

**REGIONAL IMPACTS AND BENEFITS OF  
WATER-BASED ACTIVITIES:  
AN APPLICATION IN THE BLACK HILLS REGION  
OF SOUTH DAKOTA AND WYOMING**

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**INTRODUCTION**

Many areas in the western United States have grown rapidly over the last two decades. In order to meet the demands of a growing population, future infrastructure needs must be anticipated and planned for in the present. One important need that must be anticipated is water for municipal, agricultural, and recreational purposes.

To best meet future water needs, state and local officials must have some basis for allocating available water supplies or a justification for expanding current supplies. Two possible bases for allocating supplies are (1) to allocate water to the activities that provide the greatest positive regional economic impact or (2) to allocate water to the uses that maximize the economic benefits of water supplies. These two concepts are similar, but the first is from a regional perspective and the second is from a national perspective. State and local officials are, of course, most interested in regional impacts and federal water agencies are most concerned with the national perspective.

This analysis presents a framework for evaluating water management scenarios in a region, based on the regional impacts and benefits from water-

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related activities. This framework indicates that incremental changes in the value of water-based activities must be measured for various water supply scenarios in order to make rational water supply decisions. The framework is followed by an application based on the Black Hills region of South Dakota and Wyoming. The application includes a brief description of current economic activities in the Black Hills region and estimates of the regional impacts and benefits of irrigated agriculture, water-based recreation, and municipal water supplies to households in the region. Finally, the potential incremental, or marginal, effects from changes in water supplies in the Black Hills region are presented. Because of limited information, the estimates of marginal effects are not precise; however, the section does present a methodology for evaluating different water management scenarios.

### **A FRAMEWORK FOR EVALUATING WATER MANAGEMENT SCENARIOS**

The regional impacts and economic benefits of water-based activities provide useful information to policy makers because they indicate the significance of different water-related sectors to the local economy and the benefits generated by water supplies. However, total impact and benefit estimates alone may not help policy analysts make decisions about how to reallocate portions of current or future water supplies between different uses. The total effects need to be combined with information that can be used to evaluate the effects of small, moderate, and large changes in water supplies for various activities.

An estimate of the loss in regional income, employment, value added, and benefits to the activity losing water and the gain to the activity obtaining more water is needed. These marginal changes should be the basis for choosing water supply alternatives. In order to estimate marginal changes, the reaction of water users to reduced water supplies must be known. The reaction water users will have depends on several factors, including (1) the level of conservation they are currently implementing and their ability to apply conservation techniques, (2) the existence of thresholds below which water activities are significantly affected, and (3) the timing of water supply shortages.

Measuring marginal changes in regional production, income, employment, and benefits from water supply changes requires knowledge of thresholds

where water supply shortages severely restrict water use. For example, the reservoir level where boat ramps are unusable would be a recreation water supply threshold. The minimum amount of irrigation water required to grow a crop would be an irrigation water threshold. The level of municipal water supplies that can support a household using the best available conservation methods would be a household water supply threshold. Factors that influence water supply thresholds for different water-based activities are presented below.

### **Agriculture**

If agricultural producers are informed in advance that water supplies will be reduced, then producers can take action to reduce losses. Non-irrigated crops may be planted instead of irrigated crops to allow full per-acre deliveries to fewer irrigated acres. More drought resistant crops can be planted so less irrigation water is applied on a per acre basis. In some cases irrigation efficiency can be improved to reduce overall water requirements and maintain production. A reduction in irrigation deliveries planned in advance as part of a water management plan is likely to result in impacts that are similar in magnitude to the average impact per irrigated acre or per acre-foot.

If a shortage is unexpected, however, the impacts of reduced irrigation deliveries on agricultural production can be very large. For example, if a shortage comes after planting and during a critical period of crop growth, then an entire crop could be lost as a result of a relatively small change in average irrigation deliveries. If a water-intensive crop is planted and water is not provided at the correct time, losses could be very large.

### **Recreation**

If a reservoir has sufficient facilities to mitigate low water levels, the impact of reduced recreational water supplies may be small. At such a reservoir, reductions in water supplies can be mitigated to some extent—boat ramps can be extended, people can swim and fish in different areas, and users may switch to different types of water recreation.

Recreational activities at smaller reservoirs with fewer facilities are likely to be more susceptible to water shortages than recreation at larger reservoirs. Reservoirs located near large population centers may be affected less by reservoir conditions than remote reservoirs because of the high demand for recreation facilities. Because of the large variation in recreational facilities and site characteristics of reservoirs, recreation has very site-specific

thresholds and must be evaluated on a case-by-case basis. For example, Angostura Reservoir and Keyhole Reservoir (see figure 1) have extensive facilities, so marginal changes in water elevation are likely to have little impact on the level of recreational activity at these two reservoirs.

An Unexpected drop in reservoir levels may not allow recreators time to adjust their plans for unexpected reservoir conditions and reservoir managers may not be able to quickly add ramp extensions and make other changes in facilities. But recreation facility managers are better able to adjust to unexpected changes in water supplies than irrigators are. **As** a result, the marginal impacts and damages due to unexpected shortages are likely to be less for recreation activities than for irrigation. unless a recreation use threshold is crossed.

### **Households**

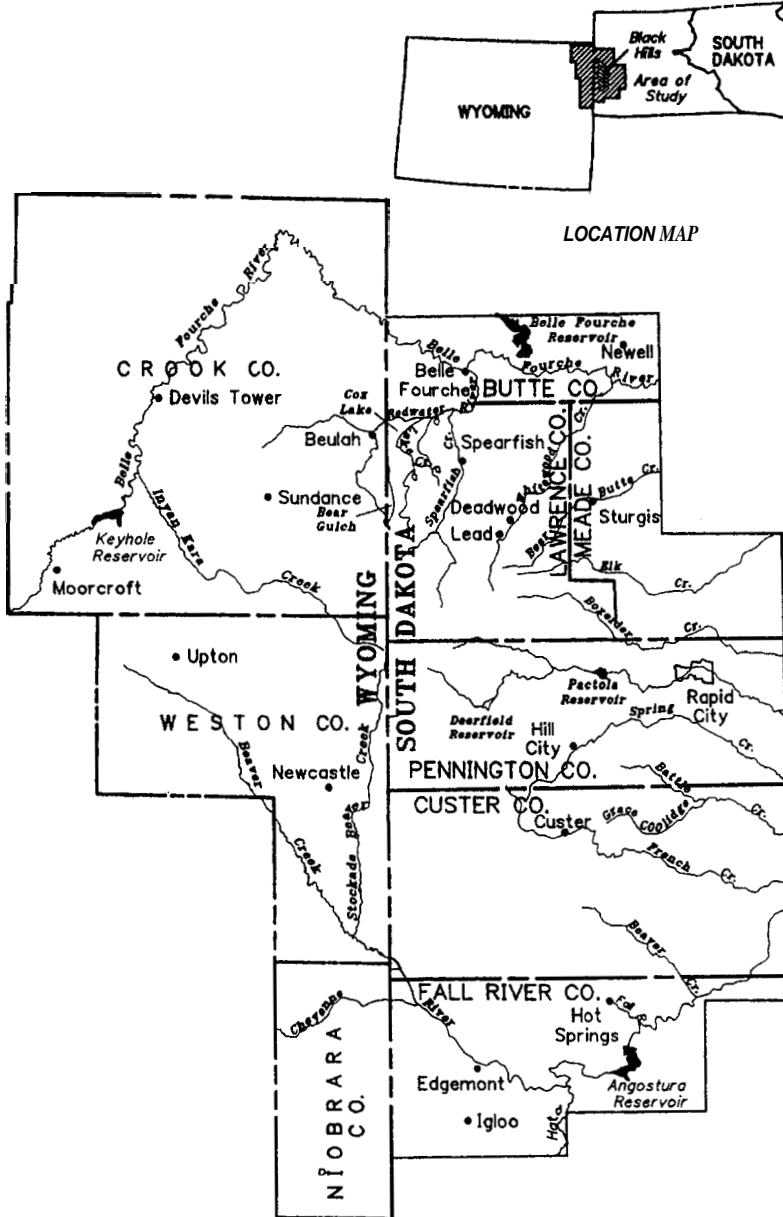
Household water use can be reduced significantly through water conservation techniques such as low water use plumbing fixtures, xeriscaping, or conservation pricing. Household water conservation requires some investment cost for new plumbing fixtures, potentially higher water bills for the same level of use, or changes in water use attitudes or habits. Additional water fixture or supply costs will reduce spending on other goods and services, potentially affecting the regional income and employment. Although many water conservation practices could be implemented quickly, many households would need time to make significant changes in water use habits.

## **THE BLACK HILLS STUDY AREA**

The Black Hills study area includes six counties in western South Dakota, three adjacent counties in Wyoming, and the city of Gillette, Wyoming. Gillette is included in the study even though it is outside of the geographic area because the city uses groundwater for municipal supplies that affects groundwater in the Black Hills region. The study area is shown in figure 1.

Water demand is a function of population size, the number of commercial establishments in the area, and the size and type of businesses and industry in the area. Changes in these variables will affect future municipal and industrial water needs. About 189,000 people live in the region that encompasses the Black Hills study area (U.S. Department of Commerce 1995).

Figure 7. Area of investigation for the Black Hills water management study



The population of the study area increased by about 40 percent from 1970 to 1995. Pennington County, South Dakota, accounts for 46.2 percent of the total population in the region and Rapid City, South Dakota, is the largest city in the area with a 1994 population of 57,609 people.

Population projections from South Dakota and Wyoming indicate that growth is expected to continue for all of the Black Hills counties except Fall River County, South Dakota (South Dakota State Data Center 1995; Wyoming Department of Administration and Information 1996). The population of the study area is projected to increase by 58.7 percent to about 300,000 people by the year 2035.

The **U.S.** Department of Commerce estimates that the total number of businesses in the study area increased 9.7 percent over the 1984 to 1994 period. The number of establishments and employees in the construction, manufacturing, and service sectors has increased substantially. The number of retail and wholesale trade, transportation, and finance establishments has also increased over this period. The region is characterized by a relatively low unemployment rate and a high level of education. Employment data by industry shows that retail trade, health and education services, agriculture, manufacturing, construction, and mining are all important sectors of employment.

### **Agricultural Activities in the Black Hills Region**

Agriculture in the Black Hills study area includes the production of irrigated and non-irrigated crops and livestock. As of 1992, there were 3,832 farm operations in the entire Black Hills study area, with 2,881 operations in South Dakota and 951 operations in Wyoming. The dominant agricultural activities in the region are livestock, hay, and wheat production (U.S. Department of Commerce 1994a).

Approximately 60 percent of the cropland acreage in the area is hay and 26 percent is wheat (U.S. Department of Commerce 1994a; Wyoming Department of Agriculture 1995; South Dakota Department of Agriculture 1994). A little under 12 percent of all the cropland in the area is irrigated. Hay is grown on about **83** percent of the irrigated land in the area and corn is grown on most of the remaining 17 percent of irrigated land.

Average agricultural sales in the Black Hills region were about \$75,000 per farm in 1992 and average production expenses were about \$60,600 per farm.

Total farm sales in the Black Hills region in 1992 were \$287.2 million and expenses were **\$232.0** million (U.S. Department of Commerce 1994). Agricultural sales and expenses by state and for the region are shown in table 1.

**Table 1. Agricultural sales and production costs**

	Average farm size (acres)	Average sales per farm	Average production expense per farm
South Dakota	2,089	\$73,192	\$59,657
Wyoming	4,597	\$80,307	\$63,257
<b>Black Hills region</b>	2,711	\$74,958	\$60,550

### Recreational Activities in the Region

There are several state and federal recreational attractions in the area as well as numerous city facilities for picnicking, outdoor games, and hiking. The rate of motel occupancy is high in the area, and recreational facilities are heavily used. Total visitor sales in the area exceeded \$235 million in 1993 (South Dakota Department of Tourism 1994).

The recreational areas included in this analysis are the Angostura, Belle Fourche, Deerfield, and Pactola Reservoirs in South Dakota, and Keyhole Reservoir in Wyoming. These are the most visited water-based recreational areas in the study area. The most recent information available for the South Dakota reservoirs that includes visitation by type of activity is 1980 data (U.S. Bureau of Reclamation 1981). Visitation data for 1976 to 1980 are used to estimate the percentage of total use attributable to different activities, which are then applied to the most recent total visitation data. A 1993 Wyoming state park visitor survey provides estimates of the types of activities at Keyhole State Park. The estimated average recreation visitation at the five reservoirs in the study area is presented in table 2.

**Table 2. Estimated visitation by activity**

Activity	Belle				
	Angostura	Fourche	Deerfield	Keyhole	Pactola
Sightseeing	46,280	12,440	1,810	27,450	19,500
<b>Picnicking</b>	28,080	3,240	1,310	10,080	10,790
Camping	29,120	920	1,680	9,270	7,600
Swimming	51,220	1,720	310	11,610	2,210
<b>Waterskiing</b>	25,740	1,560	230	4,500	1,430
Boating	43,680	2,000	1,290	7,290	8,320
Fishing	23,140	13,280	4,690	15,480	9,880
Hunting	2,600	1,280	320	0	200
Other	10,140	3,560	1,360	4,320	5,070
<b>Total</b>	<b>260,000</b>	<b>40,000</b>	<b>13,000</b>	<b>90,000</b>	<b>65,000</b>

## REGIONAL IMPACT ANALYSIS

The regional impacts from agricultural production, recreational expenditures, and residential water service expenditures are analyzed using the IMPLAN (IMPact analysis for PLANning) model developed by the U.S. Forest Service (U.S. Forest Service 1993). Regional impacts are distinct from economic benefits because they are a measure of the impact of an activity on the local economy, such as employment and income, whereas economic benefits are a measure of the gain (or loss) from an activity to society. Estimating regional impacts requires estimates of expenditures on agricultural inputs and net farm income, estimates of recreational expenditures, and estimates of residential water payments. **These** expenditure data must be detailed enough that they can be placed into expenditure categories. For example, average recreational spending must be divided into categories such as food, lodging, and gasoline in order to accurately represent regional impacts.

Secondary sources are used to estimate expenditures. Detailed agricultural expenditure data were obtained from Bureau of Reclamation farm budgets for the Angostura irrigation district (U.S. Bureau of Reclamation 1996). Recreational expenditure data were obtained from Department of Interior and Department of Commerce fishing and hunting survey data for South Dakota

(U.S. Department of Interior et al. 1993) and water payment estimates were obtained from the South Dakota Municipal League (1991).

The IMPLAN model uses the U.S. commerce department's national input-output model to estimate flows of commodities used by industry and commodities produced by industry. The social accounts of the region under consideration are included in the IMPLAN data base. Social accounts represent the flow of commodities to industry from producers and consumers as well as consumption of the factors of production from outside the region. Social accounts are converted to the input/output accounts and the multipliers for each industry. The IMPLAN program includes tables which account for the percentage of expenditures in each category that would remain within the region and expenditures that would flow outside the region.

### **Regional Economic Impacts from Irrigated Agriculture**

The 1992 Census of Agriculture provides detailed estimates of farm size, number of operations, production expenses, and revenues on a countywide basis. The detailed agricultural census data are not divided into irrigated and dryland production, however. Therefore, farm budget results from a Bureau of Reclamation payment capacity study for the Angostura irrigation district are used along with acreage data from the 1992 Census of Agriculture to estimate net farm revenues and the distribution of input costs from irrigated agricultural production (U.S. Bureau of Reclamation 1996). The input cost and net revenues per acre for irrigated production and total expenses and revenues for the study area are presented in table 3.

Net farm income was assumed to be spent on goods and services in proportion to consumer expenditures reported in the 1995 Consumer Expenditure Survey (Bureau of Labor Statistics 1997). The proportion of consumer expenditures is presented in table 4.

The impact analysis component of the IMPLAN program was used to estimate the regional impacts of irrigated agriculture in the district. This component uses the model multipliers to estimate the impact of a change in demand for goods and services on a region's value of total output, employment, and income. The change in regional activity is based on the change in final demand for a variety of goods and services. The estimated total annual costs for each input were put into the IMPLAN model as a change in final demand. For the net income category, expenditures for each of the goods and services listed in table 4 were input as a change in final demand.

**Table 3. Input costs and net revenues for irrigated agriculture**

Expense category	Cost/acre	Total Black Hills expenditures (millions)
Livestock purchased	\$ 8.93	\$ 0.92
Feed	72.92	7.52
Seed	12.75	1.31
Fertilizer	11.16	1.15
Agricultural chemicals	12.13	1.25
Petroleum products	17.15	1.77
Electricity	4.11	0.42
Repair & maintenance	7.29	0.75
Custom work	13.81	1.42
Interest	48.64	5.01
Property taxes	9.86	1.02
Net farm income	94.85	9.78
All other	38.96	4.02
<b>Total</b>	<b>\$352.56</b>	<b>\$36.34</b>

**Table 4. Distribution of consumer expenditures**

Expenditure	Percentage
Food	14.0
Housing	<b>17.6</b>
Utilities	6.5
Furnishings	<b>7.4</b>
Apparel	5.3
Vehicles	8.0
Gasoline	3.0
Automobile repairs & maintenance	6.1
Health care	5.2
Entertainment	5.0
Insurance/pensions	10.5
All other	11.4

The total impact of agriculture on the region is equal to the impacts from the purchase of farm inputs plus the impacts from spending net farm income. The total regional value added by irrigated agriculture is estimated to be \$20 million annually. Income and employment impacts are \$10 million in earnings and 700 jobs annually.

### **Regional Impacts from Recreation**

In order to estimate the regional economic impacts of recreational activities in the area, the expenditures associated with each activity must be estimated. The 1991 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation conducted by the U.S. Fish and Wildlife Service was used to estimate recreation expenditures (U.S. Department of Interior et al. 1993). The 1991 survey provided expenditures for fishing, hunting, and non-consumptive wildlife-related activities. These data were used to estimate expenditures per trip and expenditures per day and are shown in table 5.

**Table 5. Recreation expenditures by type of activity**

Activity	Dollars/trip	Dollars/day
<b>FISHING</b>		
Food	\$ 9.78	\$ 8.11
Lodging	2.52	2.09
Transportation	7.93	6.58
Privileges & other fees	0.32	0.27
Boat launch, storage, etc.	4.05	3.36
Bait	2.01	1.67
Ice	0.74	0.61
<b>Fishing total</b>	<b>\$27.35</b>	<b>\$22.69</b> .....
<b>HUNTING</b>		
Food	\$12.57	\$11.44
Lodging	2.68	2.44
Transportation	10.04	9.14
Privileges & other fees	2.73	2.49
<b>Hunting total</b>	<b>\$28.03</b>	<b>\$25.52</b> .....
<b>NON-CONSUMPTIVE, WILDLIFE-RELATED</b>		
Food	\$ 5.62	\$ 4.44
Lodging	2.61	2.06
Transportation	7.37	5.83
Other (equipment rental & fees)	0.48	0.38
<b>Nonconsumptive total</b>	<b>\$16.08</b>	<b>\$12.71</b>

There are several recreational activities in the Black Hills area that were not covered in the 1991 survey. For activities not included in the 1991 hunting and fishing survey, recreational expenditures were estimated by matching the Black Hills recreational activities as closely as possible with activities included in the hunting and fishing survey. Some cost categories were subtracted from the expenditure estimates to better reflect expected expenditure

patterns. The estimated recreation expenditures by type of expenditure are shown in table 6.

Total expenditures are likely to have over-estimated expenditures in the region because some food and fuel will be purchased at the origination point of the trip. Data from a South Dakota recreational survey indicate that about half of the visitors to Angostura Reservoir come from outside the study area (South Dakota Department of Game, Fish, and Parks 1990). The expenditure estimates presented in table 6 are based on the assumption that 50 percent of food and transportation expenditures occur within the study region. Using the same techniques as were used for estimating irrigation impacts, the regional value added by recreational expenditures in the Black Hills area are estimated to be **\$4.6 million**. Earnings impacts are estimated to be **\$2.3 million** and employment impacts are 190 jobs annually.

**Table 6. Estimated regional recreational expenditures**

<b>Expense category</b>	<b>Amount spent</b>
Food	\$1,837,000
Lodging	896,000
Transportation	1,841,000
Privileges and other fees	33,000
Boat launch, storage, etc.	658,000
<b>Bait</b>	134,000
Ice	61,000
Other	109,000
<b>Total</b>	<b>\$5,569,000</b>

### **Regional Economic Impacts from Household Water Payments**

Payments by households for water service also have a significant impact on the local economy. Water rate and payment data from the South Dakota Municipal League (1991) and water use data from the U.S. Geological Survey (1993) were used to estimate an average household water payment for the study area. U.S. Bureau of the Census 1990 housing cost data are used to compare costs between the South Dakota and Wyoming counties (U.S. Department of Commerce 1994b).

Average household water costs in the region for 1990 are estimated to range from about \$18 per month to about \$33 per month. Households in rural counties generally pay more, on average about \$30 per month. Using the number of households in each county as a weight, the average water cost for the study area is estimated to be about \$26 per month. Based on a total of 63,133 households in the region, total water payments are estimated to be about \$19.7 million annually.

Using the same techniques as were used for estimating irrigation and recreational expenditure impacts, the regional value added by household water payments in the Black Hills area are estimated to be \$13.7 million, earnings impacts are estimated to be \$6.5 million, and employment impacts are 360 jobs annually.

## **BENEFIT ANALYSIS**

The benefits from irrigation water presented in this analysis are based on estimates using the farm budget method (U.S. Water Resources Council 1983). Recreational benefits are based on the results of a regional South Dakota travel cost model and household water supply benefits are based on willingness-to-pay models estimated in previous studies.

### **irrigated Agriculture Benefits**

As was shown in the regional impact section, agriculture has a significant impact on the economy of the region. Although irrigation is limited in the region, irrigated crops account for about 10 percent of total crop sales and help support the important regional cattle industry.

Using farm budget analysis, benefits from irrigation are estimated to equal the increase in net farm revenues with irrigation compared to net farm revenues under conditions without irrigation. It is assumed that (1) crop prices and input costs reflect competitive market conditions and (2) changes in crop production in the area under consideration are small relative to national production, so crop prices will not be affected. In order to use the farm budgeting methodology to estimate the benefits of irrigation water, several pieces of data are needed to represent farm operations in the study area. These data include cropping patterns, crop yields, crop prices, and production input requirements and costs.

A 1996 Angostura Resource Appraisal Draft Study Report included a farm budget analysis of the benefits from providing irrigation water to the Angostura irrigation district based on the Water Resources Council guidelines (U.S. Bureau of Reclamation 1996). The primary irrigated crops in the Angostura irrigation district are corn and alfalfa hay, as is the case for the entire Blacks Hills area. Therefore, the benefits of irrigation water in the Angostura district are likely to be representative for the study area.

The benefits from irrigation in the Angostura district were estimated in the draft appraisal report to be about \$54.40 per irrigated acre or about \$2 1.75 per acre-foot based on an average farm delivery of 2.5 acre-feet per acre. Irrigation water benefits could vary somewhat in areas with higher or lower crop yields and different cropping patterns; however, the Angostura district average is likely to be representative of the study area. The total benefits from irrigation in the region are estimated to be \$5.6 million annually.

### **Recreational Benefits**

The techniques available for estimating the benefits of recreational activities include the contingent valuation method, the travel cost method, and benefit transfer (Walsh 1986). Data are not available for the Black Hills region to complete a contingent valuation analysis. Visitor origin data are available from the South Dakota Department of Game, Fish, and Parks from which a travel cost model can be estimated. Benefit transfer involves the use of benefit estimates from previously completed studies and adjusting those estimates to fit the conditions in the area under consideration. Travel cost estimates based on regional data are preferable to the benefit transfer method which uses generalized estimates from outside sources. Therefore, the benefits of water-based recreation in South Dakota are estimated using the travel cost methodology.

In 1990 the South Dakota Department of Game, Fish, and Parks conducted visitor origin surveys for 19 state recreation facilities (South Dakota Department of Game, Fish, and Parks 1990). These surveys included the data required to complete a zonal travel cost model. Data for all of these sites are used to estimate a regional recreational benefit model. This model is used to estimate the average benefit of recreational activities in South Dakota and the effect of different site attributes, such as the availability of boating and campsites, on benefits.

The visitor origin data show the county from which recreators came to visit a site and can be used to estimate the distance visitors must travel to each site. The Game, Fish, and Parks survey also recorded the number of visitors per vehicle, which is needed to estimate travel cost per person. Game, Fish, and Parks was also the source of information on the types of activities engaged in at each site, the number of campsites, and the size of each recreation area in acres.

Data for population, income, education, and age were obtained from county-level **U.S.** census data. Substitutes were accounted for by measuring the distance from the visitor origin to the nearest site that supports recreation similar to the site under consideration. No data from visitors outside of South Dakota were used because they could not be pinpointed to a specific county.

The visitor origin data are used to determine the number of visitors originating from a particular population zone. For this analysis, a zone is defined as a specific county. The total number of visits originating from a county are divided by the 1990 **U.S.** census estimate of population for that county to obtain a recreation participation rate. The participation rate represents the average number of trips taken by a person in that county to one of the 19 state recreation areas. The origin data are also used to determine the distance, and therefore cost, of traveling to a recreation area. The distance traveled to a recreation site was estimated by taking the distance from the largest population city in the county (usually the county seat) to the site.

Visits originating from greater than 350 miles from the reservoir were removed from the data set. It was assumed that visitors traveling more than 350 miles were stopping at multiple sites, and including those visitors would attribute some of the recreational benefits from other sites visited to the site under consideration. Including multiple site visits would result in an upward bias in the recreational benefit estimates.

The travel cost model was estimated using ordinary least squares. The model was estimated using both linear and semi-log functional forms, with visits per capita transformed into the natural logarithm. Based on the expected effect of the explanatory variables on visits per capita and tests of significance for the explanatory variables, the semi-log model performed best. Travel cost models in the literature have frequently used semi-log models.

The estimated model is:

$\ln(\text{VIS}/\text{CAP}) = f(\text{TC}, \text{SUB}, \text{ACRE}, \text{CAMPSITE}, \text{BOATING}, \text{HIKING}, \text{INCOME})$ ,  
where:

VIS/CAP = visits per capita,  
TC = estimated travel cost per visitor,  
SUB = 1 if the number of acres at the closest comparable substitute site divided by distance to the substitute site is greater than the number of acres divided by distance to the site under consideration,  
ACRE = number of acres in the recreational area,  
CAMPSITE = number of campsites in the recreational area,  
BOATING = 1 if boating is allowed at the site, 0 otherwise,  
HIKING = 1 if there are hiking trails at the site, 0 otherwise,  
INCOME = per capita income in 1990.

It is expected that travel cost will have a negative influence on visitation because it represents the marginal price of recreation in South Dakota. The substitute site variable should have a negative sign because the variable is an index representing the availability of desirable substitute sites. The availability of desirable substitutes should have a negative effect on visits per capita. The number of acres and the number of campsites are measures of site quality and would be expected to have a positive influence on visitation. The boating and hiking variable are indicators of the activities available at the sites and should have a positive sign. Fishing is not included as an activity variable because fishing is an activity at each of the 19 sites. Last, the income variable should have a positive sign because higher incomes allow individuals to “purchase” greater amounts of recreation. The travel cost modeling results are presented in table 7.

The modeling results were generally good. All of the variables have the expected sign, and the overall fit of the model is reasonably good based on the adjusted R-squared statistic and F ratio. The R-squared statistic indicates 45 percent of the variation in visits per capita is explained by the model. The estimated coefficients for all of the explanatory variables except income were significantly different from zero at the 10 percent level or better.

The per capita visitation model can be used to estimate the benefit per South Dakota recreational visit. The estimated visitation per capita model is used to estimate visitation to an average site at different prices as represented by travel cost (recreational demand curve).

**Table 7. South Dakota regional travel cost model results**

Variable	Coefficient	t-statistic	Expected sign	Significant at 10% level
Constant	-6.1549			
TC	-.05525	-16.21	YES	YES
SUB	-.28639	-2.17	YES	YES
ACRE	.000241	2.04	YES	YES
CAMPSITE	.004262	5.88	YES	YES
BOATING	.530880	2.88	YES	YES
HIKING	.252750	1.91	YES	YES
INCOME	.117270	0.98	YES	NO
<b>K-squared =</b>	0.45			
<b>F ratio =</b>	59.17			

The demand curve is estimated using the average substitute site index, average site acreage, average number of campsites, the existence of boating and hiking opportunities, and average per capita income. The natural log of visits per capita is transformed into visits per capita which is multiplied by total population to derive total visits as a function of price (travel cost). The area under the demand curve represents the benefit of recreation at an average South Dakota site.

The benefit per visit is estimated to be about \$17.70 in 1990 dollars. Indexing this value to 1994 dollars using the Consumer Price Index results in a value of \$20.10 per visit. Total recreational benefits for the five reservoirs included in this analysis are estimated to be \$9.4 million annually. This benefit estimate represents the value of a South Dakota recreational area visit rather than the value of a specific type of recreational visit. Therefore, this estimate cannot be compared to user day or activity day benefit estimates for single purpose recreational activities.

### **Municipal Water Supply Benefits**

The benefits from reliable and good quality domestic water supplies can be measured using a survey of household willingness to pay or estimating household production functions to determine the effect of good quality water on household welfare. Both of these methods require detailed data that are not available for the study area. Benefit transfer, as described in the

recreation benefit section, can also be used when site specific data are not available. Household water supply benefits are estimated in this analysis using benefit transfer.

The model used in this analysis is based on willingness-to-pay data sets from four areas: the Lewis and Clark Rural Water System in southeast South Dakota, the Fort Peck County Rural Water District in Montana, the northwest Oklahoma area, and the New Mexico portion of the Navajo Indian Reservation (Piper 1996). The variable values used to estimate household willingness to pay for good quality water supplies in the Black Hills region are presented in table 8. The average water cost of \$26 per household per month estimated in the impacts section was used for the water cost variable in the willingness-to-pay models.

**Table 8. Values used to estimate household willingness to pay**

County	Household size	Age	Mean household income	Households	Households hauling water (%)	Native American population (%)
Butte	2.58	47.6	\$25,051	3,065	3.5	1.5
Custer	2.61	48.0	\$27,662	2,370	6.0	2.4
Fall River	2.51	51.2	\$26,421	2,926	3.3	6.4
Lawrence	2.59	44.4	\$29,189	7,977	4.2	2.7
Meade	3.09	42.2	\$28,443	7,081	1.8	1.5
Pennington	2.66	42.2	\$31,697	30,634	1.5	7.2
Crook	2.73	47.1	\$28,069	1,940	7.9	0.8
Niobrara	2.45	49.5	\$28,297	1,020	1.2	0.8
Weston	2.66	45.6	\$29,347	2,452	5.9	1.1
<i>Weighted average</i>	2.69	43.9	\$29,937	—	2.7	4.8

The weighted average variable values presented above were input into the willingness-to-pay models. The willingness-to-pay estimates for good quality water supplies in the Black Hills study area are presented in table 9. Total household water supply benefits for the region are estimated to range from \$3.85 million to \$5.8 million annually.

It should be recognized that the willingness-to-pay estimates presented in table 9 represent only household domestic water supply benefits. Benefits would also accrue to businesses and industry in the area.

**Table 9. Willingness to pay for good quality water**

Model	WTP/ month	WTP/ year	WTP for the entire region
Ordinary least squares	\$66.36	\$66.36	\$4.20 million
Weighted least squares	\$60.84	\$60.84	\$3.85 million
Tobit		\$73.44	\$4.65 million
Weighted tobit		\$92.04	\$5.82 million

### POSSIBLE MARGINAL EFFECTS FROM WATER SUPPLY CHANGES IN THE BLACK HILLS REGION

The framework section near the beginning of this paper indicated that the marginal changes in regional impacts and economic benefits must be known in order to evaluate various water supply alternatives. If changes in water supplies have little or no impact on an activity, then marginal changes are small. If water supply changes have a significant impact on an activity due to the existence of water use thresholds, marginal changes can be substantial.

Irrigated agriculture generates approximately \$36 million in regional expenditures and \$5.6 million in benefits annually. Recreation is estimated to generate about \$5.6 million annually in regional expenditures and \$9.4 million in benefits. Household water payments total \$19.7 million annually and domestic water supply benefits are estimated to be as high as \$5.8 million annually. The total regional impact and economic benefit estimates

need to be combined with information about the possible impact of various changes in water supplies on these activities in order to evaluate marginal changes.

High crop yields in the Black Hills region are dependent on irrigation water. During periods of shortages, irrigators could deliver less water to the same acreage or a full per-acre amount to fewer acres. As a result, the economic effects of reduced irrigation water supplies may be similar to the average impacts and benefits per irrigated acre or per acre-foot, assuming farm operators can make adjustments in irrigation deliveries. High marginal impacts would most likely be the result of insufficient deliveries during critical times of the growing season. Some irrigation efficiency gains could be obtained through conveyance and application improvements, which may reduce agricultural losses. However, even a small reduction in irrigation water deliveries can have a significant impact on the regional economy because of the potential for reduced agricultural sales, resulting in high marginal costs.

The relatively large benefits associated with recreation in the area indicate that the recreation resource should be protected. Reservoir elevations should be maintained above levels such that recreation thresholds are not crossed. Angostura, Belle Fourche, and Keyhole reservoirs are all relatively large, with 4,500 or more surface-water acres and 40 or more miles of shoreline. The size of these reservoirs combined with the recreational facilities available make them less susceptible to changes in recreation visitation resulting from decreased reservoir levels. Deerfield and Pactola reservoirs have less than 1,000 surface-water acres and 14 miles or less of shoreline and are more sensitive to changes in water levels.

Total visitation at Pactola Reservoir is fairly high despite its having a surface area of only 860 acres. However, almost one-half of total visitation at Pactola Reservoir is attributable to picnicking and sightseeing, which is probably not affected a great deal by reservoir levels. Deerfield Reservoir is small and has a large percentage of fishing and boating visitation, so Deerfield is likely to be the most affected by reduced recreational water supplies. But only about 3 percent of total visitation at the five reservoirs occurs at Deerfield Reservoir. The characteristics of the five reservoirs in the region indicate that relatively moderate adjustments in the allocation of water away from recreation will have a small impact on the local economy and recreational benefits, resulting in relatively low marginal costs.

However, if reservoir levels at the higher use areas are lowered below thresholds for boat access, the marginal costs would be very high.

Reducing water supplies for domestic household use could have several impacts. Water conservation pricing could be implemented, which may result in higher water bills and less spending on non-water service goods and services. Households could be discouraged from locating in the area, reducing potential household expenditures in the region. Mandatory water conservation without changes in water rates could reduce water payments and increase expenditures on other goods. Households could also invest in water-saving plumbing fixtures, which would increase spending on one type of goods (plumbing). Because of the wide variety of possible household responses, the effect of a small reduction in domestic water supplies on the regional economy could be positive or negative but is likely to be relatively small. However, if municipal water supplies are reduced enough to significantly limit or even decrease the number of people who live in the area, the marginal impacts of the reduction would be very large.

The estimates of total regional impacts and benefits combined with the discussion of water use thresholds and current activities in the Black Hills region indicates that a small-to-moderate reduction in water supplies for irrigation will probably have a larger impact on the local economy and benefits than a small-to-moderate reduction in recreation or municipal water supplies. **As** a result, a reallocation of water to irrigation during periods of minor shortages without crossing recreation and household water supply thresholds will minimize negative impacts to the local economy and water use benefits. However, during major shortages recreation and municipal water supplies need to be maintained at a level that does not substantially reduce the large regional impacts and benefits associated with these activities. Irrigation water supplies could be reduced to the level where deliveries are made during critical periods of the growing season, reservoir levels could be reduced to the minimum elevation that supports recreation, and municipal water conservation practices could be implemented.

The level of population growth that has occurred and is expected to occur in the area may not allow all of the critical thresholds to be met. If this is the case, then expenditures for expanding future supplies are justified in order to support the regional economy and to generate water supply benefits.

## SUMMARY

The total regional impact and benefit estimates are useful in understanding the importance of water supplies to the regional economy and the nation as a whole. But the change in regional impacts and benefits that are caused by changes in the allocation of water must be known in order to develop water supply options that will not have severe impacts on the local economy and the value resources in the area. It is essential to make water allocation and supply decisions as early as possible in the planning process in order to allow water users sufficient time to plan for future levels of supply and to minimize the costs of shortages.

The population of the Black Hills region of South Dakota and Wyoming has grown substantially over the last 25 years and growth is expected to continue. As a result, future water supplies may need to be expanded or reallocated between different uses. This analysis presented estimates of the regional impacts and benefits of three different water uses: irrigation for agricultural production, recreation, and domestic household water supplies. According to these estimates, irrigated agriculture generates the greatest regional economic impacts in the Black Hills and water-based recreation generates the greatest benefit to the nation.

Production from irrigated agriculture is estimated to generate over \$36 million in spending and farm income annually. The annual value added is estimated to be \$20 million and 700 jobs are generated annually. Water-based recreation expenditures also have a significant impact on the local economy. Total recreation-related spending for five reservoirs in the region is estimated to total about \$5.6 million annually. These expenditures result in a value added of \$4.6 million to the region and 190 jobs annually. The regional impact of household water payments is estimated to be \$13.7 million in regional value added, \$6.5 million in earnings impacts, and 360 jobs annually.

The benefits from irrigation in the Black Hills region are estimated to be about \$54.40 per irrigated acre or \$21.75 per acre-foot of water—\$5.6 million annually. The average benefit from recreation at South Dakota state recreation sites is estimated to be about \$20 per visit. Water-based recreation at five state facilities in the area represents about 470,000 visits annually, which translates into \$9.4 million in recreation benefits annually. The best

estimate of the willingness to pay (benefit) for good quality and reliable domestic water supplies is about \$5.8 million annually.

In general, irrigation appears to be most sensitive to a small reduction in water supplies in the Black Hills region. Water-based recreation in the Black Hills region does not appear to be threatened by a small reduction in water supplies in order to supply agricultural or municipal uses. However, if water allocated to recreation was reduced during a drought and recreational facilities became unusable as a result, the impacts from reduced visitation would be very large and the reallocation of water would result in substantial economic losses.

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