January 2008

EDR 08-02

Economic Development Report

Colorado State University Extension

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http://dare.colostate.edu/pubs

THE ECONOMIC CONTRIBUTION OF INSTREAM FLOWS IN COLORADO: HOW ANGLING AND RAFTING USE INCREASE WITH INSTREAM FLOWS

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January 10, 2008

Executive Summary

Existing data from surveys of rafters and anglers in Colorado conclude that rafting use and angler days are responsive to river flows. Rafting use increases with river flows up to the top of the river bank (i.e., bankful) or high water mark. Fishing use increases up to 70% bankful.

Current (2006) commercial rafting use in Colorado results in $54 million in **expenditures**, which supports 2,600 direct and indirect jobs in Colorado and provides $38 million in **income** (wages, rents and business profits). Slightly increasing flows would generate another 200 jobs and $3 million in income annually from commercial rafting and related sectors in Colorado. Reducing flows to half of their current levels would result in a loss of 1,000 jobs and cutting income almost in half in the rafting industry and related tourism sectors.

Combining the commercial rafting economic results with USGS streamflow data allows calculation of the economic contribution of each acre foot of water on specific rivers. This ranges from a high of $352 of state income per acre foot on the Arkansas River, roughly $145 an acre foot on the Poudre River to $18 an acre foot on the Colorado River through Glenwood Canyon (where the high volume of water reduces the income per acre foot). In the case of the Arkansas and Poudre Rivers, the state income generated per acre foot is competitive with irrigated agricultural crops such as alfalfa and corn. It is particularly noteworthy that these values per acre foot are non-consumptive in that the water is still available downstream to others users, in its unaltered form.

Angler use of streams and rivers in Colorado contributes about $165 million in visitor **expenditures** to the Colorado economy in 2006. The direct expenditures and resulting indirect spending support a total of 7,258 jobs throughout Colorado. These include direct jobs in the fishing industry (e.g., guides), as well direct jobs in surrounding retail, grocery, hotel, gas stations, and indirect jobs in wholesale, transportation, etc. Adjusting the visitor expenditures for leakages out of state, but including the multiplier effect, results in a total of $127 million in **income** (wages, rents, and business profits) contributed to the Colorado economy from recreational fishing on rivers and streams. With slightly increased flows, recreational fishing and related sectors in Colorado would generate another 140 jobs and $1.4 million in income annually. A substantial reduction in flows could result in losses of 2,000 jobs related to fishing and related tourism sectors as well as $35 million in income annually in Colorado.

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The income per acre foot from fishing on the Poudre River of $19 can be added to the $145 income per acre foot for commercial rafting on the Poudre to yield a total income of $164 an acre foot. On the Arkansas River, income per acre foot associated with fishing ($6) and commercial rafting ($352) creates a total recreational value of $358 per acre foot. Overall, slightly increasing flows would generate an additional 340 jobs and $4.4 million in income from additional fishing and commercial rafting use in Colorado. Because these uses are non-consumptive, water is still available for additional uses and users downstream.

Study Objectives

The objective of this analysis is to quantify how the economic contribution of angling and rafting to the Colorado state economy varies with the amount of instream flows. Drawing upon the existing literature, we relate angler and rafting use and expenditures to river flows. Then using a regional economic model, we translate those expenditures into state income and employment to net out any leakages of visitor spending outside the state, and to include the multiplier effects of spending that is retained within the state.

Economic Principles of Demand Shift with Improved Instream Flow

Several studies have shown that river recreation uses increase with increased instream flow, up to some optimum flows (Walsh, et al., Ward, 1987, Shelby, et al. 1992). The rationale for increases in angling and rafting use with flows draws upon both common sense and economic principles. At the level of simple common sense, rafters need a minimum amount of water to literally float their boat above the rocks and fish need a minimum amount of water for survival and reproduction.

It is generally agreed by fisheries biologists that when instream flow increases, there is more fish habitat and hence increased fish populations. As pointed out by Walsh, et al. (1980) increases in instream flow in most rivers increases the number of pools, as well as the amount of flowing river, allowing for anglers to spread out and which reduces congestion. This same relationship is true for rafters: higher flows allow for spreading out of users. Up to a point, as the river flows increase, the aesthetics of the river also improve for both anglers and rafters. For rafters, higher flows often increase the size of rapids, as well speed of travel, thus requiring less rowing. All of these factors increase the enjoyment or what economists call utility. At a given trip cost determined by travel distance to the river, the higher utility, the more trips the visitor wishes to take. As illustrated in Figure 1, if 4 rafting trips per year was optimal at a travel cost of $10 per trip and instream flow of 1000 cfs, when flow increases to 1500 cfs, then the optimal number of trips might be 6. As trips increase with higher flows, additional rafter expenditures go into the tourism sector of the state economy.

DATA SOURCES

Rafting Use

Commercial rafting use was obtained from Greiner and Werner (2007). A total of 510,304 commercial user days were recorded in 2006, almost no different than use in 2005. Expenditures per day of commercial rafting of $106.53 were obtained from Greiner and Werner, 2007.

Fishing Data

The number of angler days in Colorado in 2006 and angler expenditures were obtained from the most recent USFWS National Survey (USFWS, 2007). The angler use and expenditures attributable to just stream/river fishing (i.e., excluding lake/reservoir days) was based on the last time USFWS reported such a split between river anglers versus total anglers at the state level (USFWS, 1986).

Quantifying How Angler and Rafting Use Changed With Flows

There are very few studies of how angler use and rafter use changes with instream flows in Colorado. One of the most comprehensive is Walsh, et al.'s study of western Colorado rivers. These researchers quantified how angler and rafter use changed with flows at a representative sample of fishing rivers and another representative sample of rafting rivers. In person interviews were conducted on-site with anglers and rafters. Individuals were asked how their use would change if the river was at different percentages of bankful. The term bankful refers to the river flow being at the height of the riverbank or how close the river is to the annual highwater mark. According to Ward (1987) responses to these types of intended behavior questions should be reasonably free of bias. Loomis (1993) found similar intended visitation responses to different lake levels was reliable.

Regional Economic Model

To convert expenditures to employment, we used RIMS multipliers for each of the general sectors of food, lodging, transportation (gasoline) and equipment

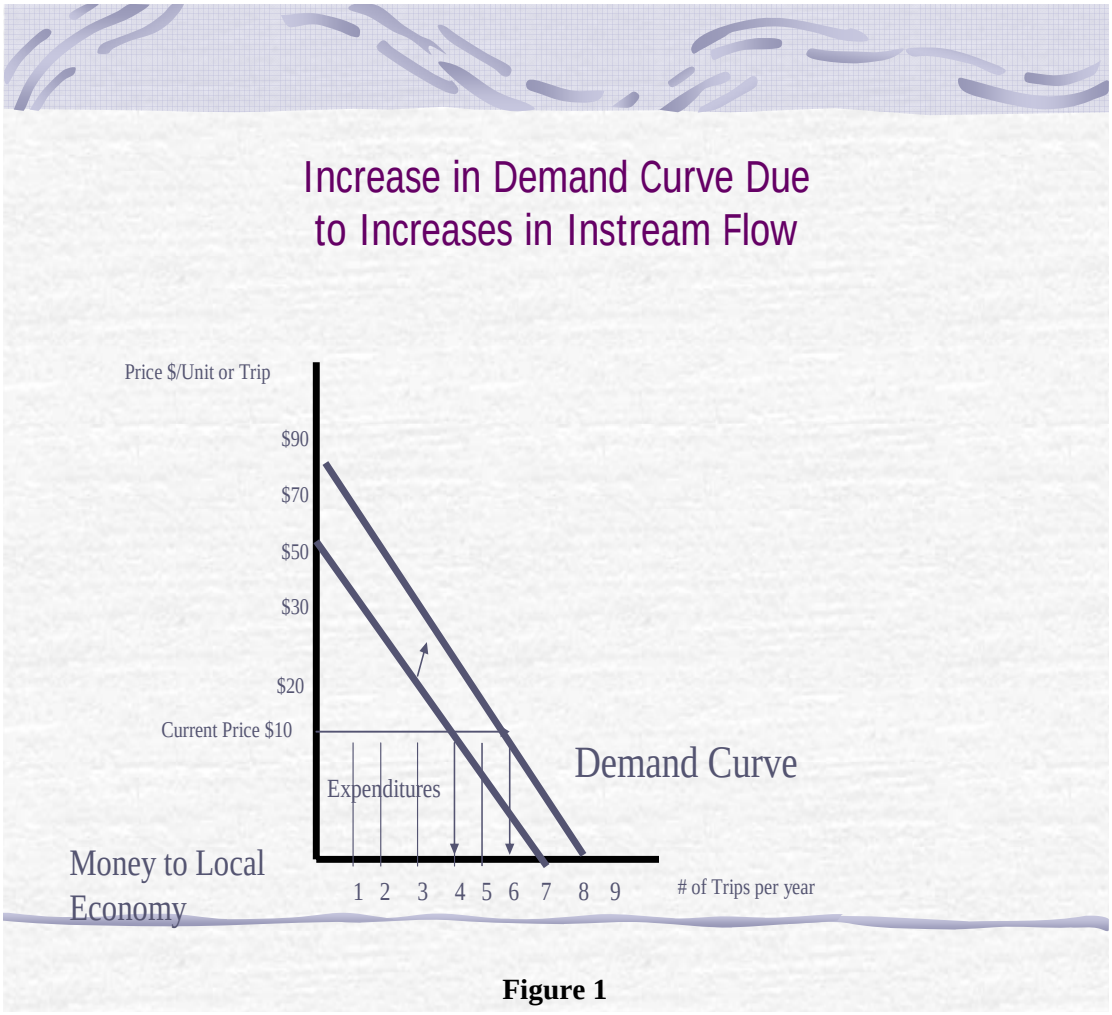

Figure 1

(retail sales) for the State of Colorado (U.S. Bureau of Economic Analysis).

METHODS

Fishing Analysis

Based on comparison of average consumer surplus of fishing of in Walsh, et al.'s Appendix Table 8 to Walsh et al.'s Appendix Table 10 it was determined that actual flow conditions during interviews in summer of 1978 were 55% of optimum or 800 Acre feet or 1600 cfs on average across the different rivers sampled in Colorado. This flow was taken as a measure of current instream flow that results in current angler use. Then we utilized the last year USFWS provided data on river anglers versus total anglers (USFWS, 1985) to calculate the ratio of river angler days to total angler days. This ratio is roughly 51%. This was multiplied by the number of angler days in Colorado in 2006 as estimated by the most recent USFWS National Survey (USFWS, 2007). Then angler days at other flows were scaled using Walsh, et al. demand shift coefficients for fishing from their Appendix Table 7.

Angler trip related expenditures are from the latest USFWS National Survey (USFWS, 2007). The trip related expenditures included food/lodging plus transportation and other miscellaneous trip related costs, for an average cost per day of $53 per day.

To convert trip related expenditures to employment, we used the RIMS II multipliers for each of the general sectors of food, lodging, transportation (gasoline) and retail sales. RIMS II multipliers are published at the state level by the U.S. Bureau of Economic Analysis. To be conservative we assumed all food was purchased in grocery stores, rather than restaurants. We used the proportion of food and lodging from a study of anglers by Loomis (2005) that showed 60% of spending in this category was food, while 40% was lodging. Other trip expenditures were assumed to be trip-related retail

spending such as film, and consumable supplies such as bait, etc. To be conservative we did not include equipment purchases, on the assumption that changes in flows would primarily change trip related expenditures, and not durable capital expenditures on equipment.

Rafting Analysis

Based on comparison of average consumer surplus of rafting in Walsh, et al.'s Appendix Table 8 to Walsh et al.'s Appendix Table 10 Net Benefits per User Day, it was determined that actual flow conditions during interviews in summer of 1978 were 70% of optimum for rafting, or 2800 Acre feet or 5600 cfs in the rivers sampled in Colorado. This flow was taken as a measure of current instream flow that resulted in current rafting use. Then rafting days at other flows was scaled using Walsh, et al. demand shift coefficients for rafting from their Appendix Table 7.

Rafting Use

Commercial rafting use was obtained from Greiner and Werner (2007). A total of 510,304 commercial user days were recorded in 2006, almost no different than use in 2005. Expenditures per day of commercial rafting of $106.53 were obtained from Greiner and Werner, 2007.

Private rafting use data is not generally available for most rivers. This is due to federal agencies such as Bureau of Land Management and the U.S. Forest Service not recording private visitor use. Private rafting information was available for the Browns Canyon area on the Arkansas River in the Arkansas Headwaters reaches for weekend use. The boat counts from May 27, 2006 through September 4, 2006 indicated that 2,434 private boats used one of the six stretches of river during those weekends and holidays (Colorado State Parks, 2007). About 53% of these boats are rafts, and 47% kayaks. At six persons per raft, this amounts to 8900 private use days. However, this recorded private use represents about 4% of the commercial use recorded on the Arkansas River. Little data is also available on private rafter expenditures. Therefore this has not been included in our analysis. However, private rafting use on the Poudre River is likely to be more substantial, but unfortunately we are not aware of any data on estimated use levels.

Selected Individual River Analysis

The information on commercial rafting from Greiner and Werner (2007) provides a breakout by individual river. We combined that information with USGS gauging station information on CFS to estimate the expenditures, income and employment per acre foot of water for selected rivers.

RESULTS

Commercial Rafting

Table 1 shows how commercial rafting use changes with flows. Based on the demand factors developed by Walsh, et al. and applied to current commercial rafting use, rafting use increases with flows in Colorado throughout the full range of flows. More importantly,

Table 1. Commercial Rafting and Estimated Percent Change in Use With Instream Flows in Colorado in 2006

% Bankful	Demand Shift*	Commercial User Days	Percent Change
10	0.1835	93,641	-82%
20	0.3477	177,433	-65%
30	0.4937	251,937	-51%
40	0.6214	317,103	-38%
50	0.7309	372,981	-27%
55	0.7787	397,374	-22%
60	0.8221	419,521	-18%
65	0.8597	438,708	-14%
70	**0.8939**	**510,304****	**NA**
80	0.9475	540,903	6%
90	0.9828	561,055	10%

*Demand shift factor based on Walsh, et al.

**Baseline commercial rafting days in Colorado from Greiner and Werner, 2007

if instream flows are reduced, commercial rafting use is estimated to fall substantially. This drop is consistent with the fact that commercial rafting use in Colorado dropped during the drought of 2002 by 200,000 visitors (Greiner and Werner, 2007).

Table 2 translates the changes in commercial user days into visitor expenditures in Colorado. These changes in expenditures are then converted to changes in employment in rafting company employment, transportation, retail, lodging, etc. in Colorado using RIMS employment multipliers (U.S. Bureau of Economic Analysis). Likewise the changes in visitor expenditures are converted to total income (direct and indirect) in Colorado using RIMS income multipliers (U.S. Bureau of Economic Analysis).

As can be seen in Table 2, current expenditures of $54 million support 2,601 jobs throughout Colorado. These include direct jobs in the commercial rafting industry (e.g., guides, bus drivers, check-in staff), as well direct jobs in surrounding retail, grocery, hotel, gas stations, etc. There are of course indirect jobs generated in industries that support these direct sectors, including bakeries, wholesale, gasoline distribution, etc. Increased instream flows have the potential to increase employment in income in Colorado. As shown in Table 2, however, large decreases in instream flow (e.g., to 30% of bankful) associated with diversions of water out of stream, could cut these jobs and income in half.

Table 3 presents individual river specific estimates of visitor expenditures and associated State of Colorado direct and indirect income. Visitor expenditures per acre foot is a gross spending measure, that does not account for the leakages of the retailer's purchases of goods produced by companies outside of Colorado (e.g., film, food products, some brands of gasoline). In contrast, income per acre foot is the total (direct and indirect) wages, rents and business profits received by employees and firms in Colorado as a result of the visitor spending. We calculated acre feet of flow utilizing USGS gauging station data on flows during the rafting season (usually May 15 to August 15th for most rivers but to the end of Labor Day weekend for rivers that were still boatable (e.g., Arkansas, Colorado). As can be seen in this table, the annual state income per acre foot of water is quite substantial on the Arkansas and Poudre, and competitive with agricultural income per acre foot of water for many typical Colorado crops such as alfalfa or corn. It should also be noted that this income does not require the diversion or consumption of water. The water is still available downstream to other users. Thus in this sense, the income generated does not necessarily preclude other downstream uses of the same water and are therefore additive to these downstream values.

Table 2. Estimated Rafting Expenditures, Employment and Income in Colorado with Different Instream Flows in Colorado in 2006.

% bankful	Total Expenditures	Total Employment**	Total Income**
10	$ 9,975,553	477	$ 7,123,043
20	$ 18,901,906	904	$ 13,496,906
30	$ 26,838,858	1,284	$ 19,164,286
40	$ 33,780,973	1,616	$ 24,121,303
50	$ 39,733,687	1,901	$ 28,371,839
55	$ 42,332,223	2,026	$ 30,227,324
60	$ 44,691,563	2,138	$ 31,912,011
65	$ 46,735,600	2,236	$ 33,371,555
70	**$ 54,362,685***	**2,601**	**$ 38,817,675**
80	$ 57,622,379	2,757	$ 41,145,259
90	$ 59,769,154	2,860	$ 42,678,165

* Estimate from Greiner and Werner, 2007;
**Estimate based on changes in commercial rafting use with flows and RIMS II income and employment multipliers from U.S. Bureau of Economic Analysis for Colorado.

Table 3. Individual River Specific Commercial Rafting Expenditures and Colorado State Income Per Acre Foot (AF)

River	AF*	Expenditures**	Expend/AF	Income***	Income/AF
Arkansas	51210	$ 25,263,757	$ 493	$18,039,586	$ 352
Colorado-Glenwood	267975	$ 6,674,080	$ 25	$ 4,765,627	$ 18
Green/Yampa	212835	$ 1,380,686	$ 6	$ 985,879	$ 5
Poudre	18165	$ 3,678,670	$ 203	$ 2,626,754	$ 145
Taylor	20865	$ 1,611,422	$ 77	$ 1,150,636	$ 55

* AF= Acre feet. Calculated using USGS stream gauging data for May 15 through end of rafting season usually August 15th 2006

** Expenditures from Greiner and Werner, 2007.

***Income calculated using RIMS II multipliers (U.S. Bureau of Economic Analysis).

Fishing

Table 4 shows how angler days changes with flows. Based on the demand factors developed by Walsh, et al. and applied to current angler, angler use would increase slightly for small increases in flows in Colorado. More importantly, if instream flows are reduced, angler days are estimated to fall substantially. In particular, when flows are reduced by half, angler days fall by about 25%.

Table 5 translates the changes in angler days into visitor expenditures in Colorado using U.S. Fish and Wildlife Service data for 2006. These changes in expenditures are then converted to changes in employment in transportation, retail, and lodging sectors, etc. in Colorado using RIMS employment multipliers (U.S. Bureau of Economic Analysis). Likewise the changes in visitor expenditures are converted to total income (direct and indirect) in Colorado using RIMS income multipliers (U.S. Bureau of Economic Analysis).

As can be seen in Table 5, current expenditures of $165 million support 7,258 jobs throughout Colorado. These include direct jobs in the fishing industry (e.g., guides), as well direct jobs in surrounding retail, grocery, hotel, gas stations, etc. There are of course indirect jobs generated in industries that support these direct sectors, including bakeries, wholesale, gasoline distribution, etc. Small increases instream flows have the potential to slightly increase employment and income in Colorado. As shown in Table 5, however, large decreases in instream flow (e.g., to 30% of bankful) associated with diversions of water out of stream, could cut these jobs and income by 25% to 30%.

Table 6 presents two individual river specific estimates of angler expenditures and associated State of Colorado direct and indirect income. Angler expenditures per acre foot is a gross spending measure, that does not account for the leakages of the retailer's purchases of goods produced by companies outside of Colorado (e.g., film, food products, some brands of gasoline). In contrast, income per acre foot is the total (direct and indirect) wages, rents and business profits received by employees and firms in Colorado as a result of the angler spending. We calculated acre feet of flow utilizing USGS gauging station data on flows during the main fishing season (usually May 15 to August 15th for the Poudre River but to the end of Labor Day weekend for the Arkansas River). Angler use on each river is the long term average use from past Colorado Division of Wildlife creel surveys. These do not appear to cover the entire length of each river, so their counts may be somewhat of an underestimate of angler use on the river. The annual state income per acre foot of water on the Arkansas is $6 and $19 on the Poudre River. Since fishing and rafting are both non consumptive uses of the same water, the income per acre foot from fishing would be additive to rafting, yielding a slight increase on the Arkansas (from $352 to $358 per acre foot), but increasing the Poudre River income per acre foot from $145 to $164 per acre foot, roughly a 13% increase. It should also be noted that this income does not require the diversion or consumption of water. The water is still available downstream to other users. Thus in this sense, the income generated does not necessarily preclude other downstream uses of the same water and are therefore additive to these downstream values.

Table 4. Angler Days and Estimated Percent Change in Use With Instream Flows in Colorado in 2006

% bankful	Demand Shift*	Angler Days	Percent Change Use
10	0.2902	900,777	-71%
20	0.5294	1,643,251	-47%
30	0.7203	2,235,803	-28%
40	0.8627	2,677,811	-14%
50	0.9542	2,961,826	-5%
55	**0.9817**	**3,103,988****	**NA**
60	0.9974	3,153,629	2%
65	1	3,161,850	2%
70	0.9908	3,132,761	1%
80	0.9359	2,905,023	-6%
90	0.8301	2,576,621	-17%

*Demand shift factor based on Walsh, et al.
**Baseline angler days in Colorado from USFWS, National Survey, 2007

Table 5. Estimated Angler Expenditures, Employment and Income in Colorado with Different Instream Flows in Colorado in 2006.

% bankful	Total Expenditures*	Total Employment**	Total Income**
10	$ 47,959,728	2,106	$ 36,854,661
20	$ 87,490,972	3,842	$ 67,232,452
30	$ 119,039,945	5,228	$ 91,476,266
40	$ 142,573,595	6,262	$ 109,560,703
50	$ 157,695,287	6,926	$ 121,180,970
55	**$ 165,264,397**	**7,258**	**$ 126,997,453**
60	$ 167,907,415	7,374	$ 129,028,481
65	$ 168,345,112	7,393	$ 129,364,830
70	$ 166,796,337	7,325	$ 128,174,673
80	$ 154,670,949	6,793	$ 118,856,916
90	$ 137,185,976	6,025	$ 105,420,586

* Estimate based on USFWS, 2007;
**Estimate based on changes in angler days with flows and RIMS II income and employment multipliers from U.S. Bureau of Economic Analysis for Colorado.

Table 6. Individual River Specific Angler Expenditures and Colorado State Income Per Acre Foot (AF) from Fishing

River	Estimated Angler Days	Expenditures*	AF**	Expend/AF	Income***	Income/AF
Arkansas	7617	$ 405,549	51210	$ 7.92	$ 312,273	$ 6.10
Poudre	8555	$ 455,490	18165	$ 25.08	$ 350,728	$ 19.31

* Expenditures from USFWS, 2007.
** AF= Acre feet. Calculated using USGS stream gauging data for May 15 through August 15th 2006 for the Poudre River and Labor Day for the Arkansas River.
***Income calculated using RIMS II multipliers (U.S. Bureau of Economic Analysis).

CONCLUSION

Data from surveys of rafters and anglers in Colorado conclude that rafting use and angler days are responsive to river flows. Rafting use increases with flow up to bankful conditions. Fishing use increases up to 70% bankful.

Current (2006) commercial rafting use in Colorado results in $54 million in expenditures, which supports 2,600 direct and indirect jobs in Colorado and provides $38 million in income (wages, rents and business profits). Slightly increasing flows would generate another 200 jobs and $3 million in income annually. Reducing flows in half of their current levels would result in a loss of 1,000 jobs and cutting income almost in half in rafting industry and tourism-related sectors.

Combining the commercial rafting economic results with USGS streamflow data allowed calculation of the economic contribution of each acre foot of water on specific rivers. This ranges a high of $352 of state income per acre foot on the Arkansas River, roughly $145 an acre foot on the Poudre River to $18 an acre foot on the Colorado River through Glenwood Canyon (where the high volume of water reduces the income per acre foot). In the case of the Arkansas and Poudre Rivers, the state income generated per acre foot is competitive with irrigated agricultural crops such as alfalfa and corn. It is particularly noteworthy that these values per acre foot are non-consumptive in that the water is still available downstream to others users, in is unaltered form.

Angler use of streams and rivers in Colorado contributes about $165 million in expenditures to the Colorado economy in 2006. These expenditures support 7,258 jobs throughout Colorado. These include direct jobs in the fishing industry (e.g., guides), as well direct jobs in surrounding retail, grocery, hotel, gas stations, etc. A total of $127 million in income is contributed to the Colorado economy from recreational fishing on rivers and streams. A substantial reduction in flows could result in losses of 2,000 jobs related to fishing and related tourism sectors as well as $35 million in income annually in Colorado.

The annual state income per acre foot of water for fishing on the Arkansas River is $6 and $19 on the Poudre River. Since fishing and rafting are both non consumptive uses of the same water, the income per acre foot from fishing would be additive to rafting, yielding a slight increase on the Arkansas (from $352 to $358 per acre foot), but increasing the Poudre River income per acre foot from $145 to $164 per acre foot, roughly a 13% increase.

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