APPENDIX B

APPENDIX B - TABLE OF CONTENTS

I. AREA OVERVIEW
- Topography and Geology . . . 1
- Soils and Vegetation . . . 4
- Climate . . . 4
- History . . . 6
- Demographics . . . 7
- Employment and Income . . . 10
- Land Ownership, Use, and Zoning . . . 15
- Transportation . . . 16

II. RESOURCE SUMMARY
- Water Quantity . . . 17
- Water Quality . . . 23
- Agriculture . . . 31
  - Crop Irrigation . . . 31
  - Livestock Operations . . . 38
  - Aquaculture . . . 42
- Domestic, Commercial, Municipal and Industrial Water Uses . . . 44
- Mining . . . 48
- Timber . . . 51
- Power Development and Energy Conservation . . . 51
- Navigation . . . 59

REFERENCES . . . 60

LIST OF TABLES

Table 1. Climatological Summary Data 1961-89 . . . 6
Table 2. Population of Twin Falls, Jerome, and Gooding Counties, Idaho. . . . 8
Table 3. Average Annual Employment . . . 11
Table 4. Average Annual Unemployment as a Percent of the Civilian Labor Force . . . 12
Table 5. Percentage of 1990 Total Personal Income by Sector . . . 12
Table 6. 1990 Income Levels . . . 14
Table 7. Land Ownership - Middle Snake Hydrologic Unit . . . 15
Table 8. Major Springs in Study Area . . . 23
Table 9. Irrigated Cropland Acreage by County . . . 33
Table 10. Average Rates of Consumptive Water Use for Crops (Twin Falls) . . . 34

LIST OF TABLES, Cont.

Table 11. Livestock Numbers by County 1992 39
Table 12. Municipal Water Supply and Waste Disposal 46
Table 13. Estimated Nonindustrial Public-Supply Water Use 47
Table 14. Estimated Rural Domestic and Livestock Water Use 47
Table 15. Estimated Industrial Water Use by County, 1980 47
Table 16. Idaho Power Company Historical Irrigation Data 1970-1989 54
Table 17. Existing Hydropower Facilities 55

LIST OF FIGURES

Figure 1. Planning region. 2
Figure 2. Generalized geologic cross section from Shoshone, Idaho to Thousand Springs area. . 3
Figure 3. Precipitation map of planning region. 5
Figure 4. Percent population change 1980-1990. 9
Figure 5. Personal income by employment sectors 13
Figure 6. Average daily discharge 1947-1991. 20
Figure 7. Average daily discharge 1988-1991. 20
Figure 8. Ground-water discharge from Milner to King Hill. 22
Figure 9. Water quality status on the Middle Snake reach. 25
Figure 10. Map of irrigation acreage and water source. 32
Figure 11. Irrigated acreage 1974 to 1987. 34
Figure 12. Beef cow distribution, January, 1992. 40
Figure 13. Distribution of milk cows, January, 1992. 41
Figure 14. Estimated percentages for commercial electric consumption 53
Figure 15. Composition of industrial electric consumption 53
Figure 16. Snake River gradient from Heise to Weiser, Idaho. 54
Figure 17. Idaho Power Company 1991 daily peak system load 56

I. AREA OVERVIEW

The Snake River from Milner Dam to the community of King Hill, Idaho is here defined as the Middle Snake reach. In the planning area the Snake River forms the boundary between Twin Falls County to the south, and Jerome and Gooding counties to the north. On the western edge of the reach the river flows through Elmore County (Fig. 1).

TOPOGRAPHY AND GEOLOGY

From Milner Dam to the community of King Hill, Idaho, the Snake River flows through a deep, often vertical-walled basalt canyon cut into the Snake River Plain. The Snake River Plain, part of the Columbia Intermontane physiographic province, is an arcuate depression, extending 400 miles across the southern portion of Idaho. It is moderately level, sloping from east to west; occasionally the low relief is broken by the occurrence of buttes. The present course of the Snake River is along the southern portion of the Snake River Plain.

The Snake River may have begun cutting its present canyon about 500,000 years ago (Covington, 1976). Immediately above Milner Dam the Snake's river bed is slightly below the level of the Snake River Plain, but in the 22 mile stretch below the dam, the river has cut a canyon 400 feet deep. At Shoshone Falls the river drops another 212 feet. Scab-land topography near the falls is associated with the Bonneville Flood. Approximately 15,000 years ago, overflow from the Pleistocene Lake Bonneville scoured the Snake River Canyon. The flood water swept the canyon and adjacent uplands of rock debris, eroding alcoves and scablands, and depositing huge bars of sand and gravel with boulders over 10 feet in diameter. Most rapids in the area are a result of a large number of boulders deposited at or below a slight widening of the canyon during the Bonneville Flood.

From Twin Falls to King Hill, the river remains 400 to 600 feet below the general elevation of the Snake River Plain. The canyon gradually widens downstream of Twin Falls to include small areas of bottomland and terraces. The largest of these areas is the Hagerman Valley, which is approximately 12 miles long and varies in width from one to four miles. Four major waterfalls occur in the Middle Snake reach: 212-foot Shoshone Falls, 130-foot Twin Falls, 36-foot Star Falls, and Auger Falls, a cascade that drops 55 feet.

The Snake River Plain is a unique series of lava flows and sedimentary deposits dominated by Quaternary basalt of the Snake River Group. The oldest rocks in the area are the Idavada Volcanics which underlie most of the Snake River basalts. This formation consists of a series of silicic, welded

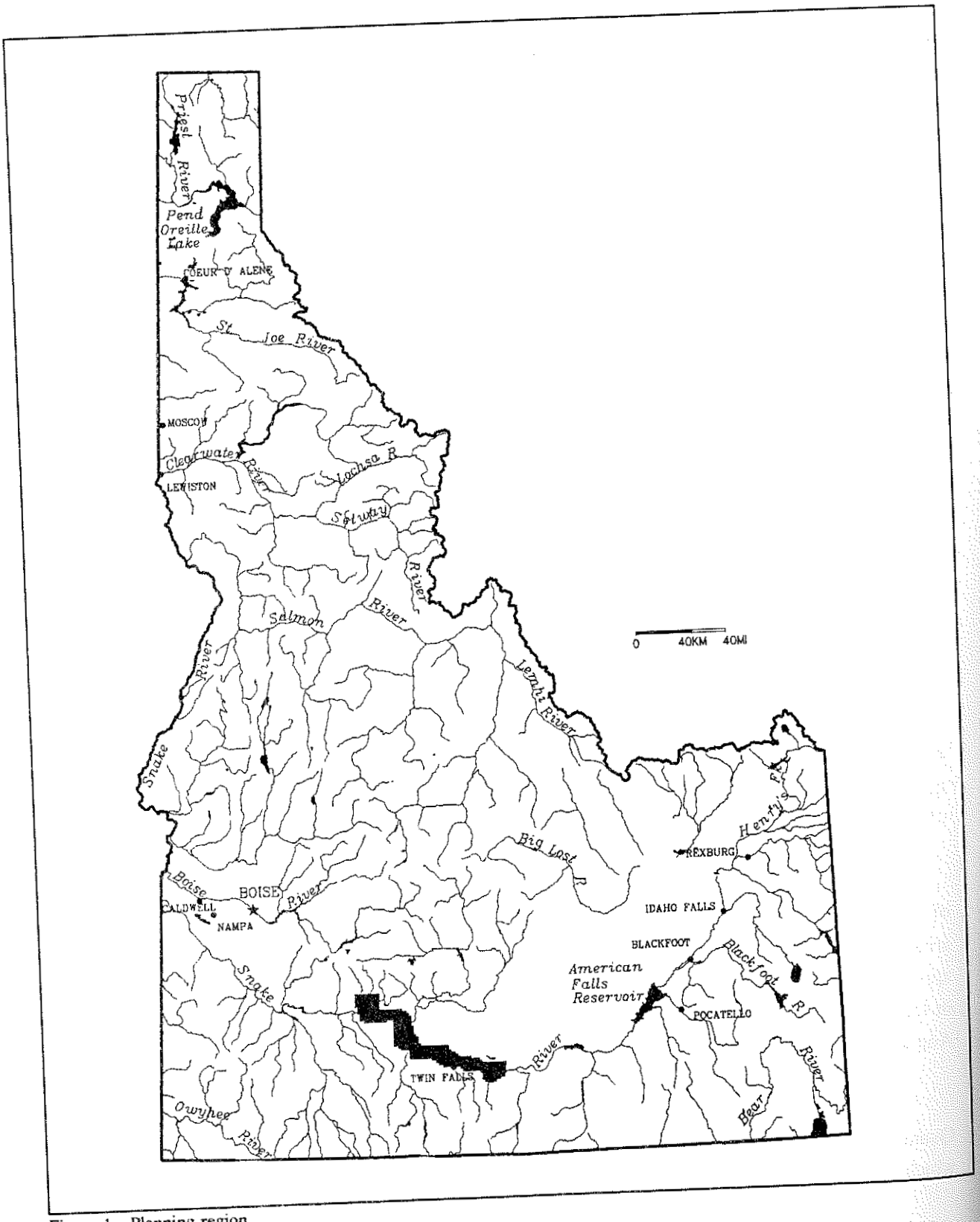

Figure 1. Planning region.

ash flows (Malde and Powers, 1962). Rocks of the Idavada assemblage are exposed within the Snake River canyon near the city of Twin Falls. They represent numerous episodes of volcanism ranging in age from 12 million to 6 million years (Street and DeTar, 1987).

A sequence of Tertiary and Quaternary basalt flows with interbedded stream and lake sediments overlies the Idavada Volcanics (Fig. 2). In the planning area, lavas on the south side of the river are Pliocene and early Pleistocene and most original features have been removed by erosion or obscured by loess. Younger Pleistocene lavas on the north side still preserve features such as pressure ridges and "aa" and "pahoehoe" lava surfaces. The aggregate thickness of the lava and sedimentary deposits is unknown, but probably exceeds 5,000 feet (Moreland, 1976). The thickness of individual lava flows is highly variable but averages about 20-25 feet (Mundorff et al., 1964). Contacts between flows are commonly rubble with high porosities and hydraulic conductivities, which make interflow zones major avenues for horizontal movement of water.

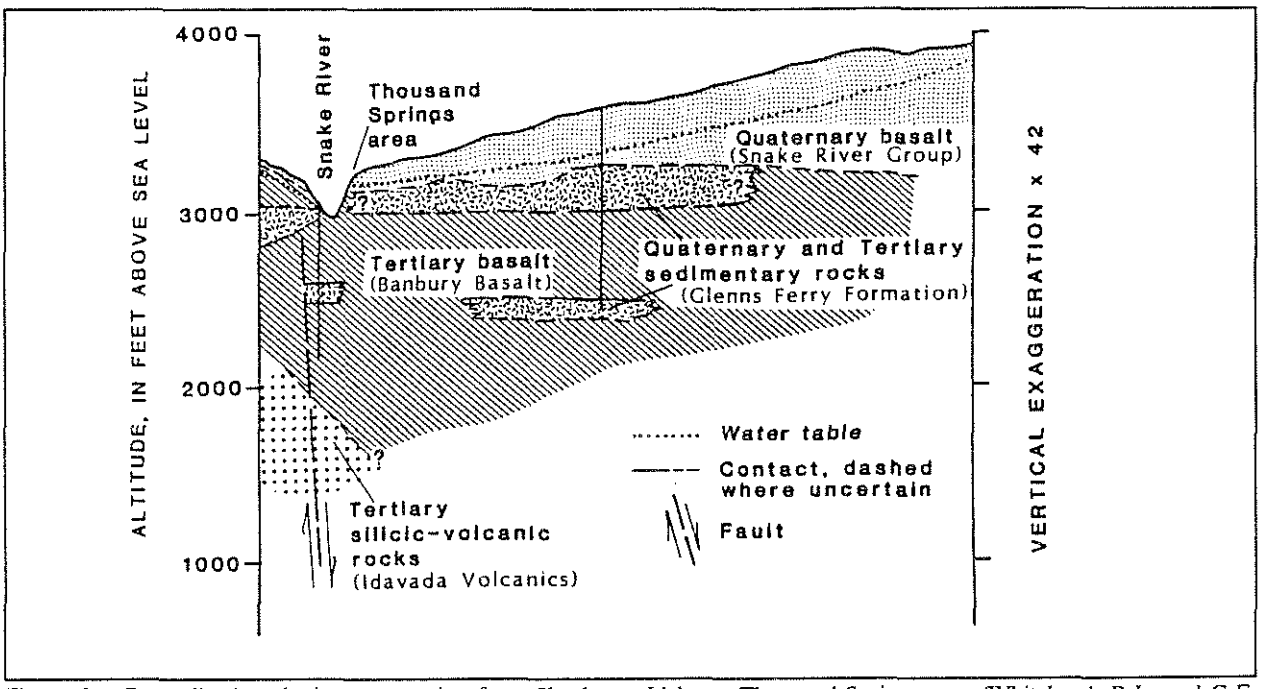

Figure 2. Generalized geologic cross section from Shoshone, Idaho to Thousand Springs area (Whitehead, R.L. and G.F. Lindholm, 1985).

Seismic and geologic field data is insufficient to establish whether any specific faults are seismically active in south central Idaho. Field evidence from faults elsewhere on the Snake River Plain indicates that they are at least 500,000 years old and are probably inactive. A zone of frequent earthquakes lies within the Basin and Range province of eastern Idaho, and the Idaho Batholith region of central Idaho. The active Howe and Arco fault systems are included in the southern part of this zone and are capable of producing strong earthquakes (Harza Engineering, 1983; Greensfelder, 1976).

The Halfway Gulch fault, located south of Grand View, Idaho, has been estimated to be capable of producing a Maximum Credible Earthquake with a magnitude of 6.0 (IPC, 1988). These fault zones are situated about 100 miles from the Middle Snake reach.

SOILS AND VEGETATION

Soils on the Snake River Plain are primarily loessal in origin. Loess is composed of wind-blown particles which have a wide range of composition. A typical Middle Snake soil profile is light in color, of medium texture, and has lime accumulation zones in the subsoil and substratum. Soil depth varies from 6 inches to greater than 40 inches. Near the canyon rim the soil depth is usually shallow and gradually grades to bedrock. Basalt outcrops are common in many areas, particularly on the north side of the river (Yankey, 1992). Loess is very fine and subject to water and wind erosion.

The loess soils are good for most climatically adapted crops, and are relatively free of salt problems due to high permeability. The lack of precipitation in the region limits native vegetation and the organic residue that becomes soil humus, but leaching of soluble minerals from the soil profile is not far advanced. In contrast, soils formed on alluvial terraces in the Hagerman area are relatively high in organic matter. Other areas of alluvial soils occur along tributaries (IDWR, 1978).

Plant species in the canyon represent a mixture of dryland and riparian vegetation. Riverine vegetation is dominant along the river bank. Willow is the primary plant species, but cattail, hackberry, alder, cottonwood, sagebrush and a variety of other shrubs are intermixed. The dry areas of the canyon support sagebrush-grass associations. Sagebrush, rabbit brush, cheatgrass, foxtail, wild rye and other grasses and forbs are found.

CLIMATE

The climate of the planning area is semiarid, characterized by low annual rainfall, moderately hot summers and cold winters. Annual precipitation averages 10.5 inches and varies from 50 to 150 percent of the mean (Fig. 3; Table 1). Precipitation is fairly evenly distributed throughout the year, except from July through September when it is well below monthly averages. Annual snowfall totals average 24 inches. January and July are the coldest and warmest months respectively. During the summer, temperatures in excess of 100°F are common inside the Snake River canyon. The growing season varies with elevation. The average length of the frost free growing season is 140 days at Twin Falls. The longest growing season is along river bottom areas and terraces of the Snake River canyon (IDWR, 1978; Molnau, 1992).

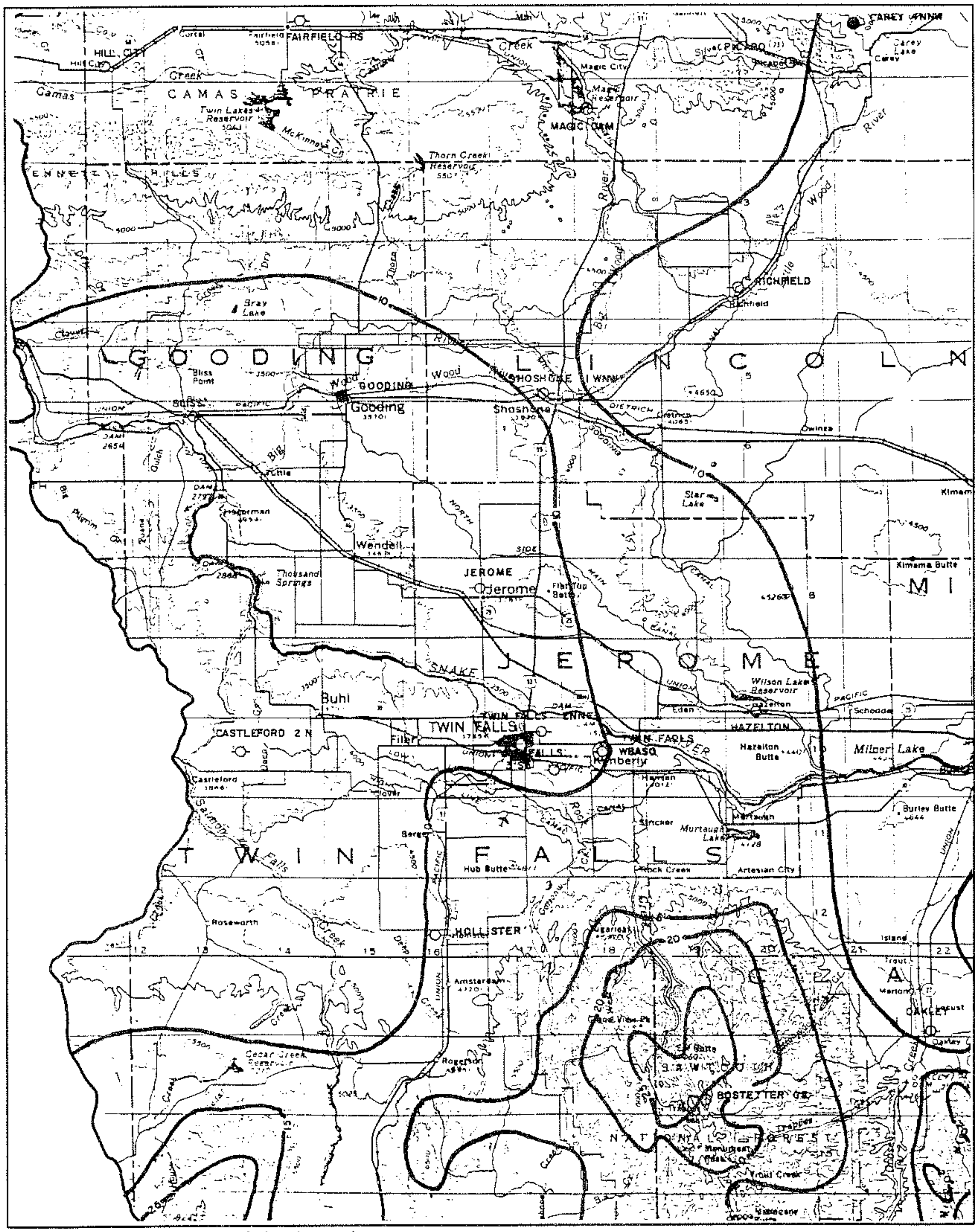

Figure 3. Precipitation map of planning region.

Pacific maritime air masses, brought into the region by prevailing westerly winds, exert a modifying influence on temperatures and contain moisture which is the source of nearly all precipitation. The maritime air masses are displaced or modified by drier continental air masses which are responsible for the clear weather, low humidity, and temperature extremes. Prevailing winds are from the west with sustained velocities of 15 to 20 miles per hour. Winds of destructive force are rare, however wind erosion occurs on newly cleared land that is left unprotected. Storms are seldom severe. Thunderstorms sometimes produce high intensity precipitation for brief periods, but are confined to small areas (USBR, 1961).

Table 1. Climatological Summary Data 1961-89

Station	Bliss	Jerome	Hazelton	Hollister	Twin Falls WSO
Elevation	3,265	3,785	4,060	4,550	3,770
Years of Record	30	30	30	30	30
Avg. January Minimum (°F)	19.3	18.2	17.3	18.1	18.8
Avg. January Maximum	36.3	35.3	34.9	36.5	34.9
Average July Minimum	54.4	55.6	53.7	54.2	53.1
Average July Maximum	91.5	90.8	88.8	86.5	84.9
Lowest Temperature 1961-1989	-22	-20	-27	-26	-19
Highest Temperature 1961-1989	106	108	103	101	101
Growing Season*	135	145	134	115	140
Annual Precipitation (inches)	10.6	10.81	10.24	10.56	10.62
Annual Snow Fall (inches)	20.6	21.4	20.4	25.0	29
Average January Precipitation	1.38	1.24	1.20	.77	1.12
Average July Precipitation	.27	.25	.25	.58	.31
Average Annual Number of Days with Precipitation					
10 inches or more	30	32	30	30	31
50 inches or more	3	3	3	3	3

*The average number of days between last 32°F temperature in spring and first 32°F in fall.

Source: Molnau, 1992.

HISTORY

Archeological evidence indicates the Snake River canyon has been intensively occupied, particularly west of Shoshone Falls which prehistorically marked the upper limit of salmon migrations. Early inhabitants most likely lived in small, highly mobile groups. The mild winters, hot springs, and natural fisheries made the canyon a favorite wintering area. Trails to and from the Snake River traverse the region. As early as the middle of the fifteenth century, small groups of Shoshoni in northern Utah may have extended their food-collecting activities into southern Idaho.

However, the main surge of Shoshoni occupation came in the late eighteenth century, after their displacement from the High Plains by the newly horse-mounted and armed Blackfoot (Butler, 1986).

An abundance of fur bearing animals along the Snake and Big Wood rivers attracted trappers, the first white men to visit the region, in the early 1800's. The numerous springs of the Snake River canyon, the rich agricultural lands of the Hagerman Valley, and gold in the sands of the Snake River induced people to remain in the area. Farming settlements and stock ranches were developed in the late 1800's. Gold mining in the Snake River began as early as 1865, very profitably at first, but declined and continued only on a small scale after 1875. Cattle raising became an important industry in the late 1870s. The area which now makes up Jerome County was originally used for migratory grazing by the earliest livestock concerns in southern Idaho.

Early settlers used water from Snake River tributaries for irrigation. They succeeded in raising wheat, other grains, and alfalfa, as well as fruits and vegetables, demonstrating the productivity of the soil under irrigation. In the summer of 1903 the Twin Falls Southside Land and Water Company tract was opened to entry. A townsite was selected near the center of the project, and delineated land was quickly appropriated. Intensive settlement on the north side of the canyon began in 1907 when the Twin Falls North Side Land and Water Company was granted permission to construct canal systems under the provisions of the federal Carey Act.

DEMOGRAPHICS

The 1990 Census indicates that 80,000 people reside within Gooding, Jerome, and Twin Falls counties. The Middle Snake region may be classified as a rural, agricultural setting, but fifty-three percent of the three-county population lives within the boundaries of a town or city with a population of at least 2,000 people. The City of Twin Falls is the largest population center with 27,591 residents.

A general trend toward urbanization, and a decrease in rural population, prevalent across the United States since the turn of the century, is reflected correspondingly in city and county population figures prior to 1970. However, beginning in the 1960s, but specifically through the 1970s, the U.S. and the region observed an increase in rural population (Table 2). From 1960 to 1990, the combined population of Twin Falls, Jerome, and Gooding counties increased by 27 percent (17,253 persons). An expansion of the area's farm and food processing sectors, the establishment of manufacturing facilities, and the emergence of the city of Twin Falls as the primary trade, financial, and services center in south-central Idaho and northern Nevada, spurred this significant population gain.

Since 1980 Idaho's population has been growing an average 6.23 percent each year. The differences in population change by county, over the last decade, are shown in Fig. 4. Nationally,

EMPLOYMENT AND INCOME

The Twin Falls region historically has built its economic base around agricultural operations and manufacturing of related food and kindred products. A substantial number of food processing companies operate in the area: Green Giant, Falls Brand Meats, Pet, Kraft, Ore-Ida Foods, Simplot, Del Monte, Coors, and Amalgamated Sugar. Universal Frozen Foods, the largest employer in the region, maintains its division headquarters in Twin Falls. Only in the past few years has a significant non-agricultural manufacturing sector emerged. These new industries distribute products generally to the western portion of the country, and possess a great deal of flexibility in location since they are not dependent on a local market (Twin Falls County, 1978).

Agriculture is still the major economic base for Jerome and Gooding counties, but Twin Falls County has shifted to an economy based more on trade and services (Gardner et al., 1990). Twin Falls, the largest town with a population of 27,591 in 1990, is an important trading center and shipping point with retail sales of more than a billion dollars annually. It offers services to approximately 150,000 people in eight surrounding Idaho counties and northern Nevada (Twin Falls Chamber of Commerce, 1992).

In 1990, the economy of the three-county area generated an average of 36,700 jobs (Idaho Department of Employment, 1991). This number includes full-time and part-time employees of private establishments and government agencies, as well as proprietors. Services, retail trade, agriculture, and manufacturing, in descending order, provide the largest number of job opportunities for area residents. The most recent business boom in the area has been dairy farms and dairy processing facilities which have grown dramatically in the last few years.

Average annual employment in the three counties shows an upward trend over the twenty year period 1970-1990 (Table 3). Total employment increased 48 percent in Twin Falls County, 39 percent in Jerome County, and 33 percent in Gooding County between 1970 and 1990. Despite the upward trend overall, Jerome and Twin Falls counties experienced large fluctuations in employment in the 1980s. Employment declines in Twin Falls County were attributed to depressed farm incomes and the closing of food processing plants, and in Jerome County, the closure of Tupperware, one of the county's largest employers.

Farming employed 12 percent of the three-county workforce in 1990, down from 23 percent in 1970, a loss of 1,600 jobs. From 1980 to 1990, farm employment declined an average of 2.7 percent annually. Offsetting this decline is growth in the agricultural services sector. Agricultural services include establishments that provide commodities and services to farms or to businesses that store and transport farm products. These ancillary businesses include distributors of livestock feed, seeds, bulbs, plants, commercial fertilizer, and other agricultural chemicals; farm machinery and

Table 3. Average Annual Employment

	1970	1972	1974	1976	1978	1980	1982	1984	1986	1988	1990
Gooding	3,784	3,856	3,839	3,982	3,837	4,605	5,025	4,964	4,978	5,103	5,059
Jerome	4,460	4,564	6,019	6,350	6,268	6,182	6,192	6,357	6,423	5,841	6,236
Twin Falls	17,128	17,694	20,405	19,250	22,055	22,275	24,003	24,335	24,749	24,540	25,460

Source: Idaho Department of Employment, *The Labor Force in Idaho* 1970-1990.

equipment dealers; and livestock dealers. Agricultural services employment increased 7.3 percent annually, adding 870 jobs between 1980 and 1990. Farm employment and the agricultural services sector together total 16 percent of the labor force.

Trades and services employed 43 percent of the civilian labor force, with construction and manufacturing hiring 15 percent; education and government 14 percent; transportation and utilities 6 percent, and the remaining 6 percent is accounted for by the finance, insurance, and real estate sector. Wholesale and retail trade employment, driven by high rates of population and income growth experienced in both the region and the state, grew 4 percent annually during the 1970s. However, a national recession in the early 1980s led to the loss of over 400 jobs in Gooding, Jerome and Twin Falls counties within the sector. A recovery in the overall levels of wholesale and retail trade employment has occurred since 1986 with the generation of 900 jobs across the three counties.

Employment in the service sector has not shown the same degree of sensitivity to local and national business climates. Since 1970 service sector employment in the three counties has increased at a steady annual rate of 3.5 percent, creating over 4,000 new jobs. Manufacturing had a net employment loss from 1980 to 1990 due to the closure of the Tupperware plastics manufacturing facility in Jerome. The addition of 300 new jobs at Universal Foods and the opening of other new processing and manufacturing facilities have recovered most of the loss. According to the Twin Falls Chamber of Commerce, (1992), the Magic Valley has increased employment by 3,900 jobs since 1989. Strong community support exists for a continued program of attracting and retaining selected, diversified and value-added industries.

In 1990, the average unemployment rate for the three-county area was 4.9 percent, compared with 5.8 percent for the State of Idaho and 5.5 percent nationally (Table 4). Over the last ten years Idaho has maintained an unemployment rate lower than the national average. In contrast, the unemployment rates for Twin Falls County, and Jerome County since 1985, have usually exceeded both the national and state average. Gooding County unemployment has generally been less than both the national and state percentage rates. Unemployment rates in the three counties have fallen

sales for each county (Idaho Tax Commission, 1991). Most of the current tourist traffic is not headed for a local destination, but is passing through the area (Hunt, 1992).

Per-capita income and the percentage of the population below the poverty level are often used as measures of local economic well-being. Table 6 lists median income, average wage, and the economically disadvantaged as a percent of the total population. Median income, as opposed to an average or per-capita income, is not influenced by the magnitude of any one income nor does the family size have any effect on the midpoint. An economically disadvantaged person is one who receives welfare, receives food stamps, or one whose income is below the current poverty level. Real income is defined as dollar income adjusted for the cost of living. A cost of living index relative to other counties or states is not compiled for Idaho or the U.S. Cost of living indices are computed for selected cities in the U.S., but these may not reflect rural conditions.

Table 6. 1990 Income Levels

Area	Median Income	Average Wage/Job	Economically Disadvantaged as % of Total Pop
Twin Falls County	$27,200	$15,975	26.92
Jerome County	24,700	13,156	23.02
Gooding County	22,400	13,033	20.73
Elmore County	21,300	16,848	27.03
State of Idaho	27,200	17,680	20.83
United States	35,700	22,120	--

Source: Idaho Department of Employment, *Idaho Demographic Profile 1992*.

The average value of a home in the three-county area is $47,600. Median rent is $220 a month (U.S. Bureau of the Census, 1990). The average home sale price in Twin Falls in 1991 was $60,000. Home prices range from $40,000 to $300,000. Typical two-bedroom home rent is $350 to $550 per month (Twin Falls Chamber of Commerce, 1992).

There are four school districts in Gooding County, two in Jerome County, and eight in Twin Falls County. The high school graduation rate in the three counties is 74 percent (Idaho Department of Commerce, 1992). The College of Southern Idaho offers two-year academic programs, a wide range of vocational training, and a variety of opportunities for part-time students and adults to further their education through special classes and night classes.

The city of Twin Falls is the medical center for south-central Idaho and northern Nevada. There are over 120 physicians and surgeons in Twin Falls, and Magic Valley Regional Medical Center in Twin Falls provides 165 beds including a 12-bed intensive care unit. Twin Falls County has a total of three hospitals with 237 beds. One hospital, a 40 bed facility, serves Jerome County.

Six physicians operate private practices in Jerome. Gooding County has two hospitals, with a total of 47 beds, and seven physicians.

Broadening of the region's economic base requires the development of activities which do not rely upon the agricultural base of the region. Because this region is neither rich in mineral resources nor a major urban market center, industries with a great deal of flexibility in location are the most likely prospects for business expansion in the area. The major locational requirements for these industries are transportation networks, the ability to distribute products to the central and western areas of the United States, and a favorable living environment. If an industry is considering a rural location which is not near a major urban area, the available labor force and its composition also become important. The Twin Falls region has generally been able to meet these requirements. The magnitude of job growth for the most part is dependent on the ability of the area to continue to attract these businesses.

LAND OWNERSHIP, USE, AND ZONING

There are discontinuous parcels of land along the Middle Snake reach remaining in federal and state ownership. Most productive land in the area, with a source of water and easy access, has been converted to private ownership. Current ownership holdings within the Middle Snake reach hydrologic unit are listed in Table 7. Ownership within the vicinity of the canyon is displayed on the Land Ownership Map.

Table 7. Land Ownership - Middle Snake Hydrologic Unit

	Acres	% of Total Acres
Private	838,170	52.00%
U.S. (BLM)	627,500	39.00%
U.S. (Forest Service)	91,206	6.00%
State	31,654	2.00%
U.S. (Bureau of Reclamation)	10,907	0.68%
Water	5,991	0.30%
U.S. (Military)	333	0.02%

The Bureau of Land Management (BLM) administers 48 miles of river shoreline through the Boise, Burley, and Shoshone Districts. State ownership includes the bed of the Snake River below the mean high water mark, excluding islands located in the river.

Agriculture is the predominant land use on the Snake River Plain, primarily irrigated crop production and grazing. At the eastern end of the reach, farming activities are tied to the irrigation canals, with grazing use more prevalent adjacent to the river. In the canyon, benches formed along the river provide limited opportunities for residential development and cattle grazing. More mixed

land uses are found as one travels downstream, because of increased water availability from springs and tributaries, and an expansion of the river floodplain. Residential development within the canyon and along the canyon rim occurs from Shoshone Falls downstream to the town of Bliss.

Canyon and Rim

Jerome County has established a preservation zone along the north side of the Snake River canyon. The Preservation Zone is defined as a belt a half mile wide from the edge of the river on public lands. The Snake River canyon and Milner Reservoir are included in the Preservation Zone. Lands in this zone are to be preserved in their natural state for future public access (Jerome County, 1984). Present building regulations on private property require a 100-foot setback from the river, and activities within the canyon are regulated.

Twin Falls County zones land within the canyon for outdoor recreation, but industrial or commercial development are the only prohibited enterprises in this zone. The county requires a 100-foot building setback from the canyon rim unless an engineer certifies that the rim is stable. This certification permits a minimum 30-foot setback. Gooding County has established a 300-foot set back from the canyon rim.

A greenbelt along the canyon rim to serve as a natural hazards setback was suggested to the counties in a *Canyon Area Study* dated 1975. The canyon rim is highly unstable and development close to the rim poses a water quality threat from septic systems (Ellwell, 1991). A primary hazard in the canyon is damage or injury by falling rock. Jointing is extensively developed in the basalt flows which form the walls of the Snake River canyon. Cracks ranging from a few inches wide to two to three feet wide can extend downward for at least 20 to 30 feet, and can extend 50 feet back from the rim (B&C Energy, Inc., 1991). Individual blocks of basalt are wedged during cold months when water entrapped in the joints expands during freezing. Extensive cracking often coincides with an area of high seepage. When one block peels off, it may jar others below and cause a slide. Talus along the bottom of the canyon is evidence of landslides or rockfall, and may be found more or less continuously wherever the canyon has steep walls.

TRANSPORTATION

The planning area is served by Union Pacific Railroad, (with Amtrak service 25 miles north at Shoshone), and two major air carriers at the Twin Falls/Sun Valley Regional Airport, (located 10 miles south of Twin Falls). Interstate 84 and U.S. Highways 30 and 93 are the primary automobile and truck transportation routes through the region. Trucking offers a major source of surface transport with 15 companies having terminal facilities in Twin Falls (Twin Falls Chamber of

Commerce, 1992). In the irrigated tracts a majority of the section lines are improved roads. Few farms are over one mile from a paved road.

The Snake River canyon, 300-600 feet deep for most of the reach, greatly influences the road network in the area. It is difficult to enter the canyon or to cross the canyon from rim to rim. Access to the canyon is limited to a few bridges, roads, and trails. Highway bridges cross the canyon to provide access from Murtaugh, Hansen, and Twin Falls on the south to I-84 on the north side of the river. Downstream, State Highway 30 crosses the river near Hagerman. Between King Hill and Twin Falls, there are three additional bridge crossings, one near Clear Lakes (Buhl Bridge), one near Bliss, and one at King Hill. An unpaved improved road (County Road 1300S) crosses the river immediately downstream of Milner Dam.

The Idaho Transportation Department recently completed an environmental assessment of alternatives for reconstruction of the Clear Lakes Grade from the Snake River Bridge to Bob Barton Road on behalf of the West Point Highway District. The current road alignment is considered substandard, causing unsafe travel conditions. The road provides the only crossing of the Snake River between Twin Falls and Hagerman, and is a critical link between agricultural areas north of the Snake River with processing facilities near Buhl. The realignment will result in wider travel lanes, paved shoulders, guardrails, and a truck climbing lane (Idaho Transportation Department and U.S. Department of Transportation, 1988). The West Point Highway District will maintain the project upon completion of construction (Thomas, L., 1992).

II. RESOURCE SUMMARY

Water Quantity

Water sources or supplies within the Milner to King Hill reach of the Snake River include precipitation, the flow of the river at Milner, tributaries within the reach, ground water flow, and returns from upstream irrigation.

PRECIPITATION

Local precipitation in the Milner to King Hill area is not a significant contributor to the water supply of the reach. Annual precipitation in the region averages 10 inches and has varied from a low of 4 inches to a high of 18 inches (1961-89) depending on location (Table 1 and Fig. 3). November through January are the wettest months, and July and August are the driest. Annual snowfall

accumulation averages 24 inches, however, mean snow depth at Bliss is about three inches in January and February. Because of the warmer temperatures in the canyon, periods of snow on the ground there are brief. Excluding the tributaries, overland runoff into the Middle Snake reach directly from snowmelt or precipitation is relatively small (Thomas, C.A., 1969).

SNAKE RIVER

The Snake River watershed upstream of King Hill, Idaho, is often referred to as the Upper Snake River Basin. The Upper Snake River Basin drains an area of 35,857 square miles in Idaho, Wyoming, Nevada, and Utah. In its upper reaches the Snake River constitutes a much larger river than that which enters the planning reach at Milner. At Heise, upstream from nearly all irrigation uses, the average annual flow of the Snake River is about five million acre-feet. The Henrys Fork and its principal tributaries add another two and a quarter million acre-feet per year above diversions. These supplies plus those of smaller tributaries are reduced by irrigation diversions to an average flow at Milner of 2.5 million acre-feet per year.

Flows at Milner vary widely from year to year. The upper storage and diversion system fully regulates the river in the driest one-fifth of all years. In those years total flow at Milner may be less than a half million acre-feet. In wetter years it can be several million acre-feet when upper basin runoff exceeds amounts needed to fill the reservoir system.

The seasonal distribution of river discharge also varies widely. In the driest years Milner flow in late fall and winter is composed almost entirely of the minimum release rate at American Falls Reservoir (about 300 cfs) plus downstream gains. These result in total flows at Milner in the range of 400 to 900 cfs. When Lake Walcott and Milner Reservoir are being filled, or when diversions begin, flows passing Milner are reduced to virtually zero.

During very dry years little flow passes Milner in the early irrigation season. However, in recent years Idaho Power Company has used its American Falls storage (approximately 45,000 acre-feet) plus water obtained from the rental pool to raise flows to the range of 600 to 1000 cfs in late June or early July. Flows of this magnitude have then been maintained as long as available storage permitted or until diversions end in the fall. When the Milner power plants begin operation in late 1992, Milner Reservoir will be kept full and a target flow of 200 cfs will be released, if available.

During non-drought years flows at Milner are substantially greater throughout the year. Typical late summer flows (low flow) are generally in the range of 1000 to 2000 cfs. In the winter or spring, flows of 2000 to 10,000 cfs occur as flood control space in upstream reservoirs is maintained or increased in anticipation of possible springtime floods. In 1984, the year of greatest

total runoff on record, flows greater than 10,000 cfs occurred from November through early February and again from late March through late June. The peak flow was 21,300 cfs on June 14.

Downstream from Milner flows increase substantially from ground water discharge, irrigation returns, and tributaries. Flows at downstream gages largely reflect those at Milner, both in their year to year and seasonal patterns, but from progressively higher base levels. Long term average annual flows at gages in the reach illustrate the magnitudes of these gains:

At Milner	3430 cfs
Near Kimberly	3800
Near Buhl	5450
Near Hagerman	9280
At King Hill	11020

Average daily discharges at the five operating USGS gages in the reach are illustrated for the period 1947 to 1991 (Fig. 6), and for the period 1988 through 1991 which corresponds to the current drought period (Fig. 7). Discharge patterns and magnitudes are significantly different for the drought period compared to the 1947-91 period of record. Conspicuously absent from the 1988-91 record are the higher flows in April, May, and June at all stations. The 1988-91 records show near zero flows at Milner for this period compared to long term average flows of nearly 5000 cfs. The seasonal flow patterns for the drought period show continually receding flows at all stations after the irrigation season. The seasonal flow patterns for the Buhl gage are representative of all gaging stations in the study reach and show the lack of higher early season flows and the declining winter-time flow. July through September flows are very similar for the two periods, reflecting the base flows supported primarily by ground water returns from the northside and southside springs.

TRIBUTARIES

Numerous small tributaries enter the Snake River in the Milner to King Hill reach. Nearly all of them carry substantial amounts of irrigation return flow and/or ground water discharge. The four largest tributaries are Rock Creek, Salmon Falls Creek, the Malad River, and Clover Creek. Rock Creek originates in mountains southeast of Twin Falls. Head-water runoff is probably in the order of 40,000 to 50,000 acre-feet per year. At its mouth the flow averages roughly 150,000 acre-feet per year as a result of irrigation return flows. Salmon Falls Creek is fully regulated by Salmon Falls Creek Reservoir near Rogerson. Salmon Falls Creek contributes about 120,000 acre-feet per year, in surface water and subsurface return flow from irrigated areas, to the Middle Snake reach.

The Malad River is the largest tributary in the reach. In years of below normal runoff it is composed entirely of irrigation returns and ground water discharge. However, in wetter years excess mountain runoff reaches the mouth. Long term average annual runoff is about 190,000 acre-feet at

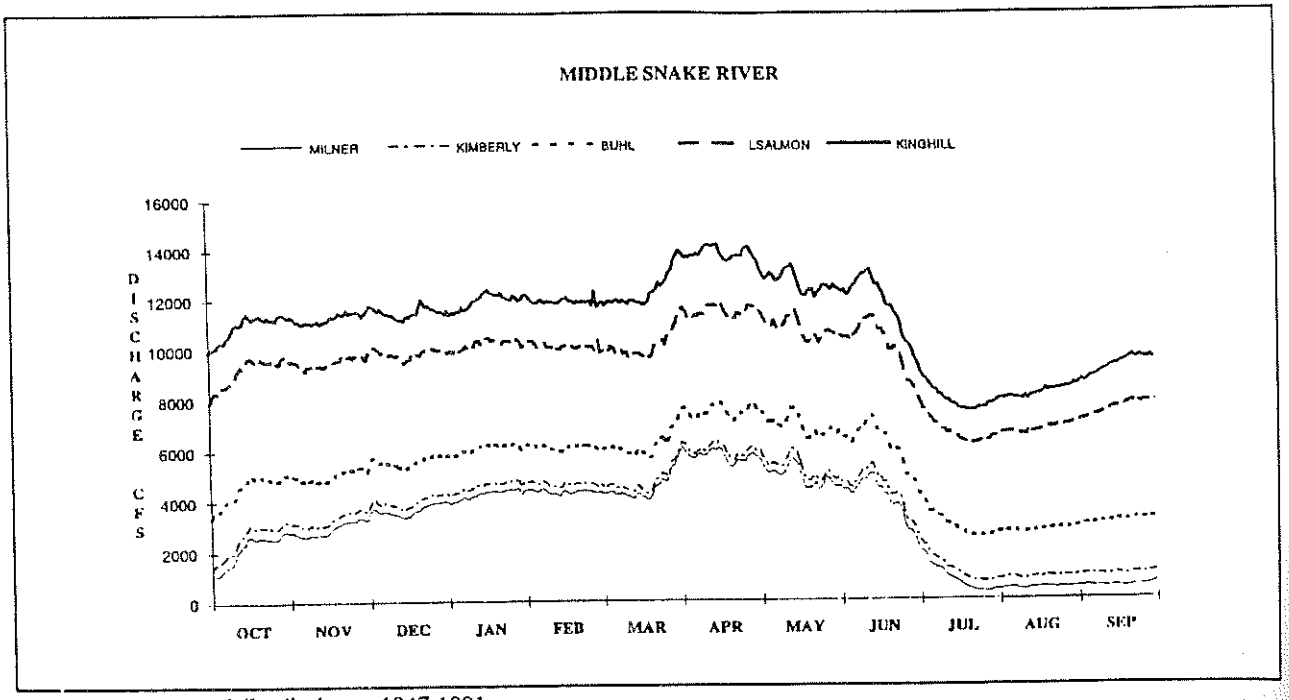

Figure 6. Average daily discharge 1947-1991.

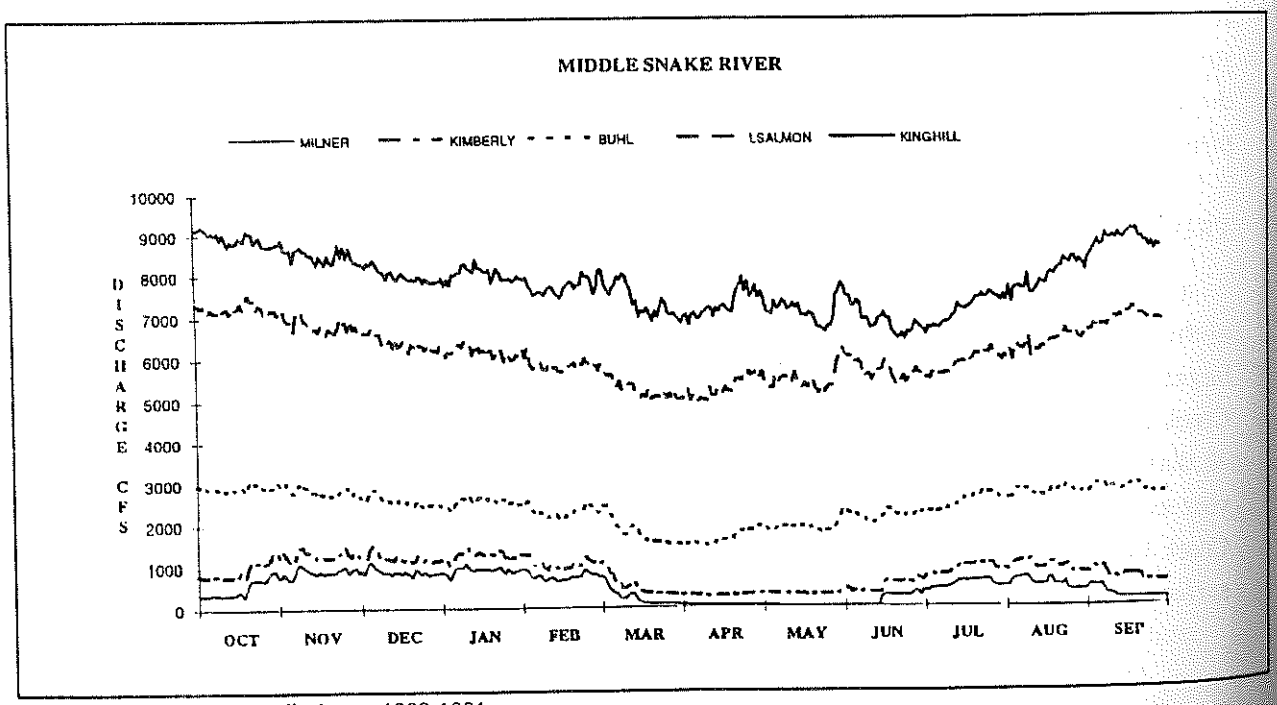

Figure 7. Average daily discharge 1988-1991.

the Gooding gage. Ground water discharge and irrigation return flow in the lower canyon adds nearly 900,000 acre-feet to that amount. About 850,000 acre-feet per year reach the Snake via Idaho Power Company's Malad power flume and power plant downstream from the mouth of the river. Clover Creek enters the Snake River one mile upstream from the King Hill gage. Its' flow is highly variable, but probably averages less than 100,000 acre-feet per year.

GROUND WATER FLOW

The largest inflow to the Middle Snake reach is from the scores of springs that issue from the Snake River Plain Aquifer on the north and east sides of the canyon. A second significant source is from the aquifer underlying the Twin Falls tract, which discharges about 500 cfs (Kjelstrom, 1986). Water in these aquifers is principally stored in and transmitted through fractures, gas-bubble voids, and lava tubes formed during the flow and cooling of molten volcanic rock, and permeable ash and soil interbeds deposited between flows. The Snake River Plain Aquifer, one of the largest ground-water systems in the United States, underlies the Snake River Plain from the vicinity of St. Anthony, Idaho, to the western terminus of the Middle Snake reach. Ground water moves through the aquifer in a general southwest direction. The aquifer is recharged by seepage from the Snake River and streams entering or crossing the plain, by the percolation of irrigation water and precipitation, and underflow from tributary basins.

In general, the basalt on the south side of the river is much less permeable than the basalt north of the Snake River. The original depth to water on the south side is estimated to have averaged about 250 feet. Irrigation began on the south side in 1905 and the water table rose rapidly in some tracts. Waterlogged areas appeared by 1912, and many drains, tunnels, and drainage wells were constructed to alleviate seeped conditions (Mundorff et al., 1960). The depth of ground water may be as little as 35 feet near Murtaugh or as great as 500 feet on the south side (Bell Rapids). Depth to ground water varies on the north side from approximately 300 feet to less than 100 feet.

On an annual basis, over 50 percent of the total streamflow that is measured at King Hill is from ground-water discharge. The Snake River Plain Aquifer presently discharges an estimated 5700 cfs into the Middle Snake reach. Ground-water discharge in the Milner-King Hill reach has varied as recharge conditions have changed. The increase in ground-water discharge from 1902 to the early 1950s has been attributed to increased ground-water recharge in surface water irrigated areas north and east of the springs. It has been in a state of slow decline since the mid-1950's when it exceeded an estimated 6700 cfs. Withdrawals from the aquifer and increasing efficiencies in irrigation application by surface water users on the plain (a major recharge source) are expected to result in continuation of the decline (Fig. 8). When these stresses moderate at some relatively fixed level in the future, aquifer outflows will begin to approach equilibrium with inputs and upstream withdrawals. Seasonally, aquifer discharge varies only slightly. The highest flows occur in the fall as a result of

the cumulative effects of recharge by surface water irrigation. Low flows occur in April or May before the effects of the new irrigation season recharge become significant.

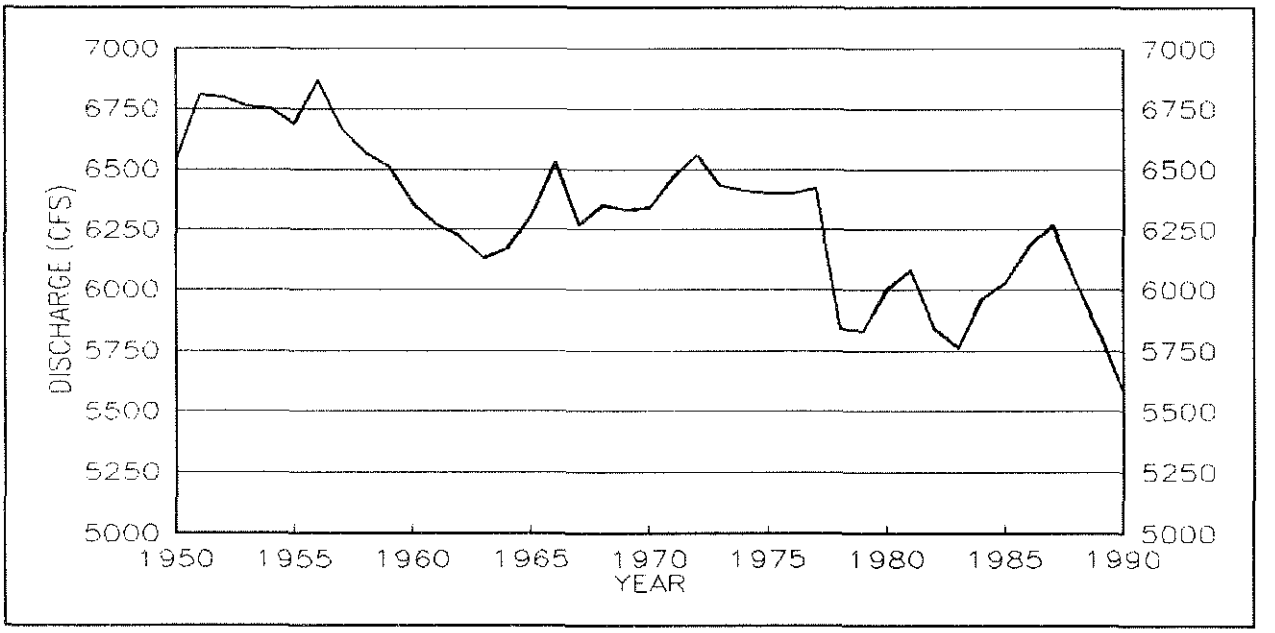

Figure 8. Average annual ground-water discharge from the north side of the Snake River from Milner to King Hill.

Springs

Discharge from the Snake River Plain Aquifer occurs throughout the Milner to King Hill reach, but the largest river gains from this source are between the Buhl and Hagerman gages. Springs issuing from the aquifer occur singly, in clusters, and in continuous zones along the Snake River canyon. The larger springs or groups of springs are named, but innumerable small springs and seeps are either unnamed or known only to local residents. Outflows from many of the springs fall almost directly into the river. Others form tributary streams, like Billingsley Creek, before entering the river. One of the largest spring groups occurs in the Malad River canyon (Table 8).

Geothermal Sites

Geothermal flow also occurs in the area. Developed uses total about 30 cfs in the Twin Falls and Banbury areas. Most of this developed water is discharged to the river after use. Some thermal water may leak upward into overlying cold water aquifers, to be discharged as part of those sources, to the river.

The geothermal resource of the Twin Falls-Banbury system is characterized by temperatures between 30° and 70°C (86° to 158°F) and shut-in well pressures of 14 to 250 pounds/square inch.

Table 8. Major Springs in Study Area

Spring Name	Approximate range of discharge (ft^3/s)
Blue Lakes Spring	180 - 260
Crystal Springs	430 - 580
Niagara Springs	200 - 360
Clear Lakes	470 - 540
Briggs Creek	105 - 115
Banbury Springs	95 - 140
Box Canyon Springs	350 - 480
Sand Springs	85 - 115
Thousand Springs	750 - 1,430
Malad Springs	1,220 - 1,360

The thermal water occurs in rhyolitic ash-flow tuffs and lava flows of the Tertiary Idavada Volcanic Group. Permeability of the reservoir rocks results from tectonic and cooling fractures, intergranular porosity of the non-welded tuffs, and voids left between successive flows. The system is recharged by rain and snow falling on the Cassia Mountains to the south. Northward dipping volcanic strata channel the water toward the center of the Snake River Plain and into northwest-trending structure zones which cross the area from Hollister to Banbury Hot Springs (Chapman and Ralston, 1970).

RETURN FLOW

Irrigation return flow occurs via numerous wasteways on both sides of the river. Although many of these have been measured, no clear separation of surface return from ground-water flow has been made. In some cases measuring sites were downstream from substantial ground-water inflows. Irrigation wasteways typically have highly varying flows as canal operations change from day to day, and generally cease flowing when canal diversions stop. Irrigation wasteways with seep water flow year round.

Water Quality

Agricultural water supply, cold water biota, salmonid spawning, and primary and secondary contact recreation are the designated uses of the Snake River from Milner Dam to King Hill. Primary and secondary recreation in the locality include fishing, boating, and swimming in limited areas. The Middle Snake reach from Milner Dam to King Hill has been assessed as not fully supporting all beneficial uses. Primary and secondary recreation as well as salmonid spawning and cold water biota are not supported or only partially supported (IDHW, 1989; 1991). By the most recent nonpoint source assessment, agricultural water supply is potentially at risk. Vineyard Creek, Clear Springs, Crystal Springs, Thousand Springs Creek, and Blind Canyon Creek are also evaluated as not fully

supporting these beneficial uses. The Snake River from Shoshone Falls to Lower Salmon Falls Reservoir has been listed as water quality-limited. Water quality in this reach does not meet applicable state standards (Fig. 9).

Idaho water quality criteria state that "waters of the State must not contain. . . floating, suspended, or submerged matter of any kind in concentrations causing nuisance or objectionable conditions or that may adversely affect designated beneficial uses" (IDAPA 16.01.2200,04). The general water quality criteria further state that "waters of the State must not contain. . . excess nutrients that can cause visible slime growths or other nuisance aquatic growths impairing designated or protected beneficial uses" (IDAPA 16.01.2200,05). Specific water quality criteria for waters designated for cold water biota must exhibit "dissolved oxygen concentrations exceeding 6 mg/l at all times" (IDAPA 16.01.2250,04.a).

A water quality-limited segment is any segment where it is known that water quality does not meet applicable standards or is not expected to meet applicable water quality standards even after the application of effluent limitations required by Section 301 of the Clean Water Act. The determination that segments of the Middle Snake reach are "water quality-limited" requires the development of a Total Maximum Daily Load (TMDL) for the river. A TMDL quantifies pollutant sources and allocates allowable loads to the contributing point and nonpoint sources so that the water quality standards are attained for that waterbody (IDHW, 1991).

The Snake River has historically been a biologically productive system. As early as 1811, the Wilson Hunt party observed that the river was a "light pea-green color." Since that time the watershed has undergone significant development and the river has undergone major physical modifications. Water quality in the Middle Snake reach has been effected by diminished stream flows, nutrient inflows, and sediment. Irrigated crop production, fish rearing facilities, municipal sewage treatment plants, animal holding areas, urban development, and range activities all impact the water quality of the Middle Snake reach. In addition, flow alteration brought about by hydrologic modifications hinder waste assimilation and flushing; the ability of the river to absorb these nutrient and sediment inflows has been severely hampered for the last five years by extremely low flows.

One of the repercussions of excessive sediment and nutrient loading coupled with flow modification is excessive aquatic plant growth. During the summer, high nutrient levels, low flows, and high water temperatures promote the occurrence of algal blooms in low gradient reaches of the river. In some slow-flowing stretches of the area, detached benthic algal growth form floating mats, and shallow sediment deposits support extensive beds of rooted aquatic plants (IDHW, 1991). Dissolved oxygen measurements in deep holes between Twin Falls and Hagerman fall below 4.0

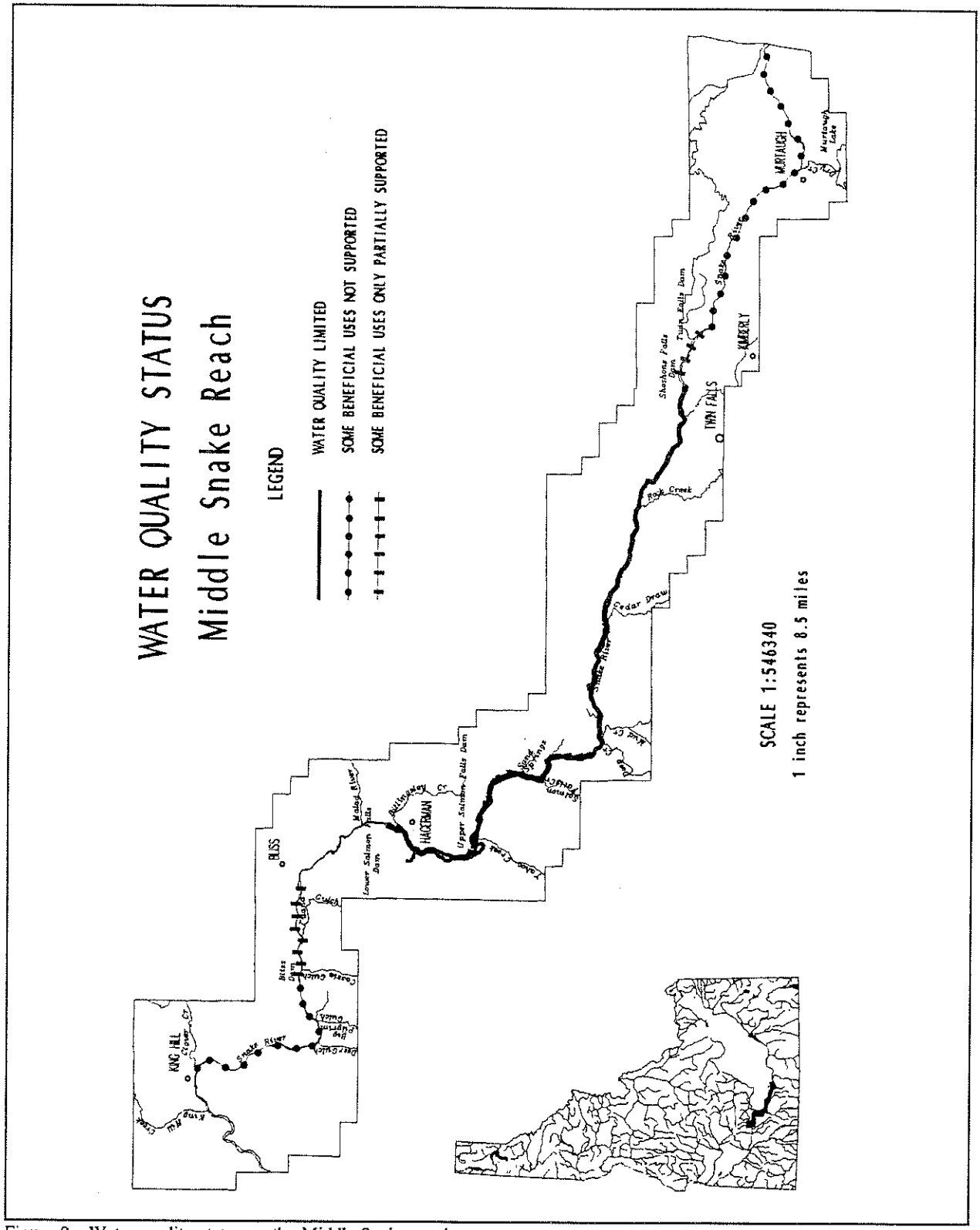

Figure 9. Water quality status on the Middle Snake reach.

parts/million at night and pools are stagnant with considerable organic waste build up which act as sediment sinks (Hill, 1991).

Several evaluations of water quality conditions in the Snake River system have been undertaken since the early 1970s. In 1975, the Environmental Protection Agency (EPA) prepared a river basin water quality status report for the Upper and Middle Snake River. The study found that nutrient concentrations in tributaries to the Snake above King Hill, for the most part exceeded the "algal bloom potential levels." In addition, the total phosphorus load at King Hill exhibited an increasing trend and ground-water inflow in the Hagerman reach was found to be a significant source of nitrate and nitrite (U.S. EPA, 1976a). A study conducted by the EPA in October 1976 focused on nonpoint sources. The *Upper Snake River Basin Nonpoint Source Basin Status Evaluation* concluded that phosphorus, nitrogen, and bacteria levels between Milner and King Hill were not acceptable and nitrate nitrogen, metals, and pH levels were objectionable. Additionally, low, hot summer flows, turbidity, silt, pesticides, nutrients, and low dissolved oxygen detrimentally affected beneficial water uses. Blooms of blue-green algae and diatoms during the spring, summer, and fall were also noted as a problems.

In 1979 a water quality study was performed by Parametrix, Inc. and Tetra Tech, Inc. for the state Division of Environmental Quality (DEQ). The major objective of this study was to identify, quantify, and assess the importance of the sources of nitrogen and phosphorus impacting the Snake River. The study found that 74 percent of the nitrate within the Middle Snake reach is contributed to the reach below Twin Falls, primarily from spring influx, and 14 percent comes from the Snake River above Milner. The three major tributaries (Rock Creek, Salmon Falls, and the Malad River) contributed nine percent. The study found the contributions from the five municipal sources to be insignificant. For total phosphorus, spring influx in the reach contributes about 20 percent, with the Snake River at Milner Dam contributing 60 percent (or 32 percent when the diversions are accounted for), the three tributaries eleven percent, and municipal sources about seven percent. All other sources contributed less than 5 percent each. One limitation of these numbers is that the ultimate nonpoint sources of nutrients, especially with respect to the springs, have not been identified. These unidentified sources include surface runoff, irrigation return flows, and effluent from aquaculture facilities.

The Idaho Division of Environmental Quality initiated a water quality monitoring study in 1990 to evaluate the cumulative impacts of existing and proposed activities. Concurrent sampling of 55 sites, including 13 instream sites, effluent from 10 fish hatcheries, 19 irrigation return flow streams, and 13 tributary streams, was conducted for the period June 1, 1990 through July 25, 1991. The study data will be utilized in a river water quality model being developed by the U.S. Environmental Protection Agency.

Findings from the study indicate that concentrations of nitrate plus nitrite nitrogen and total phosphorus, and water temperature exceed guidelines or adopted water quality criteria for the designated beneficial uses in the main stem of the Snake River (Brockway and Robison, 1992). Low river flows at Milner and decreased spring inflow during the last five years have exacerbated the water quality, algae, and macrophyte problems in the reach. The Middle Snake reach transports up to 30 tons/day of nitrate+nitrite nitrogen, two tons/day of phosphate phosphorous, and 350 tons/day of suspended solids. During the Brockway study, over 12,500 tons of sediment settled in the reach.

Average total nitrogen concentrations increase from 1.7 mg/l at Milner to 2.6 mg/l at the Clear Lakes Bridge. Average concentrations then decrease to 1.8 mg/l below Lower Salmon Falls Dam, and remain relatively constant to King Hill. Total nitrogen contributions for the study period were 4,500 tons from the nine measured tributaries, 2,600 tons from measured fish facilities, and 310 tons from irrigation return flows. Total nitrogen loads in the main river increase from approximately 570 tons at Murtaugh to over 13,000 tons at the King Hill gage (Brockway and Robison, 1992).

Irrigation return flows from the south side of the river often contain ground water from shallow field drains. The average concentration of total nitrogen in these return flows was reported at 2.6 mg/l. The average concentration of total nitrogen in north side return flows, consisting primarily of surface runoff, was 0.6 mg/l. Samples from tributary streams averaged 2.6 mg/l, and measured fish hatchery effluent entering the river averaged 2.4 mg/l. Samples of effluent from a trout processing plant near Blue Lakes averaged over 52 mg/l total nitrogen.

Average concentrations of total phosphorus in samples from the Snake River ranged from 0.07 mg/l to 0.17 mg/l. Concentrations of total phosphorus declined from 0.15 mg/l at Murtaugh to 0.7 mg/l near Shoshone Falls, then increased to 0.17 mg/l below Warm Creek. Average concentrations then declined again to 0.09 mg/l at Gridley Bridge, to 0.08 mg/l below Lower Salmon Falls dam, and then remained at that concentration throughout the remainder of the reach. The increase in the average total phosphorus concentration in the Shoshone Falls to Warm Creek section may be attributed to inflow from the Twin Falls sewage treatment plant. Reductions in total phosphorus concentrations in the Murtaugh to Shoshone Falls and the Warm Creek to Lower Salmon Falls Dam reaches likely indicate nutrient uptake by algae in the reservoirs and slow-moving segments.

Average total phosphorus concentrations were 0.24 mg/l in samples from irrigation return flows, 0.11 mg/l in tributary streams, and 0.10 mg/l in measured fish hatchery effluent. Reported water quality criteria for total phosphorus for aquatic life range from 0.025 to 0.10 mg/l (U.S. EPA, 1976b; Bauer and Smith, 1978).

Total phosphorus loads for the monitoring period (June, 1990 through July, 1991) in the Snake River increase from 60 tons at Murtaugh to over 600 tons at the King Hill station (Brockway and Robison, 1992). Total phosphate loadings were 219 tons from measured tributary streams, 112 tons from measured fish hatcheries, and 37 tons contributed from measured irrigation return flows. Most phosphorus is adsorbed to fine sediments, and therefore enters the river through surface sources

Suspended sediment loads in the main river increase from less than 10 tons per day at Murtaugh Bridge to as much as 350 tons/day at the King Hill gaging station (Brockway and Robison, 1992). Total loading to the river from measured sources was nearly 80,000 tons during the study period (June 1990 - July 1991). The nine measured tributaries contributed 53,000 tons, the 18 measured irrigation return flows added 21,000 tons, and the hatchery discharges contributed 6,000 tons of sediment. The sediment load entering the study area at Murtaugh was estimated at 3,400 tons, and the load leaving the study area was estimated at 70,000 tons. Based on these estimates, at least 13,000 tons of suspended sediment were deposited in the Murtaugh to King Hill reach of the Snake River during the study period.

Nutrient and sediment concentrations in the main river reflect seasonal regimes and the inflow of spring water from the Snake River Plain Aquifer. Computed seasonal loadings for suspended solids and phosphates in irrigation return flow streams show elevated values during the irrigation season; however, total nitrogen concentrations in perennial irrigation return flow streams are highest during the winter because of increased percent contribution of shallow groundwater from subsurface drains. Total nutrient loads in effluent from fish facilities are relatively constant throughout the year. Nutrient and sediment levels in tributary streams reflect the integrated effects of irrigation and ground-water returns, and aquacultural activities (Brockway and Robison, 1992).

Once in the river, sediments are deposited wherever the current slows. The nutrient-rich sediments speed the growth of aquatic plants, which further slow water velocity. When the plants die, the decay process consumes oxygen and contributes to nutrient and sediment build-up on the bottom of the stream bed.

POLLUTANT SOURCES

Water quality of the Snake River is being degraded by numerous sources which may meet state water quality standards on an individual basis. The Middle Snake reach is impacted by return flows from irrigated agriculture, runoff from confined animal feeding operations (CAFOs), hatchery effluent, hydroelectric development, and point source discharges. These contributions become critical during the summer when flow levels are low. The parameters of concern include sediment and temperature, with phosphorus being the critical limiting nutrient (IDHW, 1989).

Hatchery Effluent

Because of the high quality of the spring water issuing from the Snake River Plain aquifer, the Middle Snake reach is ideal for fish farming. It is estimated that 80 to 90 percent of the spring flow in the reach is utilized for fish production. Ninety-eight active commercial facilities are located adjacent to the Snake River or its tributaries in the planning area (Agte, 1992). There are also four state and federal hatcheries located along the reach. Waste materials associated with the hatchery operations include uneaten and undigested food, fecal matter, and metabolites which exist in soluble, colloidal, or suspended forms (IDHW, 1991). The accumulated waste materials are periodically removed by various types of raceway cleaning methods. The unsettled, resuspended and soluble waste materials are continuously discharged in the raceway effluent.

Decomposition of fecal and feed solids depletes the dissolved oxygen concentration in the receiving water, and results in the release of dissolved nutrients. Moreover, aquaculture wastes support a diverse population of micro-organisms which also contribute to oxygen depletion, and may be deleterious to other aquatic species. The addition of phosphorus from fish hatcheries to aquatic habitats can also present serious, long-term pollution problems. The biologically available fractions of phosphorus and nitrogen in fish farm discharges contribute to the enhancement of algal and vascular plant growth, thereby exacerbating eutrophication of the receiving water. Currently, commercial aquaculture facilities are authorized by permit to discharge a total of 117,500 pounds of suspended solids per day to the Snake River (IDHW, 1991).

Livestock Operations

A significant number of dairies and confined animal feeding operations are located in the planning area. Dairy cattle produce an estimated 85 pounds of manure (feces and urine) per day per 1,000 pounds of live weight. Jerome County has an estimated 17,500 pounds of waste per cow per year, which is above the state average. The manure contains 9.3 pounds of solids, 0.37 pounds of nitrogen, 0.069 pounds of phosphorus, and 0.27 pounds of potassium. In one year a 500 cow herd of 1,000 pound cows can produce about 7,750 tons of manure containing 850 tons of solids with 34 tons of nitrogen, 6 tons of phosphorus, and 25 tons of potassium.

In addition to the manure wastes, the washing of tanks, pipelines, equipment, cows, parlor, and milk house floors can produce 735 to 2,600 gallons per day of additional liquids (IDHW, 1991). The manure produced by a dairy operation contains about 43% more liquid with about the same amount of solids per 1,000 pounds live weight as do feedlots. This, coupled with the liquids from the washing operations, means that dairies require more storage, handling, and lot management than do feedlots.

Feedlot cattle produce an estimated 62 pounds of manure per day per 1,000 pounds of live weight. The manure contains 8.9 pounds of solids, 0.43 pounds of nitrogen, 0.09 pounds of phosphorus and 0.23 pounds of potassium. A 500 head lot can produce about 6,900 tons of manure per year with 810 tons of solids, 39 tons of nitrogen, 8 tons of phosphorus, and 21 tons of potassium (IDHW, 1991).

Irrigation Return Flows

During the irrigation season, 13 perennial streams and over 50 agricultural drains contribute irrigation tailwater to the Snake River.

A 1969 study of the 203,000 acre Twin Falls Canal Company irrigation project indicated that 50 percent of all the irrigation water for the project area became subsurface drainage water; evapotranspiration accounted for 36 percent and the remaining 14 percent was surface runoff. Thus 64 percent of the total water input became irrigation return flow into the Snake River (Carter et al., 1971). The study also indicated that the mean concentrations of all ionic components measured in subsurface drainage water exceeded those in the input water diverted at Milner Dam except for phosphorus. Results showed that more water was used than was necessary to maintain a salt balance in the soil and considerable leaching took place. The net output of soluble salts from the project was about one ton per acre (Carter et al., 1973). Estimates of irrigation erosion by the Soil Conservation Service (SCS) identify substantial areas of serious erosion on surface-irrigated lands in Jerome and Twin Falls counties. Furrow irrigated crops on slopes greater than 2 percent will erode 50-60 tons of soil per acre per year (U.S. Soil Conservation Service, 1991).

The Twin Falls Canal Company has excavated horizontal drainage tunnels under shallow perched water tables. Tunnels were terminated when fractures in the basalt carrying significant amounts of water were intercepted. The tunnels then served effectively as drainage channels to convey excess water into surface drains, or natural channels. Approximately 50 drainage tunnels ranging from 0.25 to 1.5 miles long were excavated before the practice was replaced by relief wells connected by tile drains in the 1930's. These relief wells were 35 to 70 feet deep, and tile drainage lines connecting them were 3.5 to 10 feet below the soil surface. These wells flow from hydrostatic pressure, and water is conveyed to natural surface drains by the tile lines. This practice also proved effective in lowering the water table, and it is still used today .

Other Sources

Rangeland and dryland farming, urban nonpoint sources and stormwater runoff, impacts from development and road construction, and sand and gravel operations also impact water quality in the Middle Snake reach. The impacts are compounded by associated stream channel alterations.

Municipal sewage treatment plants discharge directly or indirectly into the Snake River and its tributaries. The Twin Falls and the Hagerman sewage treatment plants discharge directly into the Snake River.

Agriculture

The Middle Snake region historically has built its economic base around agricultural operations. Grain, hay, beans, and potatoes, along with beef, dairy, and fish operations are the primary agricultural commodities. These commodities provide the raw products for food and seed processing plants located throughout the area. In 1990 the estimated market value of crops, livestock, and fish produced in Gooding, Jerome, and Twin Falls counties totaled $450 million.

CROP IRRIGATION

Approximately 500,000 acres of cropland are irrigated with water from the Snake River diverted at Milner Dam into the Twin Falls, North Side, Milner-Gooding, and the Milner Low-Lift canals. Irrigation diversions are also made from Snake River tributaries and springs, and farmers irrigate roughly 150,000 acres in the area from deep wells (Fig. 10). The existing network of irrigation companies in the planning area is extensive. Two-thousand six-hundred miles of irrigation canals serve the upland area bordering the Middle Snake reach (Map: Diversions and Canals). Irrigation organizations are listed in Table 9, which also lists irrigated acreage by county and water source.

There are 2,740 irrigated farms in Gooding (621), Jerome (768), and Twin Falls (1,351) counties covering 515,432 acres (Fig. 11; 1987 Census of Agriculture, U.S. Bureau of the Census). Average farm size is 300 acres, and 99 percent are individual or family owned. About 47 percent of the irrigated acreage is in furrows, and 53 percent is watered by sprinklers. Irrigated acreage represents 52 percent of all farm acreage, and 84 percent of total cropland in the three counties.

The primary crops are hay and alfalfa, cereal grains, beans, and potatoes. The irrigated soils have qualities that dictate the growing of close-growing crops and legumes, such as alfalfa or grass hay, at least 50 percent of the time. Pasture and alfalfa are more prevalent on the north side of the river due to rougher terrain and shallower soils, and comprise 70 percent of the crop production in Gooding County (UI, 1991a). Jerome County had more acreage in cereal grains than any other crop, however, beans, potatoes, and sugar beets are important crops in the central and eastern portion of the county (UI, 1991b). Beans are the main commodity in Twin Falls County, but potatoes, sweet corn, sugar beets, seed crops, barley, wheat, hay, and alfalfa are also planted in significant quantities (Idaho Agricultural Statistics Service, 1991). Climate and low humidity have made the Magic Valley the world's major snap bean seed producer, sustaining approximately 90 percent of supply.

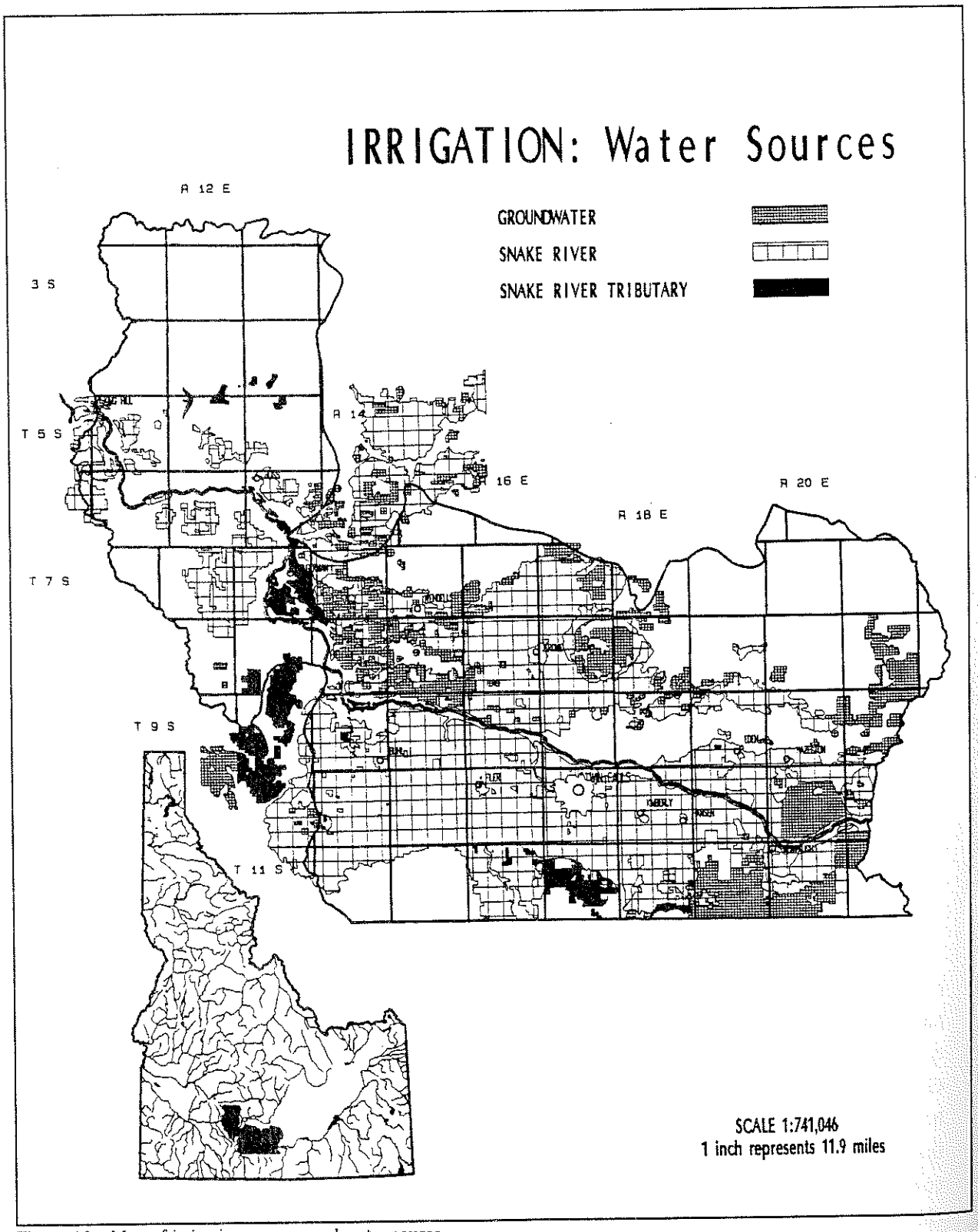

Figure 10. Map of irrigation acreage and water source.

Table 9. Irrigated Cropland Acreage by County

	Twin Falls	Jerome	Gooding	Elmore
Ground-water Source	32,396	54,442	42,648	
Surface Water Source	280,679	134,314	85,318	
Snake River Diversions	234,236	134,314	75,378	11,200
Snake River Tributary Diversions	9,853		1,996	
Salmon Falls Creek Diversions	42,790			
Thousand Springs Diversions			7,268	
Malad River Diversions			676	
Combined Ground Water and Surface Water Diversions	18,313		1,797	
TOTAL	337,588	188,756	129,763	11,200
Irrigation Organization				
Private Ground Water	32,396	45,233	44,445	
Private Snake River Diversions	424			
Milner Irrigation District	13,500			
Twin Falls Canal Co. (Snake River)	202,030			
North Side Canal Company		102,887	39,177	
North Side Pump Company		12,158		
American Falls Reservoir District No. 2		10,037	36,201	
A & B Irrigation District - Ground Water		9,209		
A & B Irrigation District		9,232		
King Hill Irrigation District				11,200
Bell Rapids Mutual Irrigation Co. (Snake River)	20,820			
Private Snake River Tributary Diversions	2,173		9,264	
Private Salmon Falls Creek Diversions	10,852			
Magic Water Corporation (Salmon Falls Creek)	7,120			
Salmon River Canal Co. (Salmon Falls Creek)	36,591			
Cedar Mesa Canal Co. (Snake River Tributary)	5,783			
Mud Creek Water User's Association	543			
Rock Creek Water District	5,356			
Private Malad River Diversions			676	
TOTAL	337,588	188,756	129,763	11,200

Source: IDWR, 1978; Bright, 1992.

Between Milner Dam and King Hill the Snake River is deeply entrenched below the surface of the Snake River Plain and has limited irrigation use. There are about 8,000 acres irrigated along the river in the canyon bottom, most of which are in the Hagerman Valley. Most of these lands are irrigated from various tributary creeks and springs rather than from the Snake River proper. Hay, grain, and forage crops predominate, but the high summer temperature and a comparatively long growing season allow for a wide crop selection in the canyon. Watermelons, cantaloupes, and tree fruits are successfully grown. Orchards are found along the canyon bottom between Twin Falls and the Buhl Bridge. An enterprise new to the Snake River bottom lands is the wine industry. Rose Hill winery has recently begun operations in Hagerman.

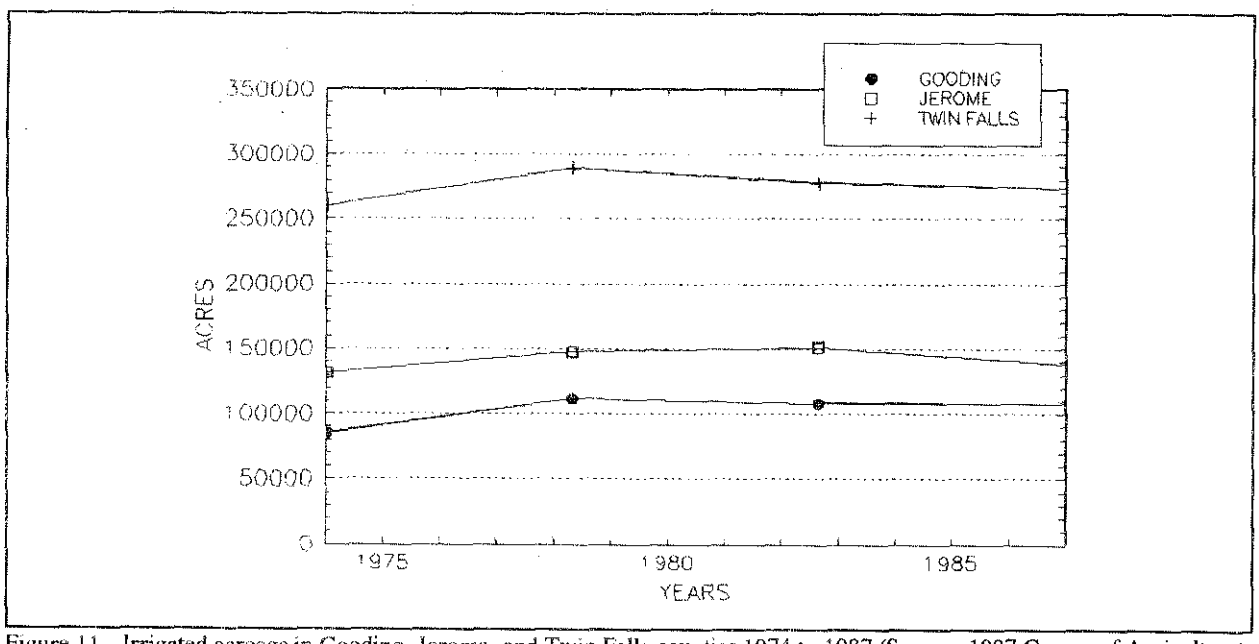

Figure 11. Irrigated acreage in Gooding, Jerome, and Twin Falls counties 1974 to 1987 (Source: 1987 Census of Agriculture).

Crop consumptive use of water varies with crop type and location. Generally, alfalfa, potatoes, and sugar beets have the highest consumptive-use rates at all locations (Table 10). Row crops such as corn, small vegetables, and beans use less water. Average crop consumptive irrigation requirements at Twin Falls are 18 inches per year. Irrigation requirements vary from year to year, depending on temperature and the amount and seasonal distribution of precipitation. Winter, spring, and fall precipitation will reduce irrigation-water withdrawals if adequate soil moisture delays the start of irrigation in the spring or hastens its end in the fall. Scant precipitation during summer months has less effect on irrigation-water withdrawals.

Table 10. Average Rates of Consumptive Water Use for Crops (Twin Falls)

Sugar Beets	21.9 acre-inches/acre
Dry Beans	15.6
Corn Silage	16.8
Spring Grain	13.2
Potatoes	21.3
Winter Grain	19.2
Alfalfa	23.2
Grass/Pasture	18.3
Orchard	18.9

Source: Corey, G.L. and R. Sutter, 1971. *Agricultural Water Needs: Consumptive Irrigation Requirements.* Idaho Water Resource Board, Water Planning Studies No. 5.

The amount of water applied to crops generally exceeds irrigation-water requirements because of on-farm losses. Water evaporates from exposed water surfaces in gravity-distribution systems. Runoff and seepage occur when more water is applied than can be evapotranspired or absorbed and retained by the soil. Water also seeps from unlined ditches. The U.S. Soil Conservation Service (1977) estimated that about 40 percent of water diverted for irrigation in the Snake River Basin is lost to evaporation, runoff, and seepage.

Early irrigation development was limited to the Snake River canyon and several of the tributary streams. Large scale irrigation began in the early 1900s with effective use of provisions of the Carey Act of 1894 and the Reclamation Act of 1902. Federal legislation facilitated the transfer of public lands to individuals for private reclamation projects. The new federal involvement provided coordination and funding for construction of dams, reservoirs, and canals, which in turn, stimulated expansion of irrigated acreage. The Twin Falls Project was one of the largest projects developed under the Carey Act.

In 1900 the Twin Falls Land and Water Company obtained a permit to appropriate 3,400 cfs of natural flow from the Snake River and received a segregation of 244,026 acres of desert land. In 1903 the project began with the construction of the Low Line Canal and Milner Dam on the Snake River. The first water deliveries were made in the spring and summer of 1905. In 1910, the operating company was turned over to the project settlers.

On the north side of the Snake River canyon, the Twin Falls North Side Land and Water Company initiated Carey Act projects. The North Side project was designed to divert water from the Snake River at Milner Dam into two offstream storage reservoirs enabling lands in Jerome, Gooding, and Elmore counties to be irrigated. The original plan proved to be infeasible when difficulties were encountered with the offstream storage reservoirs. The developing company then contracted with the U.S. Reclamation Service for the enlargement of the dam at Jackson Lake, Wyoming. The first water deliveries were made in 1909. In 1920, the irrigation system, consisting of 100 miles of main canal and 800 miles of laterals, was completed and turned over to the settlers for operation as the North Side Canal Company.

Water rights for most unregulated flow in the Snake River were decreed by 1908, and in low water years supplies were inadequate. Supply was augmented by federally financed construction of additional dams and reservoirs in the Upper Snake Basin. When demand for irrigation water increased after World War II, ground water was the logical source of supply.

Since the 1960s, total area irrigated with sprinklers has increased. This is due, in part, to development of lands unsuitable for gravity irrigation, but increasing energy costs associated with

pumping water have also made efficient water-distribution systems more economical. On the north side tracts, sixty to seventy percent of the acreage under irrigation is watered by sprinklers (Alberti and Diehl, 1992). On the south side changes are being made in irrigation methods, but at a much slower rate. Only about 20 percent of irrigated acreage on the south side is watered by sprinklers (Hauman, 1992). The rapid change in irrigation methods on the north side is attributed to improved productivity with sprinklers on the north side's rougher terrain.

The increasing number of sprinkler irrigation systems has reduced water demand but has increased canal system control problems. The canal systems were designed for gravity delivery and flood or furrow irrigation. When pumps shut down, the smaller lower laterals and ditches cannot handle the increased water volume. Sprinkler operators are usually asked to continue diverting at a constant rate.

The Department of Water Resources has 1,400 water rights on file for the diversion of surface water for irrigation in Gooding, Jerome, and Twin Falls counties. Aside from the primary canal company diversions, many of the surface water rights and permits are for miscellaneous drains and ditches in the area northwest of Buhl. A total of 1,579 water rights are on file with the Department for the diversion of ground water for irrigation in the three counties. The centers for this development are Hazelton Butte and Flat Top Butte in Jerome County, land south of Wendell in Gooding County, and the Dry Creek area, south of Murtaugh.

Milner Dam Diversions

The Twin Falls Canal Company delivers water to approximately 203,000 acres of irrigated cropland in Twin Falls County, through a system consisting of 110 miles of main canals and over 1000 miles of laterals and drains (Hauman, 1992). Because the company has the water rights to divert most of the natural flow at Milner, it has not purchased much upstream water storage. The flow rights allow the diversion of 3,000 cfs with a priority date of 1900 and 600 cfs with a priority date of 1915. Following original project construction, the canal company augmented water supplies with storage purchases in Jackson Lake and American Falls Reservoir. They currently hold 96,000 acre-feet at Jackson Lake, and 150,000 acre-feet at American Falls.

The average annual diversion (1971-1991) for irrigation by the Twin Falls Canal Company is 1,113,700 acre-feet of water, an average of 5 acre-feet per acre. Construction charges have been paid and maintenance charges are approximately $16.00 per acre for each individual land owner for all the land in the legal description. Water is in the canal system from about April 1 through November 15 in a normal year. Canal flows during the early spring and fall are considerably lower than during the peak irrigation season of June, July, and August because some crops do not require early spring and fall irrigation. Most crops are irrigated by small furrows. In the early spring the

tract usually has good water supplies as natural flows are high. When flows recede in July and August, and with little upstream storage, water supplies are vulnerable.

Sprinkler installations on the tract are centered in the Murtaugh area, and in the Balanced Rock Soil Conservation District (SCD) on the western margin. The Balanced Rock SCD is providing funds for sprinkler conversion.

The North Side Canal Company distributes water to approximately 161,000 acres of agricultural land located in Jerome, Gooding, and Elmore counties. The Northside Canal Company holds water rights to 300,000 acre-feet of natural flow from springs at American Falls, and 800,000 acre-feet of upper river reservoir storage. Storage rights include Palisades, 116,000 acre-feet; Jackson Lake, 312,000 acre-feet; and American Falls, 397,470 acre-feet. They also have a 15 cfs right on the Big Wood River (1890), and Snake River rights on filings of 300 cfs, (1900); 2,250 cfs, (1905); 350 cfs, (1908); 1,260 cfs, (1920); and 300 cfs, (1915). During years with a small snowpack, and consequently low reservoir levels upstream, the company must reduce its water deliveries.

The average annual diversion is approximately one million acre-feet, or an average of 6.5 acre-feet per acre. Conversion to sprinkler systems has been particularly rapid over the last 3-5 years on the North Side tract. Approximately 70 percent or over 100,000 acres of the project are irrigated by sprinklers. Some piping of canals is being done to allow for the installation of pivots.

The Milner-Gooding Canal was constructed by the Bureau of Reclamation from 1928 to 1932 as part of its Minidoka project. The 70 mile long canal was built to supply Snake River and reservoir storage water to 65,000 acres in the Shoshone and Gooding areas. The Milner-Gooding Canal is operated by American Falls Reservoir District No. 2. An average of 474,000 acre-feet of water, mostly from reservoir storage, is diverted annually by the Milner-Gooding Canal. The District has 400,000 acre-feet of storage in American Falls Reservoir.

In the eastern portion of Twin Falls County 13,500 acres are served by the Milner Irrigation District. The District was formed in 1921. Annual diversions average 60,000 acre-feet, an average of 3.7 acre-feet per acre. Thirty percent of the District is irrigated with sprinklers (Bright, 1992).

Diversions Below Milner

Below Milner, 90 percent of irrigation withdrawals from the Snake River are pumped. From Milner to near King Hill, the river is entrenched several hundred feet. Water is withdrawn along this reach by large, high-lift pumps that supply water to tracts on the canyon rim and by smaller pumps

that supply water to canyon bottom lands. Large pumping stations typically have several pumps that feed one or more penstocks that discharge into a canal system on the canyon rim.

The Bell Rapids project, a private development in northwestern Twin Falls County, involves about 28,000 acres. The first crop year for the Bell Rapids project was 1971. Irrigation water is pumped from the Snake River in the Lower Salmon Falls Pool. Some of the land is currently under the Conservation Reserve Program.

The Cottonwood development totals 5,000 acres on Black Mesa in eastern Elmore County. Annual diversions are 3,500 acre-feet.

The King Hill Irrigation District provides water to 11,200 acres in Elmore County. The District has a water right from the Malad River with a priority date of 1902. Eighty-five percent of the district irrigates with sprinklers. In 1979 the District transferred its Malad River water right to the Snake River and currently diverts water at three pumps along the Middle Snake reach: Wiley, Black Mesa, and King Hill. Average annual diversions above King Hill (1979-1991) are 31,700 acre-feet.

Ground-Water Irrigation

Development of ground water for irrigation on the Snake River Plain began in the mid 1940's. South side ground-water development began in the mid 1950's in an area west of Buhl known locally as Blue Gulch. The Snake River Plain Aquifer is readily accessible with pumping lifts ranging from 100 to 500 feet. Most ground-water development has been conducted privately by individual farm operations, primarily in those areas not included in the initial surface water irrigation tracts because of their isolated locations or excessive elevation. Sprinkler irrigation is the most common irrigation method used with ground-water pumping.

Within areas served by surface water diversion, individual farm operations have developed ground water as a supplemental water source and to increase the flexibility of on-farm irrigation methods and scheduling. More than 300 irrigation wells are interspersed in surface-water irrigated areas in Jerome and Gooding counties.

LIVESTOCK OPERATIONS

Livestock and trout account for half the market value of agricultural products in Gooding, Jerome, and Twin Falls counties. A significant number of dairies and confined animal feeding operations are located in the three county area. The USDA 1992 estimate for all cattle and calves in the area was 303,500 head. Lambs and sheep are estimated at 43,000 head (Table 11). Very few

sheep are raised in farm flocks; most are raised in the upland, mountain areas. Poultry operations account for 298 farms, and 153 farms raise hogs and pigs in the three counties (1987 Census of Agriculture, U.S. Bureau of the Census).

Table 11. Livestock Numbers by County 1992

	All Cattle	Milk Cows	Lambs and Sheep
Gooding	98,500	26,000	16,500
Jerome	90,500	32,500	11,000
Twin Falls	114,500	16,500	15,500
Total	303,500	75,000	43,000
Percent of State Total:	17%	42%	16%

Source: Idaho Agricultural Statistics Service, 1992.

Beef industry cow/calf numbers have declined steadily over the last five years due to low profit margins. However, the number of dairy cows in Jerome and Gooding counties has increased at a steady rate because of the abundance of both land and feed. Cow-calf operators have enjoyed two years with prices at or near record levels. This has been helpful since feed costs have also risen. The availability of cheap forages has declined due to the growth of the dairy industry. The dairy industry and the beef industry both draw from the same supply of alfalfa hay since there is little grass hay available (UI, 1991b).

Beef cattle graze rangelands, both public and private, primarily in the northern and western portions of the north side counties, and south of the Twin Falls irrigation tract in Twin Falls County. Most of the rangeland is public land administered by the U.S. Bureau of Land Management. At least 80 percent of the range users also feed their livestock on locally produced hay (UI, 1991b).

The Bureau of Land Management leases lands to 10 permit holders for livestock grazing in the canyon bottom. The grazing season for these allotments typically runs from August through March. Rangeland is valued at $1.92 per animal unit month (AUM), while irrigated pasture is valued at between $12 and $17 per AUM (Barnum, 1992; Vodraska, 1992).

In 1990, the three-county area contained 40 percent of the state's milk cows, a proportionately large number (Fig. 13). The dairy industry has expanded rapidly over the last few years and shows indications of continued growth. The trend toward increased dairy output is evidenced by new processing facilities, expansion of existing facilities, general favorable milk to feed cost ratios, and favorable lands costs.

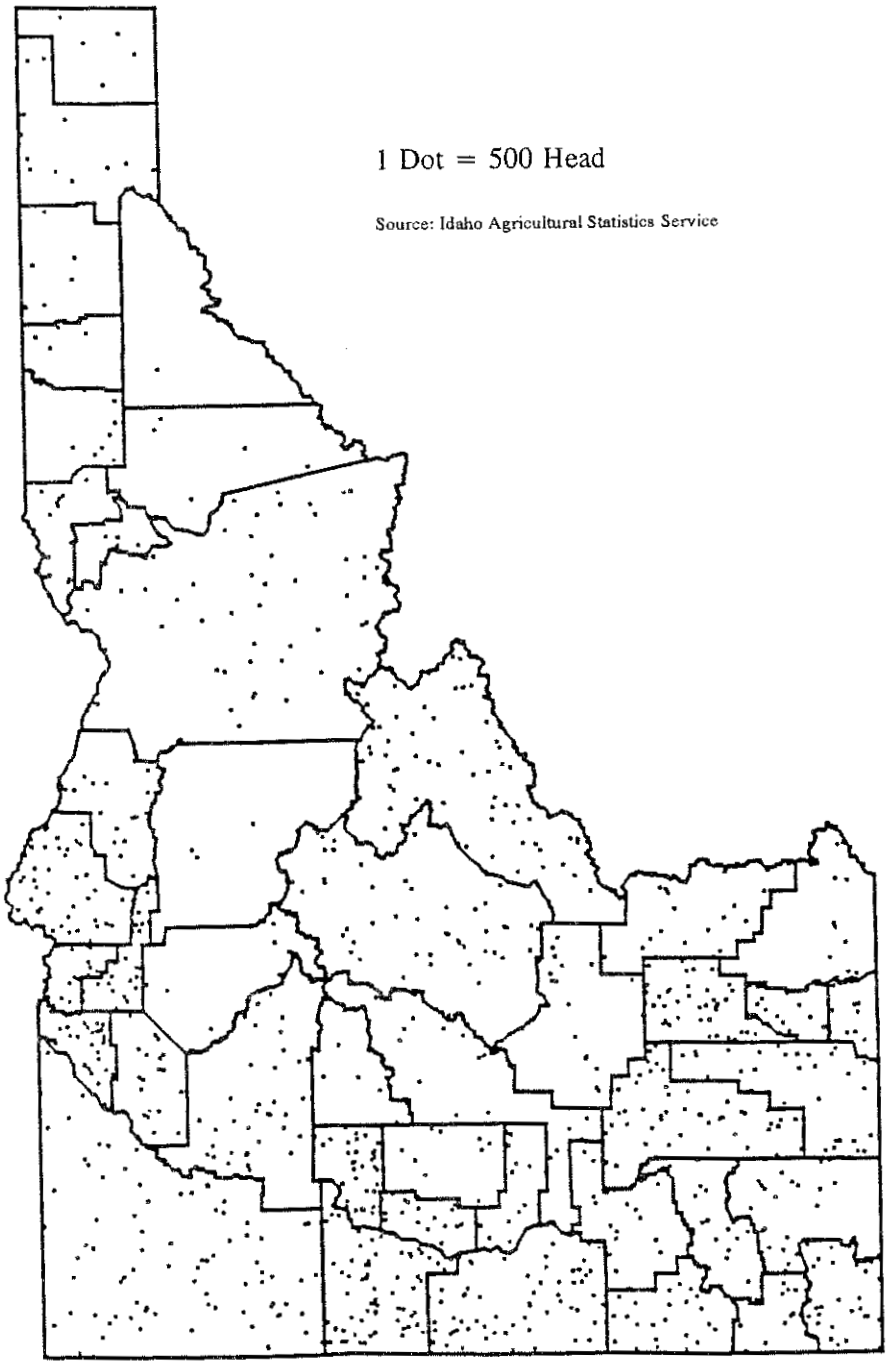

Figure 12. Beef cow distribution, January, 1992.

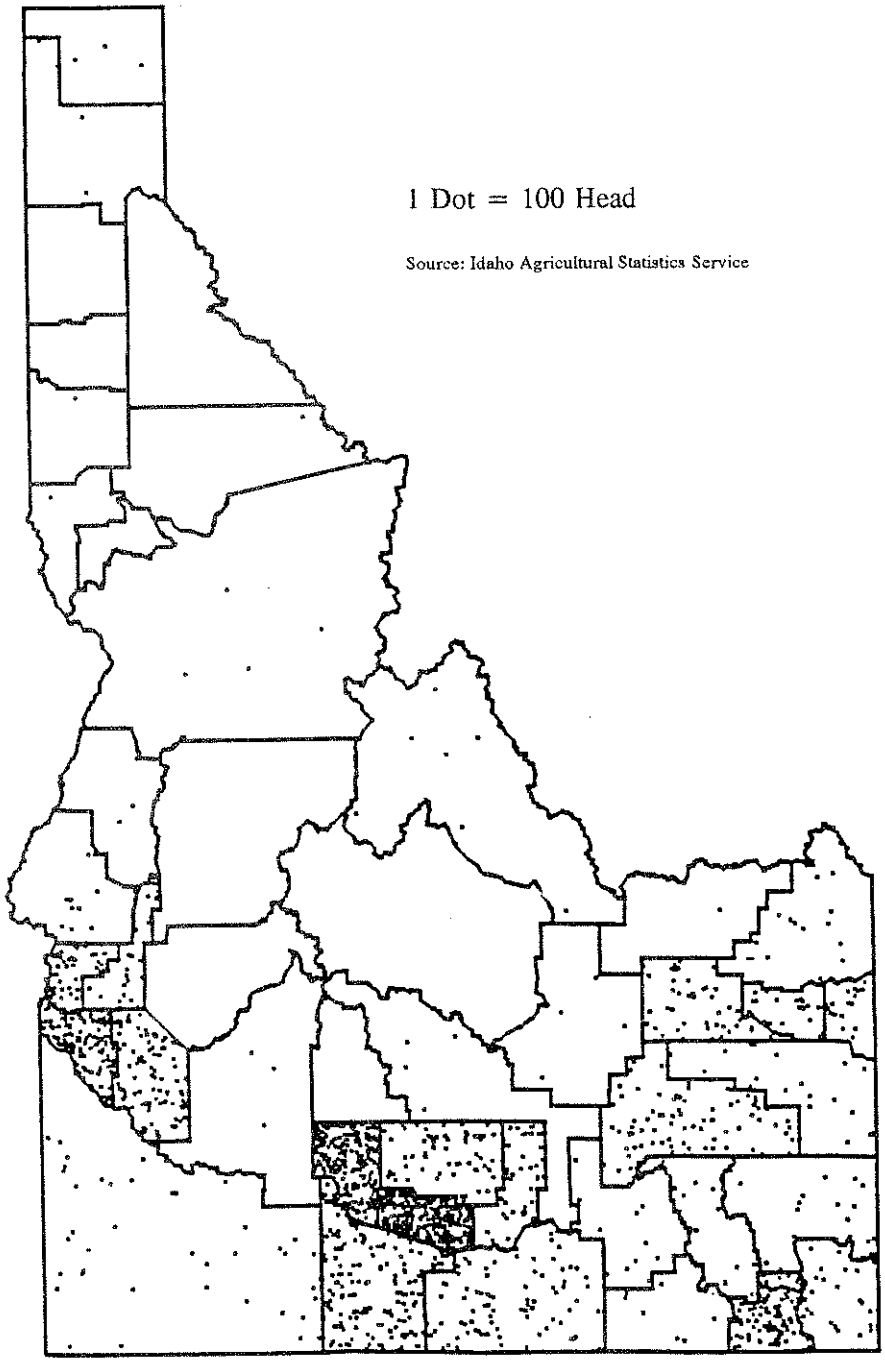

Figure 13. Distribution of Milk Cows, January, 1992.

Avonmore, Inc., an Irish firm, has established a cheese manufacturing plant near Gooding. Jerome Cheese Company will complete a new 2.1 million pound per day cheese plant in Jerome in 1992. The combined production of the Jerome and Gooding plants will require three million pounds of milk per day. In the past few years, expanding dairies have been sending about a million pounds of milk per day outside the area for processing into cheese.

A major problem within the local dairy industry is labor. Dairymen complain that good trained labor is not readily available and a large amount of time must be spent in training after the employee goes to work. There are good incentives for those in these positions by way of high pay ($1,700-$2,000 per month) and in some cases workers are given a cow per year which they may place in the herd (UI, 1991b).

The Department of Water Resources has 503 water rights on file for the diversion of surface water for livestock in Gooding, Jerome, and Twin Falls counties. The average surface water appropriations for stockwater are 0.28 cfs and 11.6 acre-feet. A total of 381 water rights are on file with the Department for the diversion of ground water for livestock in the three counties. Average appropriations for ground-water are 1.4 cfs and 14.5 acre-feet.

AQUACULTURE

The constant flow of clean, cool (59°F) spring water, tributary to the Middle Snake reach, makes this area ideal for aquaculture. In 1991, Idaho Fish and Game had 98 active commercial fish culture permits on file for facilities adjacent to the Snake River, or its tributaries, in the planning area (Map: Aquaculture Facilities). With few exceptions, the fish raising segment of Idaho's aquaculture industry is headquartered within a few miles of Buhl. Usable springs and wells for fish rearing can be found outside the Middle Snake planning area, but they are often not artesian, not of high volume, or are of poorer temperature or water quality (Klontz and King, 1975). Four state and federal hatcheries also operate along the Middle Snake reach, and fifty-five private ponds, which raise fish for personal consumption or non-commercial use, are located in the region.

The phenomenal growth of this industry in the planning area is attributed to the availability of large quantities of water optimally suited for raising both rainbow trout and channel catfish, the major fish species raised for human consumption in the United States. It is estimated that 80 to 90 percent of the spring flow along the Middle Snake reach is utilized for fish production. The larger fish farms use water from springs emerging from the Snake River Plain Aquifer along the north-east canyon wall. About 25 percent of the fish produced in the planning area are raised on small farms. Many of the smaller farms use water from springs arising south and west of the river, or water from seep tunnels, creeks, or canals (Lemmon, 1992).

The Idaho aquaculture industry ranks as the third largest food-animal producing business in the state (Brannon and Klontz, 1989). The majority of the fish raised are sold as processed fish. The Idaho industry has not targeted trout sales to private recreation establishments. In 1991 the commercial food fish industry in the planning area produced an estimated 40 million pounds of rainbow trout, or about 65 percent of the nation's production of processed trout (Irving et al., 1992). The local channel catfish industry contributed over 600,000 pounds to local production (Ray, 1992). Aquaculture revenues are estimated at $60 million annually, with an industry payroll of 750-900 people (Johnson, 1992). Fish feed sales and a growing fish-culture equipment manufacturing industry are value-added businesses that add significantly to industry receipts.

Devils' Corral Spring, near Shoshone Falls in Jerome County, was the site of the first commercial fish farm in Idaho. Started in 1909, the fish farming operations were discontinued one year later. The site remains today virtually unchanged. In 1919 a commercial fish farm began operation on Rock Creek, in the city of Twin Falls. By the 1920s Snake River bottomland was opened to homesteading, and in 1928 the Snake River Trout Farm at Clear Lake, the first modern raceway farm, began operation. Four trout farms were in production by 1935 and eight in 1950. The early 1970s saw an explosion in aquaculture facilities development and expansion adjacent to the Middle Snake reach. While there are about 96 licensed trout producers in the planning area, most of the production comes from about half a dozen major facilities (UI, 1991c).

Rainbow trout, which have been farmed since the 1880s, are the dominant trout stock, although aquaculture managers experiment with all trout species. Rainbow trout are preferred because they are more resistent to stress and extremely adaptable to domestication. Brood farms are located primarily in California and Washington, although there are a few Idaho establishments that supply local hatcheries. Trout typically attain a market weight of 10 to 14 ounces in 10 to 11 months. The aquaculture industry, however, has not limited itself exclusively to rainbow trout. Sources of cooler water and geothermal waters have been used to raise cutthroat trout, coho salmon, catfish, and tilapia. The hot water is mixed with cooler spring water for catfish and tilapia culture. Catfish average 12 to 16 months to processing with a typical market weight of 2 to 3 pounds.

Farm pond operations are an important part of the local aquaculture industry. Landowners with water resources on their property build ponds for raising fingerlings and then raise the fingerlings themselves for sale to the processors, or lease their facilities to larger farms or companies. Locally raised fish are slaughtered, packaged, and marketed from several local processing facilities. The fish are shipped fresh or frozen. The planning area has three large processing plants (over 10 million pounds), two medium-sized processors (3-4 million pounds), and two small processors (Campbell, 1992).

Over 1,700 ponds or raceways, with a water capacity of approximately 17 million cubic feet, are used to raise food fish in the planning area. Production averages over 15 pounds/gallon per minute (gpm), and with the serial reuse of water up to 80 pounds/gpm is possible (Brannon and Klontz, 1989). Assuming 10 months for rearing, trout require 5,400 gallons of water per pound of fish. No two individual fish raising facilities are alike in pond design, water utilization, fish density per unit of water volume, or fish husbandry methods. However, most of the commercial fish hatcheries in the region are a series of flow-through raceways that continuously pass water through the units.

High water turnover rates, between one and two changes per hour, help alleviate chronic ammonia levels; ammonia being the main form of nitrogen excreted by fish. Ammonia, even at low concentrations, will impair the growth and stamina of fish. The majority of the raceways are designed for the multiple use of water before it is discharged. Under the operating design of most farms, water passes serially from raceway to raceway, effectively reused up to five times.

The Department of Water Resources has 224 decrees, claims, licenses, or permits on file for the diversion of surface water for fish rearing in the planning area. The median diversion rate is 14 cfs. A total of 23 permits or licenses are on file for the diversion of ground water with a median filing of 2 cfs.

Domestic, Commercial, Municipal, and Industrial Uses

Ground water supplies approximately 60 percent of the domestic, commercial, municipal, and industrial needs in the planning area. The cities of Hagerman and Twin Falls rely on readily available spring sources in the Snake River canyon. Domestic uses include drinking, food preparation, washing, and lawn and garden watering. Public uses include schools, fire departments, and municipal parks. Most commercial establishments also use public supplies. Industrial water use incorporates manufacturing processes, cooling, and employee sanitation.

Public supply systems provide 25 percent of domestic and commercial water. There are 15 community water systems in the planning area which provide water of culinary quality to residents of Elmore, Gooding, Jerome, and Twin Falls counties. These systems are managed for the most part by the communities or by mutual non-profit water companies. Management consists of development of a source, construction and maintenance of some type of conveyance facilities, water purification treatment, periodic sampling, compliance with state and federal water quality requirements, distribution to local users, collection of revenues, repayment of capital costs, and payment of operation, maintenance, and replacement costs. These management responsibilities must be carried

out in such a way that the water system complies at all times with specified public health regulatory standards.

Table 12 profiles community water use, Table 13 estimates public-supply water use by county, and Table 14 estimates rural domestic and livestock water use. Exact water use quantities are difficult to define because approximately three-quarters of the communities do not have individual domestic or business water meters, and many do not have functioning meters on their city wells. Solley et al. (1983) estimates average rural domestic use at 98 gallons per day per person.

Food processing is the primary industrial use of water in the planning area (Table 15). Municipalities provide all industrial water within city limits. Food-processing industries withdraw relatively large volumes of water for meat packing; fruit, vegetable, and fish preparation and preservation; and beet sugar refining. Withdrawals for food processing have a distinct seasonal pattern. Water use for sugar refining and potato processing is highest from September through March. Water use for canning and freezing of fruits and vegetables peaks from July through October. Water use for milk- and meat-processing industries is relatively constant throughout the year.

The Department of Water Resources has 401 decrees, claims, licenses, or permits on file for the diversion of surface water for domestic, commercial, or municipal use, and 5 water rights for industrial use in Gooding, Jerome, and Twin Falls counties. Filings for the diversion of ground water for domestic, commercial, municipal, and industrial use total 621, 163, 43, and 24 respectively. Domestic diversion rates average 0.11 cfs. Water rights for the industrial use of ground water in the three county area average 0.2 cfs.

Well depths in the planning area vary from 50 to 400 feet. The ground water is of high quality, and up to the present time, very little contamination has occurred. Recent studies have shown an increase in nitrates as the water flows through agricultural areas. Current nitrate levels average 3 parts per million, well below the 10 ppm limit for drinking water (McMasters, 1992).

GEOTHERMAL RESOURCES

Thermal water has been used in Idaho since prehistoric times. Current uses in the planning area are for resorts, fish rearing, and greenhouses. Several resorts using thermal water are operated in the canyon, and greenhouse operations using geothermal energy are located near Bliss and Banbury Hot Springs. Much of the thermal water discharged through wells and springs is of low temperature ($< 100°C$). The hottest wells (65°C) in the planning area are at Banbury Hot Springs northwest of Buhl, and White Arrow Hot Springs near Bliss. The greatest potential, as far as present knowledge of the resource in Idaho is concerned, is for space heating and greenhouse use. Annual withdrawal of

Table 12. Municipal Water Supply and Waste Disposal

County Code	City	1990 Population	Population Served	Water Source	Water Supply		Method of Waste Treatment/Disposal	Average Discharge	
					Water Right	Capacity		Winter	Summer
GD	Bliss	185	64	2 City wells	0.2 cfs	1.40 mgd	Septic Tanks	----	
TF	Buhl	3516	1800	4 City wells	7.5 cfs	3.60 mgd	Lagoon - unnamed creek - Snake River	0.55 mgd	0.62 mgd
TF	Castleford	179	96	2 City wells	1.0 cfs	0.36 mgd	Total containment lagoon	----	
JR	Eden	314	130	2 City wells	3.0 cfs	0.28 mgd	Lagoon - waste ditch - Snake R.	Unquantified	
TF	Filer	1511	625	4 City wells	3.0 cfs	1.70 mgd	Lagoon - (Winter) Cedar Draw to Snake R., - (Summer) land application	0.03 mgd	----
GD	Gooding	2820	1200	2 City wells	11.0 cfs	3.60 mgd	Lagoon - (Winter) Little Wood River, - (Summer) land appplication	.25 mgd	.75 mgd
GD	Hagerman	600	350	Big Spring & Potter Spring	4.0 cfs	3.30 mgd	Lagoon - Snake R.	.20 mgd	.25 mgd
TF	Hansen	848	320	3 City wells	2.5 cfs	1.80 mgd	Lagoon - unnamed creek - Snake R.	0.07 mgd	
JR	Hazelton	394	243	3 City wells	1.3 cfs	0.97 mgd	Lagoon - land application	Unquantified	
JR	Jerome	6529	3500	4 City wells	16.5 cfs	7.50 mgd	Sewage treatment plant - Jerome Canal - Snake R. or treatment plant irrigation	0.60 mgd	----
TF	Kimberly	2367	1028	4 City wells	5.5 cfs	3.80 mgd	Trunkline to TF sewage treatment plant	0.27 mgd	
EL	King Hill	60	36	2 City wells	0.3 cfs	0.06 mgd	Septic Tanks	----	
TF	Murtaugh	134	30	1 City well	0.5 cfs	0.46 mgd	Lagoon - subsurface drainfield	Unquantified	
TF	Twin Falls	27,591	10,000	Alpheus Cr. Spring	52.4 cfs	27-28 mgd	Sewage treatment plant discharges to Snake R.	6.67 mgd	6.67 mgd
				2 wells-S. Side	8.5 cfs	6.00 mgd			
GD	Wendell	1963	853	3 City wells	4.6 cfs	2.10 mgd	Lagoon - land application	Unquantified	

EL=Elmore
GD=Gooding
JR=Jerome
TF=Twin Falls

g/d=gallons per day
mgd=million gallons per day

Table 13. Estimated Nonindustrial Public-Supply Water Use by County, 1980

County	Population Served by Public Supplies	Withdrawal for Public Supply (acre-feet per year)	Water Source GW = Ground water SW = Surface water
Gooding	5880	1400	GW/SW
Jerome	8630	2200	GW
Twin Falls	33340	3800	GW/SW

Source: Goodell, 1988.

Table 14. Estimated Rural Domestic and Livestock Water Use by County, 1980

County	Rural Population	Rural Domestic Withdrawal (acre-feet)	Livestock Withdrawal-Surface Water (acre-feet)	Livestock Withdrawal-Ground Water (acre-feet)
Gooding	4000	400	400	400
Jerome	6200	700	400	300
Twin Falls	6200	700	400	200

Source: Goodell, 1988.

Table 15. Estimated Industrial Water Use by County, 1980

County	Total Withdrawal (acre-feet)	Ground Water (acre-feet)	Surface Water (acre-feet)	Public-Supply Systems (acre-feet)
Gooding	1790	1700	0	90
Jerome	100	40	40	20
Twin Falls	10900	5100	900	4900

Source: Goodell, 1988.

the thermal Twin Falls - Banbury Aquifer is estimated to be 23,600 acre-feet per year, (4,364 acre-feet for the immediate Twin Falls vicinity and 19,326 for the Banbury area).

In Jerome County thermal water at 43°C is discharged from a well located beside the Snake River. Subsurface temperatures are predicted at 89° and 93°C. No other thermal water is known in Jerome County and the potential for further prospects is unknown. Thermal water in Twin Falls County is widely scattered, occurring principally in the northwestern and eastern part of the county. There are 56 thermal water occurrences with surface temperatures of 20°C or above. Low temperature (20-30°C) thermal wells are located within one mile of King Hill. Prospecting for more thermal water in this area may prove fruitful, and the prospect of hotter water at depth is possible (Mitchell et al., 1980). Most of the thermal water is associated with known faults or linear features thought to represent some type of rock fracture. Recharge to the fracture-controlled systems could be

anywhere along their length and interbasin ground water transfer may be associated with those that are regional in length.

Mining

The Snake River, in the planning reach, has cut into the eastern Snake River Plain, a downwarped and downfaulted structural basin filled with basalt. The basaltic lava flows may overlay older rhyolites, granites, gneiss, or sedimentary rocks. Exposed rocks in the planning area range in age from early Tertiary volcanics to modern sediments being deposited by streams, rivers, and wind. Most rock outcrops are of basaltic composition.

Alluvial deposits of sand, silt, and gravel, with some boulders and cobbles, commonly form bars and terraces in the Snake River and on the canyon rim. Early Pleistocene Tuana Gravel is associated with canyon cutting and consists of pebble and cobble gravel interbedded with sand and silt. It is extensive downstream of Twin Falls, and is overlain only by recent alluvium. Melon gravels, or rounded boulders and cobbles of local basalts, are located throughout the reach and are associated with the Bonneville Flood. As the flood swept down the canyon, it picked up boulders and smaller rocks in the torrent and deposited them in terraces, backwaters, and eddys. Alluvium in the canyon consists of sands and gravels that occur intermittently in the river channel and in major tributaries, and fine-grained flood-plain deposits adjacent to the Snake River.

There are few precious metal occurrences and no known deposits of base metals in the planning area, however, there are several deposits of industrial minerals. Sediments of the Idaho and Snake River Groups contain important deposits of diatomite and silica sands. Sand and gravel are also readily available along the Snake River (Map: Mining Prospects, Claims, and Leases). Some of the mineral deposits, which include clay, diatomite, pumice, and dimension stone for use in the construction industry, contain significant quantities of high quality materials (U.S. Bureau of Mines, 1991).

Water is essential in mining and processing minerals, however, total water requirements of the industry are small. The primary use of water by the mining industry is in mineral processing. The Department of the Interior has estimated that the mining industry consumes less than one-half of one percent of all diverted water, and recycles the same water several times (USGS, 1990). Since total water requirements of the industry are relatively small, water supplies for mining should be adequate.

GOLD

In the late 1800's miners and settlers prospected the Snake River for gold. Below the Blue Lakes Country Club the river was mined for gold during the late 1880s, and again during the Depression. Snake River placers produced 23,000 ounces of gold in Cassia, Minidoka, and Jerome counties (Idaho Bureau of Mines and Geology, 1964). Since the 1930's no major gold mining has occurred along the reach. Recent commercial mining attempts have failed financially.

Snake River gold is a fine "flour" gold associated with gravels at various localities along the river. Much of the placer material is probably of glaciofluvial origin. The gold can be panned with some care and is about 93 percent pure. Gold placer prospects and mined claims are located on the Mining Prospects, Claims, and Leases Map.

INDUSTRIAL MINERALS

Diatomite (diatomaceous earth) - Diatomite has been mined at several sites in the planning area. There is a large deposit located on the upper portion of Clover Creek in Gooding County, and smaller deposits are located near the Snake River in Elmore County between Pasadena Valley and Big Pilgrim Gulch, and in Twin Falls County near Banbury Hot Springs. The quality of the diatomite deposits varies from noncommercial, with considerable impurity, to good (U.S. Bureau of Mines, 1991; Strowd et al., 1981; Idaho Bureau of Mines and Geology, 1964). Deposits are usually mined by open-pit methods and are seldom free of other sediments and organic debris, so most diatomite requires treatment after mining to prepare it for industrial use.

The primary use of powdered diatomite is as a filter aid in the separation of suspended solids from water, beer, wines, liquor, fruit and vegetable juices, dry-cleaning fluids, raw sugar liquors, etc. Other uses are as a filler for paint, paper, or rubber, a carrier for pesticides and hazardous liquids, as various additives, in insulation, and as a marker.

Clay - A small quantity of silty (common) clay is being mined by Snake River Pottery near Hagerman, for use in decorative pottery products and to make custom kitchen and bath tile. There is also some clay associated with a diatomite deposit near the Snake-Salmon Falls Creek confluence. Clay production is not a major component of economic activity in the planning area. The best known use of clays is in the manufacture of fired ceramic products which consume about two-thirds of all industrial clay. Clay could be used in the future to seal settling ponds.

Pumice - Pumice deposits in Idaho are large enough for the state to rank fourth in national production. Current production comes from three commercial operations in southeastern Idaho, and a quarry near Fairfield. Pumice has been mined on the north side of the Snake River in Jerome County

(U.S. Bureau of Mines, 1991). The major use of pumice is in the construction industry, where it is used in concrete aggregate and admixtures, building block, and as plaster aggregate. Cinder cones have been exploited for road building.

Dimension stone - Dimension stone is any stone which is quarried, cut, shaped and possibly polished for structural, architectural and ornamental applications. Basalt near the confluence of Deep Creek and the Snake River has potential for dimension stone (U.S. Bureau of Mines, 1991). The basalt is usually gathered from where it lies loose on the ground, loaded onto flatbed trucks, and shipped to local and regional building supply dealers.

Uranium - There is one reference to a uranium prospect near the Hagerman Fossil Beds (Strowd et al., 1981; U.S. Bureau of Mines, 1991). No mining has taken place at this site, nor is it likely to be developed due to the proximity to the Hagerman Fossil Beds National Monument.

Sand and Gravel - Sand and gravel production comprises the largest mineral industry in the planning area and deposits are readily available throughout the length of the Middle Snake reach (Map: Mining Prospects, Claims, and Leases). Major production is from alluvial gravels. High-purity silica for specialized use in the electrochemical industry may be found in the sand and sandstone of the Idaho Formation in the southwestern part of the State. The formation is found on the west side of the Snake River northwest of Buhl.

One large sand and gravel dredge has been in operation in the Middle Snake reach downstream from Niagara Springs for four years. Due to low flows for the past two years and the eight foot draft of the floating dredge, there has been little production, though the operator indicates demand for sand and gravel for construction concrete is increasing. He would ordinarily be producing 20,000 tons per year (Sligar, 1992). The Idaho Department of Transportation and the County Highway Districts are the largest consumers of natural and manufactured aggregates.

OIL, COAL, OR GAS

Commercial quantities of oil, coal, or natural gas have not been produced in Idaho. Like most of Idaho, the Middle Snake planning area is underlain by rocks that are not favorable either as source rocks or reservoir sites for oil or gas; the lithologic, structural, and environmental conditions of deposition are all generally adverse. Widespread volcanism and faulting of the rock materials is incompatible with the accumulation of oil and gas (U.S. BLM, 1982; Idaho Bureau of Mines and Geology, 1964). Tertiary sedimentary rocks comprise the more favorable potential oil or gas sources and reservoirs. However, these deposits are fluviatile and lacustrine in origin and not marine, as is the case in large producing fields. There are no filings for oil and gas leases in the planning area (Idaho Department of Lands, 1992).

Timber

There is no commercially harvestable timber in the Snake River canyon or along the rim of the canyon in the Middle Snake reach. The nearest suitable timber for commercial and private harvest is located approximately 40 miles southeast of Twin Falls, on the Twin Falls and Burley Ranger Districts of the Sawtooth National Forest (Todd, 1992).

Power Development and Energy Conservation

Unlike other forms of energy used in Idaho, large quantities of electrical energy are produced within the State. The State has historically relied on hydropower as its principal source of electricity. Private and public utilities, along with the federal government, own and operate the hydroelectric system which provides approximately 60 percent of the State's electrical needs. Idaho currently has no in-state thermal generating capacity, other than limited cogenerating facilities which utilize forest products and waste from food processing.

Idaho's three major private electric utilities: Idaho Power Company, Utah Power and Light, and Washington Water Power, supplied the State with 1826 average megawatts of electricity in 1990. Currently planned additions by these utilities total 307 average megawatts through the year 2000 (Conservation Monitor, 1992). The major utilities are engaged in interstate operation. Power needs are supplied from generating facilities through transmission interconnections that make the most economic use of the overall power supply of the region.

Electricity, supplied by Idaho Power Company, is available for all homes and businesses in the Middle Snake region. The predominate heating fuels are oil and natural gas. The City of Twin Falls and most of the smaller cities and towns are served by Intermountain Gas Company.

Per capita, Idaho uses an above average amount of electrical energy (U.S. DOE, 1992). This probably results from the low cost of hydro-produced electricity. Idaho Power's quarter million residential customers paid 4.7 cents/kwh in 1990. The nationwide average rate is 8 cents/kwh, nearly twice that paid by most Idahoans (IPUC, 1991).

In 1990, the number of electric power customers in Idaho increased 1.9 percent. At the same time, average residential consumption decreased 1.4 percent. The decline in per-customer use may be related to increased conservation measures, or the dramatic decline in natural gas prices and the resulting decisions of consumers to use natural gas instead of electricity for space and water heating.

As much as 20 average megawatts of conservation has been purchased by Idaho Power in previous conservation programs, and is reflected in the company's current loads (IPC, 1989).

Over the decade, consumption per residential customer has decreased slightly. In 1990, consumption per residential customer was 14.34 megawatt hours in the Idaho Power service area, down from 14.77 megawatts hours in 1980 (IPC, 1990; IPC, 1991b). Forecasts project it to continue to decline to approximately 13.5 megawatt hours by the year 2000, and 13.0 megawatt hours by 2010 (IPC, 1991b).

Electric power consumption per commercial customer has dropped dramatically; from 79 megawatt hours/customer in 1978 to 56.5 megawatt hours in 1990 (IPC, 1990; Finn, 1980). Figures 14 and 15 show the distribution of electricity consumption for commercial and industrial customers. Industrial sales have grown steadily in the Idaho Power service area over the last decade. Food processing accounts for over 50 percent of Idaho Power's industrial demand for electricity.

The intensity to which electricity is used in irrigated agriculture has been changing over time (Table 16). Irrigation power consumption is comprised of horsepower growth, with total irrigated acres remaining constant, or an increase or decrease in total electricity-using irrigated acres. Growth in new irrigated acreage has slowed considerably since 1978. However, growth in supplemental acres may reflect the number of conversions from gravity methods of water application to sprinkler application methods.

More than half of the total drop of the Snake River, between Heise and Weiser, is in the 92-mile Middle Snake reach. The river drops 1,570 feet between Milner Dam and King Hill (Fig. 16). The steepest gradient is 32.4 ft/mile between Milner and Kimberly (Kjelstrom, 1986). Consequently, hydroelectric facilities have been attracted to this reach. Today, six hydroelectric dams are located on the Snake River between Milner and King Hill, and forty percent of the State's hydroelectric power facilities are located on the Snake River, its tributaries, or adjacent canal systems in the planning region (Map: Hydropower Sites - Middle Snake Reach). The 63 facilities, however, comprise only eight percent of installed capacity and average annual generation within the State (FERC, 1988).

About 300 megawatts of hydropower capacity have been developed in the Middle Snake region. Five hydroelectric projects, owned and operated by Idaho Power Company, operate as run-of-river plants with some storage used for peaking purposes (Table 17). Company projects at Thousand Springs, Clear Lakes, and the Malad River utilize flows collected from springs emerging from the canyon walls.

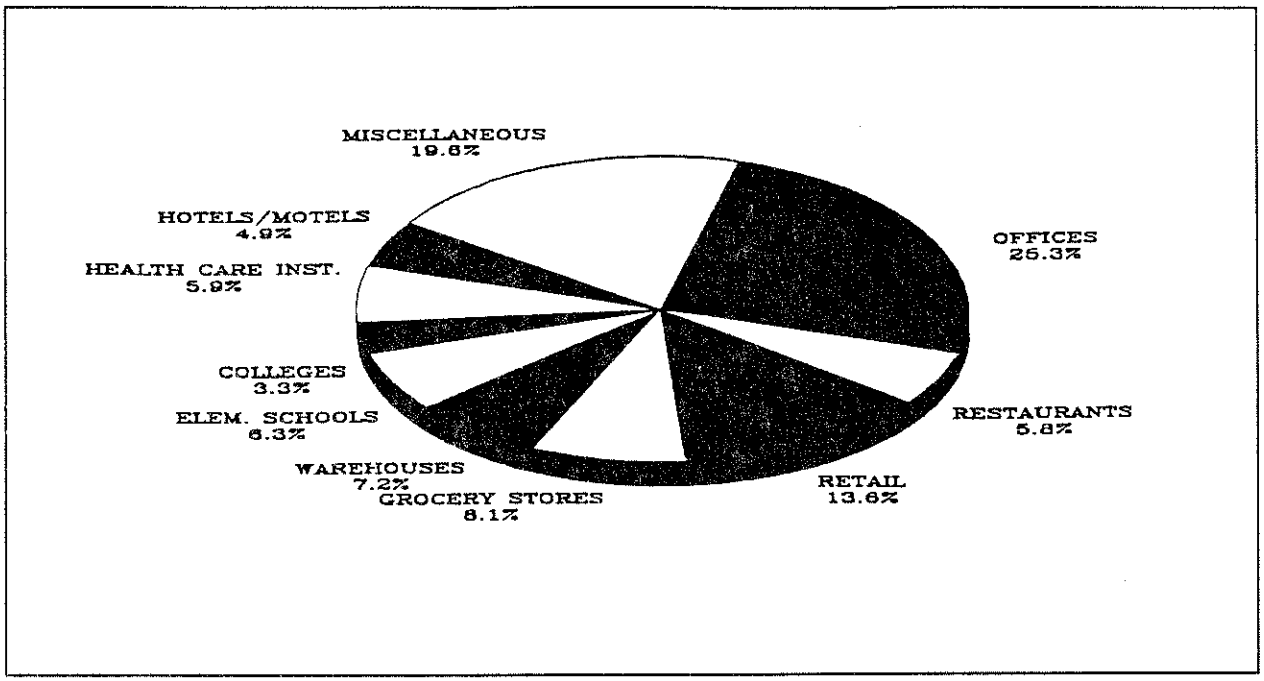

Figure 14. Estimated percentages for commercial electric consumption (IPC, 1991e).

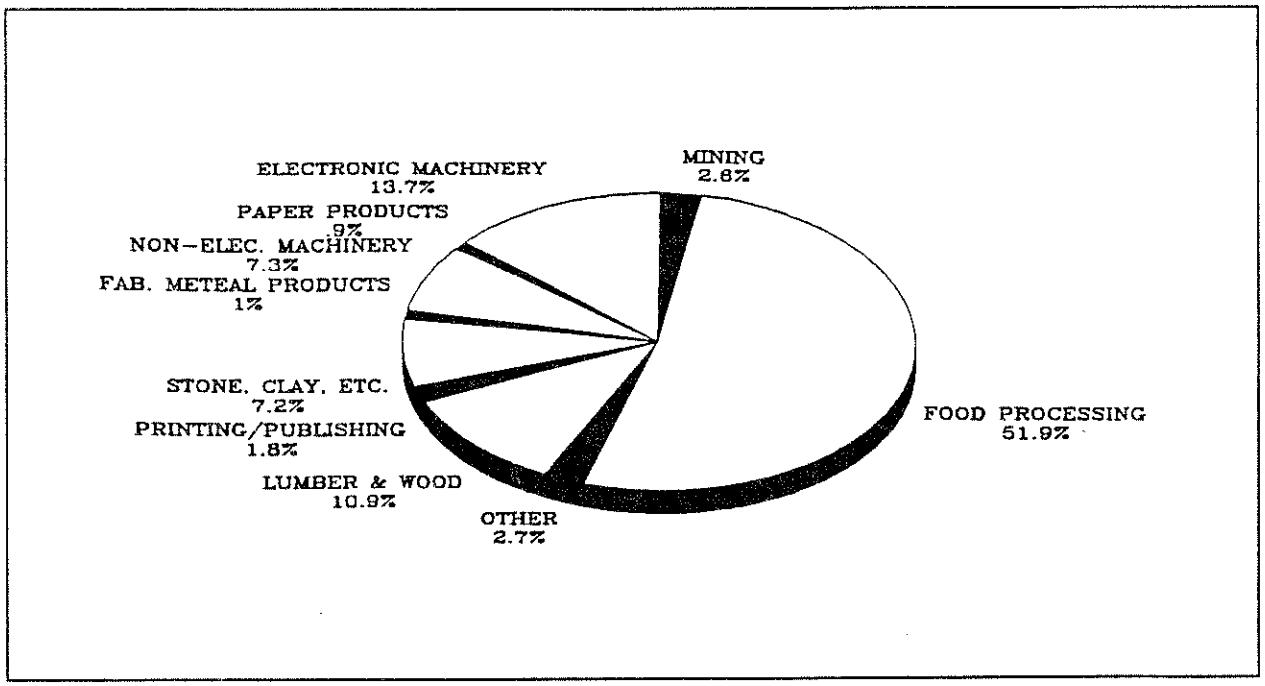

Figure 15. Composition of industrial electric consumption (IPC, 1991e.)

Table 16. Idaho Power Company Historical Irrigation Data 1970-1989

YEAR	NEW ACRES ADDED	SUPP'L ACRES ADDED	TOTAL ACREAGE (000)	TOTAL MWH (000)	TOTAL HP (000)	MWH/ACRE	MWH/HP	HP/ACRE
1970	35,029	21,006	1,095.4	816.4	581.5	.745	1.404	.531
1971	26,177	20,530	1,142.1	892.6	616.4	.782	1.448	.540
1972	28,220	24,954	1,195.3	995.3	648.0	.833	1.536	.542
1973	43,144	31,058	1,269.5	1,132.4	731.8	.892	1.547	.576
1974	66,672	54,407	1,390.6	1,382.5	845.0	.994	1.636	.608
1975	43,406	71,642	1,505.6	1,301.9	938.4	.865	1.387	.623
1976	37,760	61,723	1,605.1	1,381.3	994.7	.861	1.389	.620
1977	25,623	48,682	1,679.4	1,661.1	1,031.1	.989	1.611	.614
1978	20,807	49,709	1,749.9	1,463.9	1,102.8	.837	1.327	.630
1979	9,043	51,694	1,810.6	1,773.5	1,358.9	.979	1.305	.750
1980	7,691	39,734	1,858.1	1,500.3	1,237.6	.807	1.212	.666
1981	13,672	43,051	1,914.8	1,773.9	1,295.1	.926	1.370	.676
1982	7,345	31,456	1,953.6	1,532.7	1,317.3	.785	1.164	.674
1983	3,428	11,497	1,968.5	1,340.6	1,292.4	.681	1.037	.657
1984	3,986	13,865	1,986.4	1,343.2	1,290.7	.676	1.041	.650
1985	5,111	12,726	2,004.2	1,552.4	1,365.7	.775	1.137	.681
1986	5,084	7,446	2,016.7	1,436.7	1,351.1	.712	1.063	.670
1987	3,593	10,768	2,031.1	1,577.7	1,216.3	.777	1.297	.599
1988	7,248	15,941	2,054.3	1,669.1	1,210.0	.812	1.379	.589
1989	4,870	30,174	2,089.3	1,627.7	1,324.3	.779	1.229	.634

Source: IPC, 1991b.

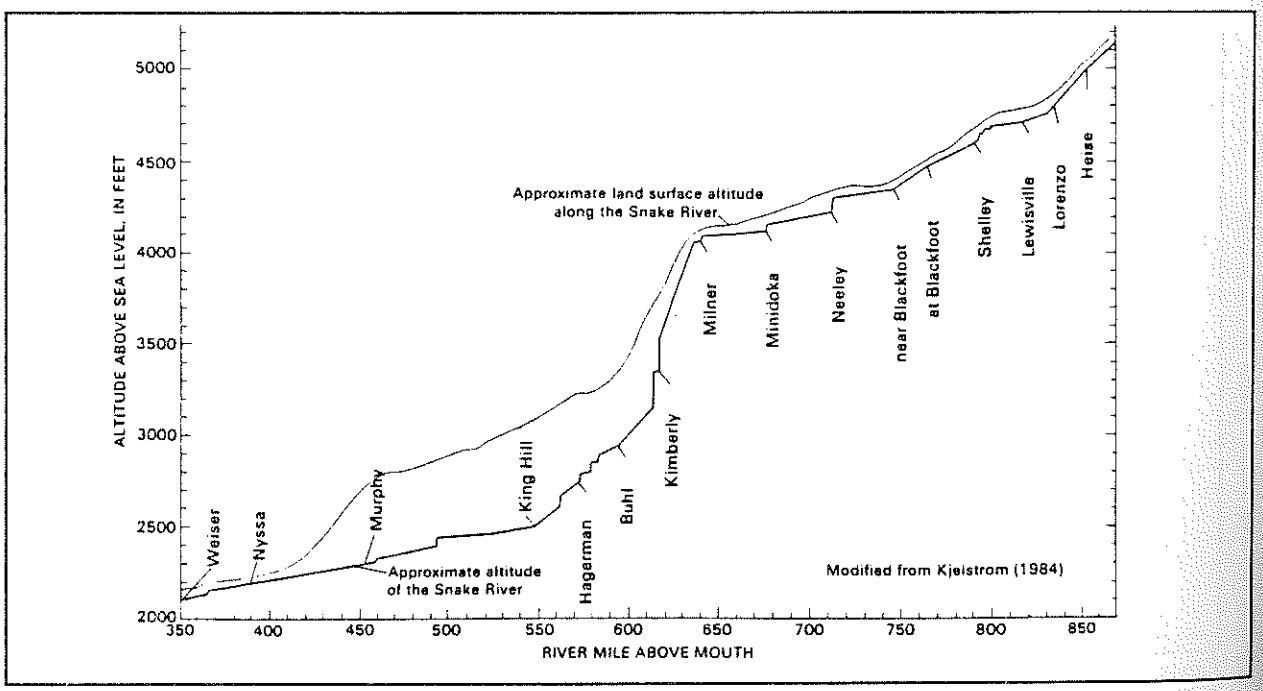

Figure 16. Snake River gradient from Heise to Weiser, Idaho (Kjelstrom, 1986).

Table 17. Existing Hydropower Facilities

	Generating Capacity (MW)	Capacity Rating (CFS)	Avg. Generation (MW Hours)	Water Used (acre-feet)
Gooding County				
Bliss	75.0	15,000	400,000	7,247,000
Clear Lake	2.5	500	18,000	314,000
Lower Malad	13.5	--	120,000	863,000
Upper Malad	8.3	--	65,000	594,000
Lower Salmon	60.0	14,000	280,000	5,164,000
Thousand Springs	9.0	900	62,000	414,000
Small Hydro	5.5	--	30,000	---
Jerome County				
Shoshone Falls	12.0	1,000	95,000	538,000
Small Hydro	19.9	--	70,000	---
Twin Falls County				
Twin Falls	10.0	1,000	65,000	504,000
Upper Salmon	34.5	6,500	280,000	7,169,000
Milner	57.5	--	--	---
Small Hydro	28.5	--	137,000	---

Source: Sipe, 1992; FERC, 1988; Goodell, 1988.

Idaho Power, in conjunction with the Northside and Twin Falls Canal companies, has added power generating facilities at Milner Dam and constructed a second power house 1.6 miles downstream. The Company is significantly increasing the generating capacity of their Twin Falls and Upper Salmon Falls facilities, and proposes to upgrade their project at Shoshone Falls. Generating capacity at Twin Falls will go from 10 MW to 52 MW, Upper Salmon will increase capacity from 34.5 MW to 48 MW, and the potential at Shoshone could add up to 119 MW (Sipe, 1992).

In addition to the mainstem power projects, numerous small hydroelectric plants have been located on and are proposed for the canals and tributaries which feed the Middle Snake reach. Prolific activity in small-scale hydropower development traces its origins to the oil crisis of the 1970's and subsequent federal and state economic incentives aimed at accelerating the development of domestic energy supplies. Small scale power generation is encouraged by a 1978 federal law, The Public Utilities Regulatory Procedures Act (PURPA), requiring major utilities to buy power from small generators. Since 1978 more than 42 small hydropower plants have been built in the area, and 18 projects are proposed.

Idaho Power generates an average 1.2 million megawatt hours in Gooding, Jerome, and Twin Falls counties. Small hydropower producers account for an additional 230,000 megawatt hours. In 1989 the region used 2.26 million megawatt hours: 32 percent in residential billings, 33 percent industrial and commercial, and 35 percent went to irrigation (IPC, 1991c). Figure 17 shows that

regional power use peaks in the winter with heating, and again in the summer with cooling and irrigation pumping demand.

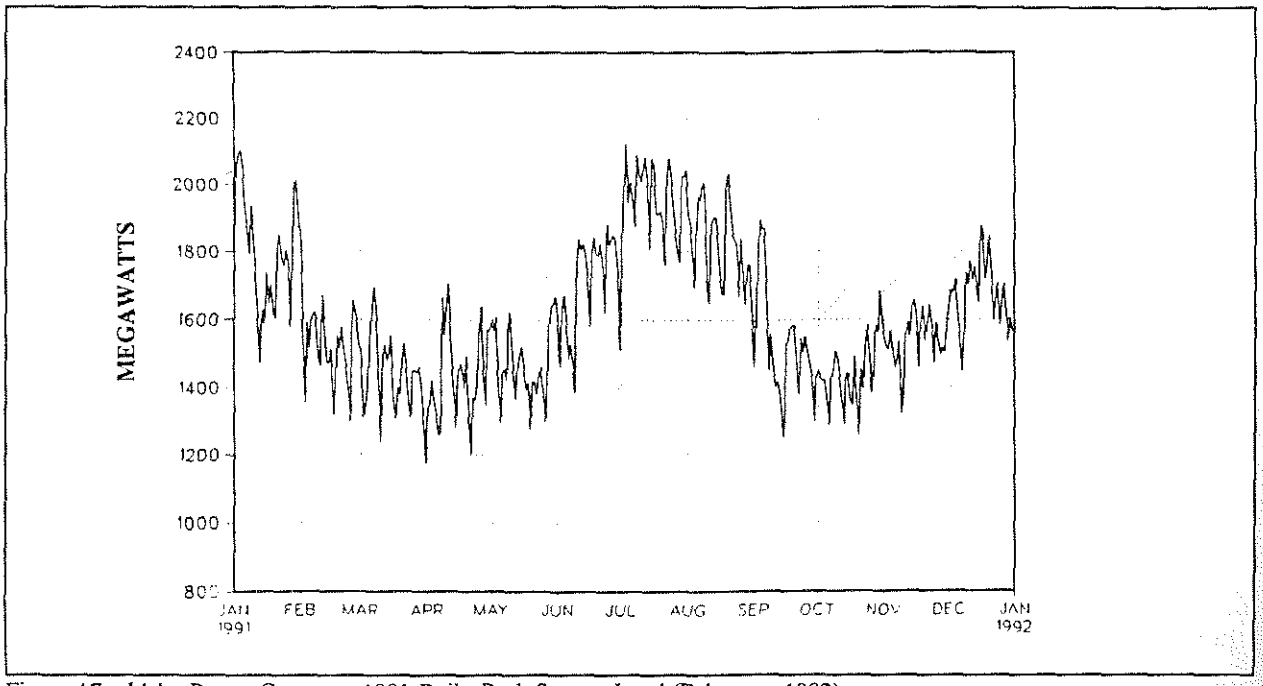

Figure 17. Idaho Power Company 1991 Daily Peak System Load (Fuhrman, 1992).

NEW HYDROPOWER PROJECTS

Seven new hydropower projects are proposed for the Snake River in the Middle Snake reach. The projects have active preliminary permits or license applications on file with the Federal Energy Regulatory Commission (FERC), and Auger Falls has been licensed for construction.

Star Falls (FERC #5797) - B&C Hydro, Inc. submitted an application for license to the FERC on August 11, 1992, for a hydropower project at Star Falls. The current application proposes a 400-foot-long, 20-foot-high concrete overflow dam/weir that would span the Snake River approximately 1,000 feet upstream of Star Falls. The dam/weir and upstream pool would stand approximately 7.5 feet above the existing high water mark of the Snake River. The pool would extend 3.3 miles upriver. The current configuration of the Snake River for the first 3.3 miles upstream from Star Falls is slack water pools. The normal maximum water surface area would be 135 acres. A minimum bypass flow of 300 cfs is proposed, and applicants say the project would have the capability of drawing down the pool to pre-project conditions. A low flow outlet/penstock intake structure would be located at the right abutment of the dam. The project would have two powerhouses, with the main powerhouse underground, approximately 800 feet downstream from Star Falls. A small bypass

powerhouse, with an installed capacity of 0.5 MW rated at 300 cfs, is proposed below the right abutment of the dam.

The main power plant would be an automated, run-of-the river plant with a peak capacity of 6,100 cfs. The main powerhouse would have one turbine with an installed capacity of 19.2 MW rated at 4,600 cfs, and a second turbine with an installed capacity of 7.6 MW rated at 1,600 cfs. The minimum flow usable by the 7.6 MW turbine would be approximately 375 cfs. The average annual plant factor for the main powerhouse is calculated at 44 percent for an estimated average annual 104,400 megawatt-hours. The main plant does not have any "dependable" capacity. The average annual plant factor for the bypass powerhouse is evaluated at 90 percent for an estimated average annual 3,000 megawatt-hours.

Auger Falls (FERC #4797) - Cogeneration Inc. was licensed by the FERC on March 29, 1991, to construct a low dam and diversion structure above Auger Falls and the Snake River's confluence with Warm Creek, (below the Jerome Country Club). The proposed project utilizes topographic features of the river without the need for a reservoir. The diversion structure consists of an 18-foot-high, 340-foot-long concrete weir/dam, and a canal just under two miles in length. Water would be diverted down the canal to a powerhouse below the falls (River Mile 609).

In the powerhouse, three generators are rated at 43.6 MW under turbine flows of 5,000 cfs, at a rated gross head of approximately 127 feet. The plant would produce an estimated 150,000 megawatt-hours per year. The instream maintenance flows vary seasonally between 350 and 1,200 cfs.

Boulder, Empire, and Kanaka Rapids (FERC #10772, 10849, 10930) - LB Industries submitted applications for license to the FERC on May 29, June 5, and June 19, 1992, for three run-of-the-river hydroelectric projects proposed for a five mile segment between Cedar Draw and Deep Creek. Boulder Rapids is located at River Mile (RM) 597, Empire Rapids at RM 594.5, and Kanaka Rapids at RM 592. The designed hydraulic capacity of each powerplant is 3,000 cfs, and the minimum instream flow in the bypass reach for each project would be 1,000 cfs.

At Boulder Rapids a wetlands peninsula, extending 320-feet into the river, would divert flow of the Snake River into a 2,331-foot canal which leads to the powerhouse below the rapid. The canal is unlined and follows the route of an existing high flow channel for the first 1,313 feet. The powerhouse would house four turbines and two generators. The proposed installed capacity is 4.9 MW with an estimated average annual generation of 25,250 megawatt-hours.

The Empire Rapid project would divert flow from the Snake River with a side channel turnout just upstream from the Buhl-Wendell Bridge. The turn-out would be a 640-feet-long earth-lined canal at an existing high-water channel that follows the north bank. The powerhouse, approximately 1,000 feet downstream of the bridge on the north bank, incorporates multiple generating units with an installed capacity of 3.1 MW, operating under a head of 12 to 18 feet. The estimated average annual generation is 18,767 megawatt-hours.

At Kanaka Rapids a side channel turnout on the south side of the river and a natural rock sill on the north side would divert flow from the Snake River to a 2,400-feet canal. The canal would extend from the turnout to the powerhouse below the rapids; the first 800-feet would not be lined and would follow the route of an existing high flow channel between a seasonal island and the south bank. The powerhouse would house four turbines and two generators. Proposed installed capacity is 6.3 MW, with an estimated average annual generation of 40,923 megawatt-hours.

A.J. Wiley (FERC #11020) - Idaho Power received a preliminary permit for study of the Wiley site in September, 1991. Based upon preliminary studies for a previous FERC licensing application, the hydropower proposal consists of a 100-feet-high dam, 1,150 feet long, located on the Snake River about one mile southwest of Bliss, Idaho. The resulting reservoir would back up water to the base of Lower Salmon Falls Dam, about 8 miles upstream, and store 13,500 acre-feet. Operation of such a hydropower facility would be constrained by, or impact, the operation of Lower Salmon and Bliss dams. Total gross head available for development between the tailwater of the Lower Salmon project and the maximum operating level of Bliss Reservoir is approximately 80 feet. Estimated average annual generation is 494,500 megawatt-hours.

Dike (FERC #10891) - Bart M. O'Keeffe of Dike Hydroelectric Partners of Sacramento, CA received a preliminary permit to study the feasibility of a 66 MW hydropower project near Bancroft Spring on July 16, 1990. The project entails a 500-foot-long and 70-foot-high roller compacted concrete dam. The dam would create a 560-acre reservoir with a storage capacity of 19,000 acre-feet. Two 33 MW turbines would operate under a rated head of 67 feet and a design flow of 15,000 cfs. Estimated annual generation is 360,000 megawatt-hours.

Canal Companies - Many small hydropower systems are now being installed on irrigation canals, even though water may flow only part of the year. These projects can often be cost effective because construction costs are usually less than projects built on natural streams. Also, because of the absence of fish populations, the canal projects do not present environmental conflicts. The Twin Falls and Northside Canal companies are looking at six new hydropower projects which could produce 40 megawatts of electricity during the irrigation season. The fall in the Northside canal system could develop 100 megawatts of power during irrigation season operation (Diehl, 1992).

GEOTHERMAL RESOURCES

Low to moderate temperature geothermal sites are extensive on the Snake River Plain. Aquifers in the study area are within a zone of regionally high heat flow which extends from northern Nevada to Yellowstone National Park. Heat flow values within the area are between 2.2 and 2.5 Heat Flow Units based on data from thermal gradients derived from bottom hole temperature evaluations. Subsurface temperatures in the area are, however, below temperatures for potential power generation (Mitchell et al., 1980). The thermal anomaly over the region is believed to be related to the Cordilleran Thermal Tectonic Anomaly and local thinning of the crust associated with Basin and Range extension (Street and DeTar, 1987).

Navigation

There is no commercial navigation, defined as moving commodities by water, on the Middle Snake reach. Under the Idaho Admissions Act and the Idaho Constitution, the State claims title to all bodies of water that are navigable. State title applies to the main stem of the Snake River above and below Shoshone and Twin Falls (Idaho Department of Lands, 1986).

Outfitters use the Snake River for commercial floating expeditions. To date, six outfitters are licensed to operate on the Middle Snake reach by the Outfitters and Guides Licensing Board. Twelve permits are listed for four segments: Murtaugh Bridge to Twin Falls Reservoir, Twin Falls to Lower Salmon Falls Reservoir, Lower Salmon Falls Dam to Bliss Reservoir, and Bliss Dam to C.J. Strike Reservoir.

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