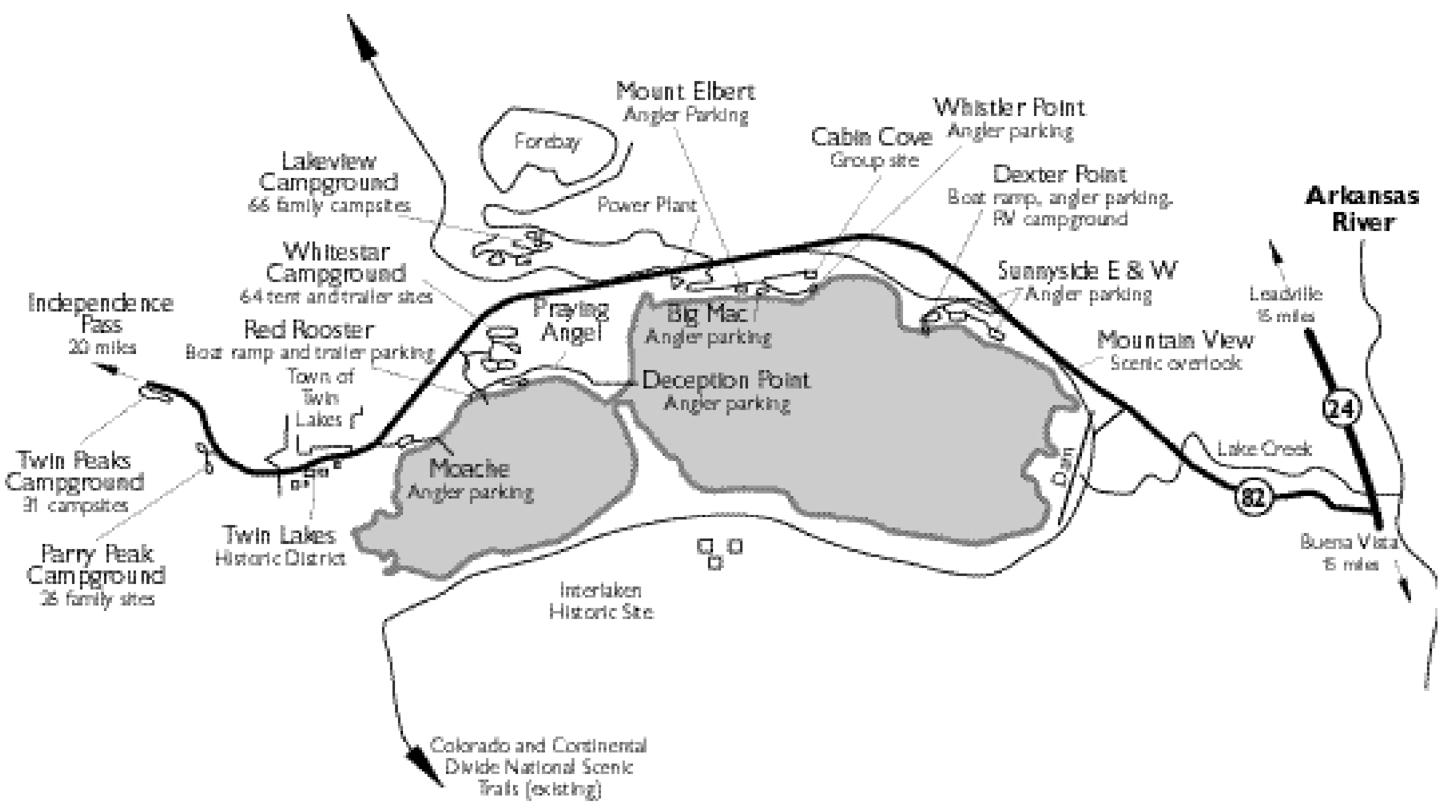


TABLE 6-8

Reservoir Recreation Values

Reservoir(s)	Description	Reservoir Values
Upper Reservoirs (Turquoise, Twin Lakes, and Clear Creek)	These reservoirs are located near the upper end of the study area, offering high-elevation recreation opportunities including fishing, boating, camping, and picnicking. Most of the recreation activities at these reservoirs occur during June, July, and August, except for winter ice fishing.	~ Fishing (shore, ice, and boat fishing) ~ Boating
Pueblo Reservoir	Lake Pueblo State Park, located at Pueblo Reservoir, offers opportunities for swimming, boating, water skiing, wind surfing, camping, and both warm- and coldwater fishing. The reservoir is one of the most intensively used State Parks in Colorado. Most of the recreation use occurs in April, May, June, July, August, and September, except for winter fishing. There are significant recreational opportunities at this reservoir throughout the year as well.	~ Fishing (shore, ice fishing, and boat) ~ Water skiing ~ Power boating ~ Personal watercrafts ~ Sailboarding ~ Sailboating

FIGURE 6-8

Pueblo State Park

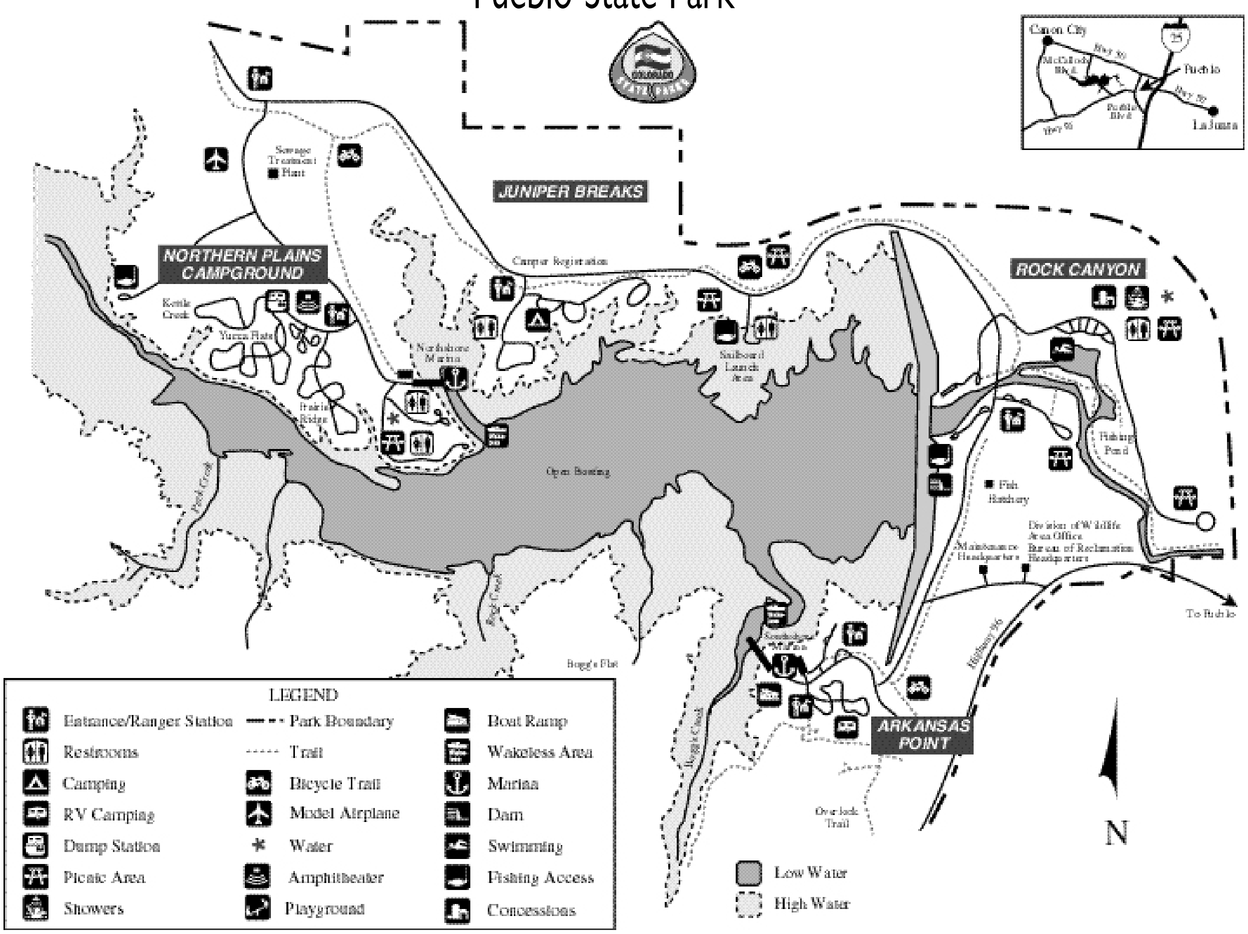


TABLE 6-9

Reservoir Angling Estimates 1994-1998

	Twin Lakes (1995) [1]	Turquoise (1997) [1]	Clear Creek (1995) [1]	Pueblo (1998) [2]
January	138	191	796	9,500
February	138	191	796	15,210
March	138	191	796	35,560
April	138	191	796	52,800
May	141	191	1,114	55,800
June	543	2,522	2,304	66,880
July	579	2,638	3,134	60,440
August	519	1,766	2,676	56,500
September	149	725	1,920	38,400
October	138	191	796	20,100
November	138	191	796	15,500
December	138	191	796	13,200
Total	2,897	9,179	16,720	439,890

[1] Source: Colorado Division of Wildlife and USDA Forest Service (Angler use in the winter was estimated, not surveyed, to be 50 percent of the summer use at Twin Lakes and Clear Creek Reservoirs, 20 percent at Turquoise Reservoir, and 10 percent at Pueblo Reservoir.)

[2] Source: Colorado Division of Parks and Outdoor Recreation

Hydrology and Water Augmentation

Riverflows within the upper Arkansas River vary considerably from month to month and year to year depending on precipitation, weather, natural runoff patterns, and operation of the BOR's Fryingpan-Arkansas Project. Figure 6-9 displays the mean daily base flows for three periods of time. Figure 6-10 displays an average hydrograph for the upper Arkansas River. The solid black line represents the average of the mean monthly flow as measured at the Wellsville gaging station for water years 1991 to 1995. Mean monthly flows for water years 1995 and 1996 are shown as dashed lines in Figure 6-10 as an indication of the variability that can occur from one year to the next. Riverflows are particularly variable during spring runoff, which generally occurs from May through June. In wet years, such as 1995, relatively high riverflows are common in the river well into August and September. In dry and average years, the spring runoff is generally shorter in duration and smaller in magnitude.

Riverflows within the study area are regulated to some degree by the operation of the Fryingpan-Arkansas Project and releases from Turquoise and Twin Lakes. The Fryingpan-Arkansas Project was designed and built to capture, store, and regulate "nonnative" water (i.e., waters diverted from the western slope) primarily for the purpose of providing irrigation water for agricultural use downstream. Overall, project operations increase the total amount of water that flows through the system by an average of 69,500 acre-feet annually, relative to preproject conditions. Nonnative, project water is generally stored in Turquoise and Twin Lakes Reservoirs during the spring and released in late fall and winter. These releases augment native flows and increase the total flow of the river. Timing of releases, riverflows, and reservoir levels are also affected by the needs and calls of water rights owners in coordination with the State Engineer's Office.

FIGURE 6-9

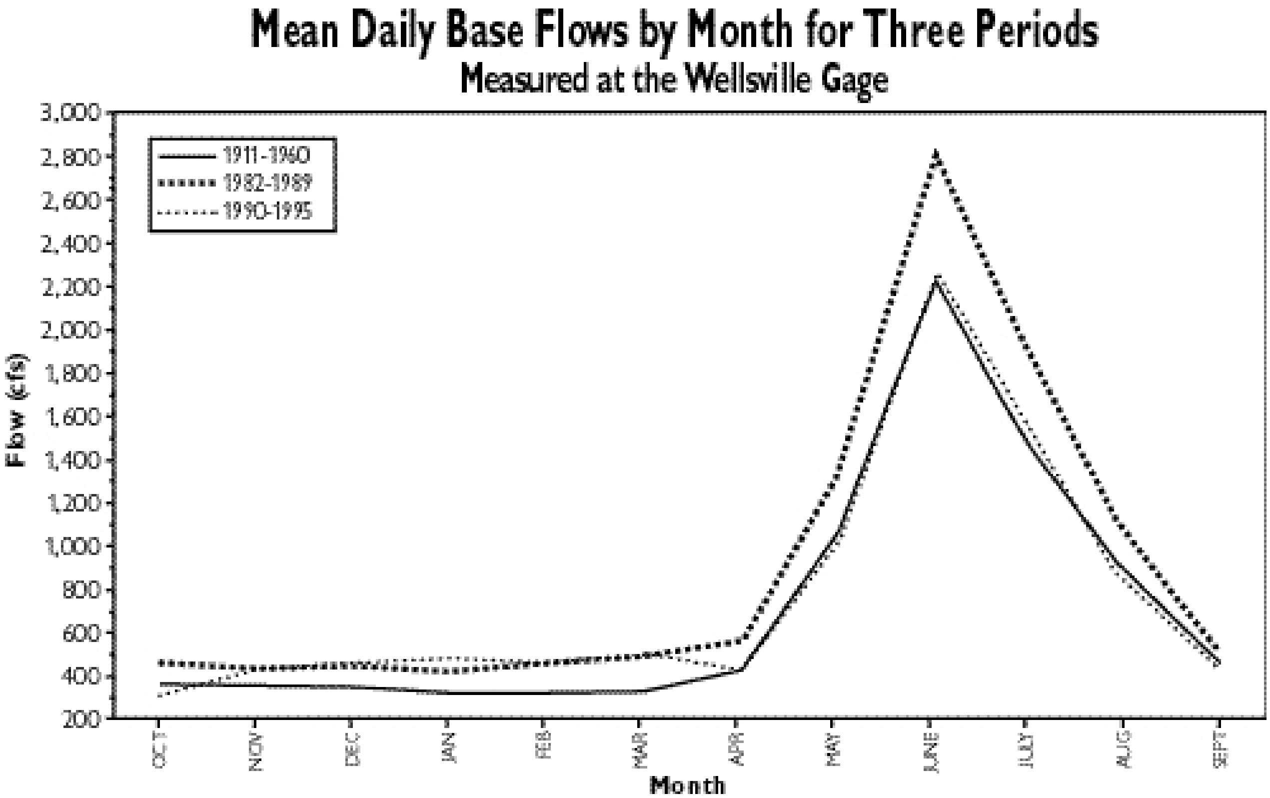
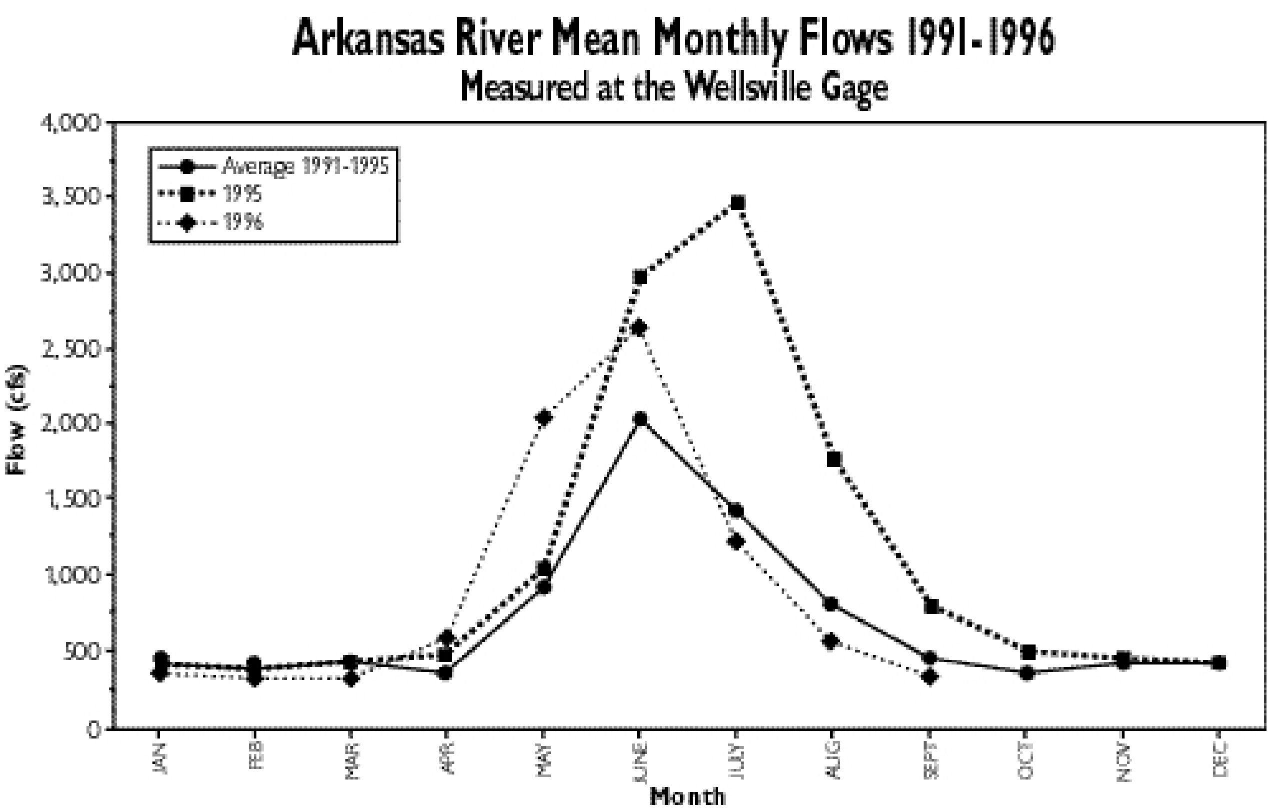


FIGURE 6-10



In 1990, an annual flow program was initiated to enhance white-water boating, river angling opportunities, and the fishery resource. Under this program, Fryingpan-Arkansas project operating procedures have been modified when feasible and used to maintain minimum acceptable flows on a year-round basis. This has been accomplished by changing Fryingpan-Arkansas releases and municipal flow releases from fall periods to mid- to late summer periods. When native flows in the river have dropped below specified levels, project water has been released to augment that low flow. The distribution of the augmentation water differs from year to year depending on native flow conditions.

Following are the key elements of this annual flow program (as paraphrased from the 1998-1999 annual flow letter to BOR):

- ~ The highest priority is the maintenance of a minimum year-round flow of at least 250 cfs to protect the fishery.

- ~ Winter incubation flows (mid November through April) should be maintained at a level of not more than 5 inches below river height during the spawning period (October 15 to November 15). The optimum flow range is from 250 to 400 cfs, depending on spawning flows:

Minimum Incubation Flow November 16 - April 30		**Spawning Flow** October 15 - November 15
250 cfs	if	300 - 500 cfs
325 cfs	if	500 - 600 cfs
400 cfs	if	600 - 700 cfs

- ~ To the extent possible, between April 1 and May 15, the Bureau of Reclamation (BOR) should maintain flows within the range of 250 to 400 cfs in order to provide conditions favorable to egg hatching and fry emergence.

- ~ Deliveries in excess of 10,000 acre-feet should be subject to review and consideration, prior to such deliveries, by the BOR and the Southeastern Colorado Water Conservancy District.

- ~ Subject to water availability, BOR should augment flows during the July 1 to August 15 period at 700 cfs through releases from the Fryingpan-Arkansas River Project. The 700 cfs level is a target; when augmentation occurs, every effort should be made to ensure that flows are as little above, or as little below, 700 cfs as possible. The Colorado Division of Parks and Outdoor Recreation (CDPOR), using funds collected from commercial outfitters, shall be responsible for replacing evaporative losses caused by summer augmentation.

- ~ BOR should avoid dramatic fluctuations on the river as much as possible throughout the year. When it is necessary to alter flow rates, BOR should limit the daily change to 10-15 percent.

- ~ It may be possible to improve feeding conditions for brown trout by reducing flows between Labor Day and October 15 in years when flows would otherwise be higher than those recommended by the Colorado Division of Wildlife (CDOW). If potential benefits warrant the effort, Arkansas Headwaters Recreation Area (AHRA) managers, the CDOW, BOR and the Division II Engineer should work with the water users to seek opportunities for reducing flows after Labor Day.

Water lost to evapotranspiration due to the summer augmentation program (and the fact that waters are being released during the hot summer months as opposed to the cooler winter months) is paid for by commercial boater fees and released to water users by AHRA. A provision within the flow program maintaining flows of 700 cfs from July 1 through August 15 has caused concerns regarding potential impacts on the river fishery associated with flow conditions during the late summer. These concerns prompted implementation of a detailed water needs assessment for the river, of which this report is a component.

Water levels at Turquoise, Twin Lakes, and Pueblo Reservoirs are determined primarily by natural runoff conditions and project operations. Typically, the upper reservoirs (Turquoise and Twin Lakes) are lowered during the late fall and winter months to make storage space available for the following spring runoff. The reservoirs are generally filled in June and July and remain relatively full until they are drafted again in the fall. Lake Pueblo is operated somewhat differently. Rather than maximizing spring storage, the reservoir fills during the winter months (as the upper reservoirs are drafted). Lake levels typically peak in May or June, then decline steadily over the summer months in response to downstream irrigation demands. Figures 6-11 through 6-13 display monthly lake levels at the three reservoirs during the calendar year 1996.

Assessment Methodology

Two recreation user surveys were specifically designed and implemented for the purpose of assessing recreation water needs within the study area; one was oriented towards river recreation, and one was oriented towards reservoir recreation. In addition to these two user surveys, several other secondary data sources were reviewed and evaluated. Information from these secondary sources was used to test the accuracy and validity of the primary survey data. Where appropriate, results were compared, contrasted, and combined to provide the most accurate and comprehensive analysis possible. The overall goal of this approach was to obtain multiple viewpoints using multiple evaluation techniques as a means of corroborating findings and minimizing

FIGURE 6-11

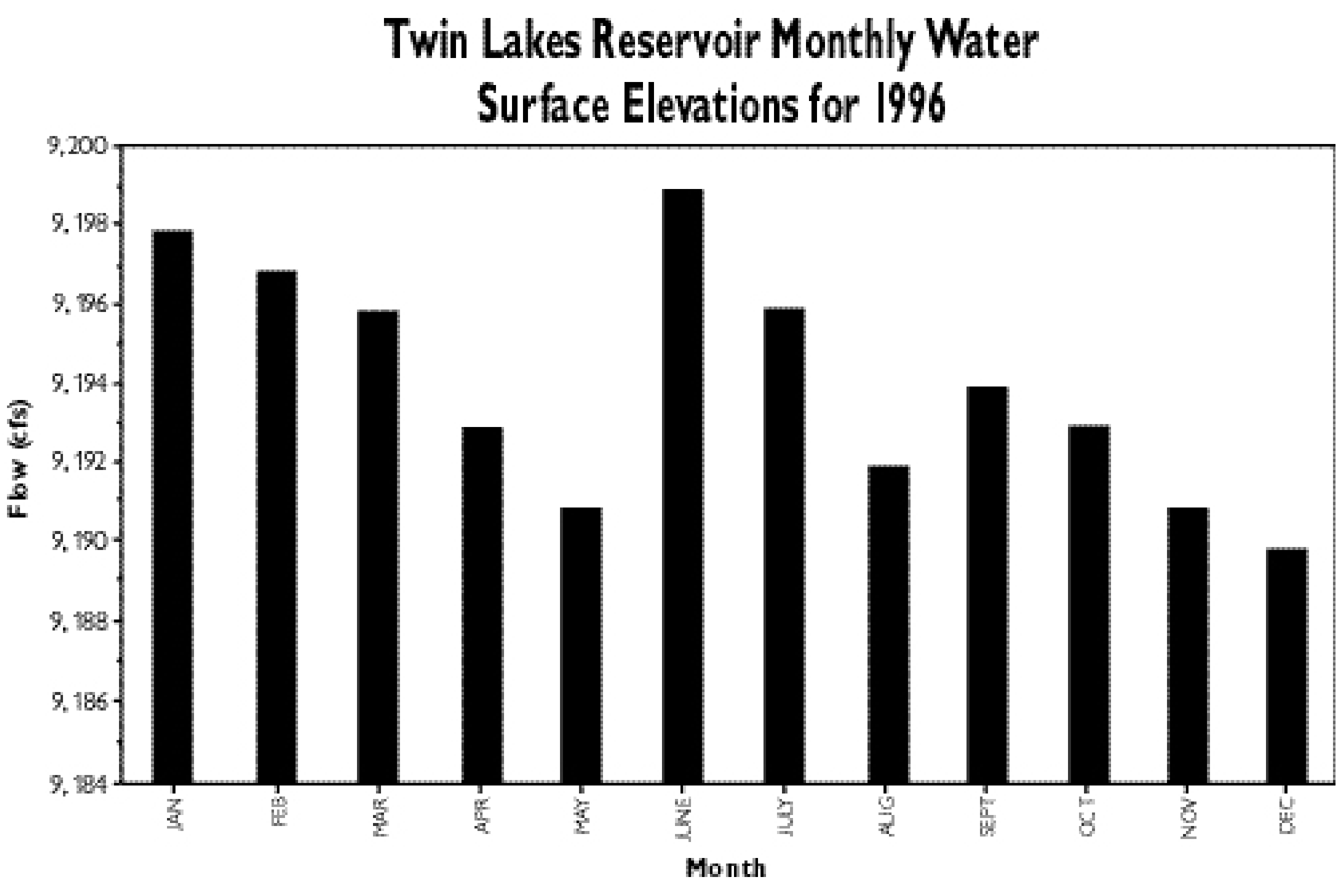


FIGURE 6-12

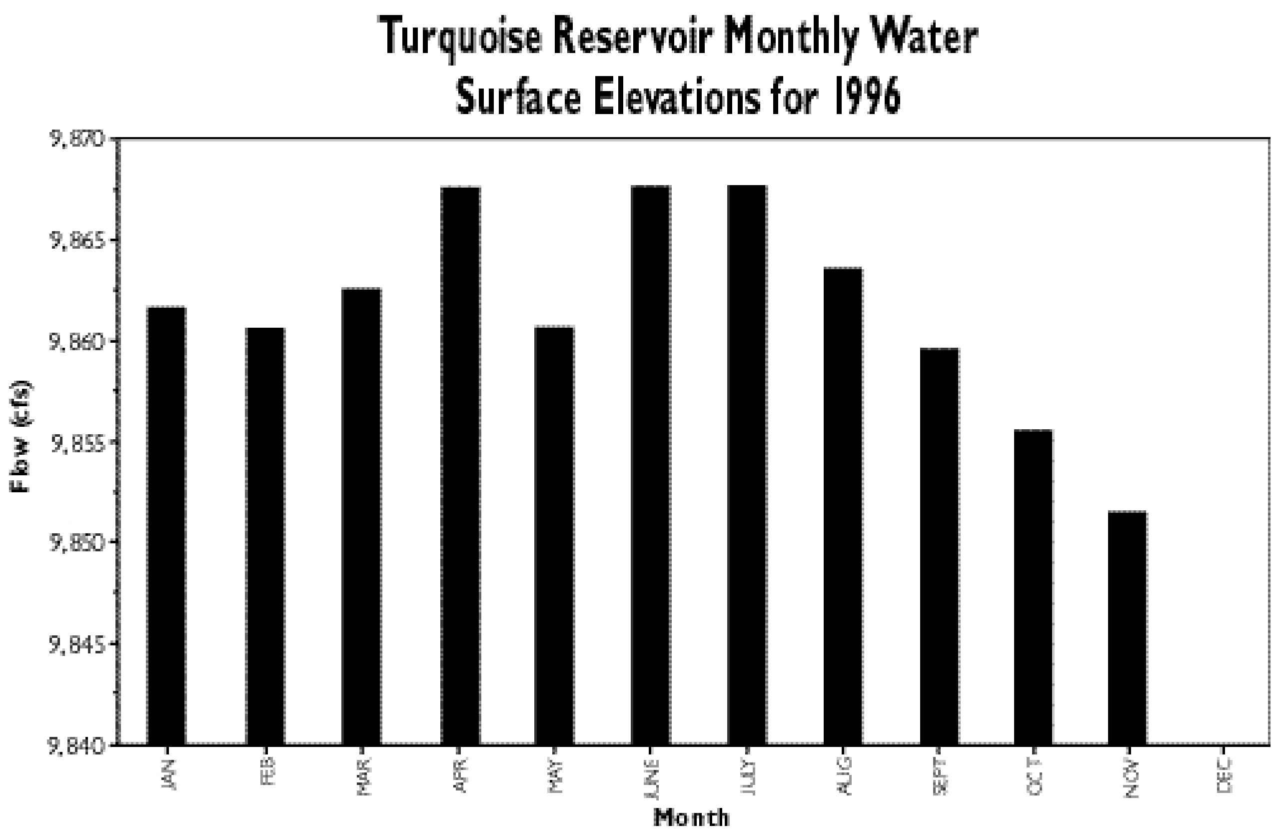
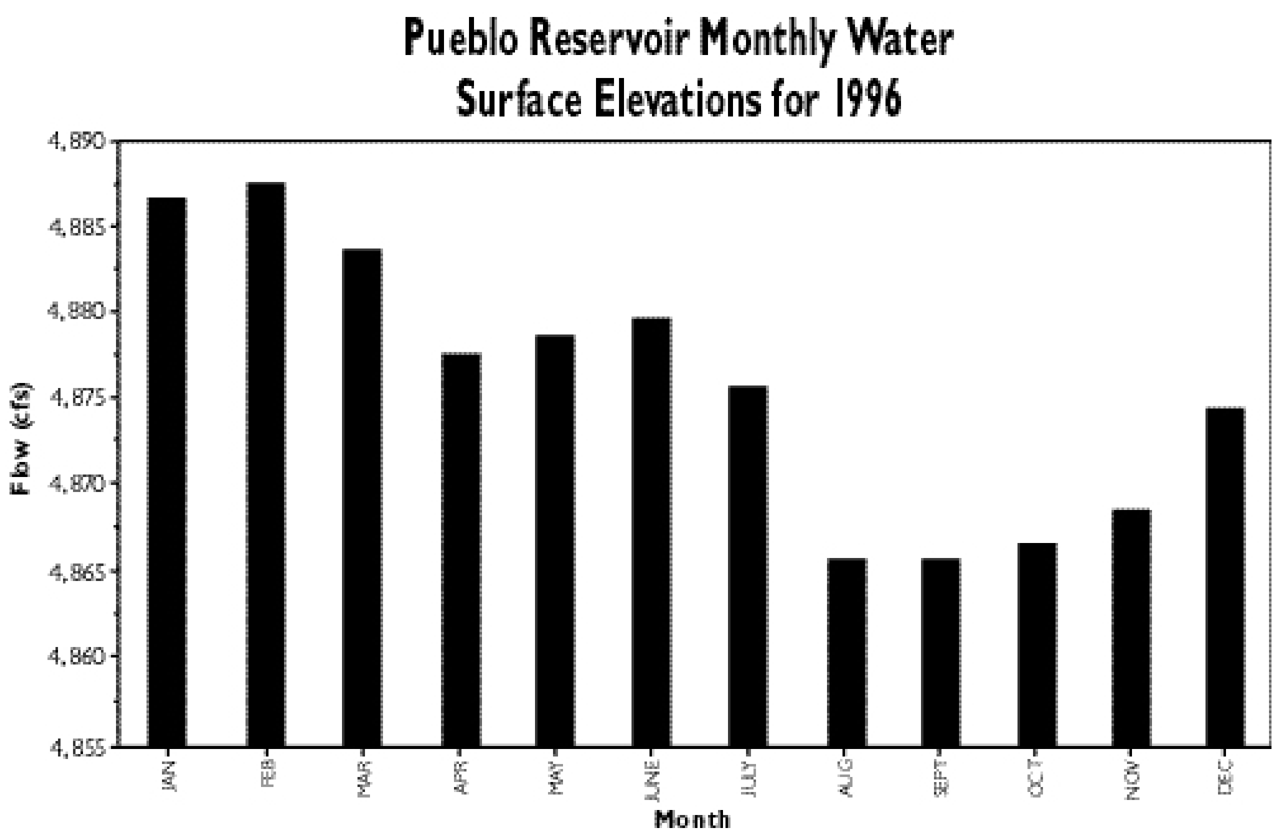


FIGURE 6-13



potential bias that could be associated with reliance on only one assessment technique. In total, information from over 4,000 different users was used in determining water needs for river and reservoir recreation.

The two primary data sources (1994 reservoir user survey and 1995 river user survey) were specifically designed with the intent of evaluating river and reservoir water level needs. Both surveys relied on widely accepted social survey techniques that have been applied elsewhere to evaluate similar relationships. The methods were selected to provide the best available information given the particular circumstances for the Arkansas River. In the case of the reservoir surveys, because little existing information regarding users and user preferences was available, user contact surveys were designed and employed specifically to gather data on user opinions at discretely different lake levels. Considerable time was spent by the CDPOR and CDOW at each of the reservoirs to maximize the sample sizes of the data sets for each lake level. Rigorous statistical tests were applied to this data by staff at Colorado State University to evaluate relationships between lake levels and a variety of measures of user satisfaction. The data set was sufficiently robust to accommodate these analyses.

With regard to the river data and the 1995 river user survey (as described below), off-site surveys of knowledgeable, experienced users (often referred to as flow comparison surveys) are recognized as one of the best methods for establishing flow preference curves. This technique provides a series of individual preference curves (based on actual, past experiences) that can be aggregated to develop overall curves for specific recreation activities. The technique allows the researcher to control both the flow being evaluated and the user conducting the evaluation. In the case of the Arkansas River, the presence and relative accessibility of so many frequent, experienced river users makes this assessment technique an ideal choice. In designing and implementing the survey, a focus group was assembled to pretest the survey instrument and a comprehensive mailing list was compiled to ensure that a range of different users were sampled. Ultimately, the survey yielded responses from over 400 users.

The statistical reliability of this data and its conclusions were strengthened by comparing and contrasting the results with several other surveys, as described in detail under "Results." This technique allows for cross referencing and provides additional protection against bias that could be associated with one particular study or assessment technique. This technique also allows for further examination of the variability in the data, not only within a given data set, but from one data set to another, which has tremendous value in evaluating the overall congruency of the data. Specific statistical analyses employed are described in more detail below and under "Results." Ultimately, the results from all the various data sources examined are remarkably similar, particularly given the inherent variability associated with recreation analyses that attempt to identify preferences for large populations representing a broad diversity of activities and interests (see "Results").

Data Sources

The data sources that were reviewed, evaluated, and analyzed to determine water needs for recreation on the Arkansas River and its associated storage reservoirs included:

Primary Data
1994 reservoir user survey
1995 river user survey

Secondary Data
1991 river user survey
Creel census data
1994 focus group meeting
Arkansas Headwaters Recreation Area visitor use data
Physical habitat modeling data
Reservoir surface area/elevation curves

These data sources include surveys of experienced users, casual users, private boaters, commercial boaters, and anglers of all types for all six segments of the river from Leadville to Pueblo Reservoir and all four of the basin reservoirs. Of the users surveyed regarding river conditions, approximately 70 percent were anglers and 30 percent were boaters. Activities surveyed at the reservoirs differed according to the individual reservoir. Tables 6-10 and 6-11 summarize survey data used for the river analysis. Table 6-12 summarizes activities surveyed at each reservoir. The specific reservoir elevations sampled and the number of users interviewed are shown in Table 6-13. Each of the data sources evaluated is described briefly below.

TABLE 6-10

Data Sources and Sample Sizes Used for River Recreation Analysis

	No. Boaters	No. Anglers	Total
1995 river user survey	288	131	419
1994 focus group meeting	14	5	19
1992 CDOW creel census	-	1,514	1,514
1991 river user survey	524	305	829
Total Sample Size	826	1,955	2,781

Source: EDAW, Inc.

TABLE 6-11

Representation of Private and Commercial River Boating Use

	Private	Commercial	Total
1995 river user survey	162	126	288
1991 river user survey	88	436	524
Total Sample Size	250	562	812

Source: EDAW, Inc

TABLE 6-12

Reservoir Sample Sizes and Activity Percentages *

Reservoir	No. of People Surveyed	% Boating	% Fishing
Turquoise	477	23	71
Twin	429	23	72
Pueblo	394	67	42
Total Sample Size	1,300		

* Percentages may not add up to 100 because some respondents were neither boating nor fishing and percentages may add to more than 100 because users were both boating and fishing.
Source: EDAW, Inc.

TABLE 6-13

Reservoir Survey Sample

Reservoir	Survey Dates	Elevation (ft)	Drawdown (ft)	No. Users Sampled (n)
Turquoise				
(Top of conservation pool = 9,869 feet)	May 28-29, 1994	9,845	24	69
	June 11-12, 1994	9,861	8	110
	June 25-26, 1994	9,869	0	143
	July 16-17, 1994	9,867	2	39
	August 13-14, 1994	9,867	2	116
Twin Lakes				
(Top of conservation pool = 9,200 feet)	June 11-12, 1994	9,194	6	96
	June 25-26, 1994	9,196	4	100
	July 25-29, 1994	9,193	7	26
	July 30-31, 1994	9,191	9	16
	August 13-14, 1994	9,186	14	88
Pueblo				
(Top of conservation pool = 4,880 feet)	June 25-26, 1994	4,860	20	84
	July 23-24, 1994	4,848	32	127
	August 20-21, 1994	4,842	38	70
	Sept. 10-11, 1994	4,839	41	40
	July 1-29, 1995, 19944,881	4,881	0	33

Source: EDAW, Inc.

1994 Reservoir User Surveys

~ Primary source of data for reservoir recreation analysis.
~ On-site user surveys.
~ Conducted at Turquoise, Twin Lakes, and Pueblo Reservoirs in 1994.
~ Designed by EDAW, Inc., specifically for this water needs assessment.
~ Focused on the relationship between lake levels and recreation opportunities/experiences.
~ Implemented by BLM and the CDPOR
~ User interviews conducted during several weekends throughout the summer season representing different reservoir levels.
~ Surveys focused primarily on weekend days to maximize user encounters and increase the overall sample size.
~ Total of 1,300 users contacted (477 at Turquoise, 429 at Twin Lakes, and 394 at Pueblo).

~ Sampled reservoir elevations at Turquoise Lake: 9,869 to 9,845 feet, a difference of 24 feet.
~ Sampled reservoir elevations at Twin Lakes: 9,189 to 9,196 feet, a difference of 7 feet.
~ Sampled reservoir elevations at Pueblo Reservoir: 4,839 to 4,881 feet, a difference of 42 feet.
~ Sample size for each reservoir water level ranged from a low of 16 people to a high of 127 people.

1995 River User Survey

~ Primary source of data for river recreation analysis.
~ Off-site mail survey designed by EDAW, Inc., specifically for this water needs assessment
~ Implemented by BLM and CDPOR
~ Focused on experienced users with existing knowledge of different flows.
~ Mailing list compiled from outfitters, clubs and organizations, and local users.
~ Notices soliciting input were also posted at local bait and tackle stores and in local newspapers.
~ Total of 419 respondents. Many respondents provided information for more than one activity and/or more than one river segment.
~ Two-thirds of the respondents provided information regarding boating activities, while one-third provided information regarding fishing opportunities.
~ Two-thirds of the respondents represented private interests, while the remaining one-third represented commercial interests.
~ Respondents were specifically asked to rate flow levels for different recreation activities from 200 cfs to 2,500 cfs in 100-cfs increments. Responses were based on an individuals prior experiences and knowledge of river conditions at specific flow levels.

1991 River User Survey

~ Designed and conducted by Virginia Polytechnical Institute (VPI).
~ On-site contacts followed by detailed mail surveys.
~ Focused on boaters and anglers.
~ Conducted from Leadville to Cañon City. However, angling contacts were concentrated in river Segments 3 (Stockyard Bridge to Badger Creek) and 4 (Coaldale to Pinnacle Rock).
~ Anglers were sampled from June 14 to September 30.
~ Boaters were contacted between Memorial Day and August 16.
~ Both commercial and private boaters were surveyed.
~ Encompassed flows from 300 cfs to >2,400 cfs.
~ 829 river users were asked about flows (524 boaters - 63 percent and 305 anglers - 37 percent).
~ 83 percent of boaters surveyed were commercial users, primarily customers.

Creel Census Data

~ Creel census conducted by CDOW in 1989, 1992, and 1995.
~ Focused on Arkansas River anglers, including bait anglers, lure anglers, and fly anglers.
~ Included monthly angling use estimates for censussed river segments.
~ 1992 census was conducted in spring (April and May) and fall (September).
~ 1995 census was conducted from April through September.
~ Creel data includes information regarding flow preferences provided by 1,514 anglers.
~ Riverflows ranged from 266 to 1,229 cfs during the 1989 census, 270 to 1,500 cfs during the 1992 census, and 385 to 3,520 cfs during the 1995 census.

1994 Focus Group Meeting

~ Small group of local users convened in November 1994 to discuss flow needs for river recreation.
~ Used to pretest draft mail survey.
~ Group included boaters and anglers.
~ Participants were asked to each individually complete a brief questionnaire regarding flow preferences.
~ The group also participated in an open discussion regarding flow preferences for specific recreation activities.

~ A total of 19 individuals participated in the meeting.

Arkansas Headwaters Recreation Area Visitor Use Data

~ Monthly visitor use estimates by activity type from 1991-1996.
~ Commercial and private boater counts compiled by 2-week increments for April-September for 1991-1996.
~ Commercial counts compiled by daily use and flow increments for August 16-31, between 1991 and 1996.

Physical Modeling

~ Transect results for Wellsville station.
~ Indicate how the wetted perimeter, depth, and velocity of the river change with changing streamflows.
~ Reservoir surface area/elevation curves calculated based on area capacity curves

Data Analyses

Analysis of the two primary data sources focused on identifying observed relationships between reported experiences and river and lake water levels (relative frequency analysis). Typical analyses included evaluating how average responses to specific questions varied with changing water levels, as well as how the percentage of individuals providing a particular response to a given question changed as water levels changed. Where appropriate, various statistical techniques, including T-tests and analysis of variance, were applied to determine if observed differences in responses between various water levels were statistically significant at a 95 percent confidence interval. Specific key analyses and a discussion of their statistical significance are described briefly below.

User Survey Analyses

The 1995 river user survey was specifically designed to facilitate the development of flow preference curves. Responses to question A5, which asked respondents to evaluate specific riverflows based on their past experience on a scale from totally unacceptable to totally acceptable, were averaged for each identified flow level and plotted to derive flow preference curves for different activities, different river segments, and different skill levels. Standard deviations were calculated about the means to assess the variability in the data. Regression analyses were also performed to develop lines of best fit to the data.

The 1991 river survey also asked users to rate the quality of the riverflow for their given activity. However, instead of evaluating several flows based on past experience, respondents were asked via a mail survey to recall and rate the flow level they experienced on the day they were contacted. Responses for this question were aggregated according to discrete flow ranges and average responses were calculated and plotted. These curves were then compared with the curves generated from the 1995 user survey. For comparison purposes, the 1991 data was rescaled to represent a five-point rating scheme (rather than the existing six-point scheme) that would be consistent with the 1995 data. In rescaling the 1991 data, the existing perfect and superior responses were combined to create one response that would be similar to a rating of totally acceptable on the 1995 survey. The net effect of this rescaling was relatively small because few of the 1991 survey respondents used the perfect rating. For the purpose of comparison between the two surveys, responses of “good” were equated with “somewhat acceptable,” responses of “acceptable” were equated with “marginal,” responses of “substandard” were equated with “somewhat unacceptable,” and responses of “terrible” were equated with “totally unacceptable.”

The 1992 CDOW creel census also specifically asked anglers contacted on the river to indicate whether they felt the flow they had experienced on that day was good, too high, or too low. Responses from this question were aggregated according to three discrete flow ranges (250-500 cfs, 500-900 cfs, and 900-1,500 cfs) and the relative frequency for each response category was calculated. Relative frequencies were than plotted to generate a flow preference curve for anglers. This curve was compared to the other flow preference curves described above. Flow preference curves were also created from the data obtained during the 1994 focus group meeting and compared to those developed from the 1991 and 1995 survey data.

Using the various flow preference curves described above, thresholds for acceptable and optimal conditions for angling and white-water boating were identified. Thresholds for acceptability were selected based on the point at which the flow preference curve crossed the neutral, or marginal, line. Thresholds for optimal conditions were selected based on the identified peak of the curve. As a sensitivity analysis, optimum thresholds were also selected based on clear inflection points rather than the peak of the graph. The results of this analysis for each flow preference curve were aggregated by selecting the highest and lowest values represented from all the curves to generate thresholds that represented all of the data combined. This process is presented in detail under "Results." As an additional validity check, responses to questions A2, A4, and A5 on the 1995 user survey (which specifically asked users to identify what they considered to be the optimum range, as well as the highest and lowest flow acceptable) were averaged by activity and the results compared with the results of the procedure described above. Relative frequency analyses of these questions were also performed to examine the congruency of the data.

Historical Use Analyses

Visitor use estimates for angling and boating on the river were examined relative to different historic flow conditions in the river to see if flows had a detectable effect on the amount and/or type of use on the river. Where available, bimonthly use estimates were examined specifically to evaluate the potential incremental impact of the water augmentation program on angling and boating use. Use during the months of April-September were specifically examined, with particular attention paid to April and August. Reservoir use levels for 1996 were also examined relative to measured lake level elevations.

Physical Modeling

In addition to evaluating the results of the various user contact surveys, two physical analyses were conducted to assess the impact of altered riverflows and lake levels on shoreline conditions and wadability. For the river, output from the IFIM Physical Habitat Modeling program for a transect location near Wellsville was examined to see how changes in riverflow influence the wetted perimeter of the river, water depths, and water velocities. This output provides some indication of how access and wadability opportunities may change as riverflows change. With regard to the reservoirs, existing area/capacity data were used to assess how the acres of exposed shoreline change with changing lake levels. These data provide an indication of potential threshold levels above or below which there may be significant differences in terms of shoreline access and/or boating safety.

Results

Results are presented below according to the key analyses conducted (as described "Assessment Methodology"). For each analysis, summary results are presented, followed by results from each of the data sources examined. Where data exists, results are presented by primary activity.

River Recreation Survey Results

As described under "Assessment Methodology," flow preference curves were calculated from the various surveys for each of the primary river recreation activities. Threshold flows were then derived from these flow preference curves and combined to determine the range of acceptable and optimal flow for each major activity type. Table 6-14 presents the combined acceptable flow results and the acceptable flow ranges from all of the survey data examined.

Study results indicate that, in general, the majority of anglers using the river prefer lower flows. Fly anglers, or about 54 percent of all anglers, have a threshold acceptable low flow preference of 250 cfs and an acceptable high flow preference of 800 cfs. Of course, preferences vary for anglers. Spin and bait anglers, or about 46 percent of all anglers, have a threshold acceptable low flow preference of 500 cfs and an acceptable high flow preference of 2,000 cfs. Flow preferences for float fishing anglers have a threshold acceptable low flow preference of 550 cfs and an acceptable high flow preference of 2,500 cfs. Float fishing activities (which involve a combination of angling and boating activities) are presented in the discussion on river boating. See Tables 6-14, 6-15, and 6-16, and Table 6-17 (later in this section).

However, optimum conditions vary considerably depending on the type of angling and individual skills and experience. Study results show that fly anglers have expressed an optimum threshold flow preference range between 400 and 500 cfs. Spin and bait anglers appear to be more tolerant of higher flows than fly anglers (see river angling discussion under "River Recreation Survey Results"). Spin and bait anglers have expressed in study results an optimum threshold flow preference range between 700 to 1,200 cfs. Flow preferences for float fishing are also higher with optimum conditions ranging from 900 to 1,200 cfs (see the river boating discussion under "River Recreation Survey Results").

Study results indicated that, in general, the majority of boaters using the river prefer higher flows. Kayakers, or about 10 percent of all boaters, have a threshold acceptable low flow preference of 650 cfs and an acceptable high flow preference of 2,500 cfs. Rafters, or about 90 percent of all boaters, have a threshold acceptable low flow preference of 750 cfs and an acceptable high flow preference of 2,500 cfs. See Table 6-14 and Tables 6-17 and 6-18 (later in this section).

However, optimum conditions vary for boaters depending upon type of boating and individual skills and experience. Study results show that kayakers have expressed an optimum threshold flow preference range between 1,300 and 1,500 cfs. Rafters have expressed in study results an optimum threshold flow preference range between 1,500 and 2,000 cfs.

TABLE 6-14

Overall Combined Threshold Flow Values (cfs) and Range of Acceptable Flows for Recreation

Activity	Acceptable Low Flow [Range of Acceptable Low Flows]	Optimum Low Flow [Range of Acceptable Optimum Flows]	Optimum High Flow [Range of Acceptable Optimum High Flows]	Acceptable High Flow [Range of Acceptable High Flows]
Fishing	250 [250 - 500]	250 [250 - 700]	500 [300 - 1,200]	1,200 [800 - 2,000]
Boating	550 [550 - 750]	1,000 [900 - 1,500]	2,000 [1,200 - 2,400]	2,500 [1,500 - 2,500]

Source: EDAW, Inc.

River Angling

Tables 6-15 and 6-16 display the calculated threshold values for acceptable and optimum conditions for river angling from each of the four river user surveys examined. The bottom row of Table 6-15 displays a combined set of values, which encompasses all of the data sets by selecting the lowest and highest values displayed in the table after eliminating the most extreme values. Tables 6-15 and 6-16 also provide an indication of the overall congruency of the results.

TABLE 6-15

Summary of Threshold Levels for Angling

Data Source	Acceptable Low Flow [cfs]	Optimum Low Flow [cfs]	Optimum High Flow [cfs]	Acceptable High Flow [cfs]
1995 River Survey - Fly Fishing	250	400	500	800
1991 River Survey - Spin Fishing	500	700	1,200	2,000
1991 River Survey	250	n/a	n/a	1,200
Creel Census	250	250	500	900
Focus Group	200	200	300	800
Combined *	250	250	500	1,200

* Determined by selecting lowest and highest represented value after eliminating the most extreme value.

Source: EDAW, Inc.

TABLE 6-16

Relative Frequency Distribution of Responses to Questions Regarding the Acceptable and Optimum Flows for Angling

Flow [cfs]	Lowest Acceptable Ave. = 324	Low Optimum Ave. = 386	High Optimum Ave. = 863	Highest Acceptable Ave. = 1,118
200	38%	21%	0%	0%
300	41%	35%	3%	2%
400	5%	25%	15%	4%
500	3%	7%	26%	10%
600	2%	1%	9%	15%
700	1%	1%	6%	14%
800	3%	4%	8%	11%
900	2%	2%	3%	1%
1,000	0%	1%	9%	6%
1,200	1%	1%	6%	6%
1,500	1%	1%	3%	6%
2,000	0%	0%	3%	9%

Sources: EDAW, Inc. & 1995 River Use Survey

Results from each of the individual data sources are described below.

1995 User Survey Results

Figure 6-14 displays the flow preference curve generated from all anglers surveyed during the 1995 river user survey (131 individuals). The bars shown in Figure 6-14 represent the average rating calculated for each flow. The line shown indicates the percentage of respondents that rated each flow as somewhat acceptable. These two displays simply represent two different techniques for assessing the preference for a given flow. In both cases, results show increasing acceptability as flows increase from 200 to 500 cfs, followed by a steady decline in acceptability as flows increase above 500 cfs. Figure 6-15 displays the calculated standard deviation about the mean response, as well as a fitted regression line to the average response for each flow. While the variability about the calculated preference curve appears relatively large, the regression analysis shows a very good fit with an r^2 of 0.79.

Figures 6-16 and 6-17 show calculated preference curves for respondents representing two different types of angling: spin fishing and fly fishing. Again the bars indicate the average rating for each flow, while the lines indicate the percent of respondents that indicated they would be somewhat satisfied with a given flow. A comparison of Figures 6-16 and 6-17 suggests that spin anglers and fly anglers have fairly different flow preferences. While fly anglers appear to consider flows of 400 to 500 cfs to be optimum and flows greater than 800 cfs to be unacceptable, spin anglers appear to consider flows of <400 cfs to be unacceptable or marginal and flows around 1,000 cfs to be optimum. The significance of this apparent difference should be considered with caution given the relatively low number of spin anglers sampled (28 individuals). However, the difference is a reasonable expectation given the difference in fishing style employed by the two user groups. Fly anglers typically fish relatively shallow riffle areas and commonly wade while fishing. Spin and bait anglers, on the other hand, tend to fish from shore and prefer areas where there are deeper pools. Consequently, fly anglers would be expected to be more sensitive to increasing flows than spin anglers.

FIGURE 6-14

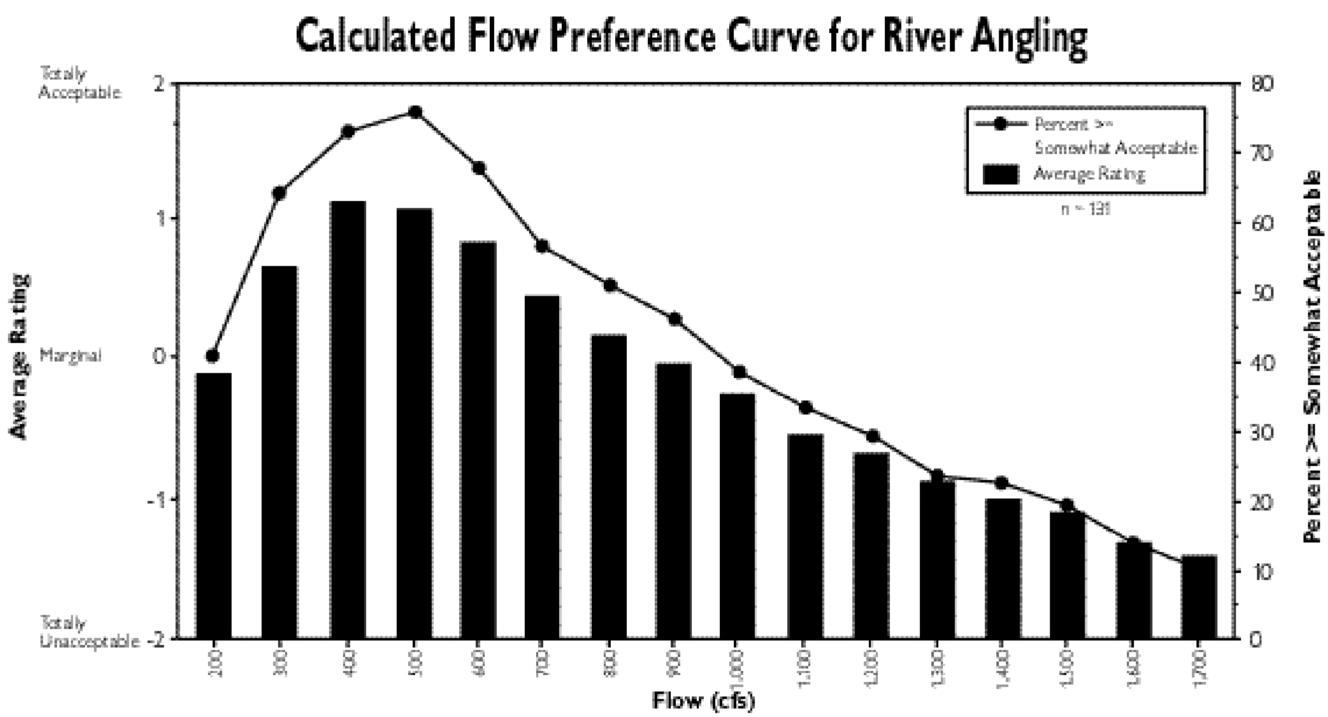


FIGURE 6-15

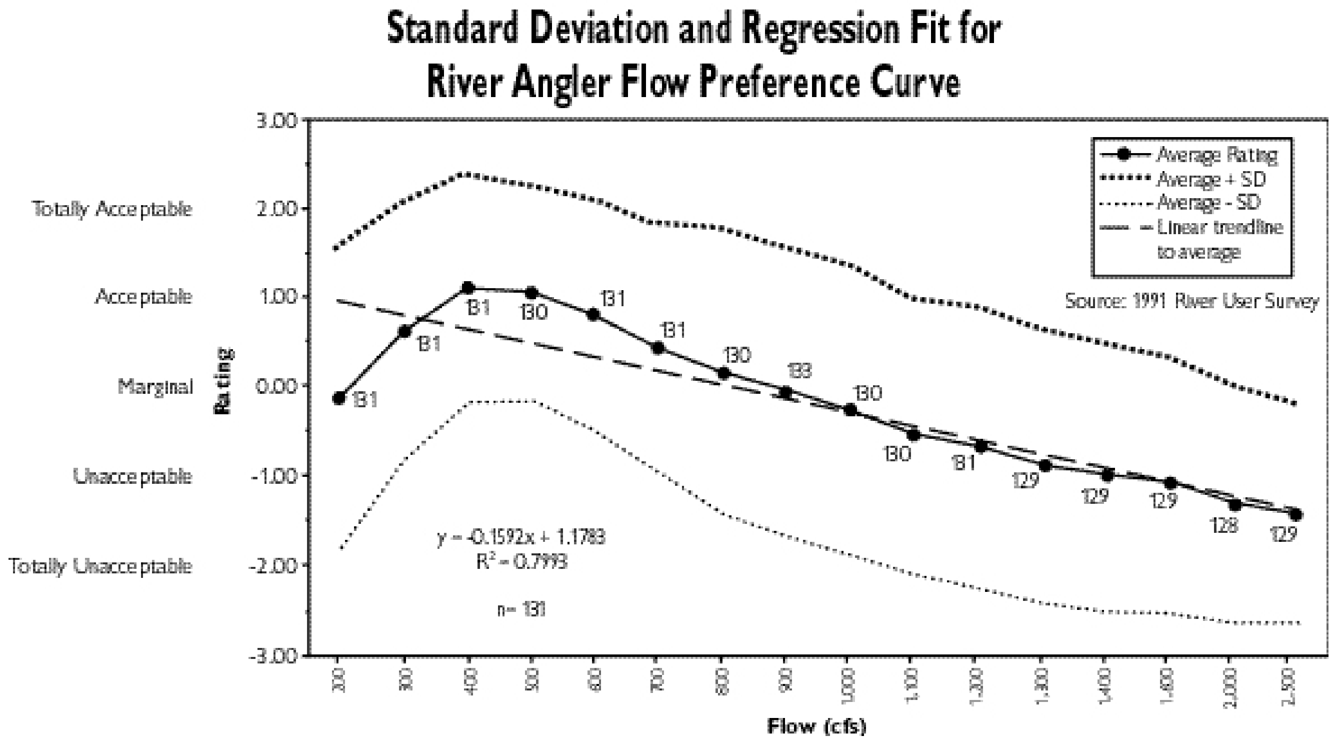


FIGURE 6-16

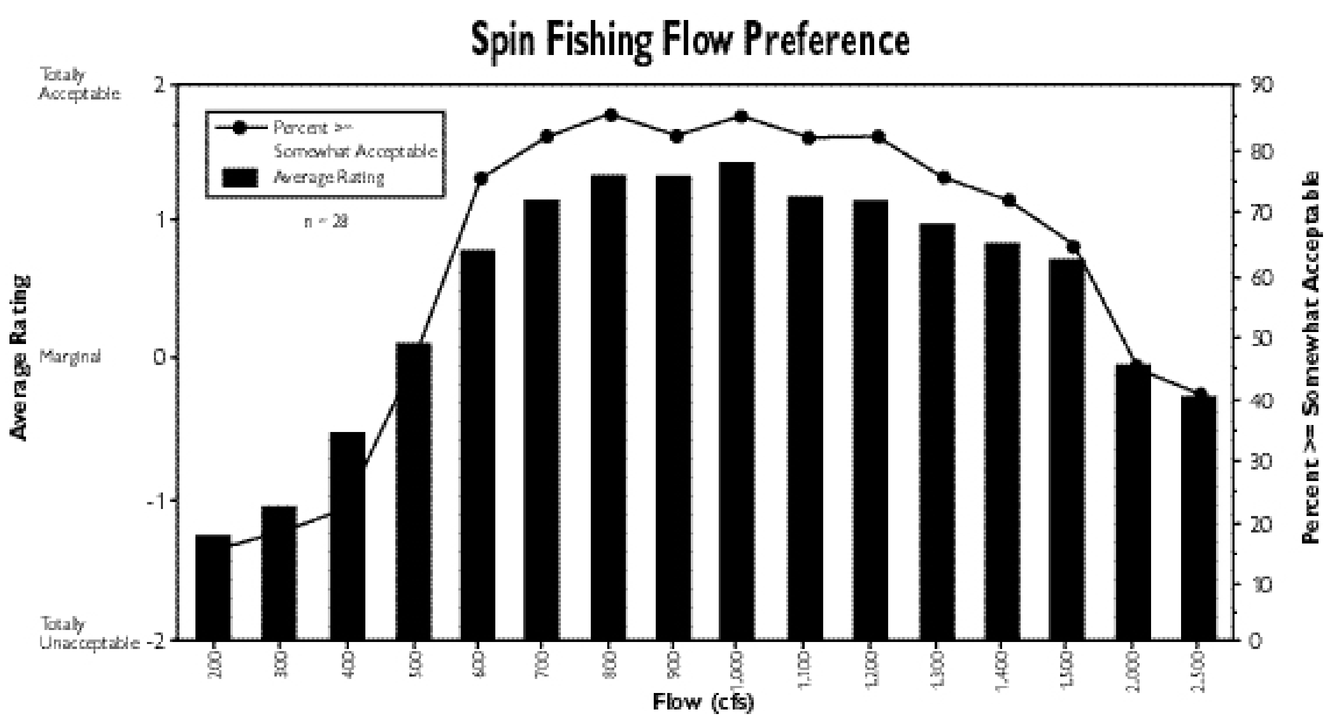
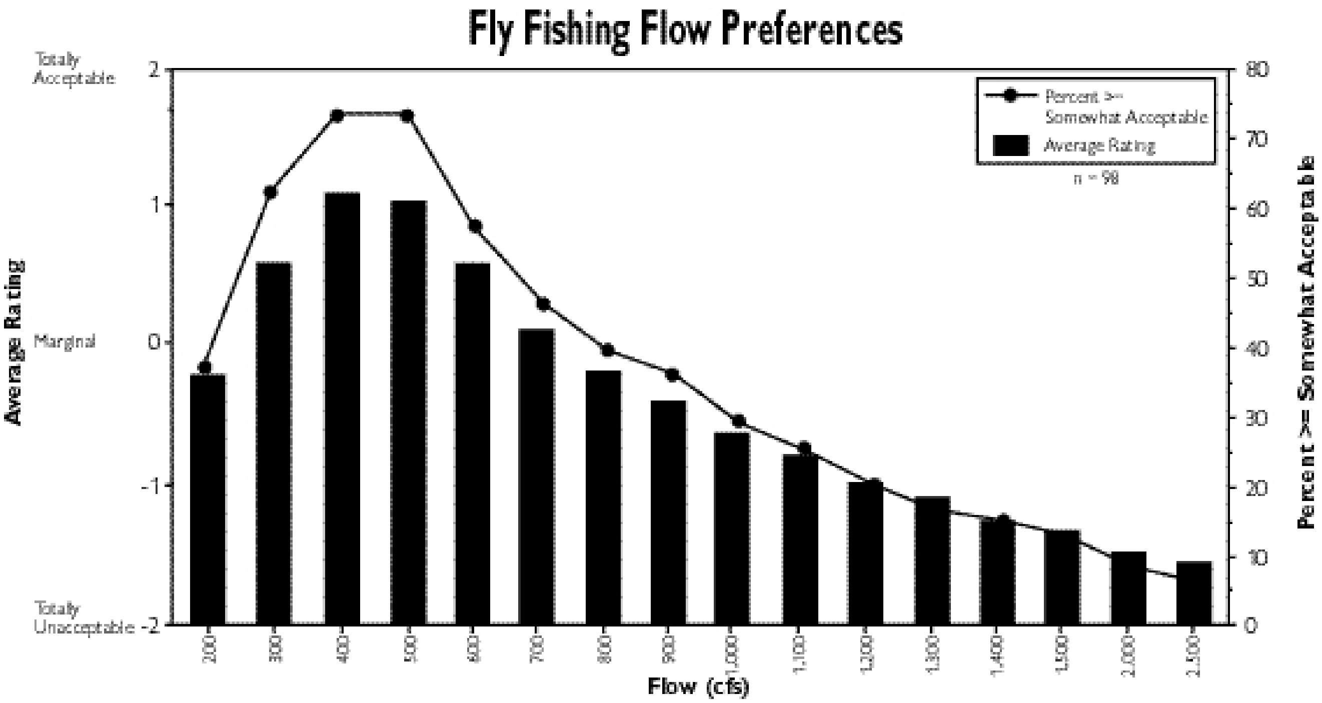


FIGURE 6-17



Figures 6-18 and 6-19 display calculated angler flow preferences by skill level and river segment. Figure 6-18 suggests that expert anglers are somewhat more tolerant of high flows than intermediate or advanced anglers, with flows as high as 1,200 cfs considered somewhat acceptable. This result may suggest that expert anglers are more adept at fishing in less than ideal conditions and/or are more knowledgeable of specific locations that are acceptable for fishing at higher flows, and therefore, they are less affected by increasing flow levels. Again it should be noted that at this level of stratification, the sample sizes are relatively low. Figure 6-18 suggests that the relationship between flow and angling opportunity does not differ significantly from reach to reach. Interestingly, it does suggest that the uppermost segment of the river is considered better at the lowest flows and worst at the highest flows. Similarly, the lower gradient segments of the river, such as segment 4 and segment 7, are more acceptable at the highest flows. This is generally consistent with what would be expected given the physical characteristics of the river channel and gradient.

Assuming that the point at which the average curve crosses the marginal level is a reasonable estimate of the range of acceptable flow, and that the peak of the curve is a reasonable estimate of the range of optimal conditions, the results shown in Figures 6-16 and 6-17 suggest the following thresholds for river angling:

	Spin Angling	Fly Angling
Acceptable Range:		
	500 - 2,000 cfs	250 - 800 cfs
Optimum Range:		
	700 - 1,200 cfs	400 - 500 cfs

In addition to asking users to rate specific flow levels, the 1995 survey also specifically asked respondents to indicate what they considered to be the lowest acceptable flow, the highest acceptable flow, and the optimum flow range (survey questions A2-A4). Results from these three questions are summarized in Table 6-16, which displays the relative frequency distribution of the respondent choices across the

FIGURE 6-18

Flow Preference by Angler Skill Level

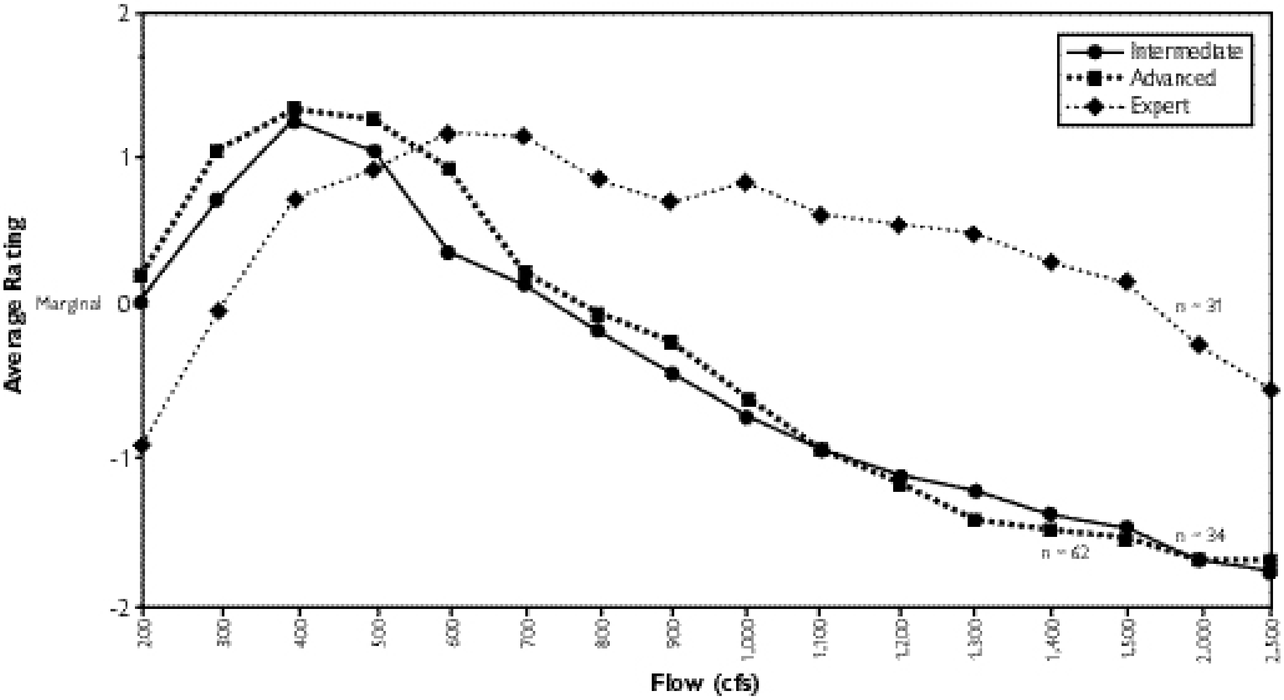
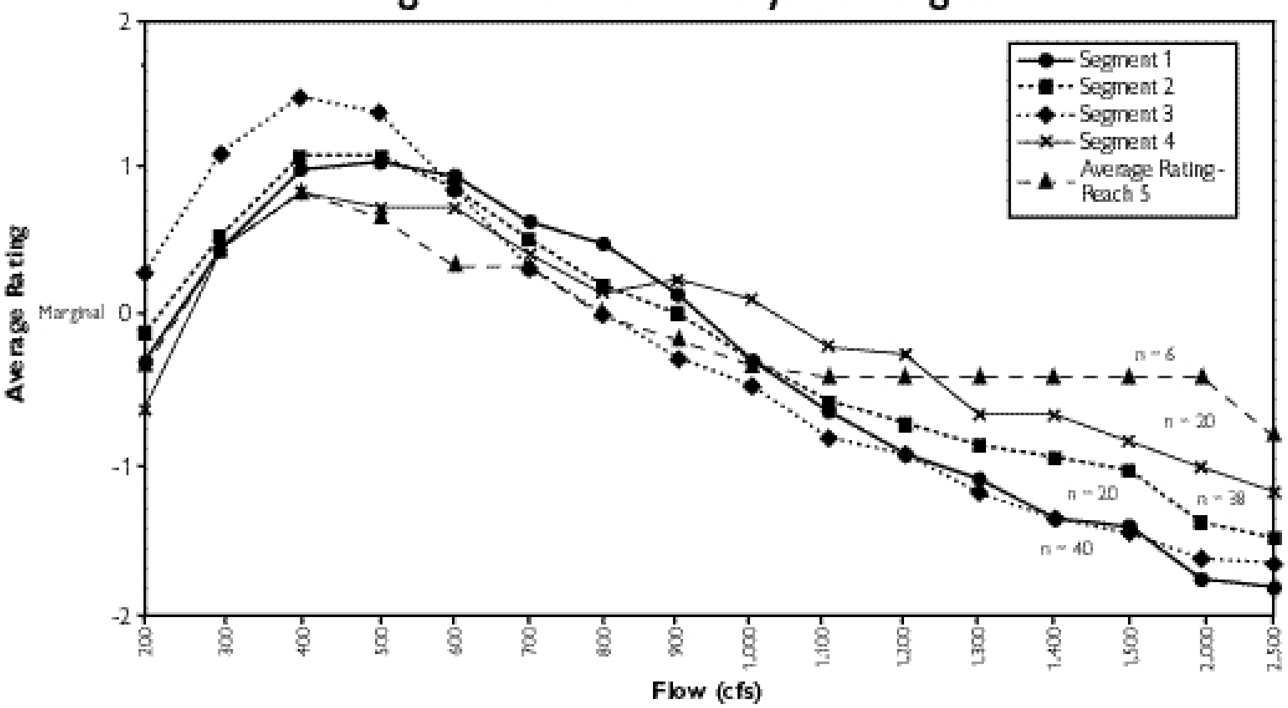


FIGURE 6-19

Angler Flow Preference by River Segment *



* Segments are defined in Table 6-3.

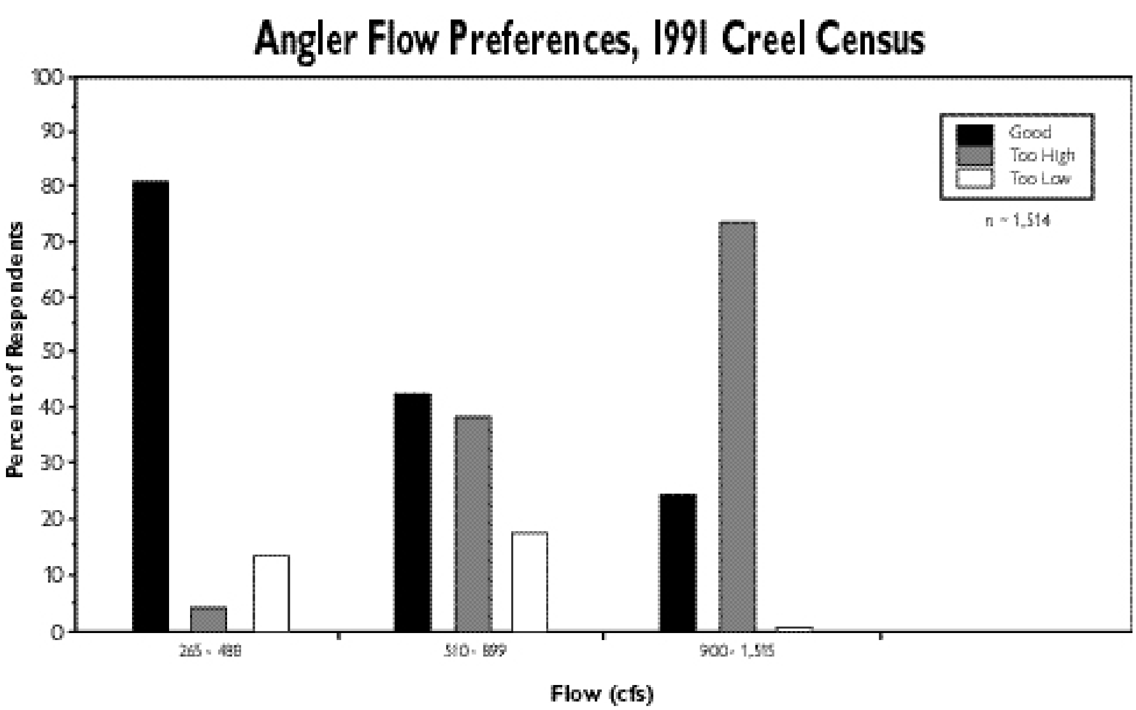
range of flows identified for all anglers. Table 6-16 also provides the average of all the responses. The average response for lowest acceptable flow was 324 cfs and almost 80 percent of the respondents indicated either 200 or 300 cfs. This result is in general agreement with the threshold values identified above. The average response for highest acceptable flow was 1,118 cfs. The distribution of responses regarding the highest acceptable flow indicates that there is not strong agreement on the exact flow, but that 51 percent of the respondents placed it between 500 and 800 cfs.

It should be noted that the results presented above were derived from a survey specifically targeted towards knowledgeable, experienced users of the river. It is assumed that these users are a reasonable surrogate for other, less experienced users and that what these users consider to be acceptable and optimum would also be considered acceptable to a less frequent user or a first-time angler visiting the river.

Creel Census Data

During CDOW's 1992 creel census of the Arkansas River, 1,514 anglers were contacted on the river and asked to indicate whether they felt flows were good, too high, or too low. Anglers did not know the flow at the time they were interviewed. Figure 6-20 displays a relative frequency distribution of the responses to this question aggregated by three flow ranges: 265-488 cfs; 510-899 cfs; and 900-1,515 cfs. These flow ranges represent a natural break in preference values as flow changed through the season. In other words, the majority of anglers thought the flow was good when it was actually in the 265-488 cfs range. The dark black bars in Figure 6-20 indicate the percentage of anglers that indicated flows were good for each flow category. Similarly, the gray bars indicate the percentage of anglers that felt the flow was too high. The results displayed in Figure 6-20 suggest that flows between 265 and 488 cfs are clearly considered superior (with 80 percent of the anglers encountered satisfied), flows between 510 and 899 cfs are marginal (about half of the anglers satisfied and half unsatisfied), and flows between 900 and 1,515 cfs are unacceptable to the vast majority of anglers encountered (approximately 25 percent of the anglers satisfied and 75 percent unsatisfied). The inverse relationship between angling quality and flows greater than 488 cfs displayed in Figure 6-20 is very consistent with

FIGURE 6-20



the results from the 1995 user survey. In terms of thresholds, results from the 1992 creel census suggest the following:

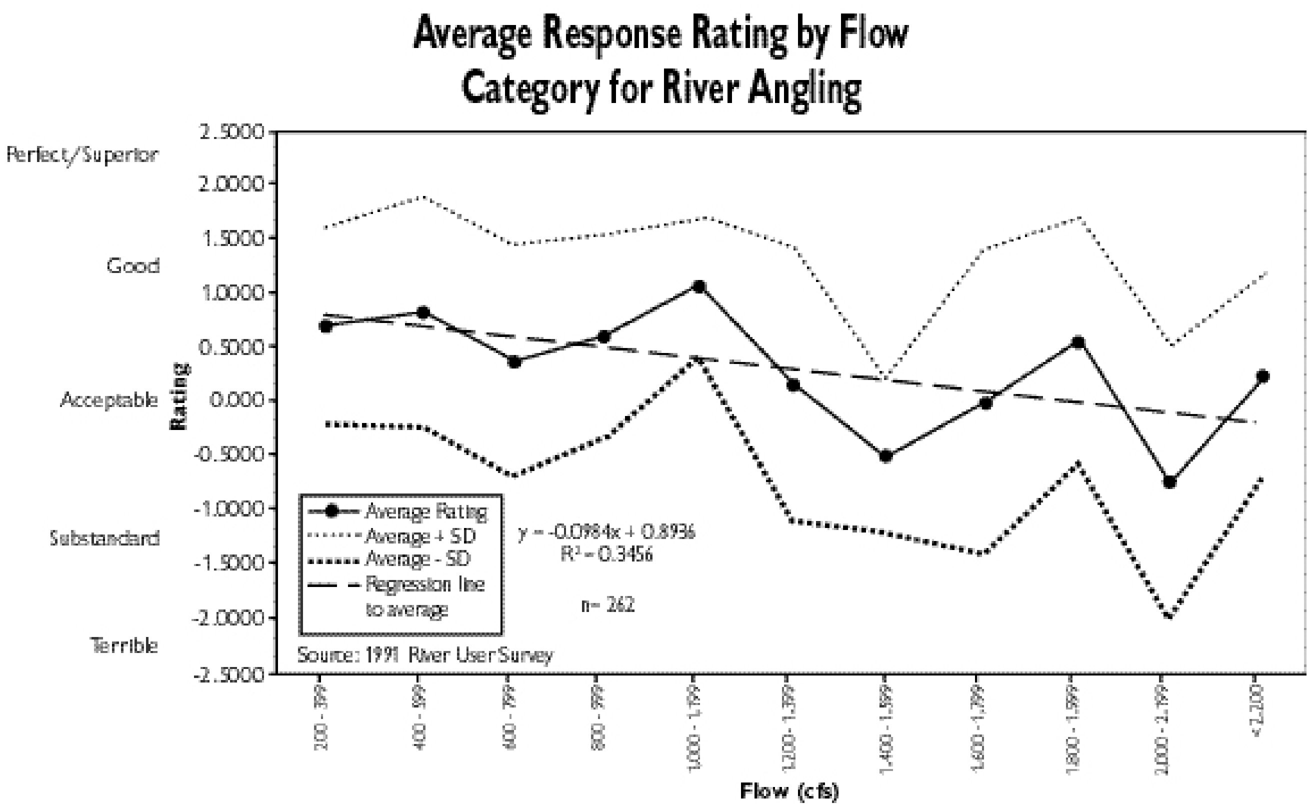
Acceptable Range: 265 - 899 cfs
Optimum Range: 265 - 488 cfs

Data from the 1992 CDOW creel census also suggest that angler water needs may differ by season. The creel census was conducted in the spring (April and May) and the fall (September). Flows below 500 cfs occurred and were sampled in both cases. However, angler reactions to these lower flows were somewhat different in the spring than they were in the fall. During the spring, almost 90 percent of the anglers contacted at flows below 500 cfs indicated that the flows were good, and very few (5 percent) indicated that they were too low. By contrast, the percentage of anglers that indicted flows below 500 cfs were good during the fall survey was smaller (approximately 70 percent), while the percentage that indicated flows below 500 cfs were too low was much larger (approximately 30 percent). These results suggest that either there is a very different user group fishing the river during these two seasons, or there are some other environmental conditions, such as water quality, that influenced user responses in the fall.

1991 River User Survey

During 1991, 305 anglers completed surveys that included a question regarding the quality of the riverflow for fishing. These users were asked to indicate whether the flow was perfect, superior, good, acceptable, substandard, or terrible. Figure 6-21 displays the average scores calculated from this data for a range of flow categories. The flow categories displayed were chosen based on the distribution of the samples across the full range of flows and is intended to create bin sizes that are of sufficient size and that are relatively even across all the categories. Figure 6-21 also displays the calculated standard deviation about the mean and

FIGURE 6-21



a fitted regression line. This display is intended to be directly comparable to Figure 6-15 which show results from the 1995 user survey. As noted under "Assessment Methodology," the perfect and superior categories were combined to convert the existing six-point rating scale to a five-point rating scale that would be consistent with the data from the 1995 user survey. Generally, this conversion has little effect on the interpretation of the 1991 survey results because the number of individuals selecting the perfect category was very small.

As shown in Figure 6-21, the calculated relationship between flow and angling opportunity is inversely proportional, with quality decreasing as flows increase. This result is very similar to the results from both the 1995 survey data and the 1992 creel census data (see Figures 6-15 and 6-20), namely that there is an inversely proportional relationship with flow.

In terms of threshold values, assuming all data points above the acceptable line on the Y-axis are acceptable and that the peak of the graph represents optimum conditions, the 1991 data suggests the following:

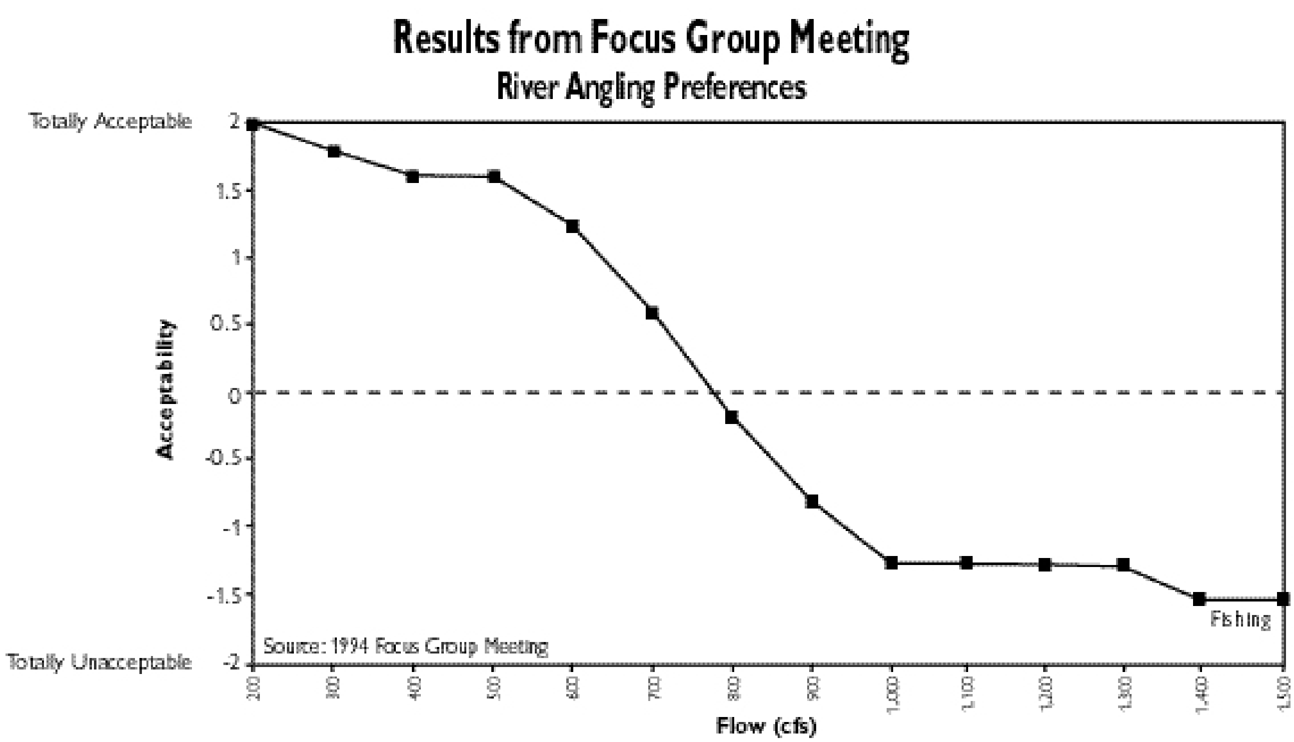
Acceptable Range: 250 - 1200 cfs
Optimum Range: No distinct peak in graph

1994 Focus Group Meeting

Participants in the 1994 focus group meeting were asked to rate specific flow conditions for angling based on their past experiences. The question provided to participants was identical to the question ultimately used for the 1995 user survey. Figure 6-22 displays the average ratings for the five anglers that participated in the focus group meeting. As with the other analyses presented above, results show declining quality with increasing flows. With regard to threshold values, Figure 6-22 suggests the following:

Acceptable Range: 200 - 800 cfs
Optimum Range: 200 - 300 cfs

FIGURE 6-22



River Boating

Table 6-17 shows threshold values for acceptable and optimum conditions for river boating from each of the three data sources examined. The bottom row of the table displays a combined set of values, which encompasses all of the data sets by selecting the lowest and highest values displayed in the table after eliminating the most extreme values. Table 6-17 also provides an indication of the overall congruency of the results. Results from each of the survey data sources examined are presented below. Results are presented for both white-water boating and float fishing.

1995 User Survey Results

Figure 6-23 displays a flow preference curve generated from all boaters surveyed during the 1995 river user survey (288 individuals). The bars in Figure 6-23 represent the average rating calculated for each flow. The line indicates the percentage of respondents that rated each flow as somewhat acceptable. In both cases, results show a steeply increasing level of acceptability as flows increase from 200 cfs to 1,000 cfs followed by a flattening of the curve, with little difference in acceptability ratings from 1,000 cfs to 2,500 cfs. Figure 6-24 displays, for the same data set, the calculated standard deviation about the mean response, as well as a fitted regression line to the average response for each flow. While the variability about the calculated preference curve appears relatively large, the regression analysis shows a very good fit with an r^2 of 0.89.

Figure 6-25 shows calculated preference curves for respondents representing three different types of boating: white-water rafting, white-water kayaking, and float fishing. These results show that the river is generally unacceptable for all forms of boating at flows less than 500 cfs and that the acceptability of the river for all forms of boating increases at a relatively steep rate as flows increase from 400 cfs to 1,000 cfs. These results also show some distinct differences in flow preferences for each of the three boating activities. At flows greater than 1,000 cfs, the acceptability of the river for white-water rafting and kayaking continues to increase, though at a relatively small incremental rate. The acceptability of the river for float fishing at flows greater than 1,000 cfs declines at a relatively steep rate. Another interesting difference between the three types of river boating is the spread in the magnitude of the acceptability ratings for flows between 400 cfs and 1,000 cfs. The acceptability of the river for float fishing was consistently rated higher for flows in this range indicating a higher tolerance for lower flows. Similarly, the acceptability of the river for white-

TABLE 6-17

Summary of Threshold Levels for Boating

Data Source	Acceptable Low Flow (cfs)	Optimum Low Flow (cfs)	Optimum High Flow (cfs)	Acceptable High Flow (cfs)
1995 River Survey Float Fishing	550	900	1,200	2,500
1995 River Survey Kayaking	650	1,300	1,500	>2,500
1995 River Survey Rafting	750	1,500	2,000	>2,500
1991 River Survey	500	1,500	>2,400	>2,400
1994 Focus Group	550	1,000	1,500	>1,500
Combined *	550	1,000	2,000	>2,500

> Means greater than value shown

* Determined by selecting lowest and highest represented value after eliminating the most extreme value

Source: EDAW, Inc.

FIGURE 6-23

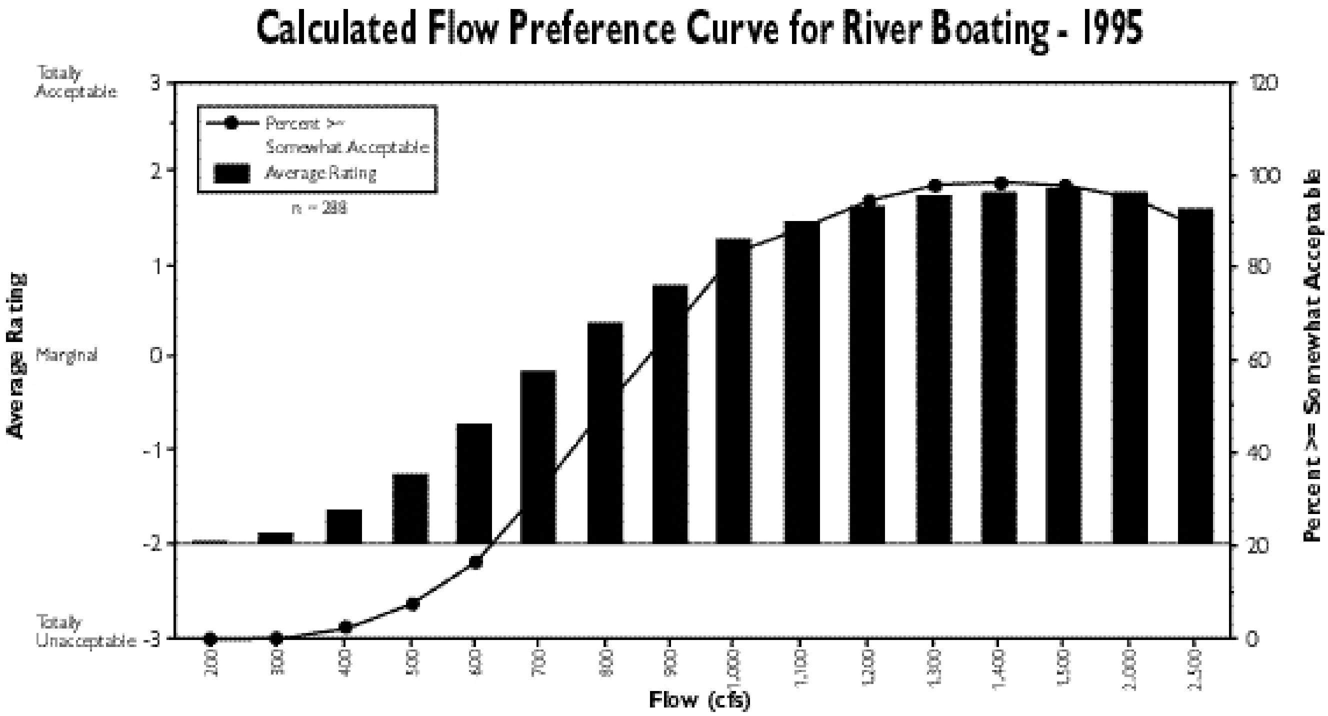


FIGURE 6-24

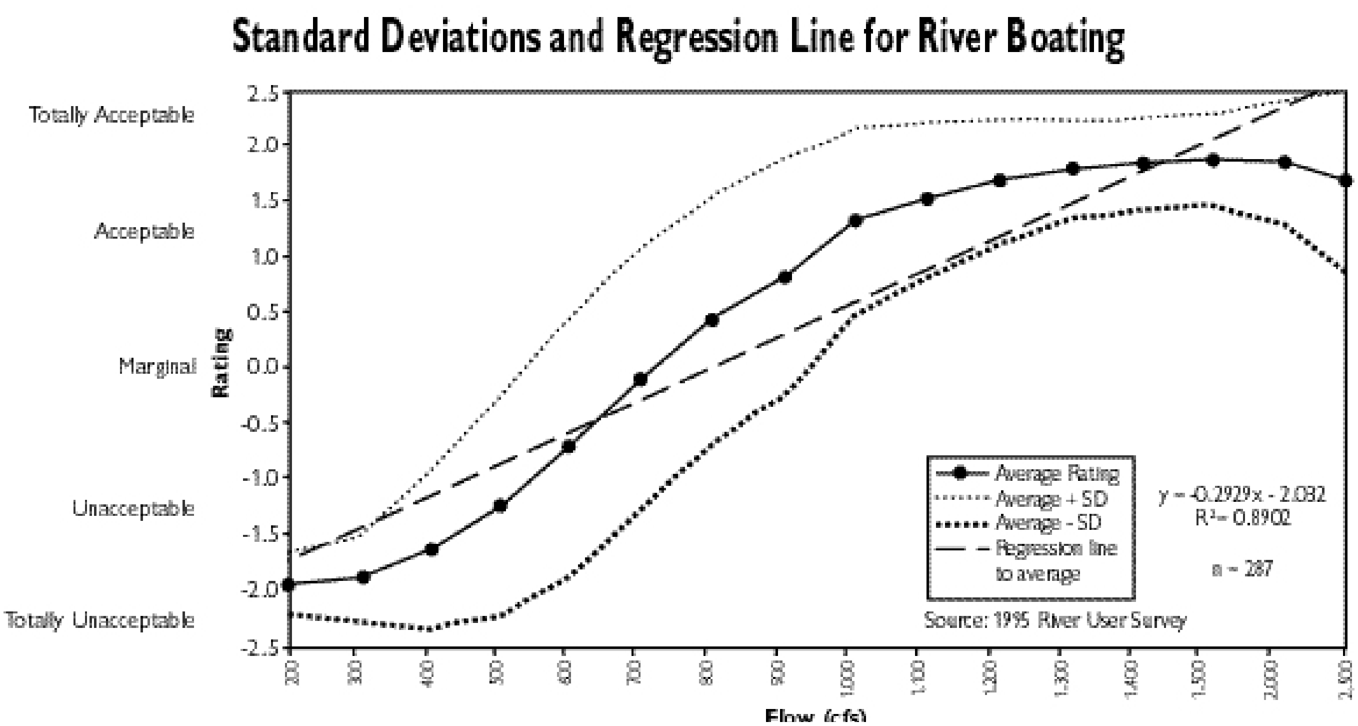
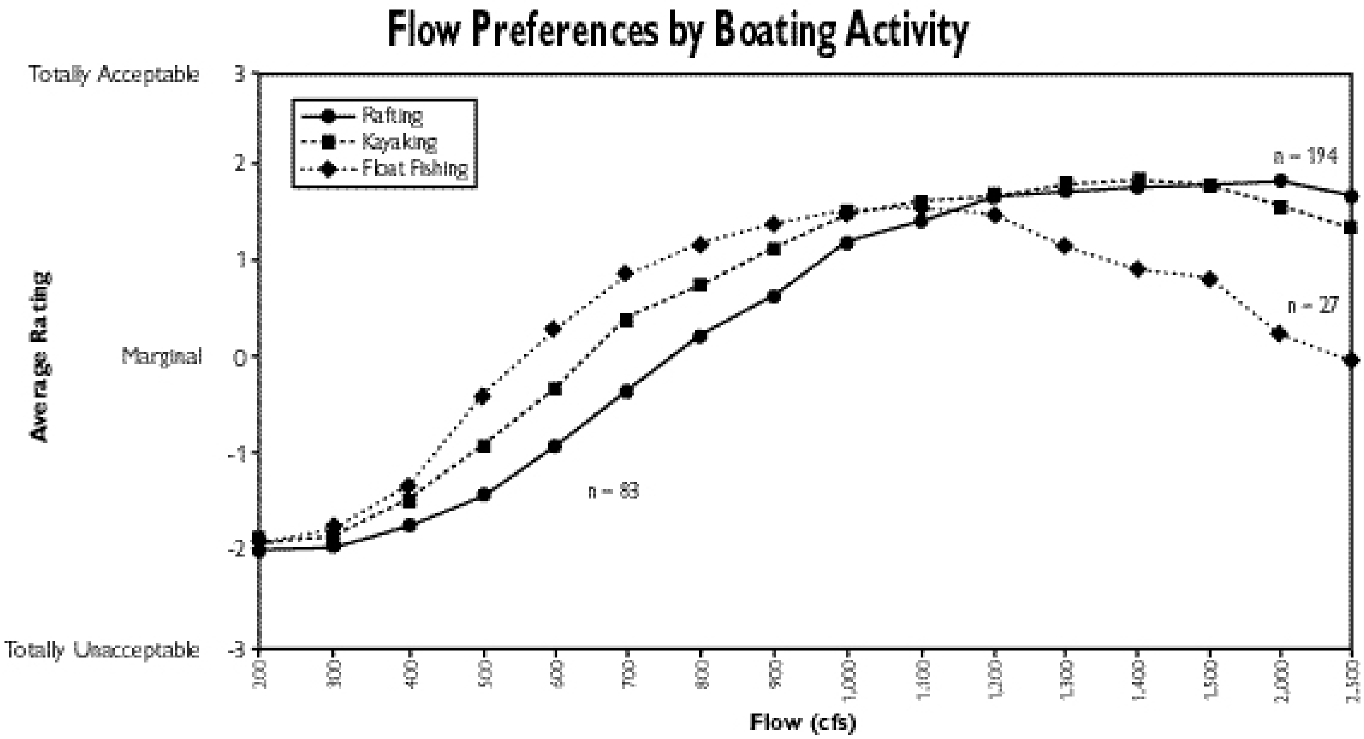


FIGURE 6-25

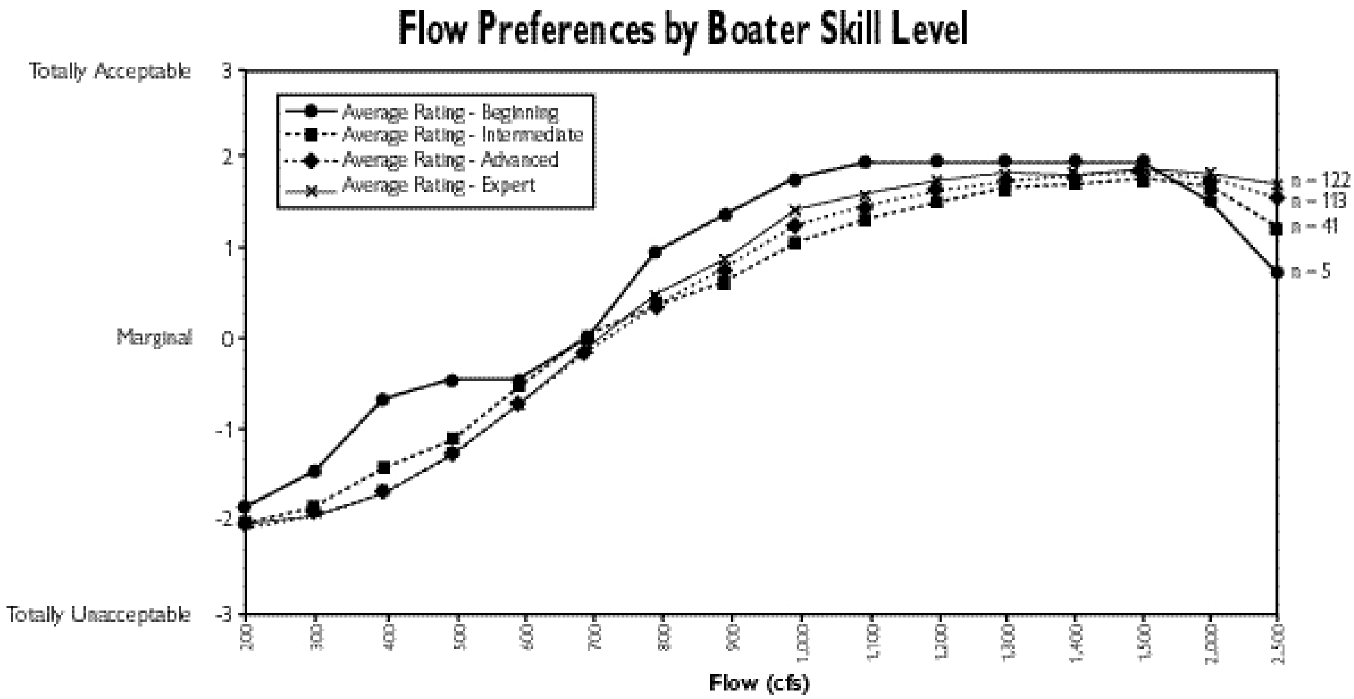


water kayaking was consistently rated higher in this flow range than it was for white-water rafting, again indicating a slightly higher tolerance for lower flows. Intuitively, these results make sense and are generally what would be expected. Float anglers are generally more concerned with the overall navigability, or floatability, of the river and the ability to fish, which is typically easier at slower velocities. Float anglers are generally not looking for a white-water experience and therefore do not require the higher flow levels that cause more challenging river hydraulics, which are attractive to white-water boaters. In fact, flows that are too high will detract from the angling experience, which is what is shown in Figure 6-25. The observed difference between white-water kayakers and white-water rafters is also predictable. Kayaks are considerably smaller and more maneuverable crafts requiring less in the way of channel widths and river depths. The white-water hydraulics required for a challenging kayaking experience are also often less than they are to provide an exciting white-water rafting experience.

Figure 6-26 displays the calculated flow preferences for different boating skill levels. These results show very little difference between intermediate, advanced, and expert boaters. However, they do show that beginning boaters consider the acceptability of the river to be greater at low flows, particularly at flows between 400 cfs and 1,100 cfs. At flows greater than 1,500 cfs, there is a relatively steep decline in acceptability for these beginning boaters, particularly as compared with the more skilled boaters. Both of these results are consistent with what would be expected.

Assuming that the points at which the average curve crosses the marginal level is a reasonable estimate of the range of acceptable flow, and that the peak of the curve is a reasonable estimate of the range of optimal conditions, the results shown

FIGURE 6-26



in Figure 6-25 suggest the following thresholds for river boating:

	Float Fishing	Kayaking	Rafting
Acceptable Range:	**550 - 2,500 cfs**	**650 - >2,500**	**750 - >2,500**
Optimum Range:	**900 - 1,200 cfs**	**1,300 - 1,500**	**1,500 - 2,000**

In addition to asking users to rate specific flow levels, the 1995 survey also specifically asked respondents to indicate what they considered to be the lowest acceptable flow, the highest acceptable flow, and the optimum flow range (survey questions A2-A4). Results from these three questions are summarized in Table 6-18, which displays the relative frequency distribution of the respondents' choices across the range of flows identified for all boating. Table 6-18 also displays the average of all the responses in the top row.

As with the 1995 user survey data for anglers, it should be noted that the results presented above for river boating were derived from a survey instrument specifically targeted towards knowledgeable, experienced users of the river. It is assumed that these users are a reasonable surrogate for other, less experienced users and that what these users consider to be acceptable and optimum would also be considered acceptable to a less frequent user or a first-time boater visiting the river.

1991 River User Survey

During 1991, 524 boaters completed surveys that included a question regarding the quality of the riverflow for boating. These users were asked to indicate whether the flow was perfect, superior, good, acceptable, substandard, or terrible. Figure 6-27 displays the average scores calculated from this data for a range of flow categories. The flow categories displayed were chosen based on the distribution of the samples across the full range of flows and is intended to create bin sizes that are

TABLE 6-18

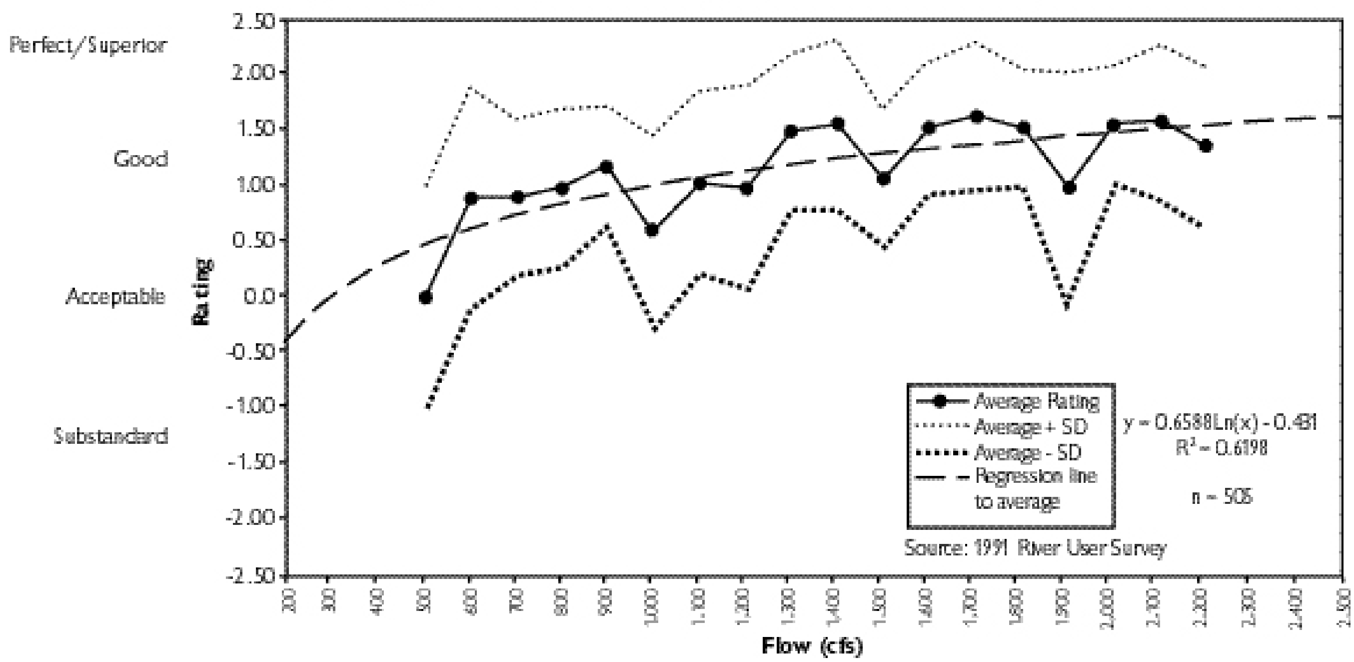
Relative Frequency Distribution for Responses to Questions Regarding the Acceptable and Optimum Flows for Boating

Flow	Lowest Acceptable	Low Optimum	High Optimum	Highest Acceptable
	Ave. = 764 cfs	Ave. = 1,144 cfs	Ave. = 2,922 cfs	Ave. = 3,762 cfs
300	3 %	0 %	0 %	0 %
400	9 %	3 %	0 %	0 %
500	14 %	4 %	0 %	0 %
600	12 %	4 %	0 %	1 %
700	17 %	7 %	0 %	0 %
800	16 %	11 %	0 %	0 %
900	8 %	7 %	0 %	0 %
1,000	16 %	23 %	1 %	0 %
1,200	2 %	9 %	1 %	0 %
1,500	0 %	17 %	5 %	2 %
2,000	0 %	8 %	15 %	5 %
2,500	0 %	2 %	14 %	10 %
3,000	0 %	1 %	23 %	20 %
4,000	0 %	0 %	13 %	13 %
5,000	0 %	0 %	2 %	15 %

Source: EDAW, Inc.

FIGURE 6-27

Average Response by Flow Category for River Boating - 1991



of sufficient size and that are relatively even across all of the categories. Figure 6-27 also displays the calculated standard deviation about the mean and a fitted regression line. This display is intended to be directly comparable to Figure 6-24 which show results from the 1995 user survey. As noted under "Assessment Methodology," the perfect and superior categories were combined to convert the existing six-point rating scale to a five-point rating scale that would be consistent with the data from the 1995 user survey. Generally, this conversion has little effect on the interpretation of the 1991 survey results because the number of individuals selecting the perfect category was very small.

The results from the 1991 survey (as shown in Figure 6-27), show a much flatter flow preference curve for boating than that derived from the 1995 survey data (see Figure 6-24). While the acceptability or quality of the experience appears to increase with increased flow, the incremental benefit is much less per cfs than displayed in Figure 6-24. In addition, Figure 6-27 suggests that all the flows sampled were considered to be acceptable, even flows in the 500-700 cfs range. No flows below 500 cfs were sampled. Consequently, it is difficult to project the preference curve below this water level. However, the data show a very steep slope between the 500-599 cfs category and the 600-699 cfs category with a fairly strong inflection point at 600 cfs. This suggests a high degree of sensitivity to changes in flow in this range and the likelihood that samples below 500 cfs would have been rated unacceptable.

The relatively flat slope of the preference curve shown in Figure 6-27 and the fact that virtually all the users sampled were satisfied is somewhat predictable given the methodology used to collect this data. On-site user surveys are generally biased towards the sampling of satisfied users. Users that consider certain flow conditions to be unacceptable, and therefore choose not to use the river at those flows, are far less likely to be encountered on the river at those flow conditions, and therefore are not represented in the sample. Similarly, users that consider certain flow conditions to be acceptable, or do not know or care about specific flows, are the users that will likely be encountered at those flow conditions. In addition to this fact, over 80 percent of the boaters surveyed during the 1991 user survey (whose responses are displayed in Figure 6-27) were commercial rafting customers. Most of these users are boating the Arkansas River for the first time and therefore have no point of reference against which to evaluate the flow experienced. This is not to say that the results displayed in Figure 6-27 are not representative of the general experiences of the commercial customer population, but that these data are not particularly suitable for the development of preference curves, which by nature require an individual to compare and contrast multiple experiences at different flow conditions.

In terms of threshold values, assuming all data points above the acceptable line on the Y axis are acceptable and that the peak of the graph represents optimum conditions, the 1991 data suggests the following for white-water boating, particularly commercial rafting:

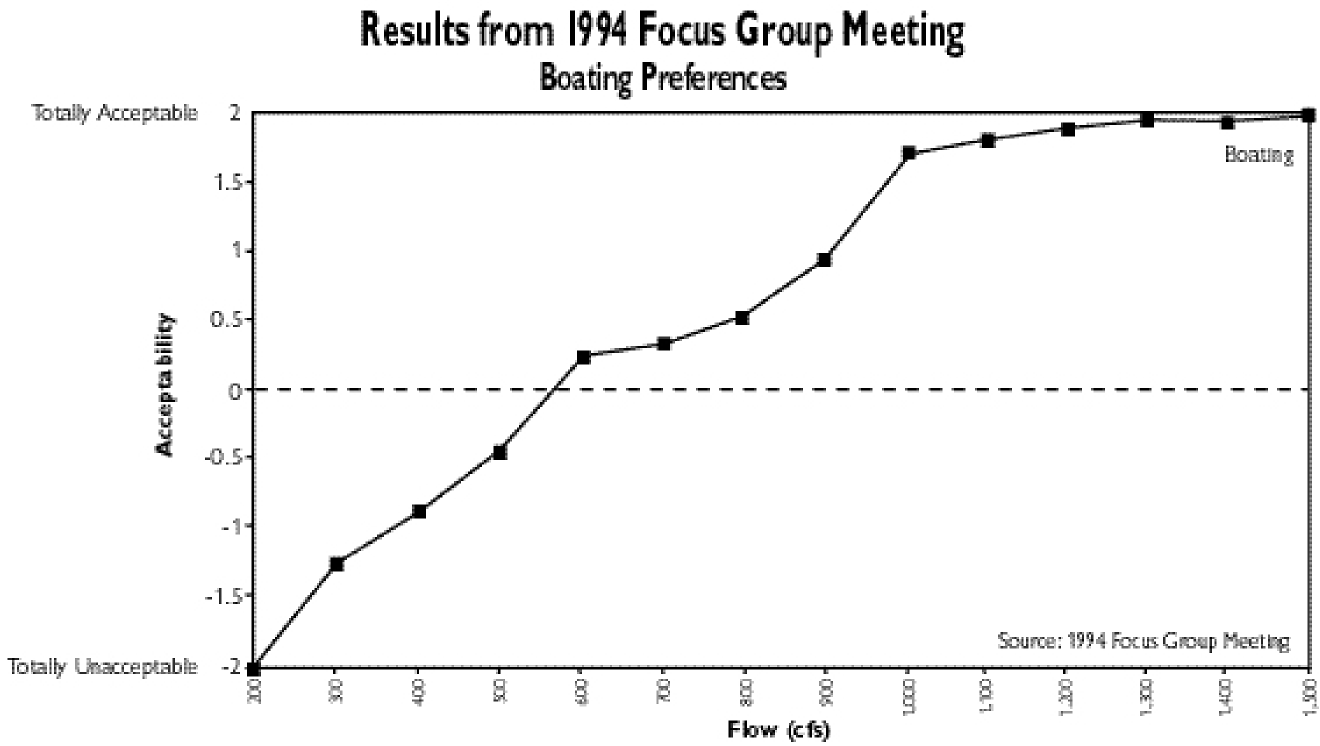
Acceptable Range: 500 - >2,400 cfs
Optimum Range: 1,500 - >2,400 cfs

1994 Focus Group Meeting

Participants in the 1994 focus group meeting were asked to rate specific flow conditions for boating based on their past experiences. The question provided to participants was identical to the question ultimately used for the 1995 user survey, except that the upper limit of the flows evaluated was 1,500 cfs rather than 2,500 cfs as in the 1995 survey. Figure 6-28 displays the average ratings for the 14 boaters that participated in the focus group meeting. As with the other analyses presented above, results show increasing quality with increasing flows in a fashion similar to that shown in Figure 6-24. With regard to threshold values, Figure 6-28 suggests the following:

Acceptable Range: 550 - >1,500 cfs
Optimum Range: 1,000 - 1,500 cfs

FIGURE 6-28



Historical Use Analysis Results

In 1995, the Arkansas River Basin had one of the wettest years on record, and riverflows were correspondingly high. This unusual event provided an opportunity to analyze how river usage corresponds with increased flows. However, other factors affecting river usage, such as summer vacation schedules and weather, were not considered in the analysis.

The analysis of 1995 usage patterns on the Arkansas River indicated increased recreation and boating use during periods of high flow (see Figures 6-29 and 6-30, respectively). Specifically, in the months of June, July, and August, when riverflows were between 1,800 and 3,500 cfs, river recreation use increased significantly. In May and September, there were approximately 20,000 and 16,000 river recreation users, respectively, while in June, July, and August, there were 60,000, 70,000, and 35,000 users, respectively. For boating, there were 32,000 users in May and 23,000 users in September, while during June, July, and August, there were approximately 90,000, 105,000, and 55,000 users respectively. Conversely, 1995 angling use produced an inverse curve, meaning that when riverflow was the highest, angling usage was the lowest (see Figure 6-31). During the months of June and July, which were periods of high riverflow, angling use decreased from approximately 4,200 users in May to 850 users in June (CDOW creel survey 1995), an 80 percent decline. The AHRA estimates show about a 60 percent reduction for the same period.

River Angling

Existing data on angling use of the river over time under different flow conditions is limited. However, data from 1995 (as shown in Figure 6-31) suggests that angling use is adversely affected by very high flows (>3,000 cfs). Peak use occurred in May when average monthly flows were 1,061 cfs. Use was also relatively high in August when flows in the river averaged 1,779 cfs. These findings suggest that while anglers may not prefer flows greater than 1,000

FIGURE 6-29

Monthly Arkansas River Recreation Use vs. Flow for 1995

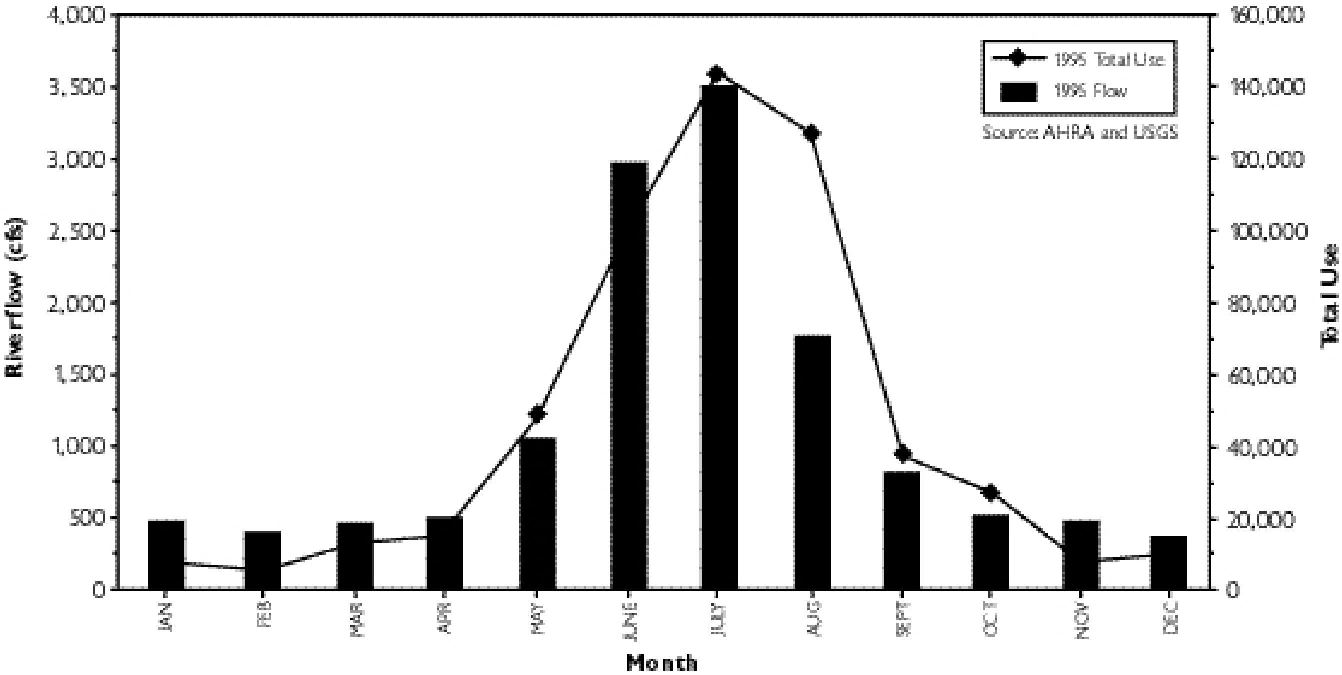


FIGURE 6-30

Monthly Arkansas River Boating Use vs. Flow for 1995

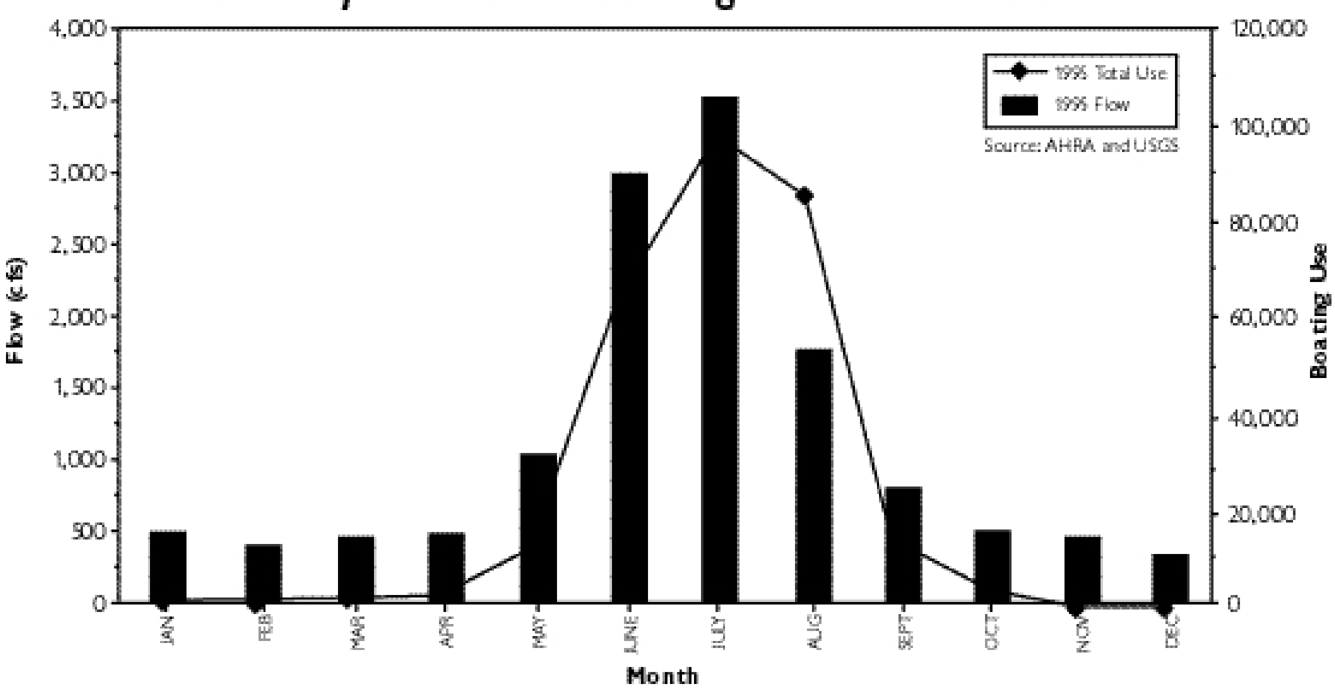
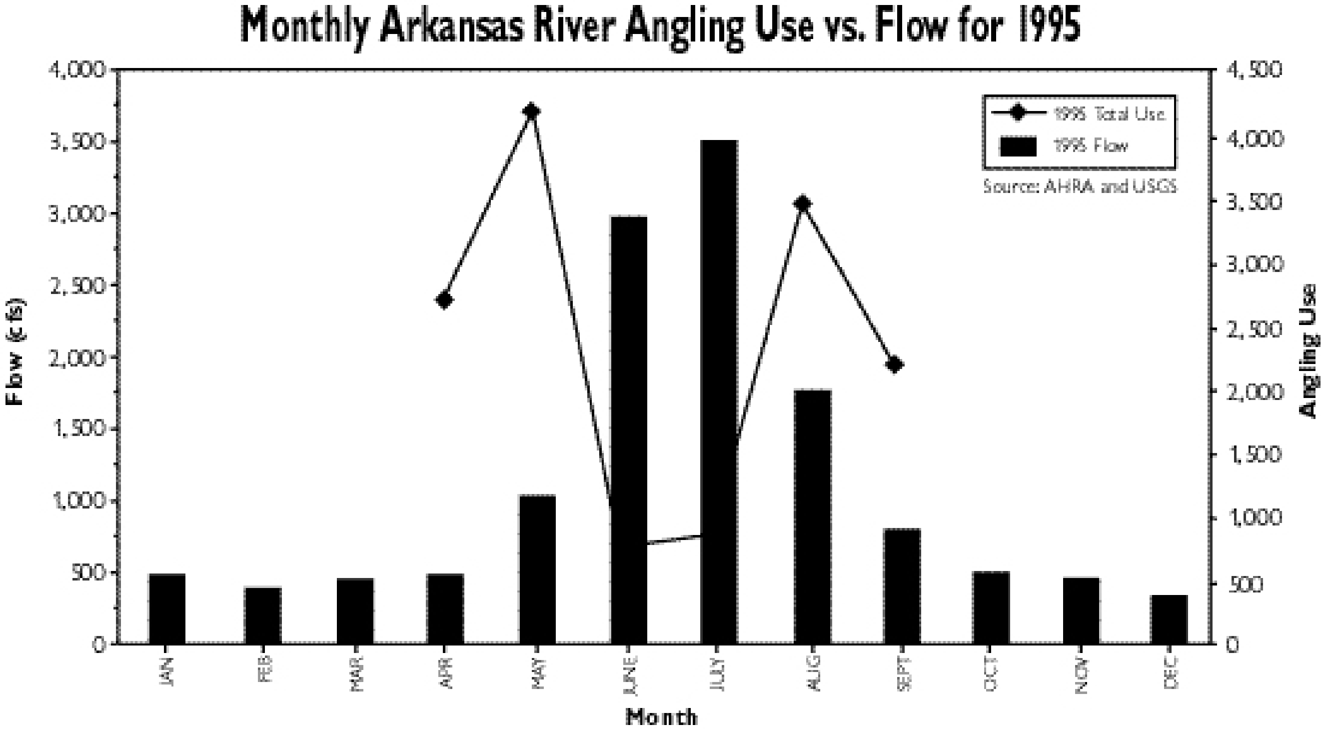


FIGURE 6-31



cfs they will tolerate such flows and do use the river at these flows. Numerous factors influence angling use, including events such as the occurrence of insect hatches that influence the quality of fishing. These factors may often be more important to the angler than flows and may tend to override the influence of flow on their decision to fish the river.

Combining what data is available from historic creel surveys on the river, it is possible to compare use patterns in relation to flow for the Big Bend to County Road 166 section of the river (2 miles) for certain months. This area was surveyed in 1989, 1991, 1992, and 1995, but was not surveyed during the same time periods each year. These data are shown in Table 6-19 for CDOW.

The data in Table 6-19 suggest that flows may influence angling use, particularly flows above 1,000 cfs, but that other factors likely also play a strong role. The highest monthly angling use observed in this section of the river occurred in August 1995 when the average flow was 1,779 cfs. The lowest use observed was in June 1995 when no anglers were seen and average flows were just under 3,000 cfs. For the month of April, the data shows that use levels were approximately equal in 1992 and 1995 (277 and 242 anglers, respectively), while average flows were 334 cfs and 512 cfs, respectively. This suggests that flow changes in this range may not have a large influence on use. For the month of May, the data shows decreasing levels of use with increasing flows. Monthly use decreased from 600 anglers in 1989 when the average flow was 791 cfs, to 275 anglers in 1995 when the average flow was 1,061 cfs. Historical use patterns for September indicate a similar trend with use levels declining as flows increase. Monthly use in September 1989 was 404 anglers when flows averaged 344 cfs. In September 1995, use was 188 anglers with an average flow of 821 cfs. This pattern is similar in June, July, and August, with the exception of August 1995 when use levels were significantly higher than in 1989 or 1991 despite that fact that average flows were 1,779 cfs.

Angler monthly use as recorded by the AHRA was also compared to average monthly flows as shown in Table 6-20. In all of these cases, it should be noted that the potential influence of other factors has not been accounted for. Observed differences in use

TABLE 6-19

CDOW Monthly Angler Use and Average Monthly Flows for the Big Bend to County Road 166 Section of the Arkansas River

Monthly	1989 [flows]	1991 [flows]	1992 [flows]	1995 [flows]
April			277	242
			[334]	[512]
May	600		583	275
	[791]		[944]	[1,061]
June	322	227		0
	[1,229]	[1,669]		[2,998]
July	213	216		59
	[1,211]	[842]		[3,521]
August	131	321		639
	[934]	[554]		[1,779]
September	404		451	188
	[344]		[423]	[821]

Source: CDOW Creel Data

TABLE 6-20

AHRA Estimates for Monthly Angler Use and Average Monthly Flows [measured in cfs at Wellsville Gage] for 1990 through 1995

Month	1990 [flows]	1991 [flows]	1992 [flows]	1993 [flows]	1994 [flows]	1995 [flows]
April		870	1,475	1,700	1,498	1,573
	[225]	[445]	[334]	[382]	[404]	[512]
May	2,565	1,980	1,960	2,210	2,785	3,115
	[498]	[949]	[944]	[1,396]	[952]	[1,061]
June	1,394	1,825	1,925	1,282	1,091	1,014
	[1,957]	[1,669]	[1,160]	[2,498]	[2,161]	[2,998]
July	2,236	3,035	3,490	3,110	3,895	2,904
	[1,041]	[842]	[822]	[1,741]	[743]	[3,521]
August	3,381	3,453	3,757	4,762	4,932	4,404
	[632]	[554]	[697]	[676]	[560]	[1,779]
September	2,572	2,628	2,822	3,386	3,503	3,539
	[327]	[314]	[423]	[534]	[338]	[821]

Source = AHRA & USGS

from year to year may have been related to factors other than flow.

River Boating

Boating use patterns and riverflows over time are displayed in Table 6-21, which compares 1992-1995 data for the month of August, and in Figure 6-32, which shows average bimonthly commercial rafting use and river flow data from 1991 to 1995. Data are displayed for 2-week increments to better account for the variability that occurs within a month. Rafting use patterns are relatively similar from year to year despite considerably different magnitudes of flow. This is particularly evident when comparing 1992 with 1993 or 1995. Peak use always occurs in June, July, and August, consistent with the peak summer recreation season and summer vacations, and is generally of a similar magnitude. This suggests a level of demand that is largely driven by factors other than flow. However, it should be noted that

TABLE 6-21

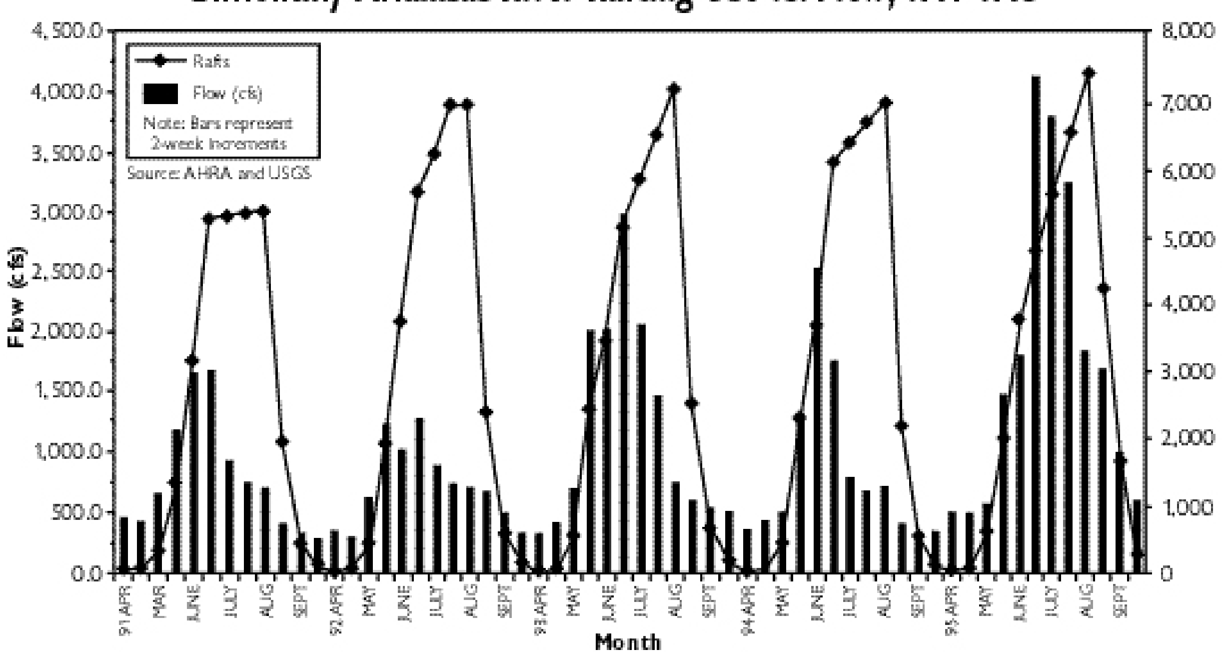
Comparison of August Commercial Rafting Use with Average August Riverflows

Year	Period	Average August Flow (cfs)	Total Commercial Rafts
1992	August 1-15	750	6,967
	August 16-31	724	2,389
1993	August 1-15	770	7,184
	August 16-31	646	2,503
1994	August 1-15	750	6,998
	August 16-31	433	2,175
1995	August 1-15	1,900	7,444
	August 16-31	1,806	4,235

Source = AHRA

FIGURE 6-32

Bimonthly Arkansas River Rafting Use vs. Flow, 1991-1995



the flow augmentation program was in place in all these years.

The greatest 2-week increment of use always appears to occur during the first 2 weeks in August as shown in Figure 6-33. From 1992 to 1994, the number of commercial rafts using the river was fairly consistent, averaging 7,050. Average flows during this period were also fairly consistent at 760 cfs, with the exception of 1995 when the river averaged 1,900 cfs during the first 2 weeks of August.

Rafting use typically declines considerably during the second 2 weeks of August as shown in Figure 6-34. However in 1995 use levels were higher than in previous years, corresponding to much higher

FIGURE 6-33

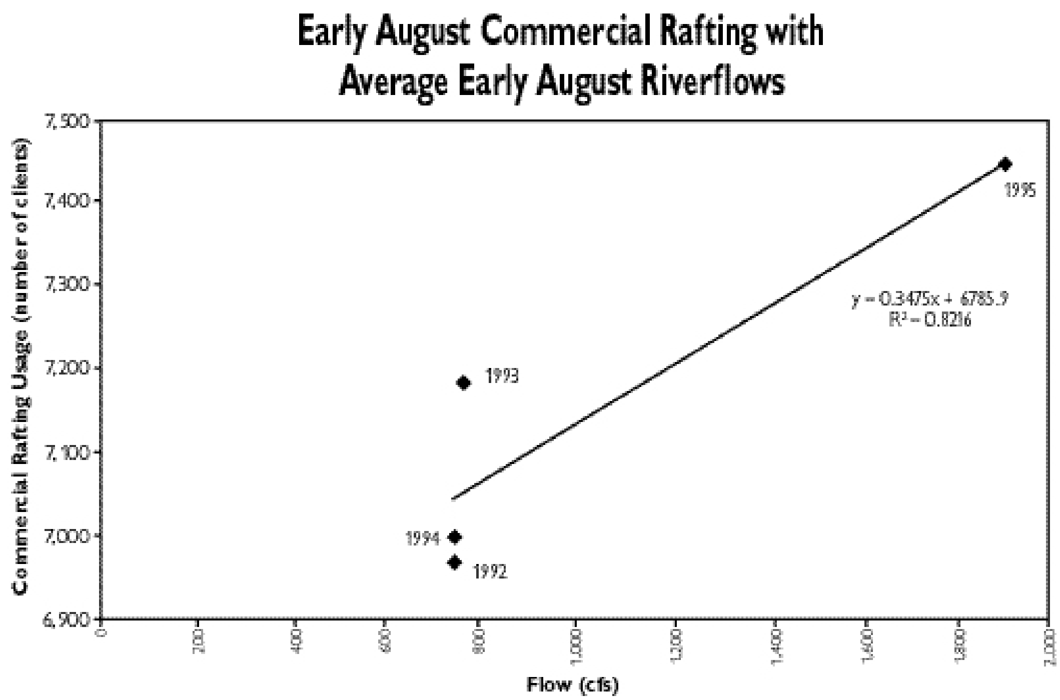
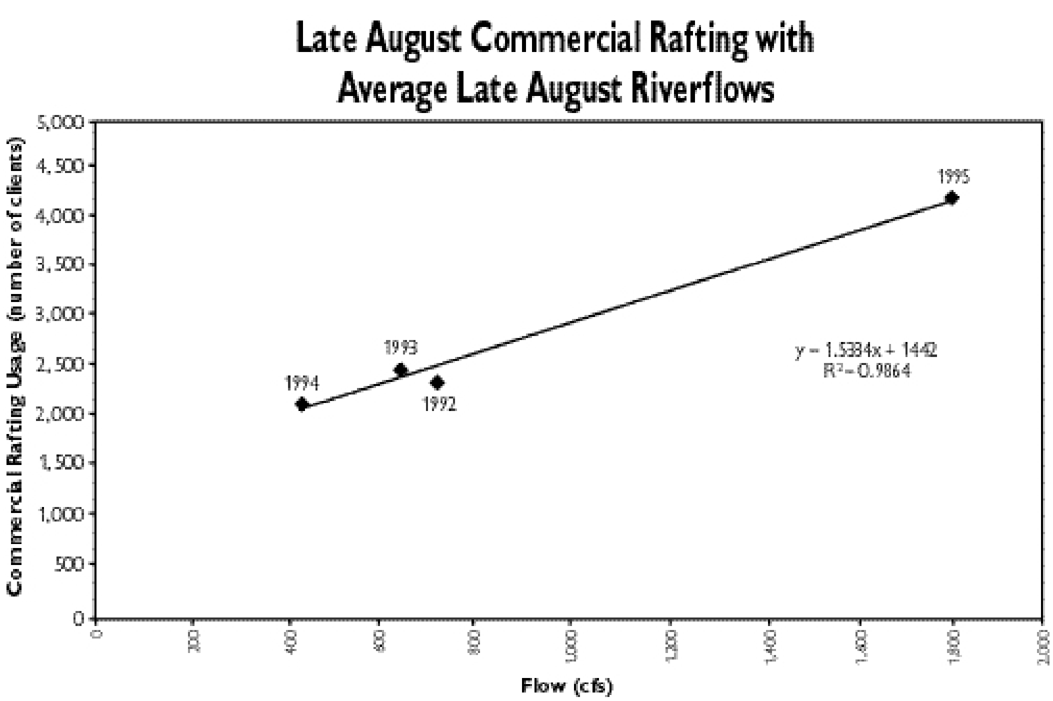


FIGURE 6-34



flow conditions. The total number of rafts using the river during the second 2 weeks in August was fairly consistent from 1992 to 1994, ranging between 2,100 and 2,500. Average flows during this time were 724 cfs, 646 cfs, and 433 cfs for 1992, 1993, and 1994, respectively. In contrast, rafting use levels during this same time period in 1995 were considerably higher (4,235) corresponding to an average flow of 1,806 cfs.

The data from Table 6-21 for 1992-1995, as well as the data from 1991, are shown graphically in Figures 6-35 through 6-41. This data illustrates the relationship between daily riverflows and daily commercial use figures during the period August 16-31. On this daily level, the data shows that, in general, as flows drop after August 15, after the 700 cfs augmentation ends, there is a corresponding drop in commercial use. Table 6-22 shows this relationship clearly even when the 1995 late August data is excluded. Overall, the data presented in Table 6-21 and in Figures 6-32 and 6-33 through 6-41 provides a general indication of how rafters have responded to different flow conditions in the past. During the months of June and July, and the first 2 weeks of August, there is not a significant correlation of flows and commercial use. It is not until flows drop below 700 cfs that clear correlation becomes apparent. In all of these cases, it should be noted that the potential influence of other factors has not been accounted for. Observed differences in use from year to year may have been related to factors other than flow.

Reservoir Recreation Survey Results

Survey results indicate that while users clearly prefer higher lake levels, water surface elevations play only a minor role in determining the overall quality of their recreation experience. This was particularly true for Turquoise and Twin Lakes Reservoirs, where the majority of users (>75 percent) indicated that

FIGURE 6-35

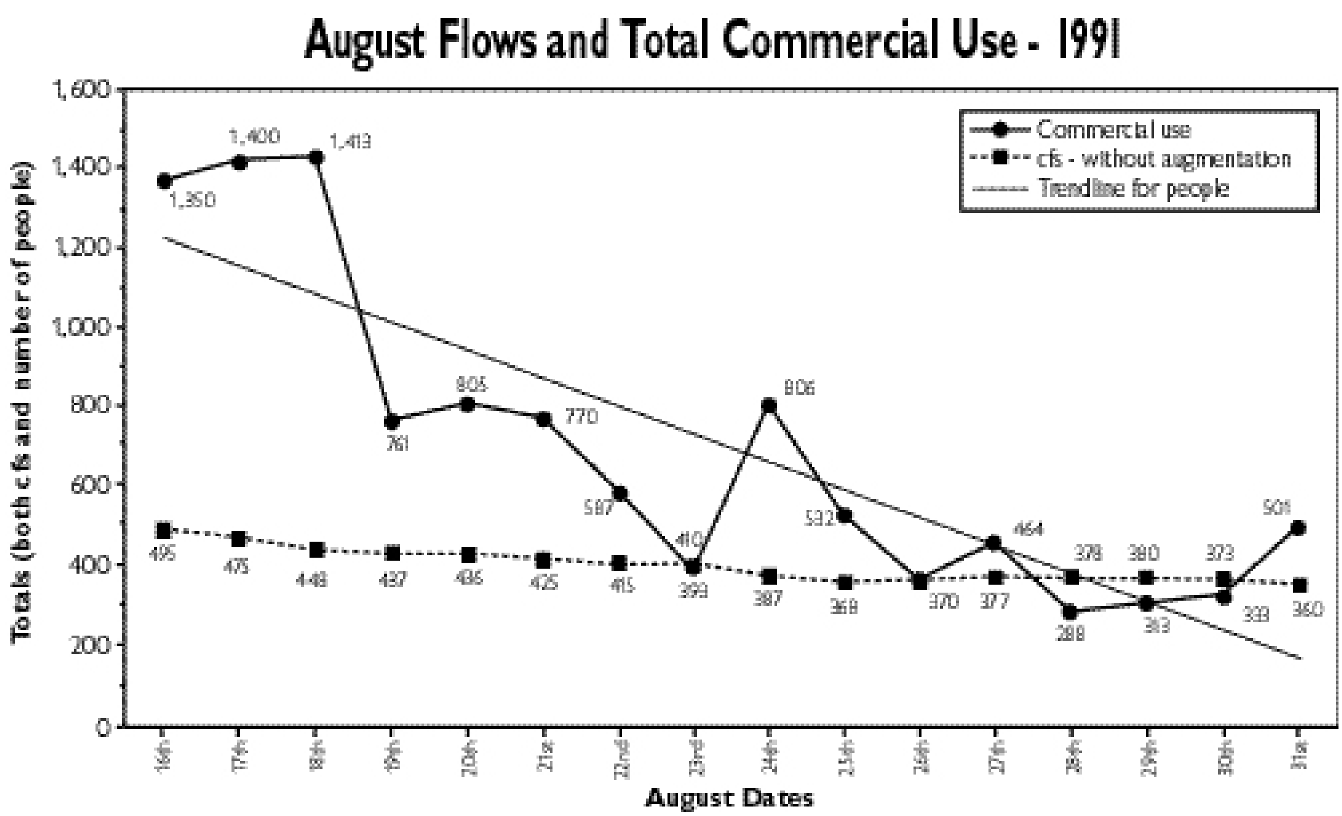


FIGURE 6-36

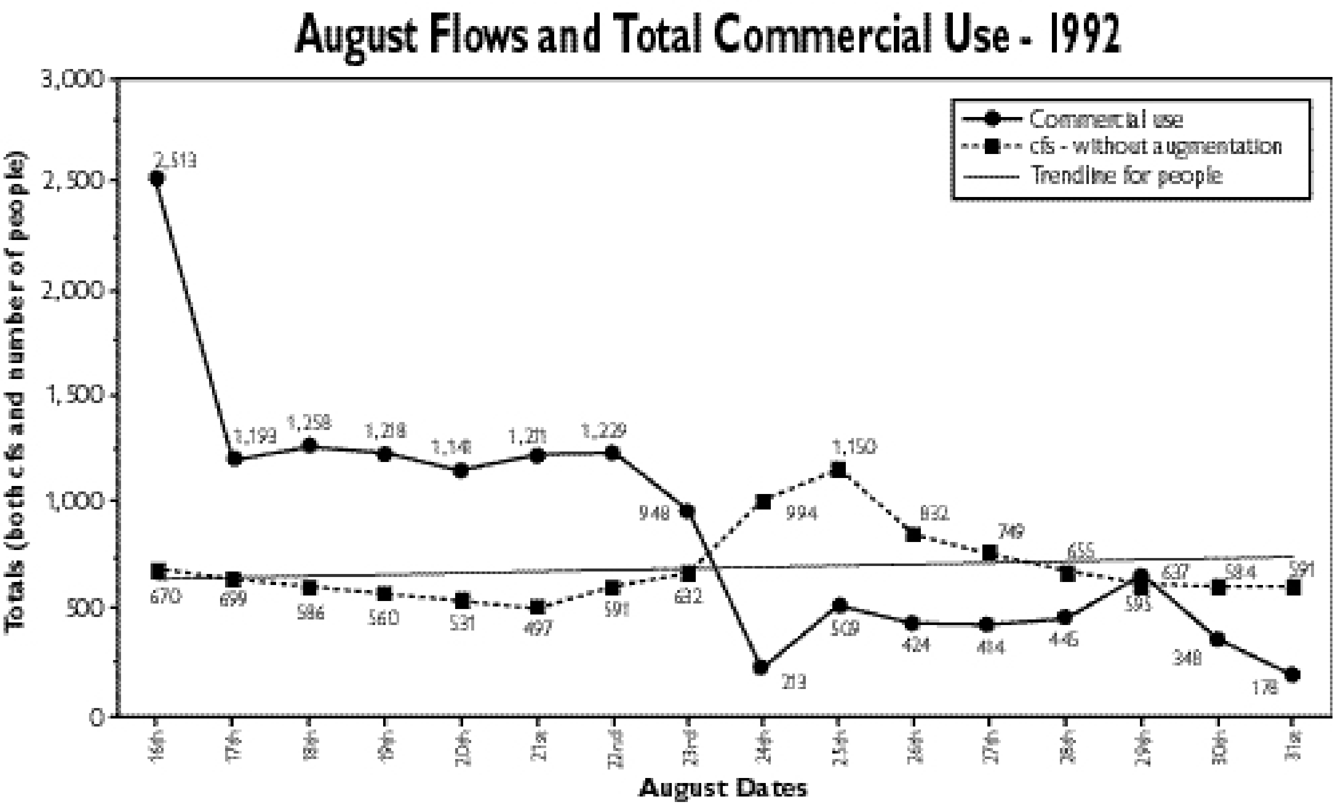


FIGURE 6-37

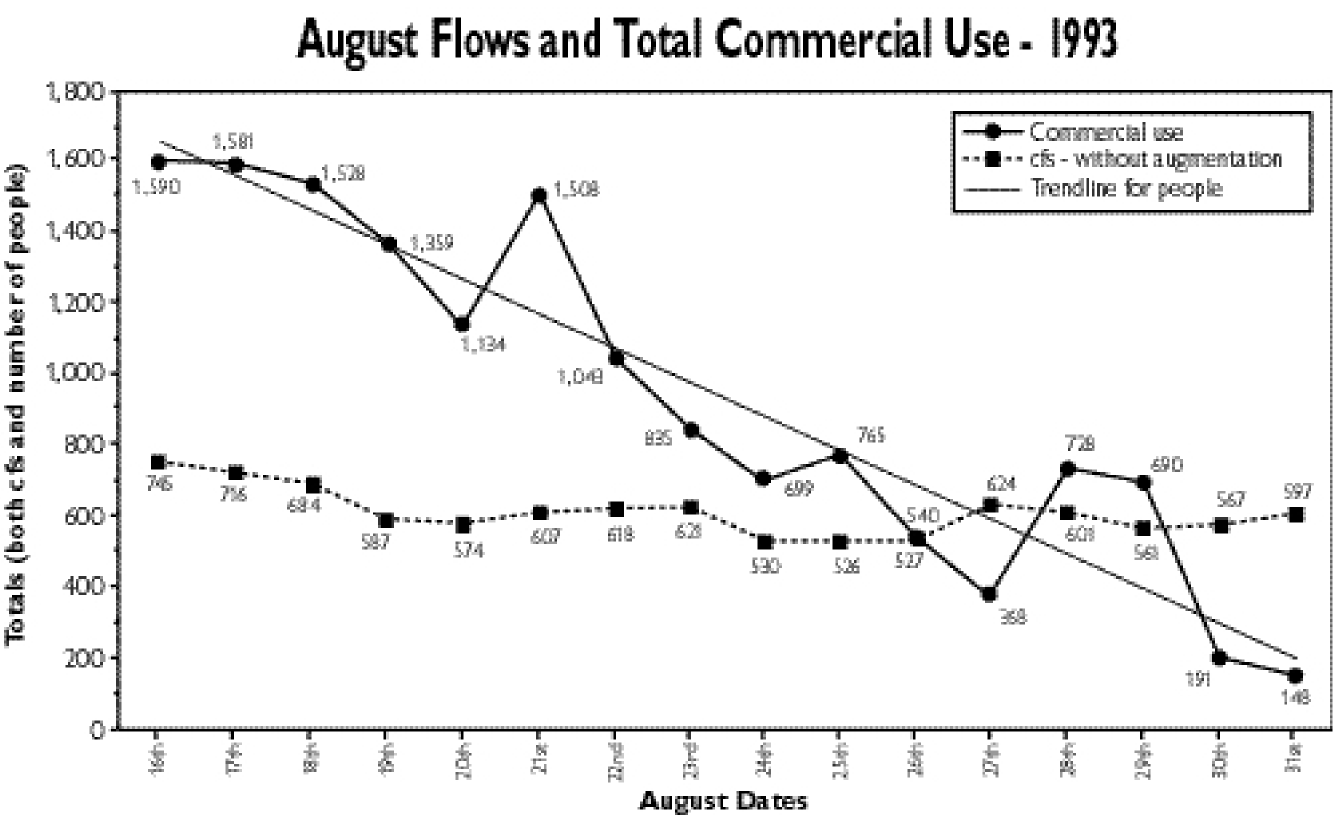


FIGURE 6-38

August Flows and Total Commercial Use - 1994

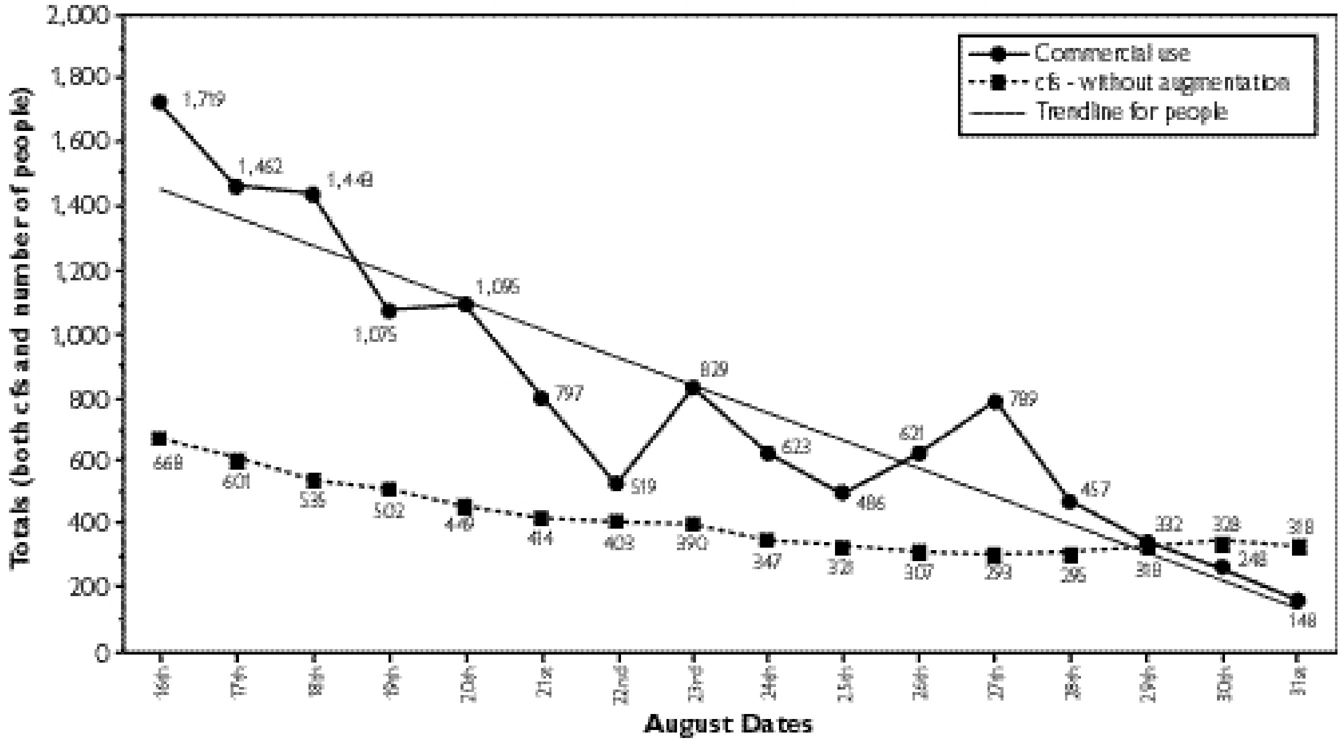


FIGURE 6-39

August Flows and Total Commercial Use - 1995

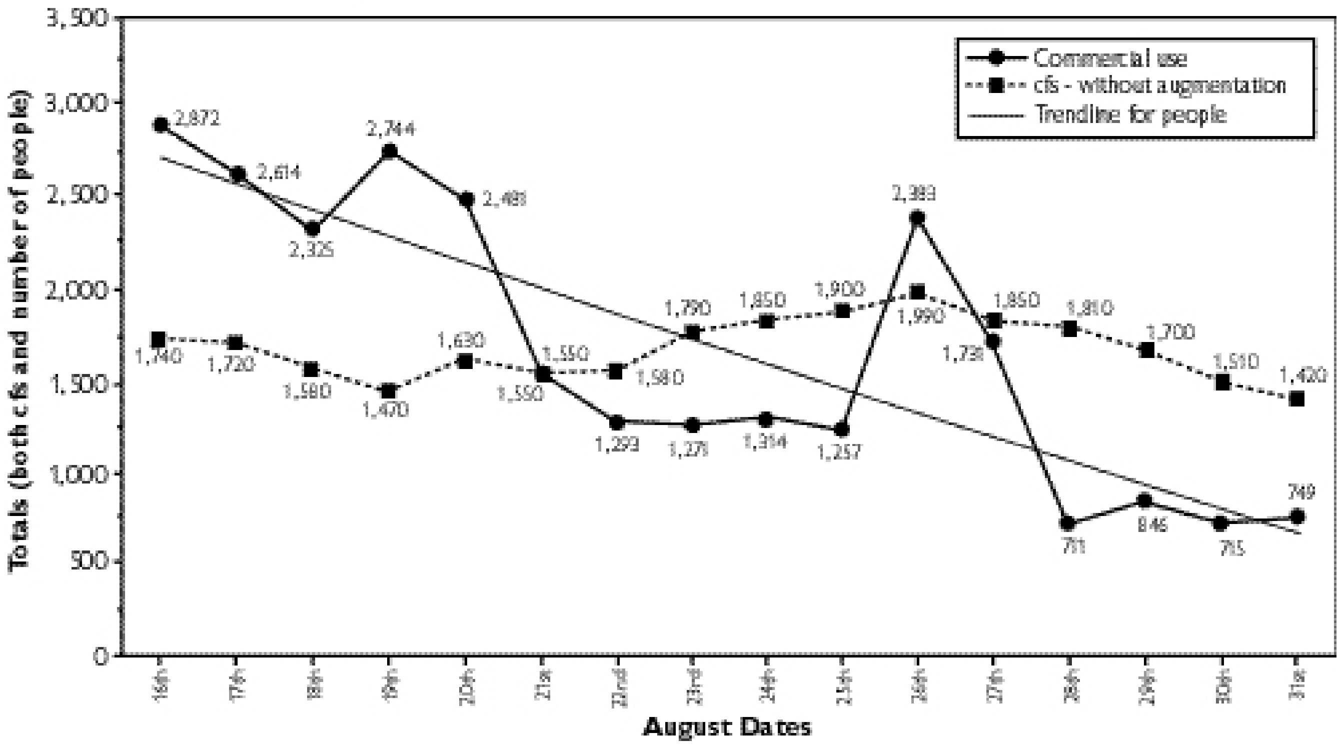


FIGURE 6-40

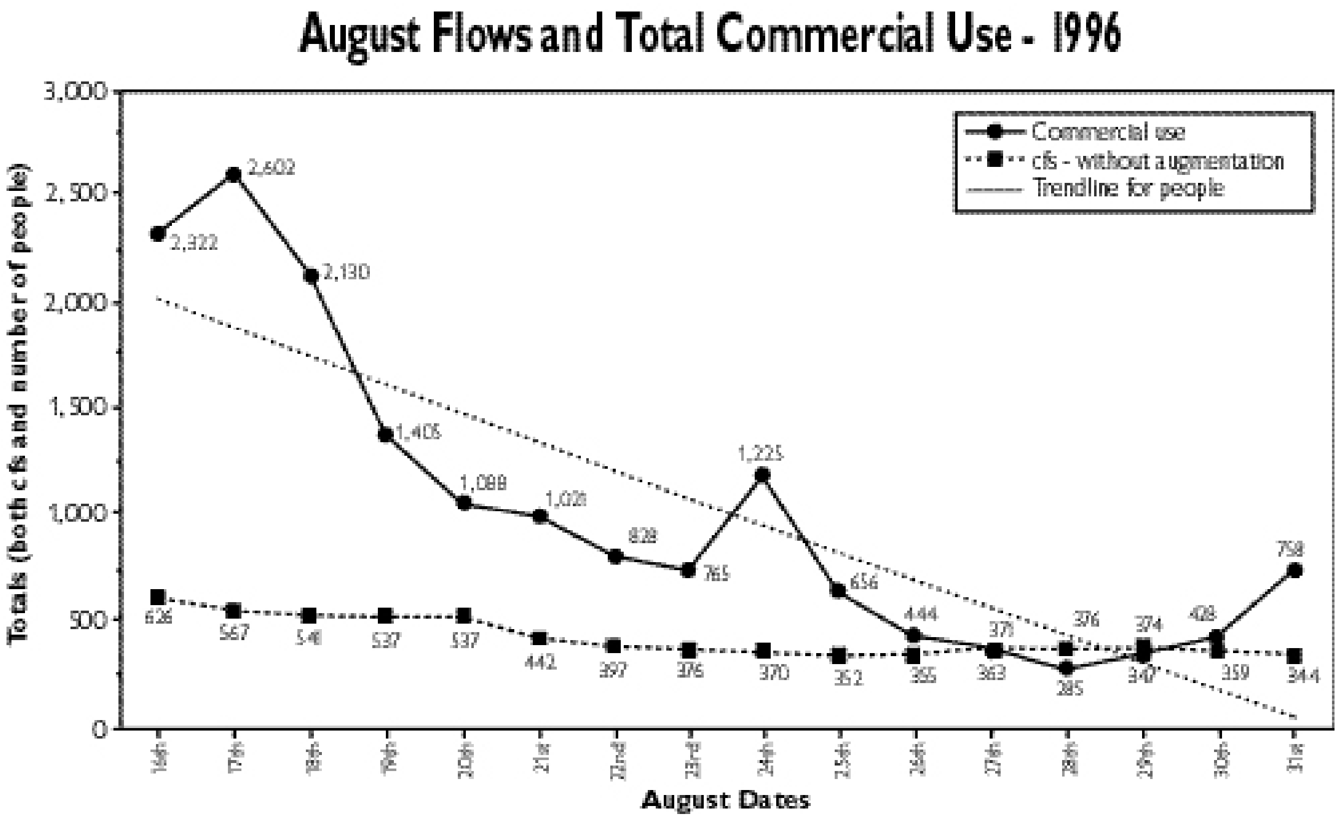


FIGURE 6-41

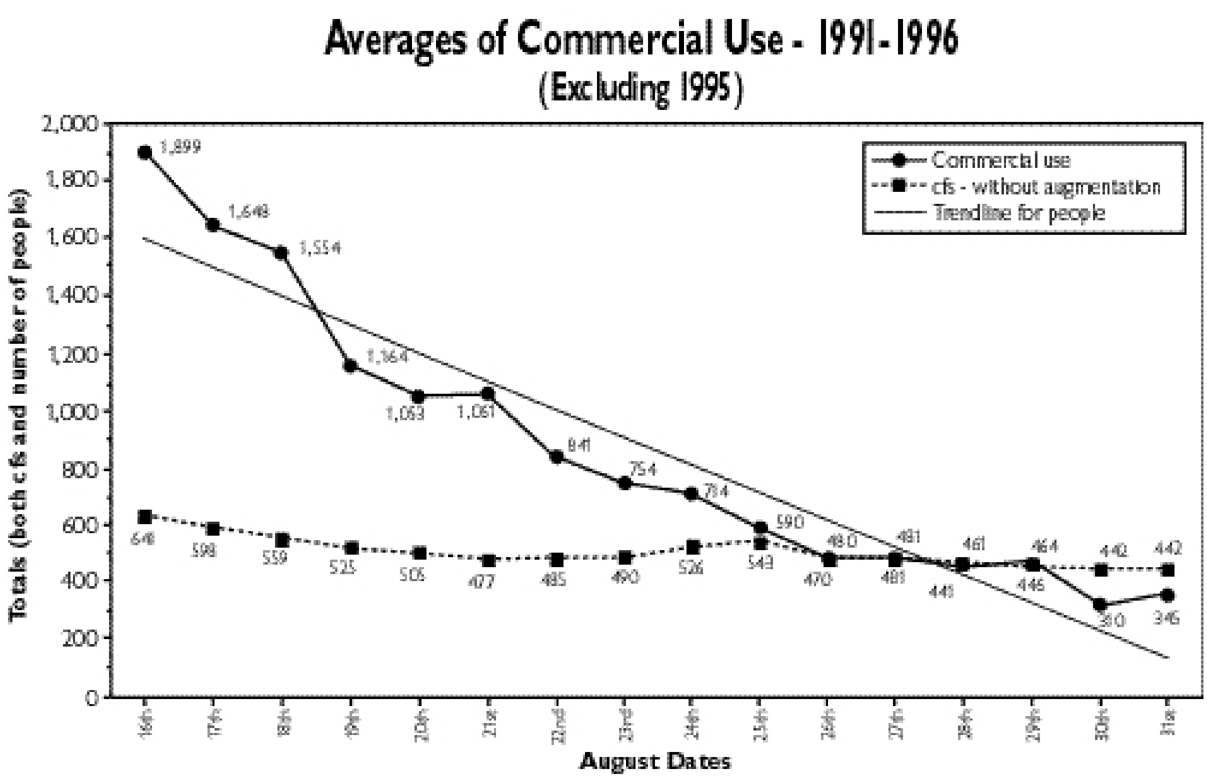


TABLE 6-22

Averages of 1991-1996 Late August Commercial Use (Excluding 1995)

Late August Date	Flows at Wellsville Gage (cfs)	Total Commercial Boats	Total People (clients & guides)
16	641	322	1,899
17	598	283	1,648
18	559	274	1,554
19	525	208	1,164
20	505	194	1,053
21	477	200	1,061
22	485	161	841
23	490	147	754
24	526	130	714
25	543	113	590
26	478	99	480
27	481	97	481
28	461	90	441
29	446	96	464
30	442	63	310
31	442	71	345

Source: AHRA

lake levels did not affect the quality of their experience and users consistently rated their overall experience as good to excellent, regardless of the lake level. Recreation users at Pueblo Reservoir appear to be more strongly affected by lake levels. At the lowest lake level surveyed (4,839 feet - 41 feet below full conservation pool), as many as 70 percent of the users surveyed indicated that their experience was affected by water level. At a higher water level (4,865 feet - 15 feet below full conservation pool), this percentage was reduced to slightly more than 10 percent, with almost 90 percent of the users indicating that they were not affected by water levels.

In all cases, at all three reservoirs, the majority of users surveyed (>87 percent) indicated that, regardless of water levels, they would choose to return under identical conditions. This suggests that while water levels have an influence on the recreation experience, water levels themselves (at least not across the range surveyed for this study) do not generally influence people's behavior patterns. Users have become accustomed to fluctuating water levels, particularly at Pueblo Reservoir.

Turquoise and Twin Lakes Reservoirs

Turquoise and Twin Lakes Reservoirs are similar in both their setting characteristics and the recreation activities that they support. Both reservoirs are situated at the upper end of the study area and both provide a relatively high elevation mountain experience. Both reservoirs are located entirely within the San Isabel National Forest and support developed day use and overnight facilities managed by the USFS. Most of the recreation use at the reservoirs is oriented towards camping, boating, fishing, and sightseeing. Approximately 60 percent of the users surveyed at Turquoise and Twin Lakes were camping, 70 percent were fishing, and 20 percent were boating. Almost all of the boating activity was oriented towards fishing.

The majority of users at Turquoise Reservoir came from the Front Range area of Colorado (70 percent). Approximately 8 percent of the users were from out-of-state. About a third of the users were first-time visitors while approximately 25 percent were frequent repeat users (had visited more than 10 times). Users at Twin Lakes were similar except that only 58 percent of the users came from the Front Range. Almost 20 percent of the users came from southeastern Colorado (as opposed to 9 percent at Turquoise), and 16 percent of the users were from out of state. As with Turquoise, about one-third of the users were first-time visitors and one-fourth were frequent visitors.

With regard to the effect of water levels on recreation, survey results indicate that users prefer higher water levels. Overall, the quality of the recreation experience was rated high at both lakes regardless of water level. The type and distribution of activities at the two reservoirs did not change with changing water levels.

Typically, reservoir water levels influence the overall appearance or aesthetics of the landscape. However, survey results for Turquoise and Twin Lakes suggest that while the appearance of the lakes is important, water levels (at least those sampled) do not play a strong role. While only 1 year was sampled, the lake level conditions experienced in 1994 were typical of the normal operation of the two reservoirs (see the "Recreation Setting" discussion for more details regarding reservoir operations). Users at both Turquoise and Twin Lakes indicated that their recreation experience was either somewhat or strongly affected by the appearance of the lakes. However, when asked if water levels themselves affected the quality of their experience, most users said no (75 percent at Turquoise and 81 percent at Twin Lakes).

Figures 6-42 and 6-43 show responses regarding the scenic beauty of the lakes versus water level. Each of the black bars shown represents a different weekend period that corresponds to a given lake level as shown with the overlaid line graph. The height of each bar graph depicts the percentage of users that consider the scenic beauty of the lake to be excellent. Results show that while this percentage generally increased as water levels increased, the change was

FIGURE 6-42

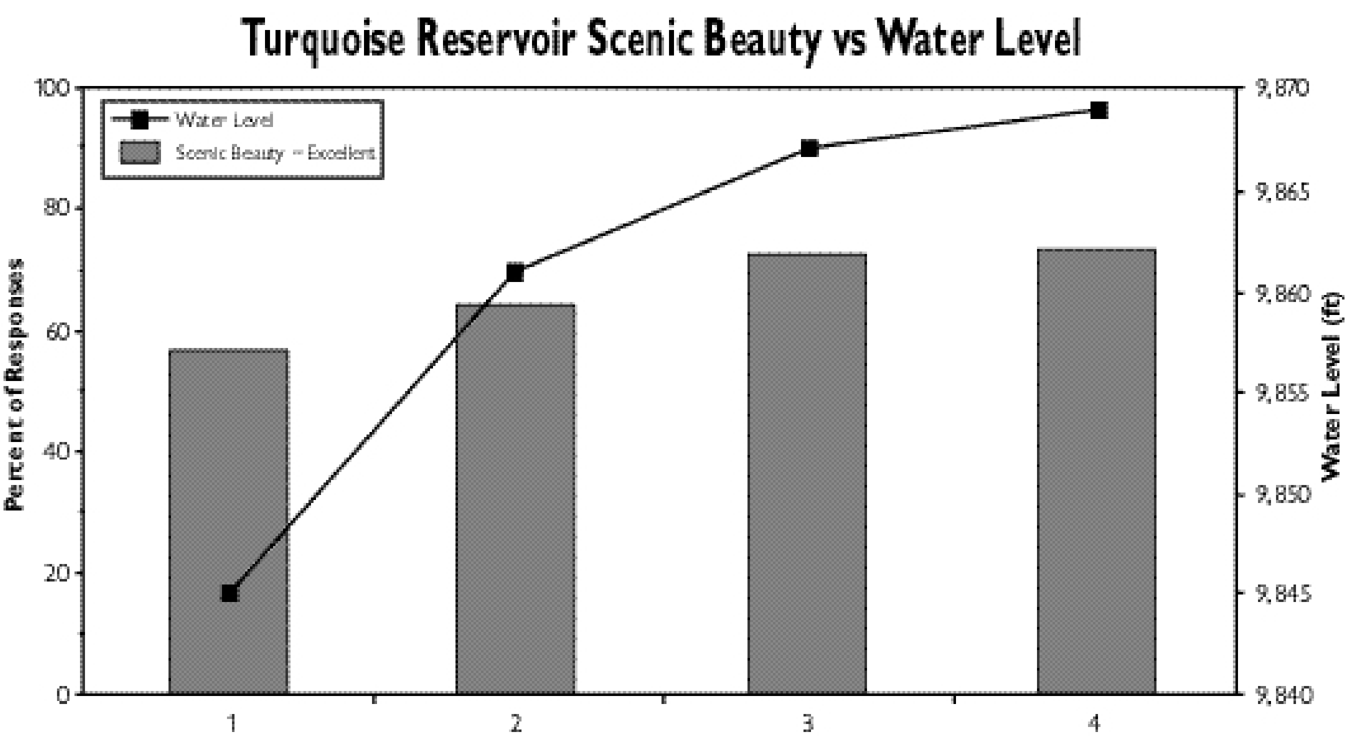
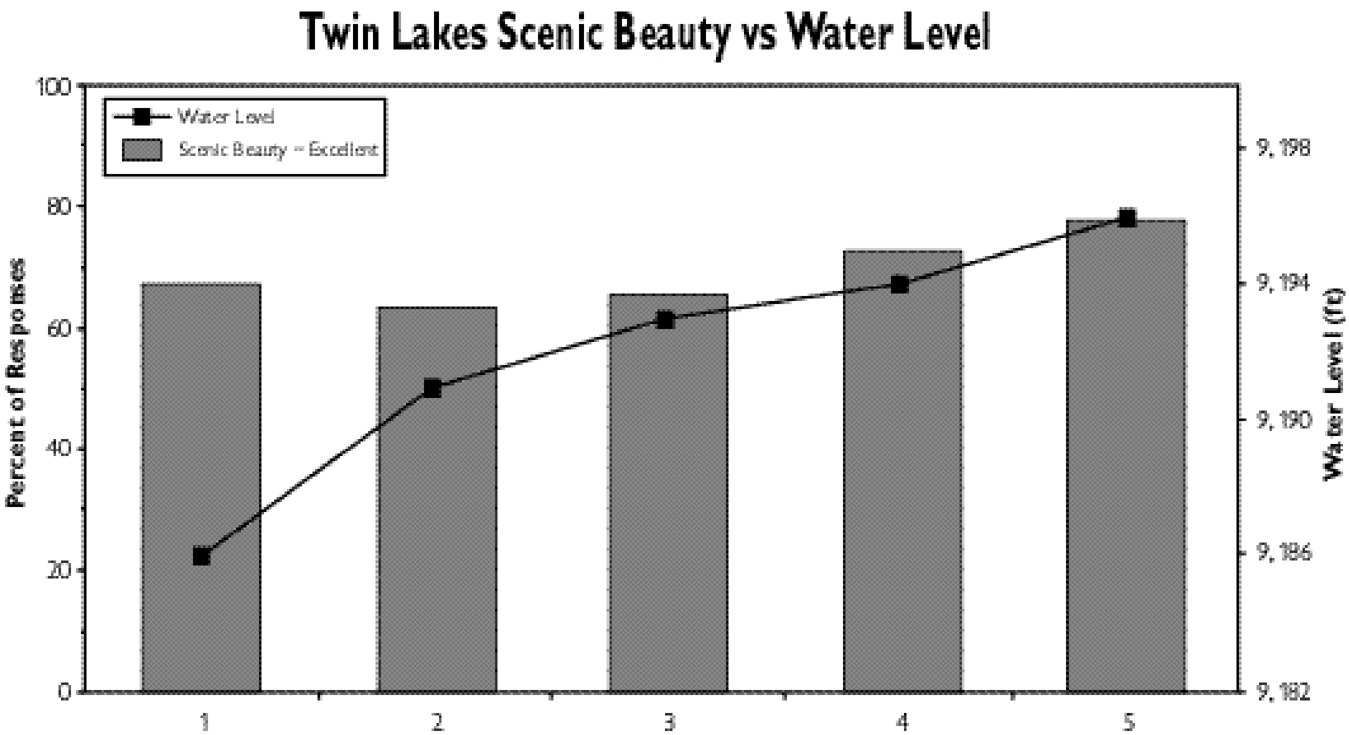


FIGURE 6-43



extremely small and the percentage of respondents rating scenic beauty as excellent was high (>60 percent), even at low water levels.

When asked if they would prefer water levels that were higher, lower, or the same, users generally indicated a preference for higher levels when the lakes were at their lowest and the same levels when the lakes were at their highest. These results are displayed in Figures 6-44 and 6-45, which show the percentage of respondents choosing either the same or higher/much higher at each of the surveyed water elevations for Turquoise and Twin Lakes. Again, each cluster of bar graphs represents a different sampling time, which corresponds to a different lake level as shown with the line graph. These results are generally consistent with the theory that users, when given a choice, prefer a full reservoir. However, they also suggest that users may not differentiate between a full reservoir and a minimal drawdown of only a few feet.
Finally, Figures 6-46 and 6-47 show how the percentage of respondents rating the overall recreation experience as excellent changed according to changing water levels at Turquoise and Twin Lakes Reservoirs. Again, there is a slight trend towards higher average scores as water levels increase, but the change is generally insignificant and the overall ratings are high even at low water levels.

Pueblo Reservoir

Located at the lower end of the study area, Pueblo Reservoir provides very different recreation opportunities from Turquoise and Twin Lakes Reservoirs. Pueblo Reservoir offers a high desert type setting and is used extensively for water-based activities including water skiing, sailboarding, and other personal watercrafts. Pueblo Reservoir is much larger than Turquoise or Twin Lakes Reservoirs and supports much higher use levels. Survey results indicate the predominant recreation activities at Pueblo Reservoir are boating (67 percent), fishing (42 percent), camping (31 percent), and water skiing (27 percent).

FIGURE 6-44

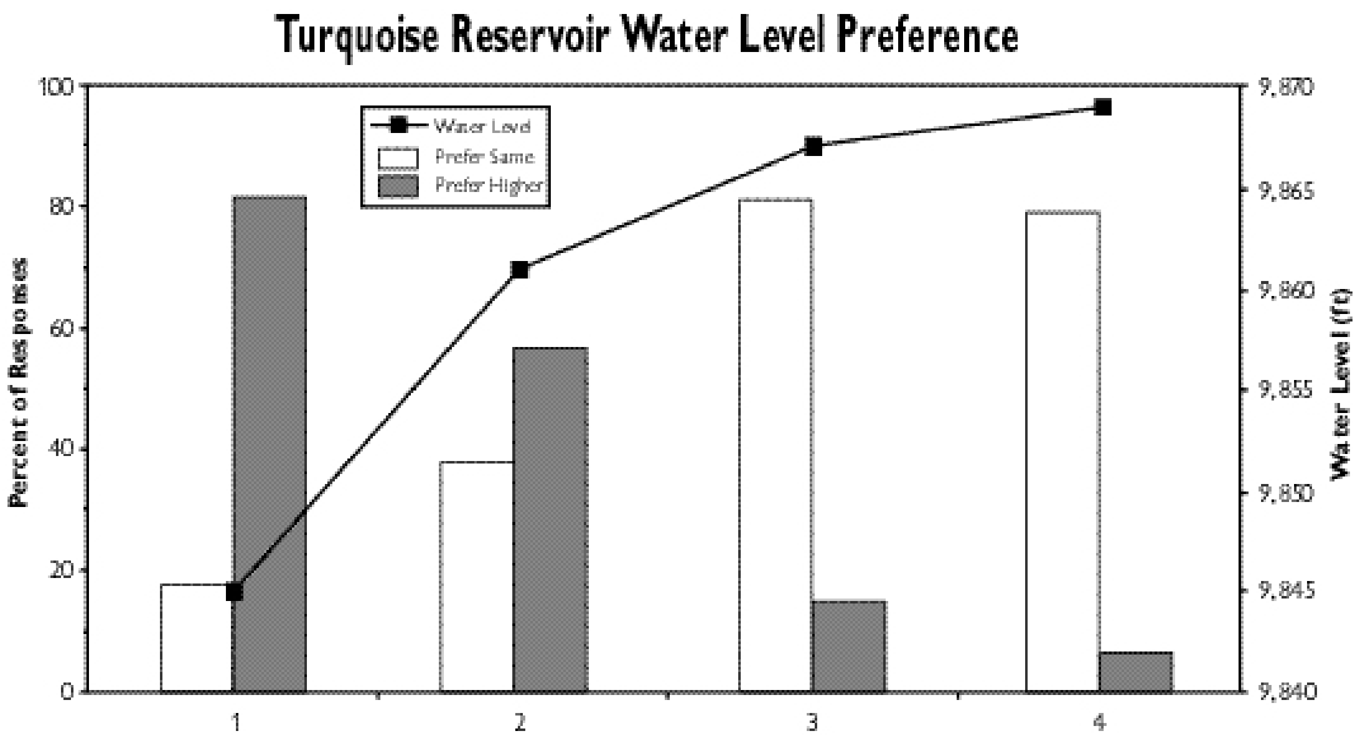


FIGURE 6-45

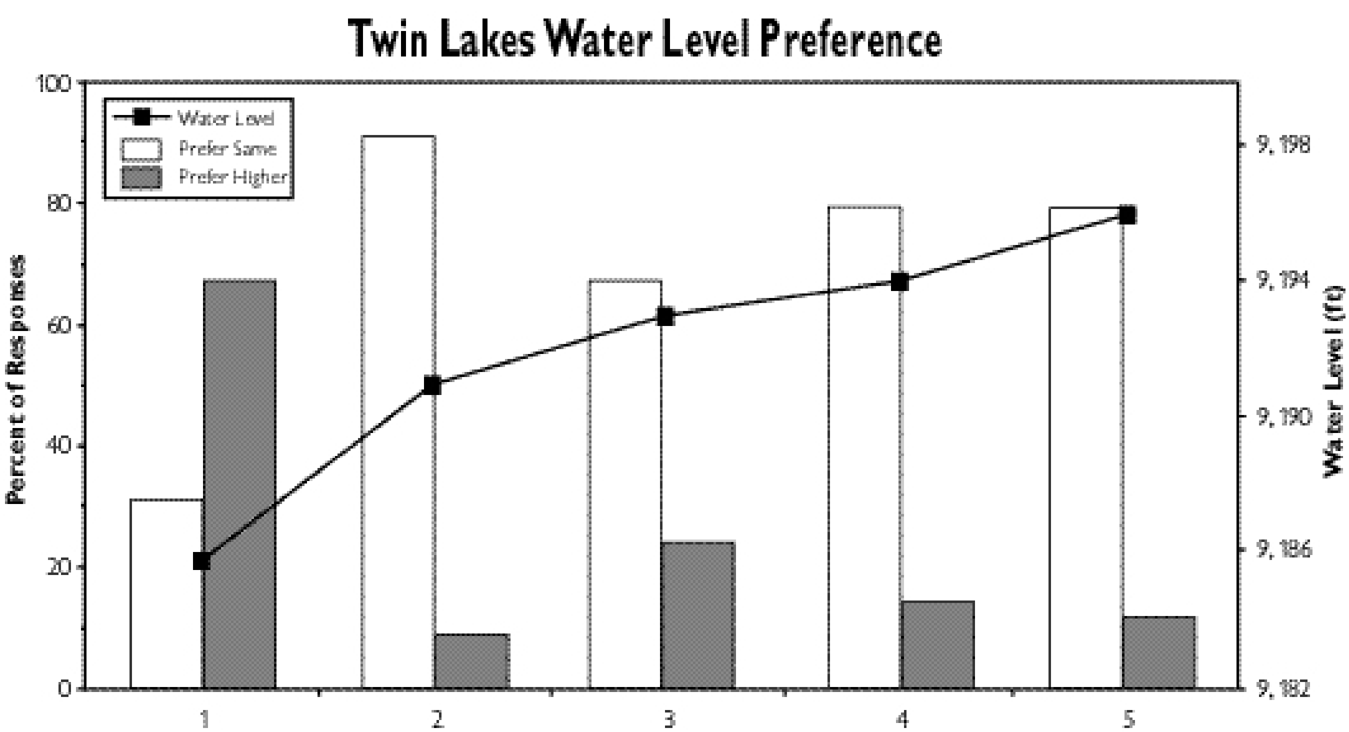


FIGURE 6-46

Turquoise Reservoir Overall Experience vs Water Level

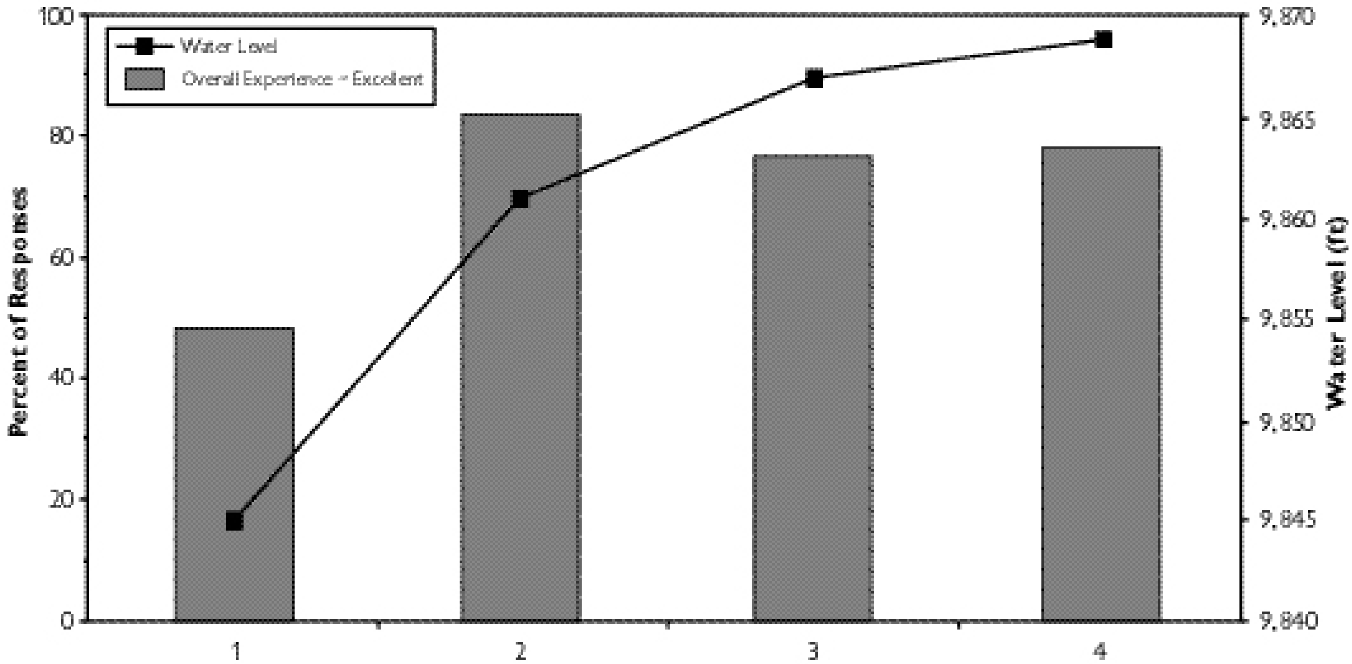
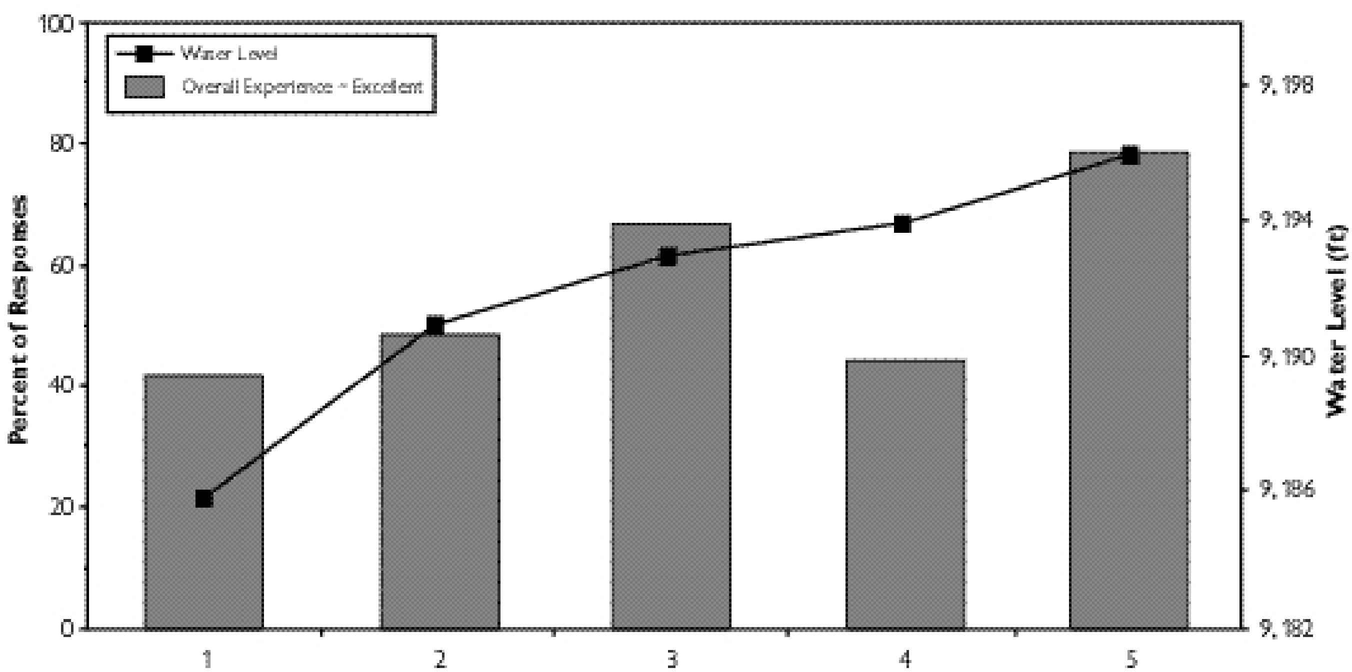


FIGURE 6-47

Twin Lakes Overall Experience vs Water Level



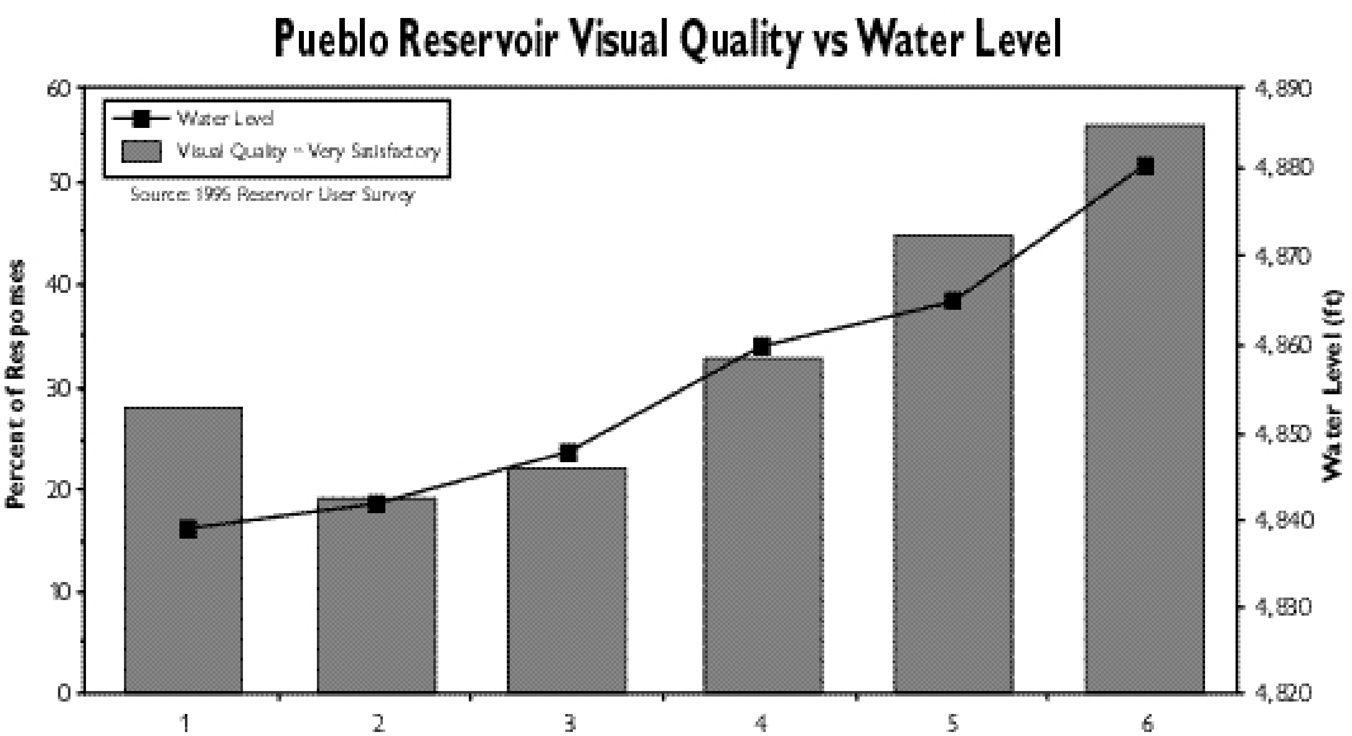
Almost two-thirds of the users surveyed at Pueblo Reservoir came from southeastern Colorado. Approximately one-third came from the Front Range, and 4 percent were from out of state. The majority of the users (54 percent) were frequent repeat users (had visited more than 10 times). About 20 percent of the users had been to the reservoir 2-5 times before, and just under 15 percent were first-time visitors.

With regard to the effect of water levels on recreation, survey results indicate a clear preference for higher water levels and concerns regarding safety, aesthetics, and the overall quality of the experience at low water levels. Unlike Turquoise and Twin Lakes Reservoirs, where the majority of users indicated that water levels did not affect the quality of their experience, 70 percent of the users surveyed at Pueblo Reservoir indicated that the quality of their experience was affected by water level at the lowest water level conditions (4,839 feet). This percentage decreased as water levels increased, but remained relatively high (>50 percent) for most of the water levels sampled. The type and distribution of activities at the reservoir, however, did not change with changing water levels.

The more pronounced influence of water level at Pueblo Reservoir compared to Turquoise or Twin Lakes Reservoirs is partly explained by the more severe drawdown at Pueblo (41 feet below full conservation pool versus 24 feet and 14 feet at Turquoise and Twin Lakes, respectively); the generally shallower nature of the reservoir shoreline; and the more water-oriented, body-contact recreation activities pursued at Pueblo.

When asked about the visual quality of the reservoir, users tended to provide higher ratings at higher water levels, as shown in Figure 6-48. Overall, 63 percent of the users surveyed indicated that the appearance of the lake had a somewhat strong to strong effect on their recreation experience.
When asked about safety, a higher percentage of the respondents tended to indicate that conditions were unsatisfactory or very unsatisfactory at lower

FIGURE 6-48



water levels. This trend is displayed in Figure 6-49. These results suggest that there is somewhat of a threshold water level between 4,850 feet and 4,860 feet at which safety concerns are significantly reduced. A similar threshold is shown in Figure 6-50, which displays user perceptions regarding shoreline access. These results indicate that a significantly higher percentage of the users are satisfied with shoreline access between water levels of 4,860 feet and 4,880 feet.

When asked if they would prefer water levels that were higher, lower, or the same, users generally indicated a preference for higher levels when the lakes were at their lowest and the same levels when the lakes were at their highest. These results are displayed in Figure 6-51, which shows the percentage of respondents choosing either the same or higher/much higher at each of the surveyed water elevations at Pueblo Reservoir. These results indicate that users, when given a choice, prefer more water in the reservoir.

Finally, Figure 6-52 shows how the overall recreation experiences of respondents changed according to changing water levels at Pueblo Reservoir. These results indicate a definite preference for water levels greater than 4,848 feet. Surprisingly, they also show that an increase in water level from 4,860 feet to 4,880 feet, a difference of 20 feet, did not make a significant difference in the overall quality of the experience. In fact, the higher water levels were rated, on average, slightly lower than the 4,860-foot level. This suggests that the recreation experiences available at Lake Pueblo when water levels are at 4,860 feet are similar to those that are available at higher elevations, such as 4,880 feet.

FIGURE 6-49

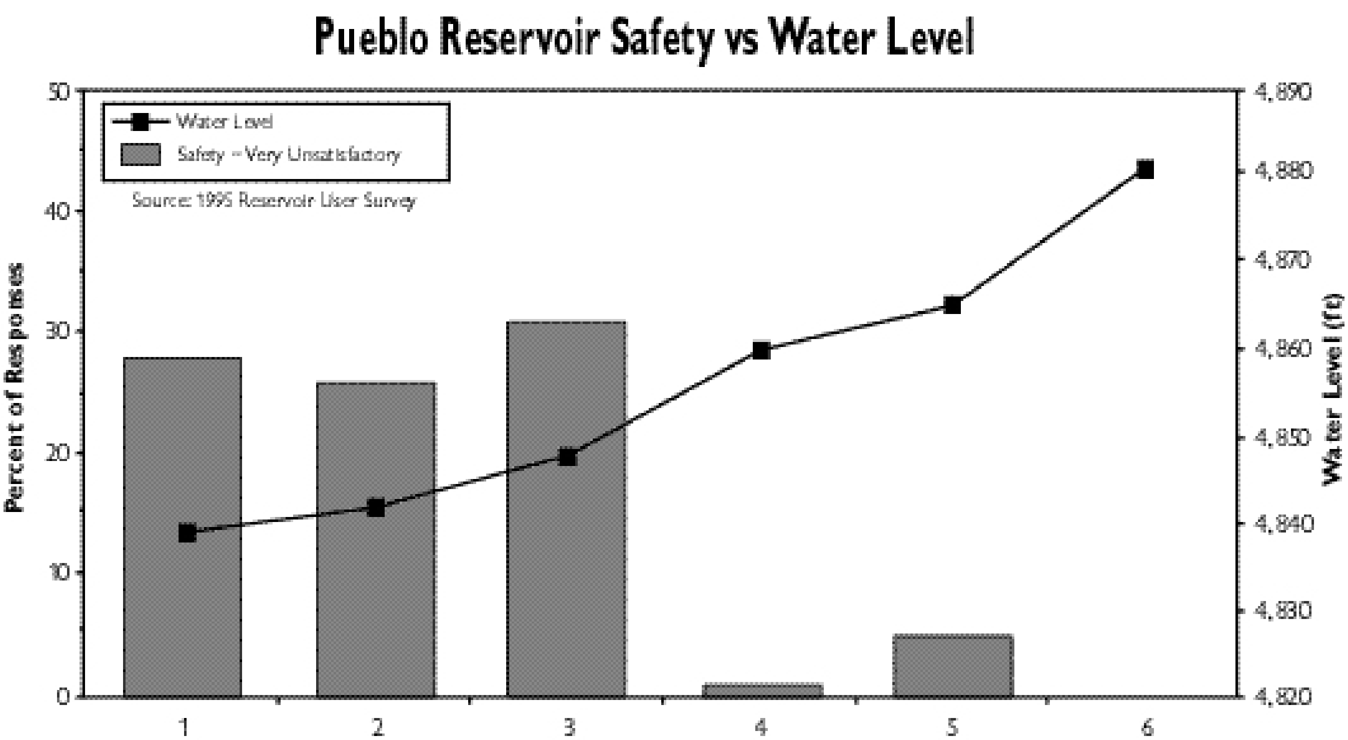


FIGURE 6-50

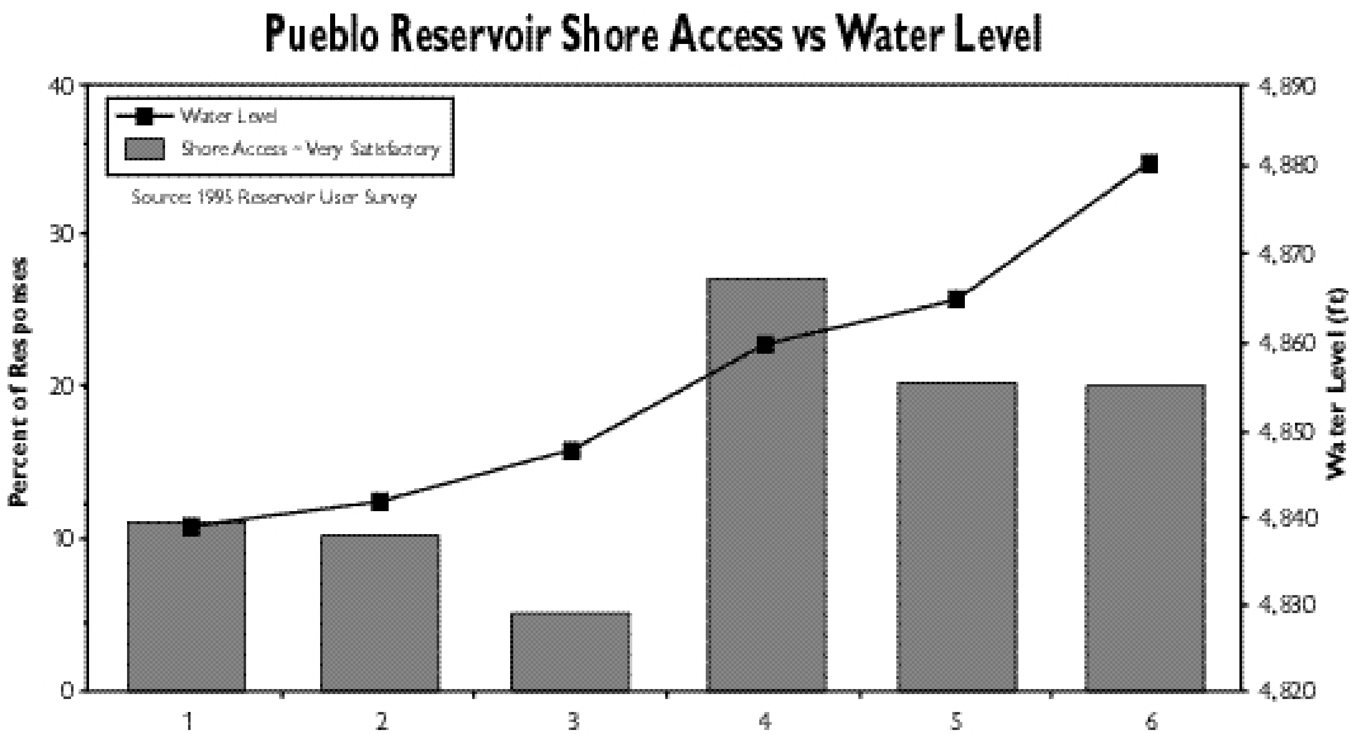


FIGURE 6-51

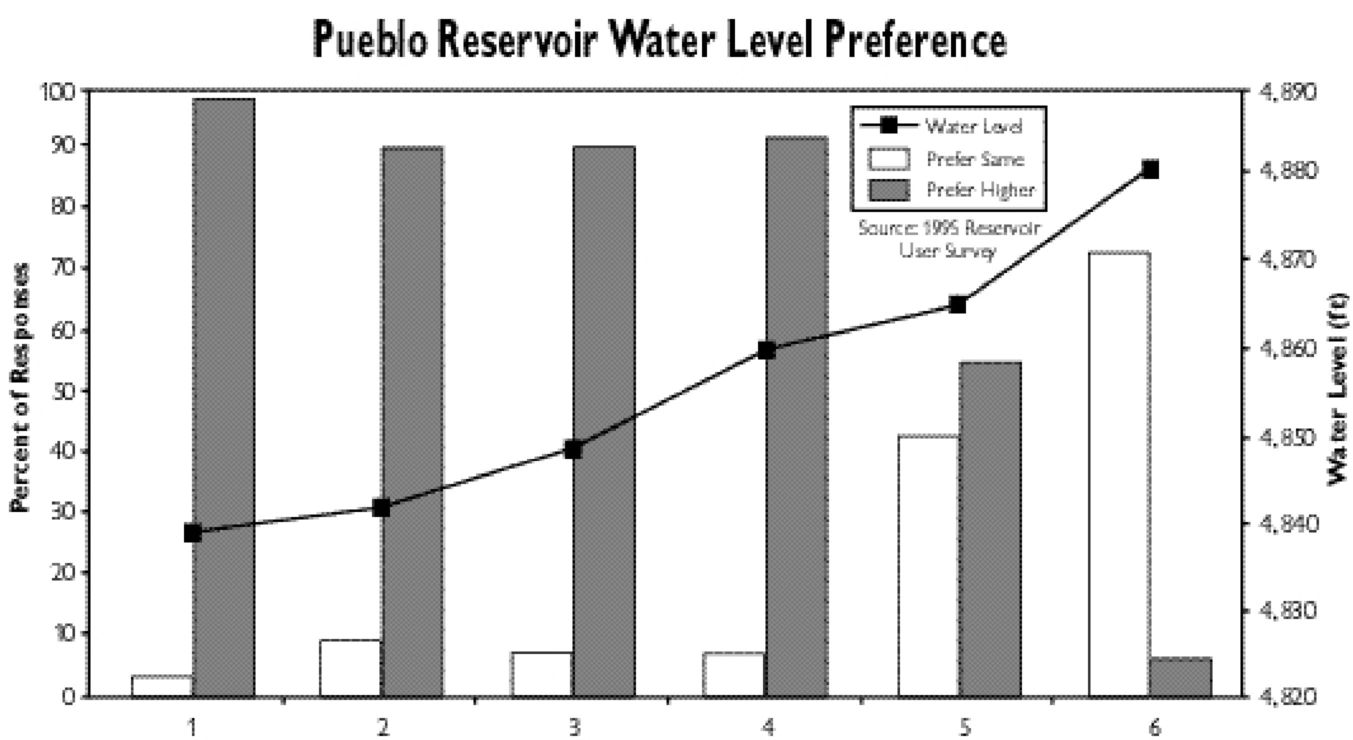
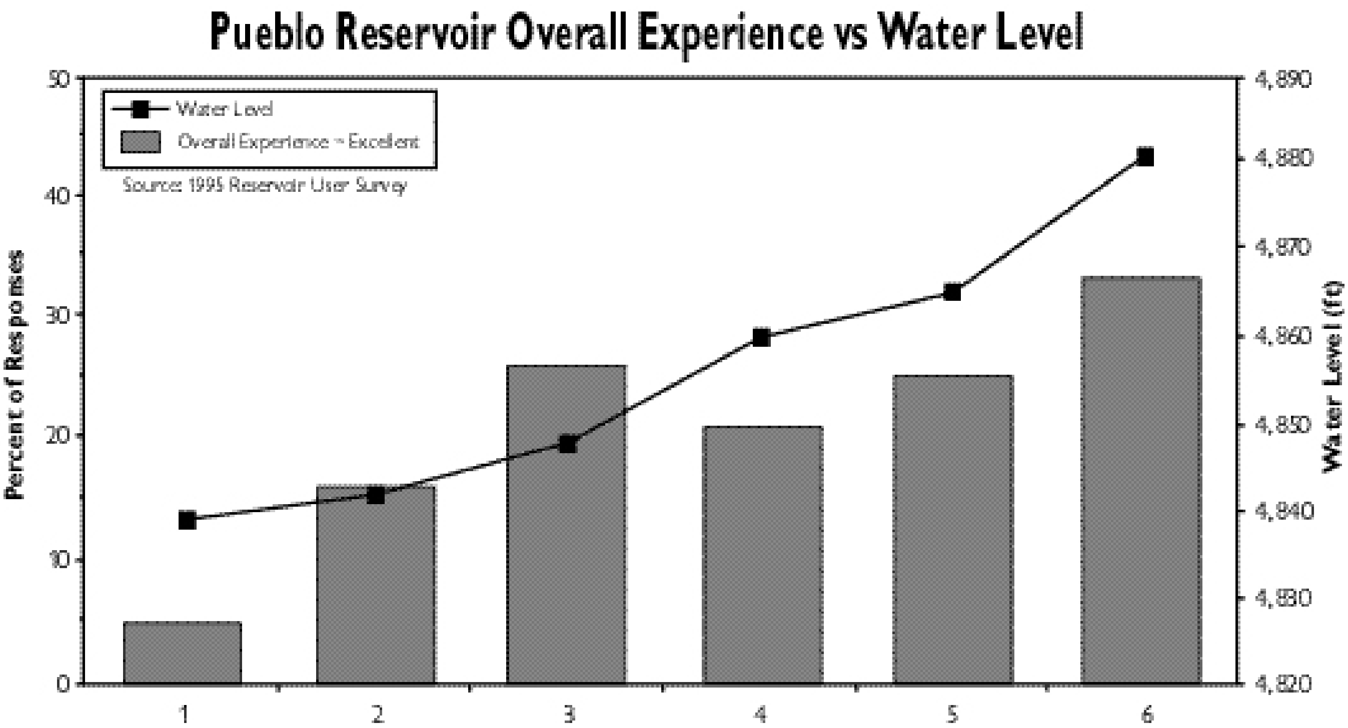


FIGURE 6-52



Physical Modeling Results

The relationship between reservoir water elevation and exposed shoreline acreage is linear at the three reservoirs, based upon physical modeling results (see Figures 6-53, 6-54, and 6-55). Twin Lakes Reservoir, at its highest surface elevation of 9,200 feet, has zero acreage of exposed shoreline. At the lowest modeled water elevation of 9,186 feet, a difference of 14 feet, there was an increase of 595 acres of exposed shoreline. The largest increase occurs with the surface elevation change from 9,199 to 9,198 feet, in which exposed shoreline increases 50 percent, from 44 to 88 acres. Surface elevation subsidence from 9,198 to 9,197 feet produces a 34 percent increase of exposed shoreline. The remaining elevation changes produce increases in exposed shoreline ranging from 25 percent to 6 percent. The relationship between draw-down and exposed shoreline has implications for both recreation and biological values. Figure 6-45 shows that a drawdown of 10 feet does not affect user preference. However, 70 percent of users prefer a higher water level when the lake is drawn down 14 feet. Biological impacts also occur with drawdowns of more than 10 feet (i.e., loss of littoral habitat - see Section 5 of the report for more details.)

The Turquoise Lake Reservoir model used decreasing water elevation changes of 5 feet. Exposed shoreline acreage ranged from 45 to 265 acres. Increases in exposed shoreline ranged between 38 percent and 22 percent for each 5-foot change in elevation. The most significant increase in exposed shoreline occurred with the water elevation drop from 9,870 to 9,865 feet, equaling 38 percent. The lowest percentage increase occurred with the water elevation decrease from 9,855 to 9,850 feet, equaling 22 percent. Again, the relationship between drawdown and exposed shoreline has implications for both recreation and biological values. User preferences are similar to those at Twin Lakes. A 5-foot drawdown does not affect user preferences (i.e., 80 percent are satisfied with the water level). However, 60 percent of users preferred a higher water level when

FIGURE 6-53

Calculated Relationship Between Twin Lakes Elevation and Exposed Shoreline

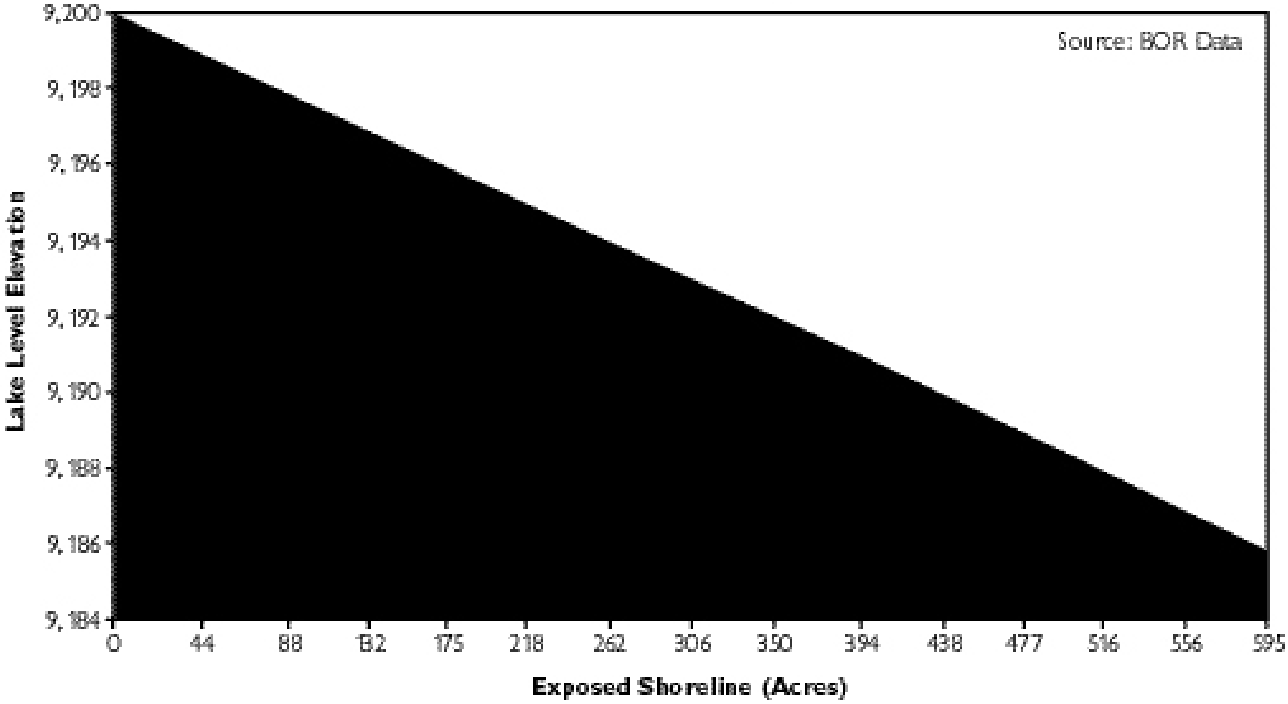


FIGURE 6-54

Calculated Relationship Between Turquoise Lake Elevation and Exposed Shoreline

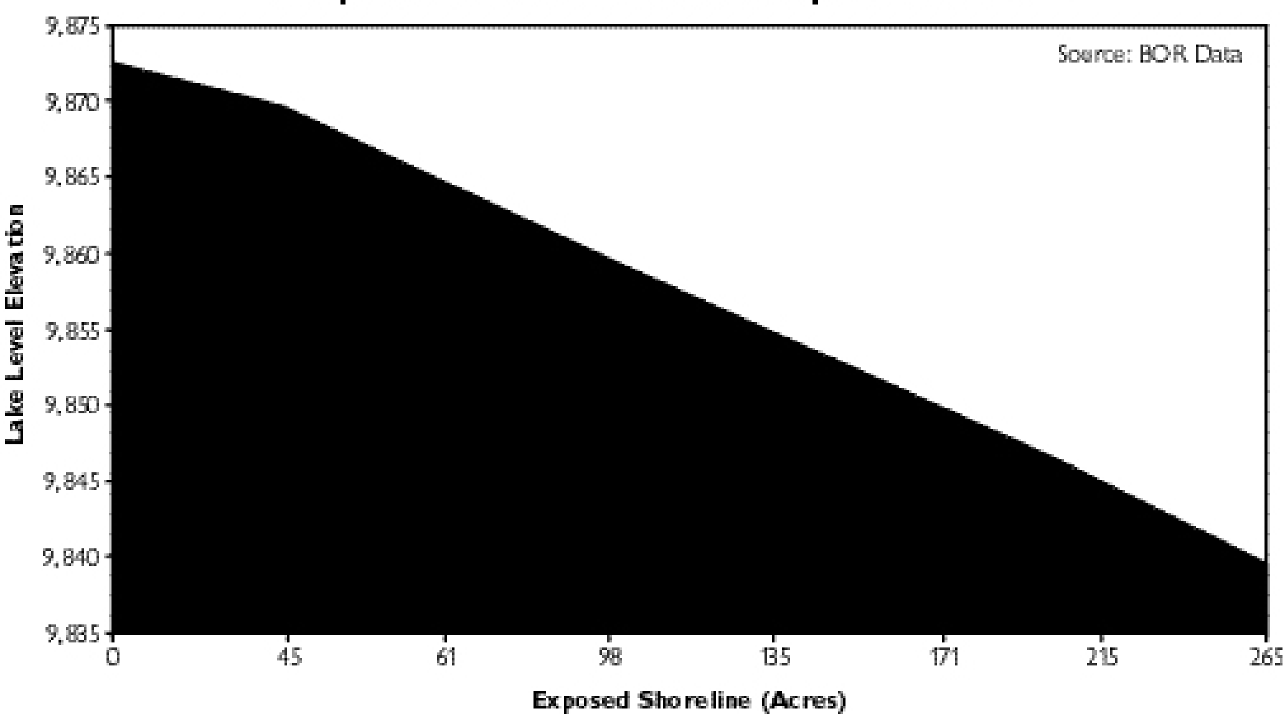
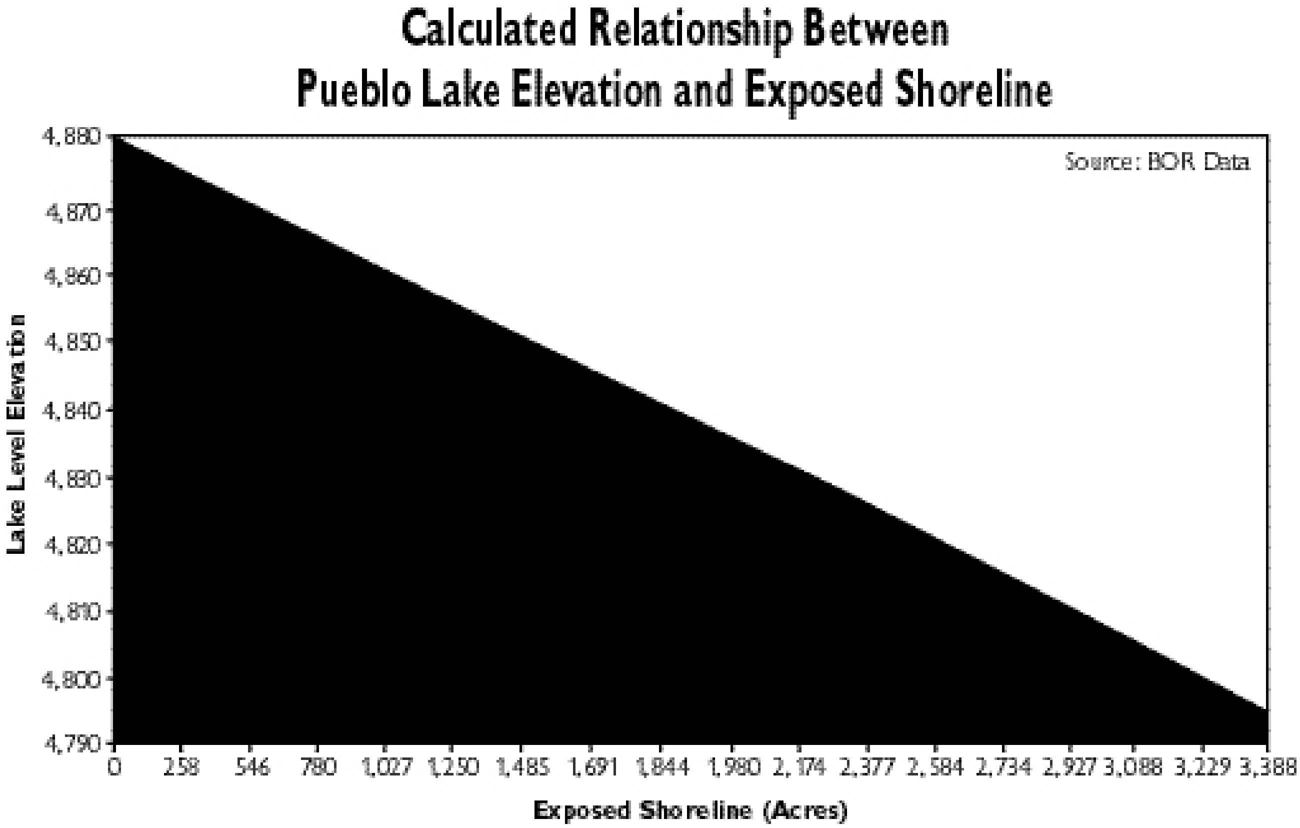


FIGURE 6-55



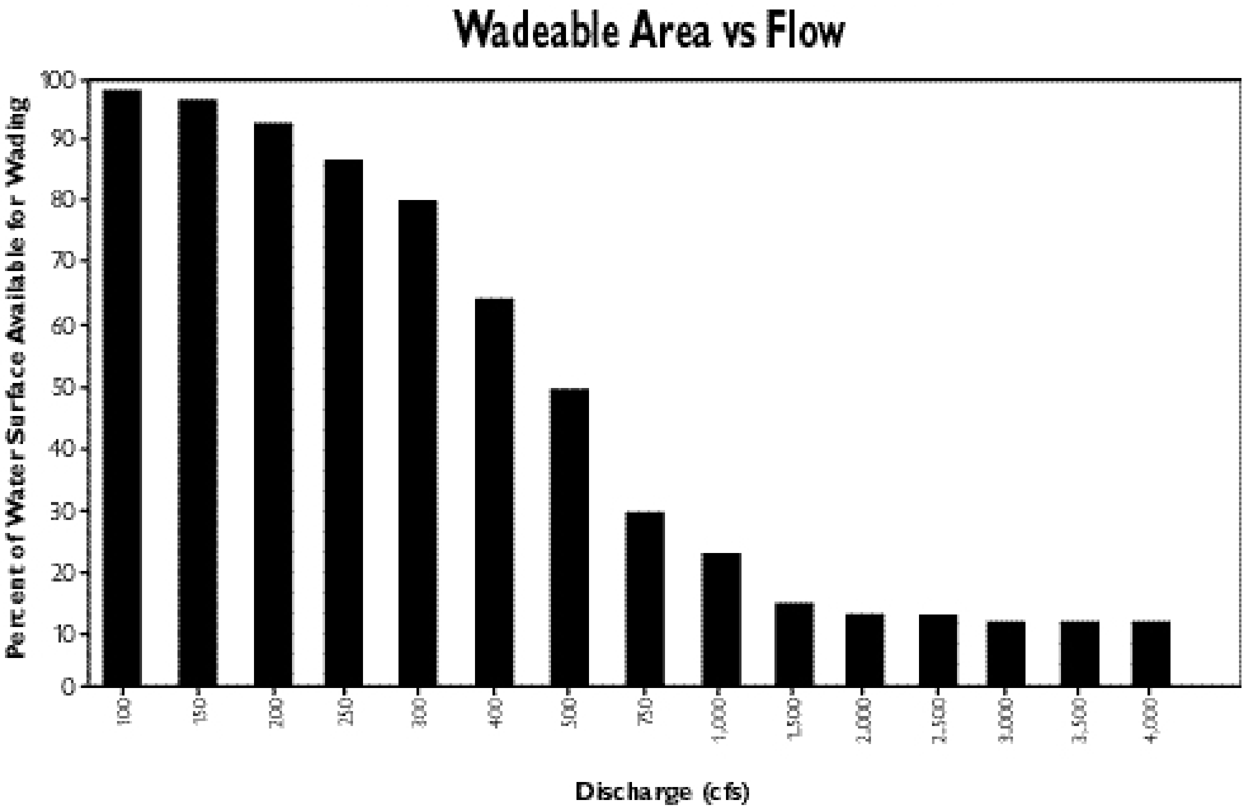
drawdown was 12 feet (Figure 6-44). Drawdowns of more than 10 feet affect user preferences and have similar biological implications to those at Twin Lakes.

The Pueblo Reservoir model presented a similar result. Exposed shoreline increases significantly with initial decreases in water elevation; for example, 53 percent more shoreline acreage is exposed when the water level drops from 4,875 to 4,870 feet as shown in Figure 6-55. However, the percent change in exposed shoreline decreases systematically and then levels off in the model's final elevation level changes. The last 10 of a total 17 elevation changes modeled show an increase of exposed shoreline ranging from only 5 to 10 percent. Figure 6-51 shows the majority of users prefer water levels higher than 4,860 feet, which is 20 feet below the top of the conservation pool.

Figure 6-56 illustrates the percentage of Arkansas River area available for wading at different riverflows. Wading area means the flow level at which the average person is capable of wading comfortably. Wading area was calculated by using wadability curves[1] and plugging those into the Physical Habitat Simulation Model used for the fisheries analysis. This produced an amount of wadable area for each fisheries site analyzed on the river, including sites such as the Floodplain reach and the Wellsville reach. When the discharge

[1] Hyra, Ronald. 1978. Methods of Assessing Instream Flows for Recreation. U.S. Fish and Wildlife Service. Publication Number FWS-OVS-78-34. 16 pp.

FIGURE 6-56



amounts are between 100 and 300 cfs at the Wellsville gage, river availability for wading ranges between 99 percent and 80 percent. Additional increases in flow alter availability significantly, with a flow rate of 400 cfs resulting in 69 percent availability. Wade area availability drops below 50 percent when flows increase above 500 cfs. Flow rates of 1,500 to 4,000 cfs all produce wading area availability below 15 percent.