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Wyoming Water Planning Program
Report No. 9

WATER & RELATED LAND RESOURCES

OF THE

PLATTE RIVER BASIN, WYOMING

September 1971



A Report from the

WYOMING WATER PLANNING PROGRAM

State Engineer's Office

Cheyenne, Wyoming



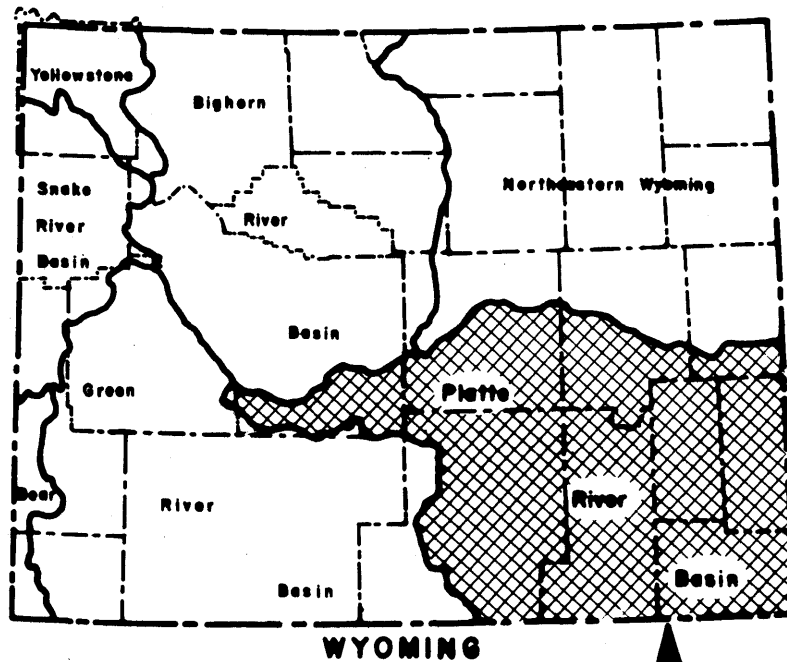
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Wyoming Water Planning Program
Report No. 9

WATER & RELATED LAND RESOURCES
OF THE
PLATTE RIVER BASIN, WYOMING

September 1971



STUDY AREA

WATER & RELATED LAND RESOURCES
OF THE
PLATTE RIVER BASIN, WYOMING

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PREFACE

This report on the Platte River Basin has been prepared for the people of Wyoming as part of a "State Water Plan." The work upon which this report is based was supported by funds provided by the Wyoming Legislature and by the Water Resources Council under Title III of the Water Resources Planning Act of 1965 (Public Law 89-80). The report is presented as part of the planning effort authorized by the 39th Legislature of the State of Wyoming, which directed that, "The State Engineer is responsible for the coordination of Wyoming's water and related land resources planning and is authorized to enter into contracts and agreements with the United States of America or its duly authorized representative agency for planning pertaining to the development of Wyoming's water and related land resources." As a result of this legislation, the Water Planning Program was established as a division of the State Engineer's Office, under the general supervision and direction of the State Engineer.

The report discusses water and related land resources in the Platte River Basin and provides a means of evaluating the water needs and resources of the Basin relative to the overall water needs and resources of Wyoming. The complete "State Water Plan" will incorporate this analysis of the Platte River Basin in the formulation of a Statewide plan, with alternatives, to develop the water and related land resources of Wyoming.

In this report, the present water uses in the Platte River Basin are inventoried and future water needs are determined. Potential water development projects are identified. Alternatives for future water resources development are presented.

This report does not attempt to prescribe a course of action. Rather, it attempts to provide information so that practical decisions can be made by the citizens of Wyoming concerning future water and related land resource development in the State.

The Governor's Interdepartmental Water Conference provides a coordinating forum for the water planning effort. State agencies with water resource responsibilities contribute useful data to the Water Planning Program and through regularly held meetings keep informed of policy, planning, and legislative considerations. Contributions to this report were made by several agencies. The member agencies of the Governor's Interdepartmental Water Conference are:

Governor Stanley K. Hathaway

State Engineer's Office

Attorney General's Office

State Department of Agriculture

Department of Economic Planning and Development

Department of Health and Social Services

Game and Fish Commission

The Geological Survey of Wyoming

Wyoming Highway Department

Wyoming Recreation Commission

University of Wyoming

Agriculture Extension Service

College of Law

Water Resources Research Institute

Data were also obtained from reports by the Bureau of Reclamation, the U. S. Geological Survey, the Soil Conservation Service, the U. S. Corps of Engineers, and others.

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CHAPTER I

DESCRIPTION OF THE BASIN

DESCRIPTION OF THE BASIN

LOCATION AND SIZE

The study area (shown on the location map, Figure I-1) for this report includes approximately 24,115 square miles in central and southeastern Wyoming. This area, frequently referred to in this report as the Basin, extends northward from the Wyoming-Colorado State line, latitude 41°00' North to latitude 43°13' North, a distance of approximately 152 miles. The Basin extends westward from the Wyoming-Nebraska State line, longitude 104°03' West to longitude 109°12' West, a distance of approximately 264 miles.

The entire drainage area of the North Platte River in the State of Wyoming and those portions of the South Platte River and the Niobrara River drainages within the State are included in the study area. Of the total area, 21,545 square miles are in the North Platte River drainage, 2,000 square miles are in the South Platte River drainage, and 570 square miles are drained by the Niobrara River. All of Laramie, Goshen, Platte, and Albany Counties, most of Carbon and Natrona Counties, and substantial parts of Fremont, Converse, and Niobrara Counties are in the study area.

HISTORY

Early Inhabitants

There is evidence that people lived near the present site of Guernsey as much as 11,000 years ago. About 6,000 years ago the region became a desert and apparently was uninhabited for 1,500 years. Indications suggest that a small population lived along the North Platte River and in some other areas of the State about 4,500 years ago (33)¹.

The prominent Indian tribes in the Basin were the Cheyenne and Arapaho which had moved into the region from Minnesota in the 18th century. The Sioux Indians moved into what is now eastern Wyoming from South Dakota in the 1830's. Many other tribes frequently hunted and fought in the Basin but preferred to make their homes elsewhere.

Fur-Trapping Era

The Basin was acquired by the United States from France in the Louisiana Purchase of 1803. Fur trade became a lucrative industry shortly after the purchase. Although the Basin did not figure as prominently in the early fur-trading industry as other areas to the north and west, early trappers explored the Basin on their way to richer trapping areas. In 1812-13 Robert Stuart of the Astor Pacific Fur Company discovered the westward overland route (which later became the Oregon Trail) along the North Platte and Sweetwater Rivers to South Pass.

A famous employee of the Northwest Company, Jacques LaRame, trapped and hunted in the headwaters and tributaries of the North Platte River around 1820.

¹ Number in parentheses refers to a specific reference listed in the Bibliography of Selected References at the end of the report.

His name has since been given to such places as Fort Laramie, Laramie Range, Laramie Peak, Laramie Plains, Laramie County, and the city of Laramie.

Indians annually brought pelts to the rendezvous at the mouth of the Laramie River. Here, in 1834, the first garrisoned trading post in Wyoming (19) was established and named Fort William in honor of Captain William Sublette. The name was later changed to Fort Laramie.

The fur trade dwindled in the late 1830's and the trappers left, but not without leaving their mark on the Basin. The trappers pioneered the routes which would later become the Oregon and Overland Trails and noted the coal deposits which would lead to the selection of railroad routes in later years. The trappers established Fort Laramie, a post which was purchased as a military fort by the United States around 1847 and which was destined to be associated with more historic incidents than any other military post in the West (19). No government explorer after 1840 made a western discovery that some of the fur trappers hadn't known about for years (90).

Western Immigration Era

The United States experienced a great westward movement beginning around 1840, and many people passed through the Basin by routes which had been explored by the early trappers. The path most used by these people en route to Oregon, Utah, and California was along the North Platte River to the present site of Casper, then along the Sweetwater River to South Pass on the Continental Divide, and then across the Divide to points west.

In 1845 at least 3,000 people passed by Fort Laramie on their way to the rich valleys of the Northwest (19). Mormons passed through the Basin en route to the Great Salt Lake in 1847. In 1849, the year of the California gold rush, traffic increased greatly on the Overland Trail, which was a more southerly route over the Laramie Plains. This trail crossed the North Platte near the present site of Saratoga, and the Continental Divide at Bridger Pass. Like the trappers, these early travelers were merely passing through, and the Basin was still without substantial settlement.

Railroad Era

The dream of a transcontinental railroad was given substance with the passage of the Pacific Railway Act of 1864. This act provided incentive to private development by giving to the railroad company the odd-numbered sections within 20 miles on either side of the railroad right-of-way with mineral rights and other benefits.

The decision to construct the railroad was made before a route was determined. General Grenville M. Dodge, chief engineer of the Union Pacific Railroad in 1866, recognized that the western immigrants' North Platte River-Sweetwater River-South Pass route was the best route from an engineering standpoint (33). However, the route finally selected was through Sherman Pass between the present sites of Cheyenne and Laramie. The Sherman Pass route was selected because hostile Indians roamed the plains to the north (61), it traversed an area of better coal deposits, it was 40 miles shorter than the other route, and it was closer to Denver.

General Dodge surveyed a townsite at the present site of Cheyenne in July of 1867, and the first settlers from Colorado arrived before the survey was completed. Cheyenne became Wyoming's first substantial settlement. The cities of Laramie and Rawlins were also established on the Union Pacific route.

FIGURE I-1
LOCATION MAP

WYOMING'S PLATTE RIVER BASIN

WYOMING STATE ENGINEERS OFFICE
WATER PLANNING PROGRAM

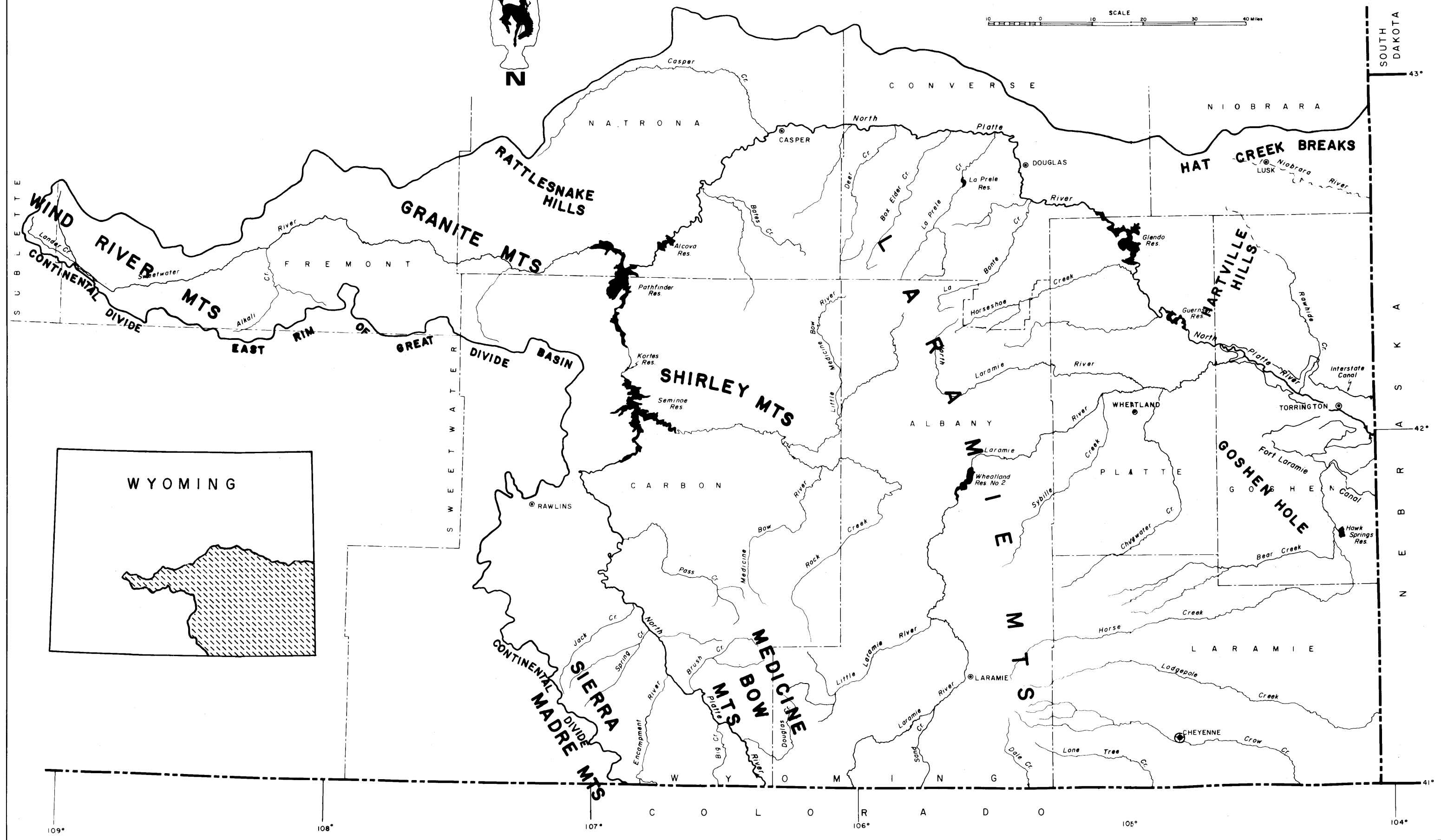


FIGURE I-1

Other railroads also played important roles in the development of the Basin. The Wyoming Central Railroad came out of Nebraska to Lusk and Douglas in 1886, Glenrock in 1887, and Casper in 1888. The Cheyenne and Northern Railroad bridged the Laramie River north of Wheatland in 1887 and moved on to Wendover on the North Platte River. The Burlington Railroad reached Cheyenne from Sterling, Colorado, in 1887.

Beginning of the Stock Growing Era

The Mormons are credited with driving the first breeding cattle into Wyoming in 1848. Trader Seth E. Ward wintered the first large work herd in the sheltered valley of the Chugwater in 1852 (59). The fact that the cattle survived the winter in perfect shape without care was the first demonstration of the tremendous potential for cattle raising in the area. In 1870 "Hi" Kelly of Chugwater shipped the first carload of live cattle out of Wyoming (59).

Cheap Texas cattle and free range combined to produce an enormous boom in the Wyoming cattle raising business. In the 1880's, Cheyenne was advertised as the cattle market of the plains and was the wealthiest city, per capita, in the world (60).

Cattle were brought to Wyoming in such numbers that over-grazing soon became a problem. This, and the terrible winter of 1886-87, caused the greatest catastrophe ever experienced by the Wyoming cattle business (60). Even though many ranchers never recovered, it brought about improved ranching methods such as range management and winter feeding which have made possible the successful ranching business practiced in the Basin today.

Cheyenne was the capital of the cow country and the birthplace of eastern Wyoming's sheep industry. In 1870 the Durbin brothers purchased 500 head of sheep and brought them to the vicinity of Cheyenne as the first band to be located there (60).

Many sheep were brought to eastern Wyoming from Oregon and California between 1880 and 1900. It has been estimated that about 2,000,000 sheep traveled across Wyoming during this period (60). Bitter disputes between sheepmen and cowmen often resulted in violent conflicts. The pattern of conflict was complicated by the fact that many cattlemen switched to sheep when sheep appeared to be more profitable and sometimes vice versa (33).

Industrial Mineral Development Era

Carbon, the first coal mining town in Wyoming, was established by the Union Pacific Railroad Company in 1868. The presence of coal had been a large factor in the railroad's location. The mine at Carbon was abandoned in 1899 and a new mine opened at nearby Hanna on the railroad's main line.

Copper was once mined in the hills northeast of Guernsey, and a smelter was established nearby along the North Platte River. The settlement, known as Fairbanks, became a ghost town when it was discovered that the copper ore occurred only in pockets and shallow veins. It was long known that Iron Mountain, in the Laramie Range, contained vast reserves of iron ore. However, these reserves remained undeveloped until the 1960's. Uranium mines and mills are presently being operated in the Shirley basin and in the Crooks Gap-Gas Hills area in the Basin.

It was reported that Mitchell Lajuenesse found oil in the vicinity of the present town of Casper in 1873 and that he had "scraped it up with a spoon and set it afire" (19). The discovery of the huge Salt Creek oil field in northern Natrona County (in Powder River drainage) in 1906 sparked a period of rapid growth of oil and gas production in Wyoming which lasted until about 1923. In 1910 the Midwest Oil Company laid a 6-inch pipeline from the Salt Creek field to a refinery at the west end of Casper. In 1911-12 the Franco-American Wyoming Oil Company also laid a 6-inch pipeline from the Salt Creek field to a refinery which they constructed at the west end of Casper. Petroleum has since become the most important industry in Wyoming in terms of taxes paid.

Modern Water Development Era

Irrigation was carried on as early as 1851 at Fort Laramie in an effort to produce vegetables to combat scurvy among soldiers (60). Many early ditches were developed along the Laramie River and its tributaries; the earliest recorded priority has a date of 1868. The first large canal in the Basin, the Pioneer Canal, was completed in 1879; it is still carrying water from the Laramie River for the irrigation of lands several miles away.

In 1886 the Wyoming Legislature adopted a comprehensive law establishing procedures to be used for the appropriation of water for irrigation. This law replaced an 1875 statute which had maintained the common-law principle of riparian rights. In the Constitutional Convention of 1889 (Wyoming achieved Statehood in 1890) Wyoming made a major contribution to the establishment of water law in the West by adopting a complete system for State control of water.

The Carey Act of 1894, named after Wyoming's Senator Joseph M. Carey, provided for the donation by the Federal Government of up to 1,000,000 acres of arid lands to each state having such lands, on the condition that the state cause the lands to be reclaimed and settled by actual settlers on small tracts.

An outstanding private development under the Carey Act was the Wyoming Development Company's Wheatland Reservoir No. 2 of 98,934 acre-feet, established 35 miles north of Laramie on the Laramie River in 1901-02. This was made possible by an 1883 direct-flow appropriation and an 1898 reservoir right (33). The project was eventually enlarged to include a total of 50,000 acres of cropland by the addition of Carey Act lands and two new canals. Other Carey Act lands were included in the Rock Creek Project on the Medicine Bow River, the LaPrele Creek unit, and the Hawk Springs Reservoir Project supplied by Horse Creek.

Some water development projects were too large to be successfully undertaken by private enterprise. It was agreed that only the Federal Government could construct projects of great magnitude, and the Reclamation Act of 1902 authorized the Federal Government to undertake reclamation projects with money obtained from the disposal of public lands.

The first Federal water development project in the Basin, and the second in the State, was the North Platte Project. This project, under a 1904 permit, called for the construction of Pathfinder Dam, 40 miles southwest of Casper, and for a diversion dam at Whalen, a few miles above Fort Laramie. From Whalen, the Interstate Canal was to carry water to 30,000 acres in Wyoming and 80,000 acres in Nebraska. Water was carried through the first 45 miles of canal in 1906, and Pathfinder Dam was completed in 1911.

Since then six other Federal dams have been constructed on the North Platte River in Wyoming for irrigation, power production, and stream regulation. These, with completion dates, are Seminoe (1939) and Kortes (1951) Dams above Pathfinder, and Alcova (1938), Gray Reef (1961), Glendo (1958), and Guernsey (1927) Dams below Pathfinder.

The potential for expansion of irrigation using surface water became limited as water supply limits were reached. An example is in the Laramie River Basin. In 1911 Wyoming started court proceedings in the Supreme Court against Colorado to limit the Colorado diversions from the Laramie River, contending that established irrigation in Wyoming would be injured. The Court decree of 1922, amendments of 1936, 1939, and a stipulation agreed upon by the two states in 1957 limit Colorado uses to 49,375 acre-feet annually. Diversions from the Laramie River to the Cache la Poudre River Basin in Colorado are limited to 19,875 acre-feet per year, and the remaining 29,500 acre-feet per year may be diverted for irrigation of land in the Laramie River Basin in Colorado.

In 1945 the U. S. Supreme Court imposed upper limits on irrigated acreage, irrigation storage, and other facets of water use of the North Platte River. Wyoming, Colorado, and Nebraska are parties to the decree. An amendment, approved in 1953, permitted Colorado to increase its irrigated acreage, and Wyoming and Nebraska to store 40,000 acre-feet (15,000 for Wyoming and 25,000 for Nebraska) during any water year in Glendo Reservoir.

The two U. S. Supreme Court decrees emphasized the need for interstate water agreements between Wyoming and her neighboring states. The Niobrara River Compact, recently ratified by Wyoming, Nebraska, and the U. S. Congress, is the latest interstate stream compact negotiated by Wyoming.

TRANSPORTATION

The most historic trails in the West either traversed the Basin or, as in the case of the Bozeman Trail (first used by John Bozeman en route to Montana gold fields in 1863), diverged from established trails which crossed the Basin.

At Bordeaux, on the military road connecting Fort D. A. Russell near Cheyenne with Fort Laramie, the trail branched north to Fort Fetterman. When gold was discovered in the Black Hills the road from Fort Russell to Fort Laramie became part of the Cheyenne-Deadwood (or Cheyenne-Black Hills) Trail, noted for its infamous road agents (59).

In 1875-76 Camp Carlin, between Fort Russell and Cheyenne, became the wholesale supply depot for some 16 forts and Indian agencies in northwestern Nebraska and Wyoming (26). Freighting in such volume required roads and bridges, and the United States Congress appropriated \$15,000 for a bridge across the North Platte River at Fort Laramie; this bridge was completed in 1875. Numerous other public and private bridges were then constructed.

As ranchers occupied the territory north of Cheyenne they followed the roads of the government freighters from Camp Carlin. In the 1850's stage lines were established, followed by the Pony Express in 1860 and the first transcontinental telegraph line in 1861.

Roads

Until about 1910 roads in Wyoming were under county jurisdiction. In 1911 the Wyoming Legislature enacted a bill to provide the first highway system in the State. The voluntary Wyoming Highways Association was formed in 1912 for the purpose of promoting through routes. The National Lincoln Memorial Highway Association in 1913 endorsed the southern Wyoming Overland Trail, along the Union Pacific Railroad, as the State's link in the transcontinental Lincoln Highway (33). The Wyoming Legislature of 1917 established a State Highway Department under a State Highway Commission and authorized the acceptance of Federal aid on a matching basis. By 1929 the State had 87 miles of oiled roads in Albany, Carbon, Goshen, and Natrona Counties.

The present U. S. and State Highway systems and county road systems permit traffic to move throughout the area and connect the Basin to other parts of the State and to Colorado and Nebraska. The Basin is crossed by two Interstate Highways: I-80 crosses the Basin east-west through Cheyenne, Laramie, and Rawlins, and I-25 north-south from Casper to Douglas, Wheatland, and Cheyenne. The highway system is shown on Figure I-2.

Railroads

The Union Pacific Railroad crosses the southern part of the Basin in an east-west direction, providing service to Cheyenne, Laramie, and Rawlins. The Burlington-Northern and the Chicago and Northwestern Railroads provide freight service in the North Platte River valley as far westward as Casper, and continue on to the central and north-central parts of the State. The Colorado and Southern Railroad provides connecting freight service between the two east-west lines, passing from Denver to Cheyenne and thence northward through Wheatland to Orin Junction a few miles southeast of Douglas.

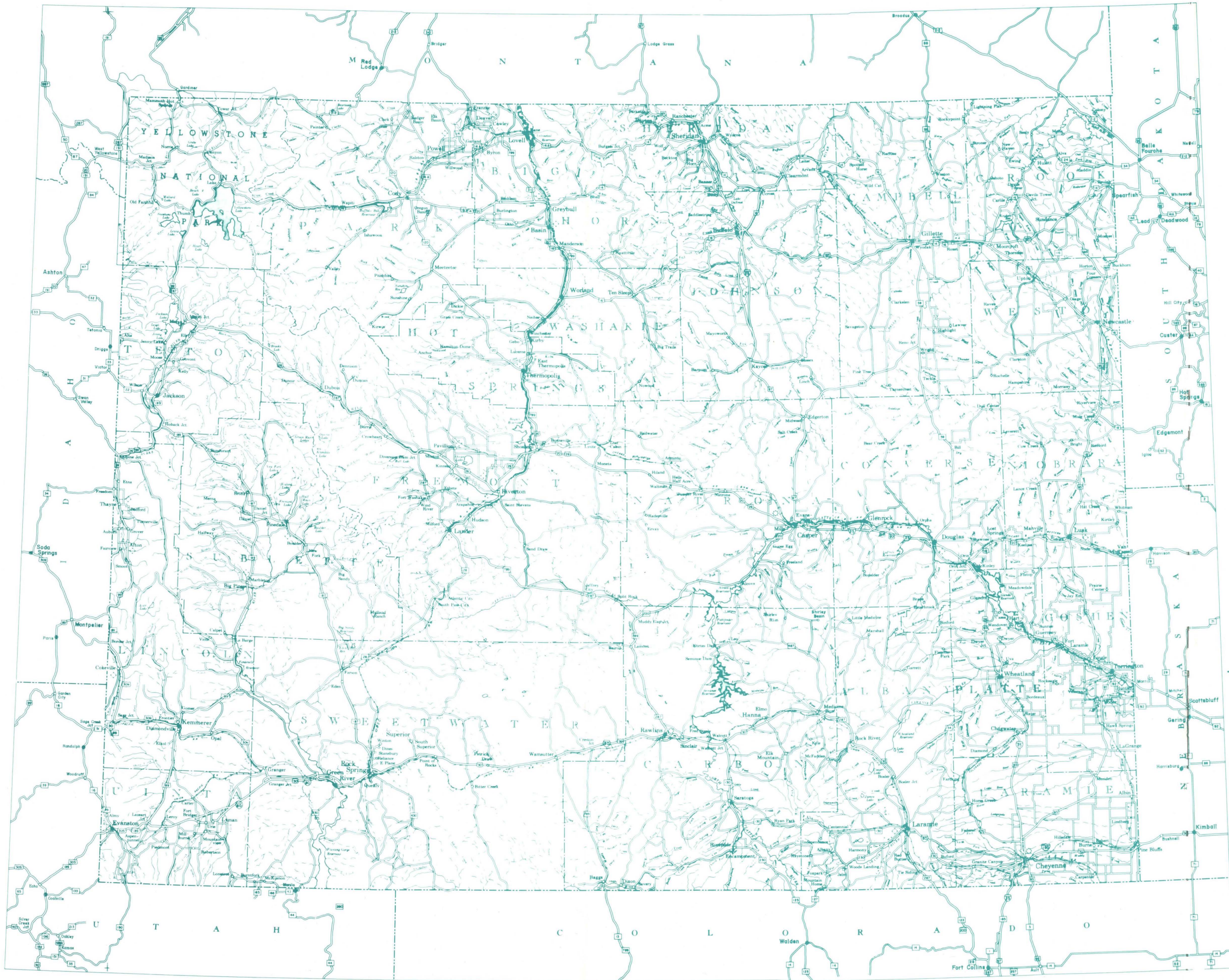
Air Transportation

Commercial air transportation is provided in the Basin by Frontier Airlines through facilities at Cheyenne, Laramie, and Casper, and by Western Airlines through facilities at Casper and Cheyenne.

POPULATION

The Platte River Basin is the most densely populated area in Wyoming. The major population centers occur along the Union Pacific Railroad and the Burlington-Northern Railroad which runs along the North Platte River. Many areas away from live streams and railroads are sparsely populated, and others are virtually uninhabited.

During the period 1940 to 1970 nearly all the population growth in the Basin occurred in Albany, Laramie, and Natrona Counties (see Table I-1). Carbon County showed a slight increase in population during this period; most of the population gains in Fremont County were outside the Basin. Converse, Niobrara, Platte, and Goshen Counties showed moderate declines in population. Rural farm population has steadily declined in every county in the Basin over the period 1940 to 1970.



GENERAL LEGEND

ROADS AND ROADWAY FEATURES	BOUNDARIES
INTERSTATE HIGHWAY	STATE
STATE HIGHWAY	COUNTY
INTERSTATE NUMBERED HIGHWAY	TOWNSHIP
STATE NUMBERED HIGHWAY	NATIONAL FOREST
COUNTY ROAD	NATIONAL PARK, RECREATION AND MONUMENT
PRIMARY HIGHWAY	
	DRAINAGE
CITY AND TOWN CENTER	INTERNET STREAM
STATE CAPITAL	NARROW STREAM
COUNTY SEAT	WIDE STREAM
CITIES AND TOWNS	LAKE OR RESERVOIR
ARMED PLACES	INTERMITTENT LAKE OR RESERVOIR
AIRWAYS AND RAILROADS	
AIR FIELD, COMPLETE FACILITIES	
AIR FIELD, LIMITED FACILITIES	
RAILROAD	

Figure I-2
TRANSPORTATION SYSTEMS
MAP
STATE OF
WYOMING
PREPARED BY THE
WYOMING HIGHWAY DEPARTMENT
PLANNING AND RESEARCH DIVISION
IN COOPERATION WITH THE
U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
BUREAU OF PUBLIC ROADS

SCALE
0 10 20 30 40 MILES
1957
Revised to January 1, 1970

TABLE I-1 -- Population Trends of Counties Wholly or Partially
Within the Platte River Drainage Basin

<u>County</u>	<u>1940</u>	<u>1950</u>	<u>1960</u>	<u>1970</u>
Albany	13,946	19,055	21,290	26,431
Carbon	12,644	15,742	14,937	13,354
Converse	6,631	5,933	6,366	5,938
Fremont	16,095	19,580	26,168	28,352
Goshen	12,207	12,634	11,941	10,885
Laramie	33,651	47,662	60,149	56,360
Natrona	23,858	31,437	49,623	51,264
Niobrara	5,988	4,701	3,750	2,924
Platte	8,013	7,925	7,195	6,486
Sublette	2,778	2,481	3,778	3,755
Total	135,811	167,150	205,197	205,749

The census figures in Table I-1 show a 1970 total population in the counties wholly or partially within the Basin of approximately 206,000 persons. Adjusting this figure to include only population within the Basin boundaries results in an estimate of approximately 171,000 persons within the report area, or about 51½% of the 1970 Wyoming population of 332,416 persons. Of these 171,000 persons, about 60% (103,418) reside in three towns--Casper, Cheyenne, and Laramie. Another 14% reside in Douglas, Glenrock, Lusk, Mills, Rawlins, Saratoga, Torrington, and Wheatland. The remainder of the people are scattered throughout the Basin in the various small towns and on farms and ranches.

LAND OWNERSHIP

Figure I-3 is a land status map illustrating land ownership within the Basin. The Federal Government owns about 26.2% of the land within the Basin. The Bureau of Land Management administers about 19.3% of the lands within the Basin, and the Forest Service manages about 6.35% of the Basin in the Medicine Bow National Forest. The Department of Defense, Bureau of Reclamation, Bureau of Sport Fisheries, and the National Park Service each administer small areas within the Basin (see Table I-2).

The remaining 73.8% of the Basin is under State, county, municipal, and private ownership. The Union Pacific Railroad owns a "checkerboard" pattern of every other section of land in a strip 20 miles wide on both sides of the railroad in the western portion of the Basin. Portions of the original Union Pacific Railroad land grant have been sold in Albany and eastern Carbon Counties, and nearly all lands outside the railroad rights-of-way have been sold to other private interests in Laramie County.

Land ownership can be compared with land areas in the Basin by referring to Tables I-2 and I-3. Lands are used principally for human habitation, livestock grazing, hayland, cash crops, feed grains, forests, recreations, mining, and petroleum production.

TABLE I-2 -- Land Ownership and Administration in the Platte River Basin

<u>Federal Lands</u>	<u>Area in Acres</u>	<u>Percent</u>
Department of Agriculture Forest Service	979,000	6.35
Department of Defense Military--Army, Navy, Air Force	10,000	.06
Department of the Interior Bureau of Land Management	2,976,000	19.28
Bureau of Reclamation	69,000	.45
Bureau of Sport Fisheries	11,000	.07
National Park Service	1,000	.01
Total Federal Lands	4,046,000	26.22
<u>Private, County, and State Lands</u>	<u>11,387,600</u>	<u>73.78</u>
Total Land in the Basin	15,433,600	100.00

Source: Missouri River Comprehensive Framework Study (1969). Figures include water areas.

TABLE I-3 -- Total Area by County, Platte River Basin

<u>County</u>	<u>Water Area</u>		<u>Land Area</u>		<u>Total Area</u>	
	<u>Sq. Miles</u>	<u>Acres</u>	<u>Sq. Miles</u>	<u>Acres</u>	<u>Sq. Miles</u>	<u>Acres</u>
Albany	30.9	19,800	4,284.1	2,741,800	4,315.0	2,761,600
Carbon	79.4	50,800	5,557.2	3,556,600	5,636.6	3,607,400
Converse	.9	600	1,926.4	1,232,900	1,927.3	1,233,500
Fremont	9.7	6,200	1,565.5	1,001,900	1,575.2	1,008,100
Goshen	5.0	3,200	2,230.0	1,427,200	2,235.0	1,430,400
Laramie	2.0	1,300	2,703.0	1,729,900	2,705.0	1,731,200
Natrona	15.2	9,700	2,991.5	1,914,600	3,006.7	1,924,300
Niobrara	.2	150	548.8	351,200	549.0	351,350
Platte	35.0	22,400	2,085.9	1,335,000	2,120.9	1,357,400
Sublette	.4	250	43.9	28,100	44.3	28,350
Basin Total	178.7	114,400	23,936.3	15,319,200	24,115.0	15,433,600

Source: Missouri River Comprehensive Framework Study (1969). Figures for Carbon County have been adjusted to include only the area in the Platte River Basin.

PHYSIOGRAPHY

The Platte River Basin of Wyoming is a region of considerable physiographic diversity. The eastern part of the Basin, adjoining the plains of Nebraska, is in the high plains region and features gently rolling plains and uplands sloping

WYOMING'S PLATTE RIVER BASIN

WYOMING STATE ENGINEERS OFFICE
WATER PLANNING PROGRAM

FIGURE I-3
LAND STATUS MAP
(Source: U.S.B.L.M. Land Status Map, 1967)

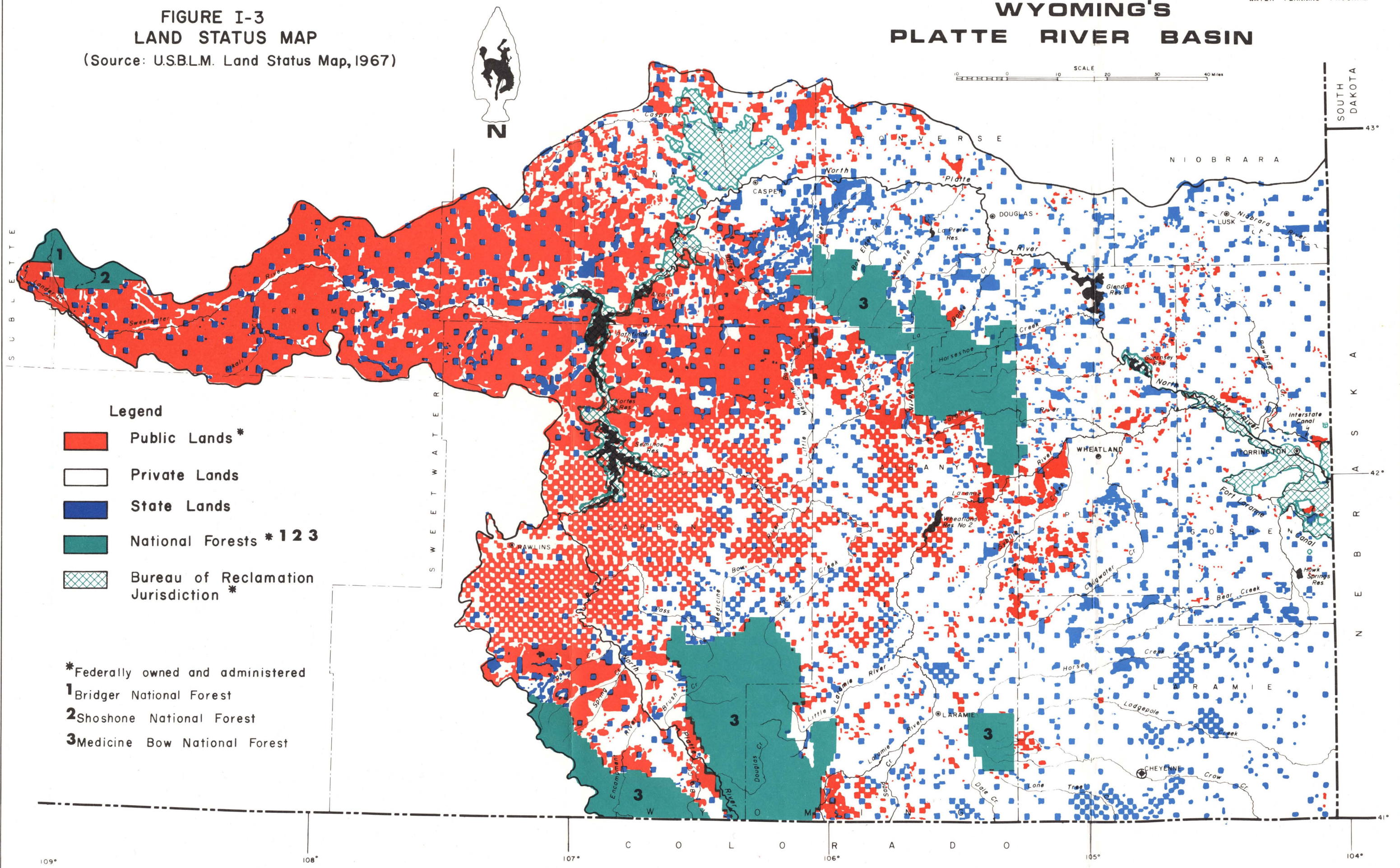


FIGURE I-3

towards the east. The western part is dominated by high mountain ranges and intermontane valleys of the Rocky Mountains, with the Continental Divide as the Basin's western boundary.

Topography

Topographic elevations vary from about 4,100 feet above sea level at Torrington, in the North Platte River valley near the Nebraska State line, to about 12,490 feet at the top of Atlantic Peak in the Wind River Mountains. Between these extremes are mountain ranges at elevations of about 8,000 to 10,000 feet, mountain valleys at elevations of 6,500 to 7,500 feet, and high plains from less than 5,000 to more than 6,000 feet above sea level. Peak elevations of the several mountain ranges and elevations of several communities are tabulated:

<u>Mountain Range and Peak</u>	<u>Elevation, Feet Above Mean</u>		<u>Community</u>
	<u>Sea Level ²</u>		
Wind River - Atlantic Peak	12,490	7,200	Laramie
Wind River - Mt. Nystrom	12,356	6,736	Rawlins
Medicine Bow - Medicine Bow Peak	12,005	6,126	Cheyenne
Sierra Madre - unnamed	11,007	5,338	Casper
Laramie - Laramie Peak	10,272	4,853	Douglas
Rattlesnake Hills - Garfield Peak	8,245	4,738	Wheatland
Granite - Savage Peak	7,843	4,098	Torrington

The mountain ranges and peaks stand out in bold relief above mountain valleys and high plains. Within the mountainous area are broad intermontane valleys drained by streams which found or made outlets through the mountains. East of the mountains the topography consists of foothills and gently rolling tableland bounded by steep escarpments.³ South of Crow Creek the mountain front, rather than developing into foothills, gives way to the plains as a gradual slope that is utilized as an access route ("the gangplank").

The plains area has been dissected by streams that have been downcutting for millions of years. Stream erosion has been very significant in the development of Basin topography. The North Platte River valley east of the mountain front contains a recent floodplain and several elevated terraces or benches that are remnants of earlier floodplains. The terraces grade into pediments,⁴ the highest of which occurs at an elevation of about 5,000 feet, 900 feet above the present level of the North Platte River. Near Fort Laramie, T.26 N., R.64 W., about 15

² Mountain peak elevations are from Army Map Service topographic map series, scale 1:250,000. Community elevations are from Climatological Summaries by the NOAA.

³ An escarpment is a continuous line of cliffs or steep slopes facing a general direction, due to erosion or faulting (earth movement which produces relative displacement along adjacent rock masses).

⁴ A pediment is a plain which lies at the foot of a mountain, formed by erosion and deposition of streams, and usually is covered by a veneer of gravel.

TABLE I-4 -- Streams Shown on Figure I-1 by Tributary Rank and Downstream Order

(MISSOURI RIVER)

(Platte River)

North Platte River ¹
 Douglas Creek ²
 Big Creek (heads in Colorado) ³
 Brush Creek ²
 Encampment River (heads in Colorado) ³
 Spring Creek ³
 Jack Creek ³
 Pass Creek ²
 Medicine Bow River ²
 Rock Creek ²
 Little Medicine Bow River ⁴
 Sweetwater River ⁵
 Lander Creek ⁵
 Alkali Creek ⁶
 Bates Creek ⁴
 Casper Creek ⁷
 Deer Creek ⁴
 Box Elder Creek ⁴
 LaPrele Creek ⁴
 LaBonte Creek ⁴
 Horseshoe Creek ⁴
 Laramie River (heads in Colorado) ²
 Sand Creek (heads in Colorado) ⁴
 Little Laramie River ²
 North Laramie River ⁴
 Chugwater Creek ⁴
 Sybille Creek ⁴
 Rawhide Creek ⁸
 Horse Creek ⁴
 Bear Creek ⁴
 (South Platte River)
 (Cache la Poudre River)
 (North Fork)
 Dale Creek ⁴
 Lone Trail Creek ⁴
 Crow Creek ⁴
 Lodgepole Creek ⁴
 Niobrara River ⁹

¹ Has its origin at the confluence of Grizzly and Little Grizzly Creeks in North Park, a 1,500-square-mile valley in north-central Colorado, about 25 miles south of the Wyoming-Colorado State line.

² Originates in the Medicine Bow Mtns. ³ Originates in the Sierra Madre Mtns.

⁴ Originates in the Laramie Mtns. ⁵ Originates in the Wind River Mtns.

⁶ Originates in the East Rim of the Great Divide Basin. ⁷ Originates in the Rattlesnake Hills.

⁸ Originates in the Hartville Hills. ⁹ Originates in the Hartville Hills and Hat Creek Breaks.

miles upriver from Torrington, the valley of the North Platte River undergoes a great widening from 2 miles to 45 miles. The valley lowland, called the Goshen Hole, is wedge-shaped and narrows in a downstream direction to a width of about 2 miles in the vicinity of Lisco, Nebraska, 100 miles from Fort Laramie.

The expanse of the northern plains area is further broken by the Hartville Hills southwest of Lusk. The northern margin of the Basin in the plains area is delineated by a persistent escarpment known as the Hat Creek Breaks (the Pine Ridge Escarpment), 300 to 500 feet above the valley of the Niobrara River and its tributaries.

Drainage System

The Basin is drained by the North Platte River and its tributaries, by tributaries to the South Platte River, and by the Niobrara River and its tributaries. The North Platte River originates at the confluence of Grizzly and Little Grizzly Creeks in North Park, a 1,500-square-mile valley in north-central Colorado, about 25 miles south of the State line. The river enters Wyoming through Northgate Canyon and continues northward through alternately mountainous and plains country until it reaches the central part of the State. Near Casper the North Platte turns eastward and flows in a southeasterly direction through eastern Wyoming into Nebraska.

Tributaries to the South Platte River originate in the Laramie Mountains and flow east-southeast through Laramie County into Colorado and Nebraska. The South Platte River joins the North Platte River in Nebraska, and the combined flow, as the Platte River, joins the Missouri River below Omaha. The Niobrara River and its tributaries in Wyoming are intermittent streams. The State-line flow of the Niobrara is variable, and at times there may be no flow. The Niobrara River flows across Nebraska and joins the Missouri River above Lewis and Clark Lake (Gavins Point Dam) on the Nebraska-South Dakota State line.

The location map, Figure I-1, shows the drainage system in the report area. Table I-4 lists the streams shown on the map by major Basin drainage (North Platte, South Platte, and Niobrara Rivers, all parts of the Missouri River drainage system) and indicates by indentation the tributary rank. Rivers and creeks are listed by higher to lower tributary rank, and in upstream to downstream order.

GEOLOGY

The Platte River Basin evolved largely as a result of events associated with the geologic development of the Rocky Mountain region. The drainage system has a complex history related to the origin of landforms in and adjoining the Basin. Patterns of deposition, uplift, and erosion of sedimentary formations have significantly influenced both surface and subsurface hydrology.

Basin Evolution

The Basin evolved geologically through many milleniums of sediment accumulation, structural deformation, and erosion. The major events interpreted from the geologic record, beginning with the earliest, are as follows:

Event
(Earliest to Latest)

Geologic Time-Rock Sequence
and Mineral Deposits

- | | |
|---|--|
| 1. Long periods of igneous activity, sedimentation, metamorphism, folding, and subsequent erosion throughout the Rocky Mountain region. Rocks that are now exposed in the cores of mountain ranges resulted from this activity. | <u>Precambrian.</u> Hosts iron ore resources. |
| 2. In the western part of the Basin, submergence and deposition alternating with emergence and erosion; prolonged emergence and erosion in the east. (Cambrian rocks are exposed near Rawlins, and Cambro-Ordovician rocks are exposed in the Wind River Range. Silurian rocks are not known to be present anywhere in the Basin. Devonian rocks may be present in the Wind River Mountains.) | <u>Cambrian through Devonian.</u> Commercial oil is produced from a basal Cambrian sandstone in the Rawlins area. |
| 3. Submergence and deposition of hundreds of feet of limestone; subsequent uplift and removal of the limestone by erosion in the southeastern part of the Basin. | <u>Mississippian.</u> The limestone is oil-productive near Rawlins. |
| 4. Gradual regional uplift and emergence. Sedimentary deposition varies significantly both vertically and laterally. (This age sequence has a wide distribution in the Basin.) | <u>Pennsylvanian through Triassic.</u> Pennsylvanian sandstones produce oil in the area between the Laramie and Medicine Bow Ranges. |
| 5. Submergence and marine deposition, followed by emergence and deposition of fresh-water sediments. | <u>Jurassic.</u> Oil-productive in southeastern part of the Basin. |
| 6. Continuing uplift in the western part of the Basin; widespread submergence and marine deposition. Gradual emergence once more and continental deposition, followed by extensive folding and faulting and mountain-building. (15,000+ feet of this age sequence are present in the western part.) | <u>Cretaceous.</u> Includes several important oil-producing sandstones. |
| 7. Continued intense folding and faulting accompanied by stream erosion and deposition of stream and lake sediments east of the Laramie Range, followed by uplift and rejuvenation of streams. | <u>Tertiary.</u> Hosts uranium minerals and coal and significant aquifers. |
| 8. Periodic uplift; more recently weathering and erosion, and stream and wind deposition. | <u>Quaternary.</u> Includes important aquifers. |

Evolution of the Drainage System

The present drainage system reflects periods of uplift and mountain building in the Basin that began more than 100 million years ago. It has been postulated that the Green River and some tributaries once flowed east in Wyoming, into the

present North Platte River drainage basin. With the origin of the Continental Divide in Wyoming, the basins of the Green and North Platte Rivers were separated.

The headwaters of the North Platte River were in areas subject to uplift. As uplift progressed, the streams eroded the sedimentary cover and entrenched themselves in the underlying granite. The course of the North Platte River where it enters Wyoming from Colorado is an example of this: the river flows towards Saratoga across relatively hard granite, instead of across the more easily erodible valley sandstone to the west. The Laramie River behaves similarly in crossing the Laramie Mountains through a granite gorge more than 1,000 feet deep, instead of flowing into the North Platte on the west side of the mountains.

East of the mountain front the action of major streams, combined with uplift, resulted in repeated cycles of downcutting and valley widening. The remnants of this activity are the various terraces, pediments, and escarpments seen in the eastern part of the Basin.

Locally, during recent time, slope wash was deposited on slopes bordering streams, alluvial fans were built on floodplains, landslide debris accumulated at the base of steep escarpments, and silt and sand were deposited in wind-scoured depressions to form sand dunes.

SOILS⁵

The wide variety of soils in the Platte River Basin is due basically to the kinds and origins of the parent materials and to variations in climatic conditions.

Mountain Soils

The soils of the forested mountains of southeastern Carbon County and southwestern Albany County are mostly shallow, well drained, dark colored, loamy, and stony. The soils in the less forested Laramie Range and the mountains of northern Carbon County are mostly shallow, well drained, and stony.

Rock outcrops are common in the mountain areas. Small areas of deep, dark-colored loamy soils occur along the small mountain streams. The mountain areas are used for summer grazing.

Foothill Soils

The foothills along the mountain fronts are usually steep and strongly dissected. The soils are developing in weathered quartzite, sandstone, and limestone and on steep talus slopes. They are mostly shallow, well drained, and stony. The soils in the Hartville Hills (north of Guernsey) and Richeau Hills (southwest of Wheatland) are similar to the foothill soils and are mostly open grasslands; some areas have brush and sparse timber cover, and a few areas have good forest cover.

Upland Soils

In the western part of the Basin are large areas of gently sloping to moderately steep uplands. The soils on the uplands are forming in residuum (sediment)

⁵ Contributed by the USDA Soil Conservation Service.

from sandstone and shale which contain variable amounts of soluble salts and/or alkali. The soils are deep, moderately deep, and shallow. They are well drained, light colored, loamy, and clayey and are used primarily for grazing. Some areas may be irrigable; if they are irrigated, care must be used to avoid the possibility of serious salinity and/or alkalinity problems.

There are many areas of steep and very steep, dissected uplands in the western part of the Basin. The soils are shallow and very shallow, loamy and clayey, developing in residuum from sandstone and shale, and are used for grazing. Rock outcrops and badland areas are common.

The nearly level to gently rolling upland soils in the eastern part of the Basin are mostly deep and moderately deep, well drained, and loamy. They are forming primarily in residuum from sandstone and siltstone and wind-reworked material from these sources. Some of the nearly level tablelands are mantled with loess⁶ and are used extensively for growing winter wheat. Some areas are irrigated. More areas are suitable for irrigation if water is available.

The moderately steep and steep upland soils in the eastern part of the Basin are mostly shallow soils developing in residuum from soft sandstone. There are many rock outcrops. These soils are used almost exclusively for grazing.

A few areas of deep sandy soils occur in the Basin. One of the most prominent areas is north and east of Torrington. At this site is found typical "sand hills" topography, with excellent grassland soils but not generally suited to cultivation because of good permeability and low available water-holding capacities.

Floodplain Soils

The soils on the floodplains in the northern and eastern parts of the Basin are mostly deep, well drained, sandy, loamy, and clayey. Along the major streams soils are developing in alluvium, but along the small streams the parent materials are of local origin. Most of these floodplain soils are irrigated. Areas of sand and gravel are common along the North Platte River.

In the western part of the Basin the soils of the floodplains are somewhat poorly to poorly drained. Some of them are underlain by gravel or cobble. Extensive areas of these soils are flood irrigated and used for the production of hay.

Fan and Terrace Soils

Large areas of nearly level to steep outwash fans and terraces occur in Albany, Carbon, Laramie, and Platte Counties. The soils on these fans and terraces are mostly well drained, dark colored, loamy, and underlain by gravel and cobble. Locally, the soils are very gravelly and cobbly. Some areas, notably the Wheatland Flats in Platte County, are used extensively for irrigated crops. Other areas are suitable for irrigation if water is available; few of these are used for dryland crops, but most are used for grazing.

⁶ Wind-deposited accumulations of fine silty material.

CLIMATE ⁷

The climate of the Basin is a product of its latitude, elevation, and topography. The plains are semiarid as a result of their distance and isolation from moisture sources. This area is in the latitudes of the prevailing westerlies with a dominance of maritime Pacific air. However, the air is modified by the several mountain ranges which are between the west coast and the Basin and which cause low-level moisture to precipitate before reaching the Basin. Moisture in the mountains of the Basin ranges from over 20 inches in the Laramie Range to over 40 inches in the Snowy Range and the Sierra Madres. Most of the plains normally receive from 9 to 16 inches of precipitation.

While the predominant air mass is maritime Pacific, continental air masses from Canada regularly invade the drainage. The shallow, cold air masses which do not have too strong a southerly push often do not cross the Laramie Range but move eastward. Upon rare occasions, continental tropical air from Mexico invades the area during the summer with resultant high temperatures and very low relative humidities. The plains to the southwest of the Laramie Range are 2,000-3,000 feet higher in elevation than those to the north and east, and consequently mean temperatures are cooler and growing seasons shorter.

Precipitation

The precipitation map, Figure I-4, shows the variation of the mean annual precipitation over the State and Basin. The average monthly precipitation and temperature are illustrated in Figure I-5, which shows the normals for representative weather stations in the Basin. Summertime precipitation is usually in the form of showers with occasional cloudbursts. Fall and winter snows are normally light, while springtime brings wet snows and rains. Annual snowfall averages from 35 to 65 inches over the plains and much more over the higher mountains. Normally, sunshine and wind keep great snow depths from accumulating on the plains, while in the mountains accumulations of several feet occur.

Water supplies of the area bear a direct relationship to the precipitation. The streams with a dependable flow rise in the mountains and derive most of their annual runoff from the spring and early summer snowmelt.

Temperature

Basin temperature variations are also shown in Figure I-5. The relatively high elevation of the Basin combined with the advent of both warm and cold air masses results in large annual and daily temperature ranges. The highest recorded summer temperature of 110° F. (Fahrenheit) occurred at Chugwater and LaGrange (elevations 5,282 and 4,582 feet respectively), but even Foxpark in the Snowy Range at 9,045 feet has recorded 90° F. The coldest official winter temperature of 55° F. below zero was recorded at Saratoga.

The growing season of the Basin is shortest on the plains southwest of the Laramie Range and longest along the North Platte River as it leaves the State near Torrington. For alfalfa and grass the growing season is assumed to be the period when mean daily temperatures are above 40° F. The growing season for other

⁷ Contributed by John Alyea, NOAA Climatologist for Wyoming.

crops has been estimated with the assistance of specialists in the College of Agriculture, University of Wyoming, and is measured from planting date to harvest. Planting dates were estimated to be a specified number of days before or after the date when the mean daily temperature rises above 40° F., depending upon crop type. Average 40° growing seasons for forage crops, as well as 32° freeze-free periods, at selected stations in the Basin are shown in Table I-5.

TABLE I-5 -- Average 40° Growing Seasons and Average Freeze-Free Periods at Selected Basin Weather Bureau Stations

Station	County	Normal Date of 40° Mean Daily Temperature ¹		Length of Growing Season (Days)	Normal Date of 32° Occurrence ²		Length of 32° Freeze-Free Period (Days)
		Spring	Fall		Spring	Fall	
Casper	Natrona	4-8	11-2	208	5-22	9-28	129
Cheyenne	Laramie	4-11	11-1	204	5-23	9-27	127
Chugwater	Platte	4-3	11-1	212	6-3	9-13	102
Douglas	Converse	4-4	10-30	209	5-21	9-19	121
Encampment	Carbon	4-16	10-28	195	6-3	9-16	105
LaGrange	Goshen	3-30	11-7	222	5-24	9-21	120
Laramie	Albany	4-18	10-27	192	5-29	9-19	113
Lusk	Niobrara	4-6	11-2	210	5-26	9-18	115
Pathfinder Dam	Natrona	4-6	11-2	210	5-20	9-23	126
Pine Bluffs	Laramie	3-30	11-3	218	5-21	9-21	123
Rawlins	Carbon	4-12	10-28	199	5-31	9-10	102
Saratoga	Carbon	4-15	10-26	194	6-10	8-29	80
South Pass City	Fremont	5-8	10-8	153	No dependable 32° occurrence-free period		
Torrington Exp. Farm	Goshen	3-28	11-3	220	5-18	9-22	127
Wheatland	Platte	3-26	11-8	227	5-15	9-25	133

¹ Taken from "Consumptive Use of Irrigation Water in Wyoming," by Trelease, Rechard, Burman, and Swartz. Wyoming Water Planning Program, Report No. 5, Water Resources Series No. 19, July 1970.

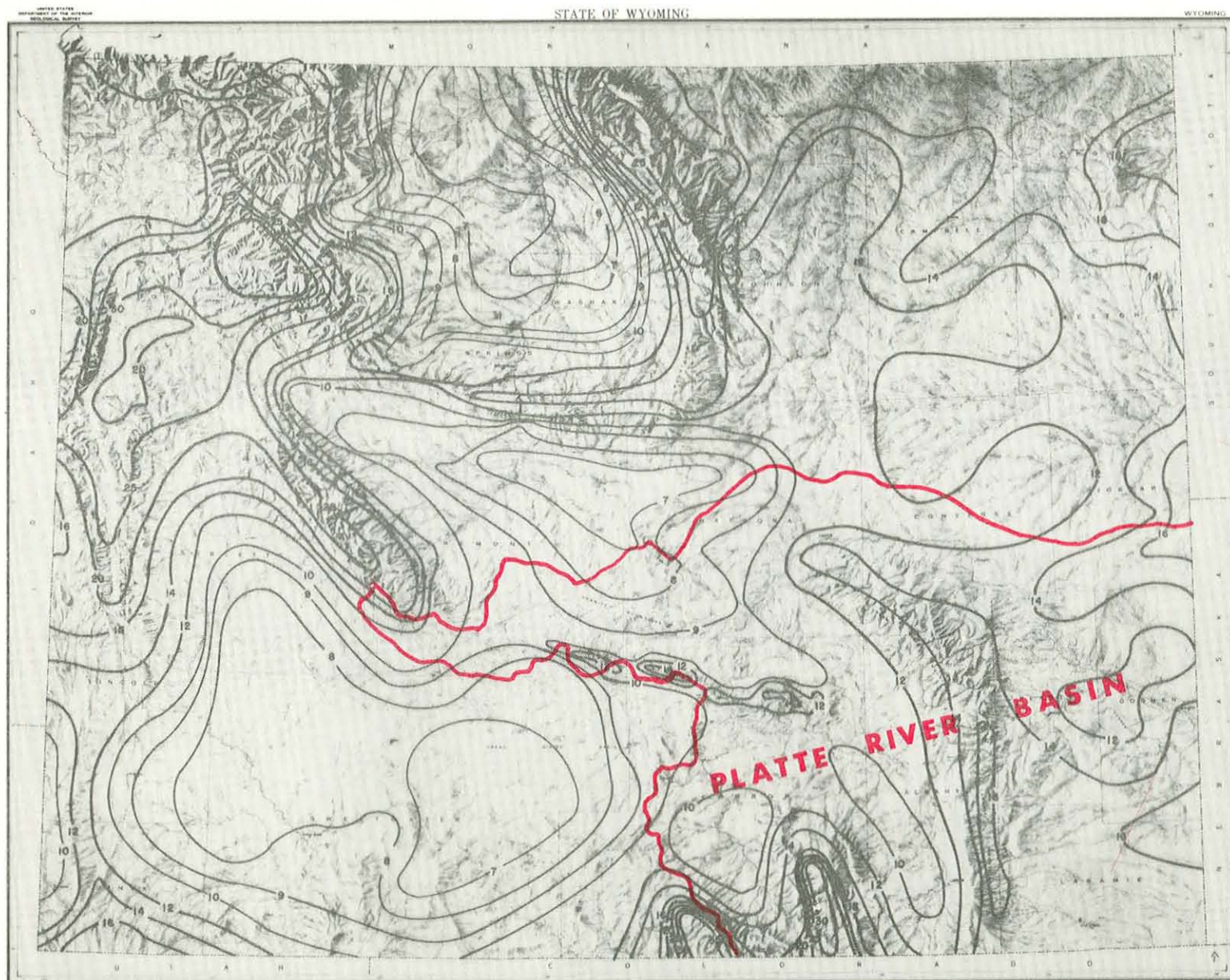
² Taken from "Climatological Summary," by John D. Alyea, NOAA Climatologist for Wyoming.

The predominant crops southwest of the Laramie Mountains are grasses, forage, and small grain. In this area, the average length of the period when the mean daily temperature exceeds 40° F. varies from 192 days at Laramie to 199 days at Rawlins. In the warmer area north and east of the Laramie Mountains, this period varies from 204 days at Cheyenne to 227 days at Wheatland. The growing season, average temperatures, solar radiation, and other climatological factors affect the evapotranspiration (water use) rate of plants. The consumptive use of irrigation water increases from the higher, cooler portions of the area to the lower, warmer portions.

Sunshine, Relative Humidity, and Winds

Sunshine is estimated to average about 65 to 70 percent of the possible day-time hours on an annual basis, ranging from about 55 to 60 percent during the winter and spring and about 75 to 80 percent during the summer and fall.

Relative humidity over most of the area is estimated to average about 55 percent annually, ranging from 35 to 40 percent for July and August and 70 to 75 percent during December. Considerable variation in relative humidity is recorded both daily and annually.



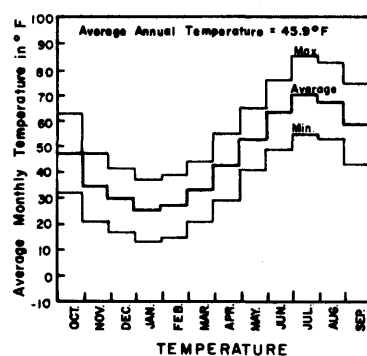
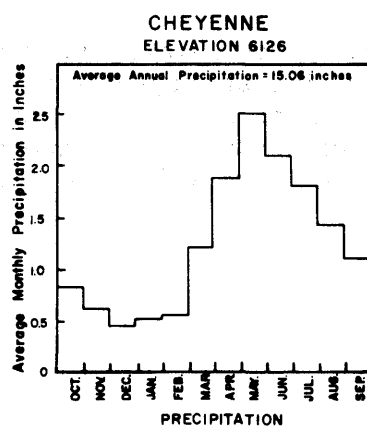
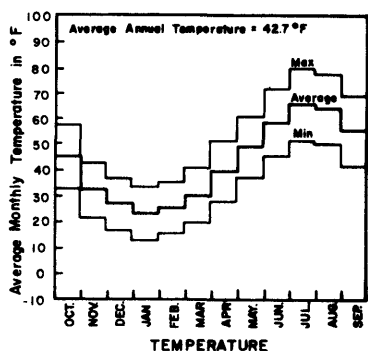
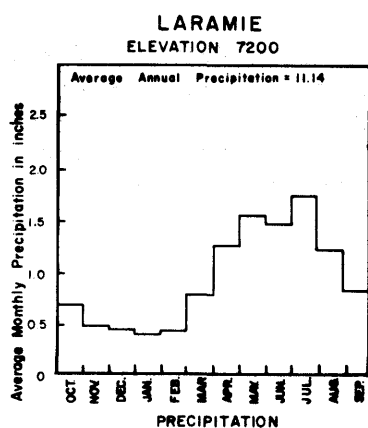
Prepared by the Wyoming Water Planning Program in
cooperation with E.S.A. Weather Bureau State
Climatologist Wyoming

MEAN ANNUAL PRECIPITATION
AS OF 1965
(IN INCHES)

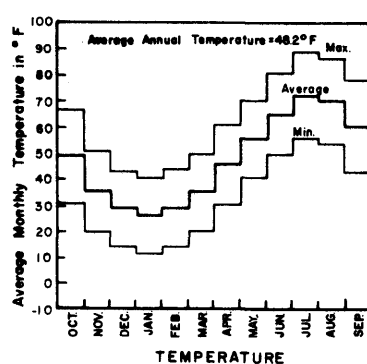
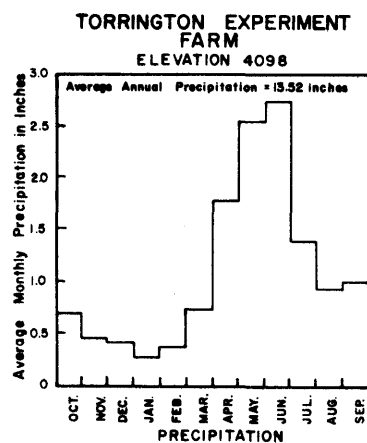
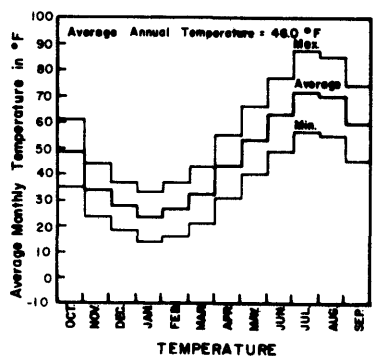
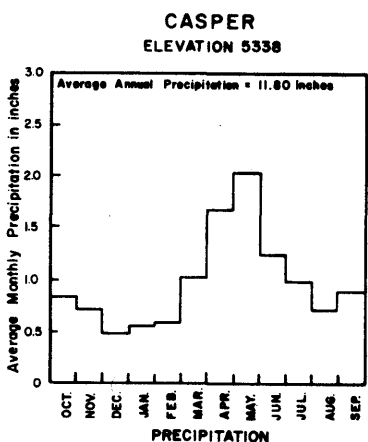
Figure I-4

Important Note:

Caution should be used in interpolating
on this map. Mountainous areas receive higher amounts
than indicated. Wide fluctuations from average can be
expected in local areas from year to year.



Source: National Weather
Service Records



**Figure I-5 Average Monthly Precipitation & Temperature
At Selected Stations Of The Platte River Basin**

Winds are relatively strong over the area and, as is typical of a semiarid climate, the strongest winds occur during daylight hours. Winds average around 12 mph (miles per hour) annually, with 15 mph winds in winter and spring and 7 to 10 mph winds in the summer. Strong winds of 30 to 40 mph with higher gusts can prevail for a few days, and occasional periods occur with very light winds.

C H A P T E R I I

S U R F A C E W A T E R R E S O U R C E S

S U R F A C E W A T E R R E S O U R C E S

The water resources of any region are its lakes, streams, groundwater, and the precipitation that creates the water supplies. The streams of the Platte River Basin are highly utilized to provide water supplies for irrigation and municipal and industrial water uses as well as for fish and wildlife habitat and well-known hunting, fishing, and other water-based recreation.

WATER SUPPLIES AND STREAMFLOW CHARACTERISTICS

The streams of the Basin that are important as water supply sources contribute the major part of annual runoff in the spring and early summer months. The late summer, fall, and winter flows are derived from groundwater effluent, mostly from the alluvial aquifers associated with the streams. These aquifers are recharged by spring runoff and irrigation.

Surface water flows are measured by stream gages maintained through cooperative agreements between the Wyoming State Engineer, the U. S. Geological Survey (USGS), and others. Figure II-1 shows the locations of the more important stream gages in the Basin. Water year 1948 (beginning October 1, 1947) has been used as the beginning of the base period for the water supply studies in this report. A base period of 1948-1968 was selected because it is current and most of the selected gages have continuous records during this time. The base period includes years of extremely low runoff as well as average years and years of high runoff.

The hydrographs of average monthly runoff (Figure II-2) show the monthly variation of streamflow at selected sites. Since crop irrigation demands are greatest in July and August, it can be seen that reservoirs are required to regulate streams to provide irrigation water for the latter part of the growing season. The North Platte River at Northgate, the Laramie River near Jelm, and Deer Creek in the canyon near Glenrock are all uncontrolled streams, while the North Platte River below Guernsey Reservoir is controlled by reservoirs. Most irrigation from uncontrolled streams has late summer water shortages.

The North Platte is the major river of the area and is one of the most highly utilized and controlled rivers in the Nation. Figure II-3 shows the average flow along the North Platte River in Wyoming. After entering the State from Colorado the river flows about 444 miles through Wyoming and into Nebraska. On the way, the water is used for recreation and hydropower production and is diverted for irrigation and municipal and industrial uses, which consume a portion of the water. In the first 126 miles of the journey through the State, from the State line to Seminoe Reservoir, the river picks up considerable tributary inflow in the Saratoga Valley. At the same time there are 85,240 acres irrigated from the river and its tributaries in this reach. In the next reach of 63 miles the river flows through Seminoe Reservoir, which controls water for the Kendrick Project near Casper, and then through the Kortess Reservoir and powerplant into Pathfinder Reservoir where it is controlled for the North Platte Project in Wyoming and Nebraska. Tributary inflow to this reach from the Medicine Bow River, the Sweetwater River, and several other tributaries provides water to irrigate 55,100 acres. From Pathfinder Reservoir, the North Platte River flows through Fremont Canyon powerplant, Alcova

Reservoir and powerplant, and Gray Reef Reregulation Reservoir. It flows past Casper, Glenrock, and Douglas and enters Glendo Reservoir 170 miles from Pathfinder. Glendo Reservoir reregulates power releases to provide irrigation water and also provides flood control storage. The river then flows through Glendo powerplant and a distance of 18 miles to the Guernsey Reservoir, which provides additional storage for the North Platte Project. After passing another powerplant it is a short distance (9 miles) to Whalen Diversion Dam. The Laramie River enters the North Platte River between Whalen Dam and the Wyoming-Nebraska State line, 58 miles from Whalen Dam. There are 87,440 acres of land irrigated from the North Platte River in this reach. Whalen Dam is the diversion dam for the North Platte Project. As can be seen on Figure II-3, about 762,000 acre-feet of water per year are diverted into the Fort Laramie and Interstate Canals for the North Platte Project. The river gain from Whalen Dam to the State line is attributed to tributary inflow and return flow from irrigation in the Wyoming portion of the North Platte Project area.

The average annual streamflow of the Laramie River is also shown on Figure II-3. The Laramie River flows some 182 miles from the Colorado-Wyoming State line to the North Platte River at Fort Laramie, Wyoming. The Laramie River is heavily used for irrigation both in the Laramie Valley and in the vicinity of Wheatland. An average of 171,800 acres are irrigated from the Laramie River in Wyoming. After flowing through the Laramie Valley, the river is regulated by the Wheatland No. 2 Reservoir to provide irrigation water supplies for the Wheatland Irrigation District.

The South Platte River Study Area (see Figure II-4, page 41) has four primary streams leaving the State: Lodgepole, Crow, Lone Tree, and Dale Creeks. These creeks have an estimated annual discharge of 8,900 acre-feet per year leaving the State, and most of the runoff is contributed by Lodgepole Creek. There are 28,335 irrigated acres in the South Platte Study Area. The Niobrara River at the Wyoming-Nebraska State line has an average discharge of 3,200 acre-feet per year.

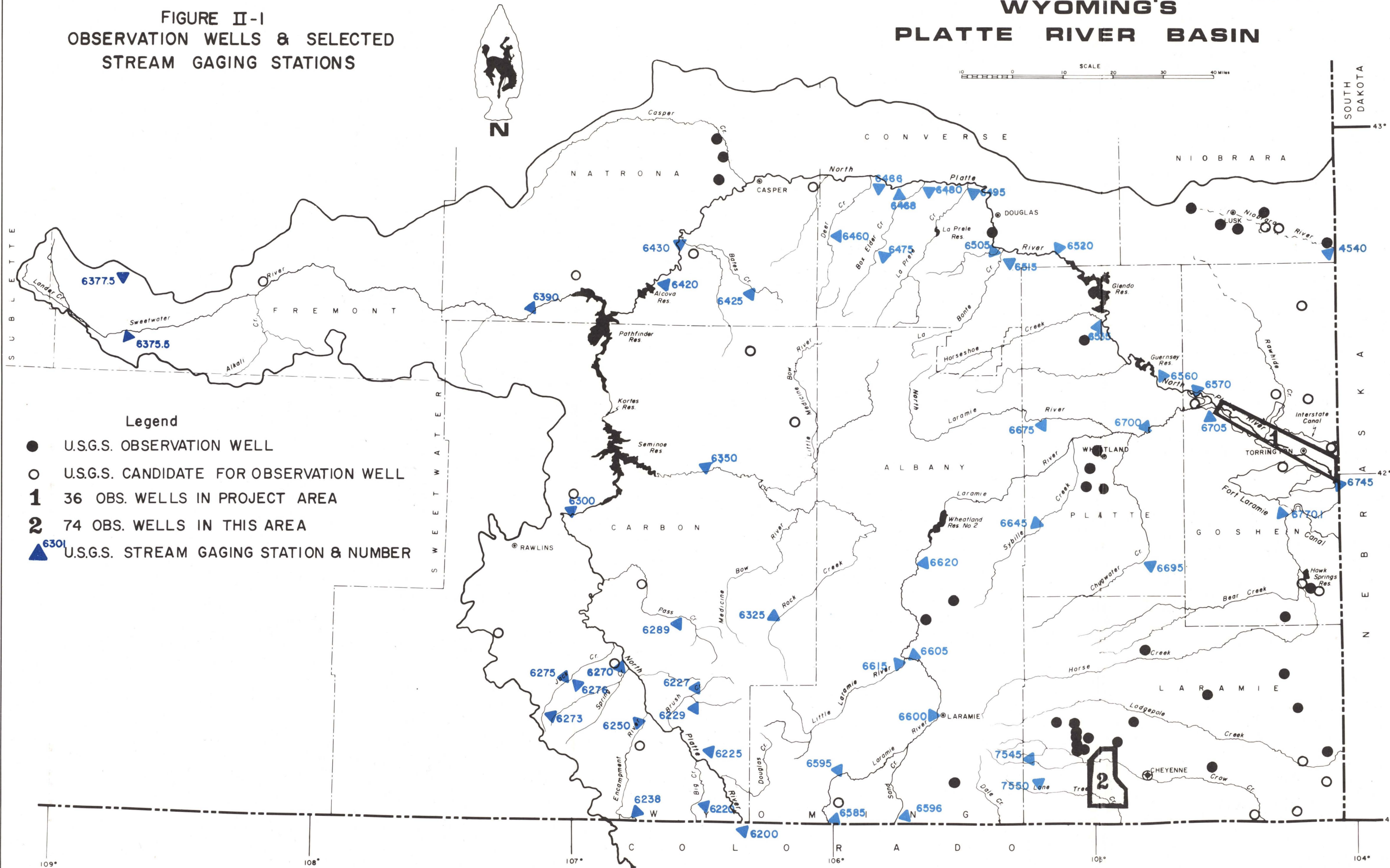
In order to calculate the total streamflow of the Basin originating in Wyoming, estimates were made of the streamflow depletions caused by man's activities. These include reservoir evaporation, stock pond evaporation, irrigation consumptive uses, and municipal and industrial consumptive uses. The data were prepared for the study areas shown on Figure II-4. Table II-1 gives a summary of the data. The estimated streamflow originating in the Platte River Study Area of Wyoming under natural conditions is about 1,240,000 acre-feet per year. Adding the measured inflow to the State, the average annual natural streamflow that would be leaving the State is estimated to be about 1,770,000 acre-feet per year. In Wyoming, 580,150 acre-feet of surface water per year are consumed by irrigation, 9,760 acre-feet by industry, 8,720 acre-feet by municipal and domestic uses, 2,760 acre-feet by evaporation from stock ponds, and a total of 176,800 acre-feet by evaporation from reservoirs that control water supplies for man's use. The total consumptive use in the Platte River Basin is about 778,000 acre-feet per year. Thus, the discharge leaving the State of Wyoming is 992,000 acre-feet per year of which about 462,000 acre-feet originate within the State boundaries.

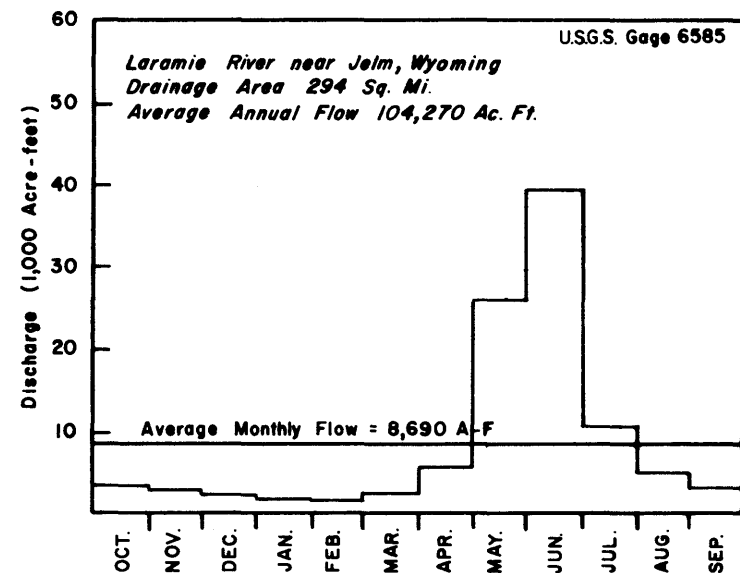
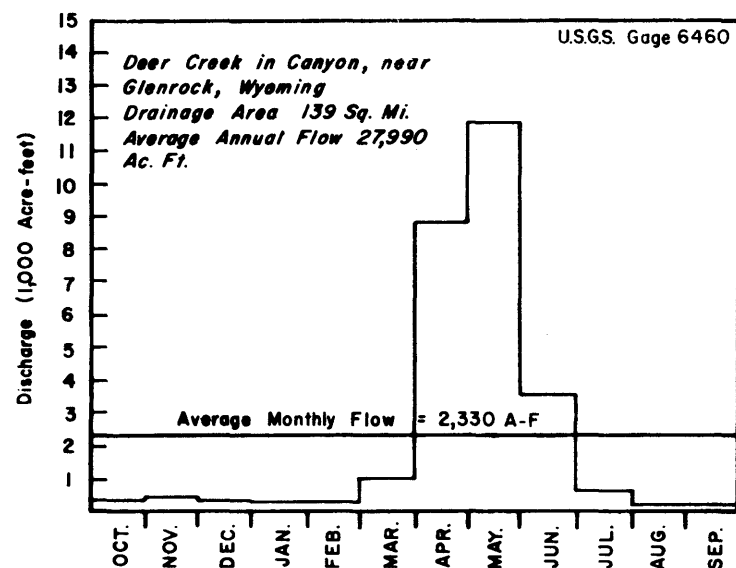
Streamflows may be artificially augmented in the future. Potential sources of increased water supplies for uses both in Wyoming and downstream states are improved watershed management, importation of water from other river basins, and augmentation of precipitation (weather modification). The U. S. Bureau of

FIGURE II-1
OBSERVATION WELLS & SELECTED
STREAM GAGING STATIONS

WYOMING'S PLATTE RIVER BASIN

WYOMING STATE ENGINEERS OFFICE
WATER PLANNING PROGRAM





Source: U.S.G.S. Records
 Note the variation in the scales

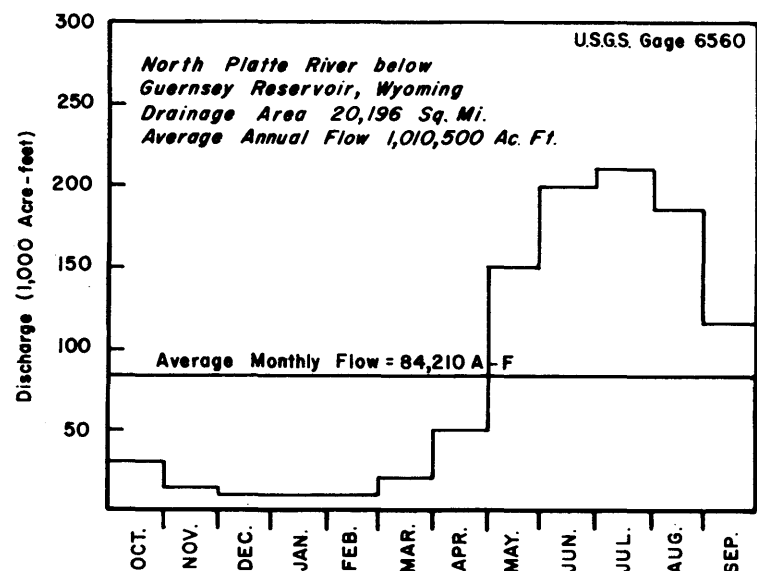
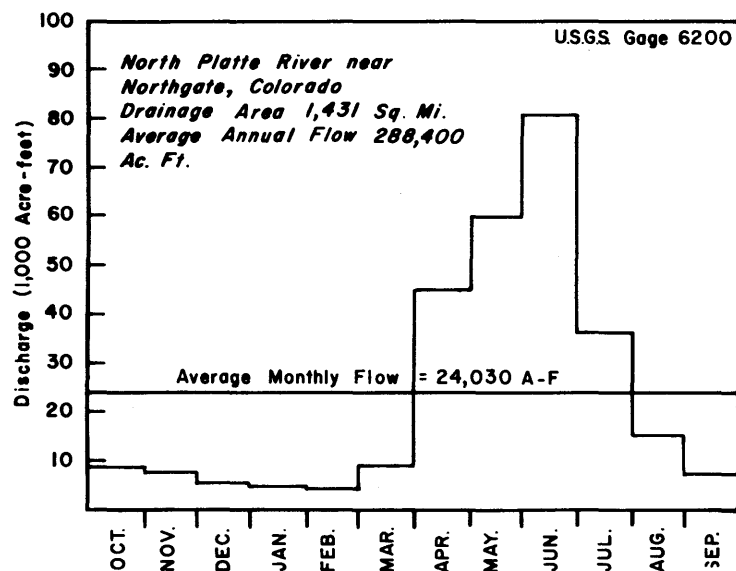


Figure II-2 Monthly Runoff of Selected Streams in the Platte River Basin

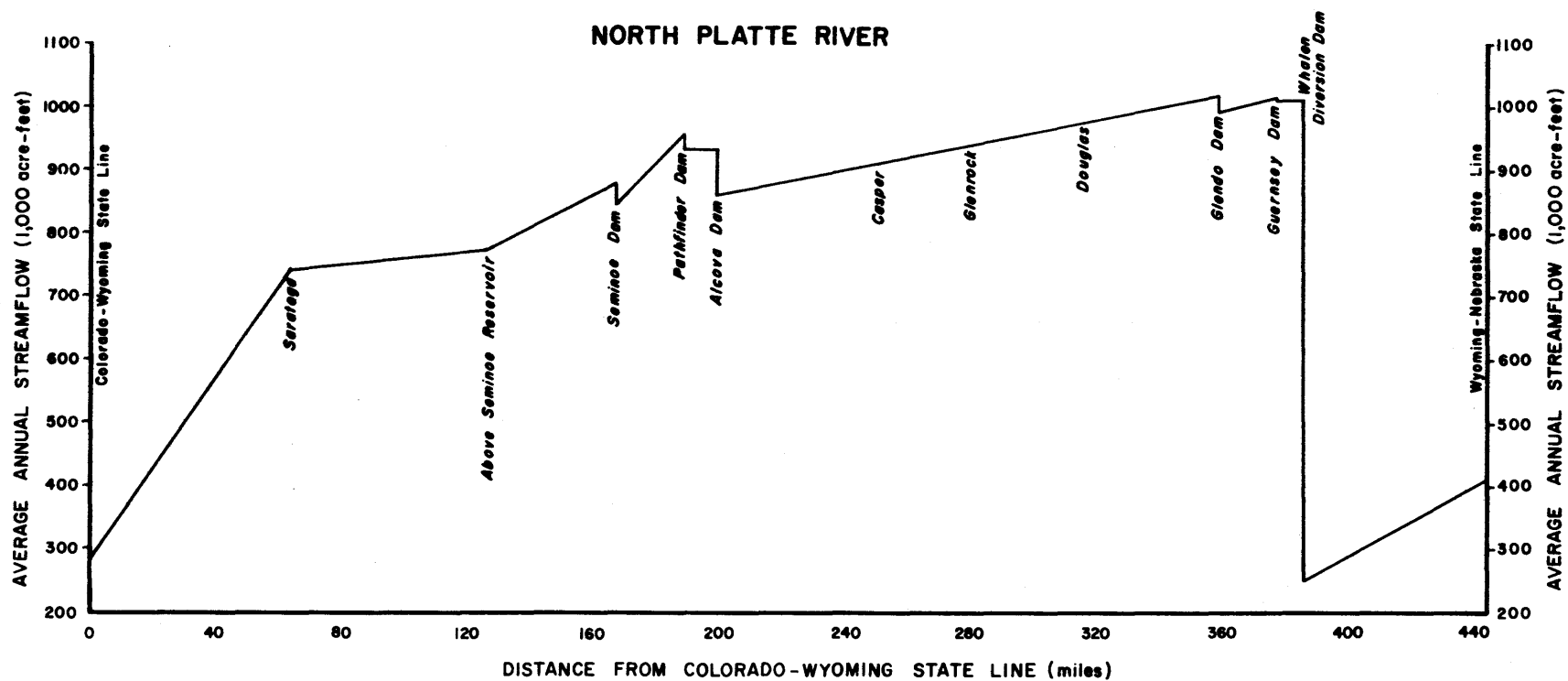
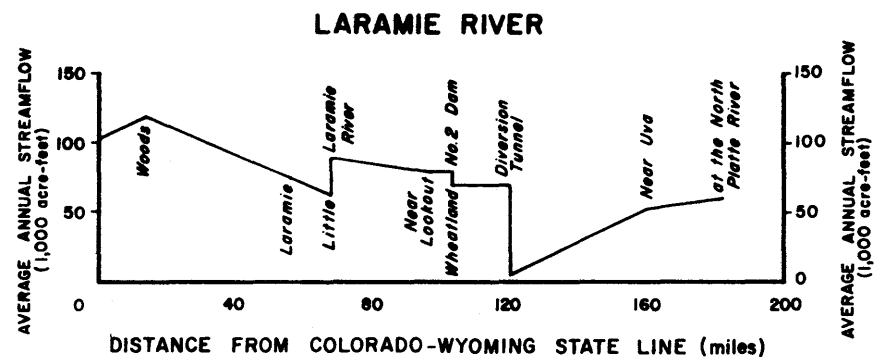


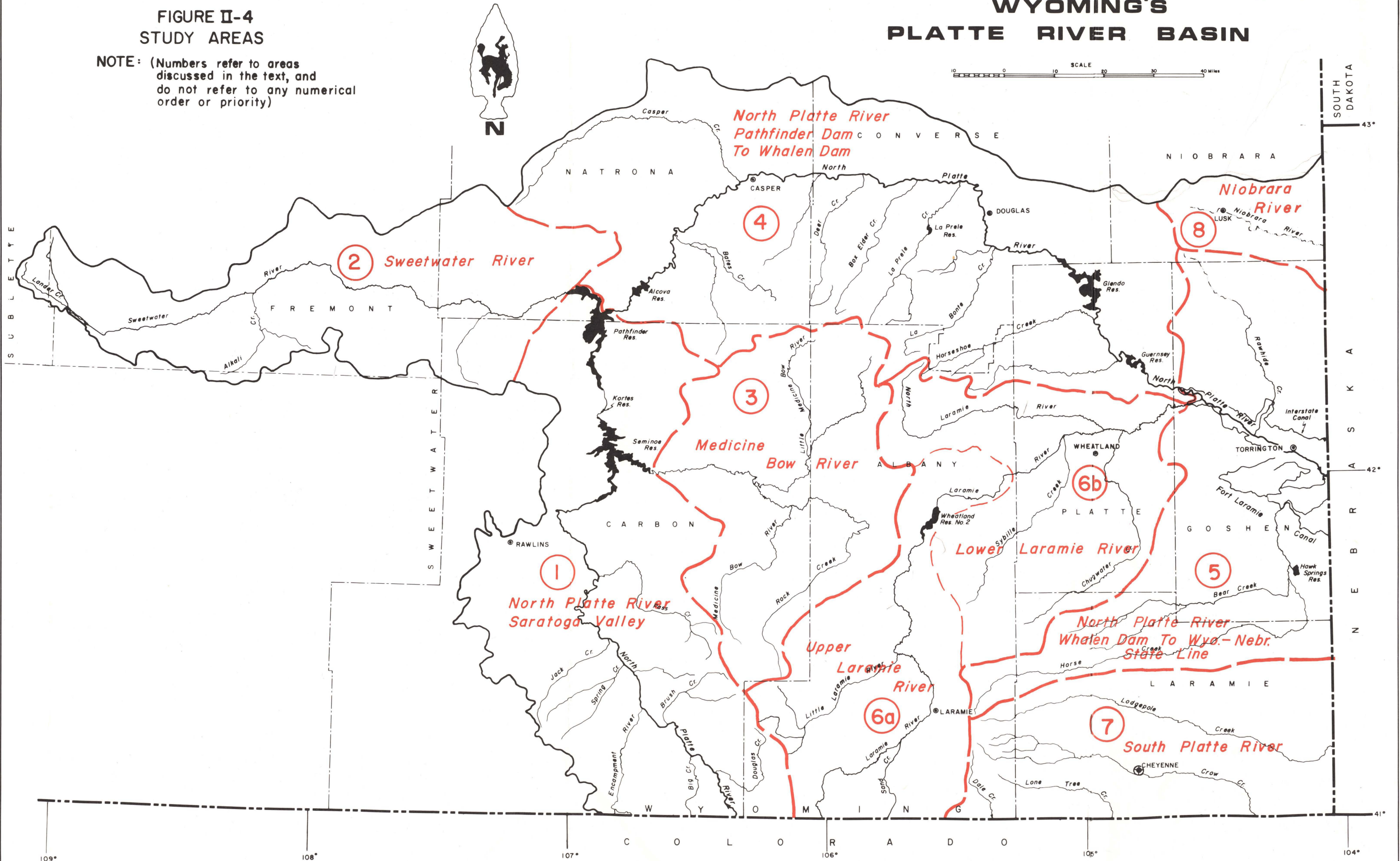
Figure II-3 Average Annual Streamflow of the Laramie & North Platte Rivers

FIGURE II-4
STUDY AREAS

NOTE: (Numbers refer to areas discussed in the text, and do not refer to any numerical order or priority)

WYOMING'S PLATTE RIVER BASIN

WYOMING STATE ENGINEERS OFFICE
WATER PLANNING PROGRAM



Reclamation is conducting extensive research on artificially augmenting precipitation. As part of this research the Natural Resources Research Institute (NRRI) at the University of Wyoming has found that precipitation can be induced over mountains from "cap clouds" that would ordinarily not produce snowfall. The NRRI is currently under contract with the State of Wyoming to develop operational procedures for increasing the snowpack on mountain ranges. The Bureau of Reclamation will soon begin an operational test of snowpack augmentation capabilities in the North Platte River Basin. It is understood that the first phase of this study will involve an evaluation of the ecology of the affected area so that the effect of the test program can be determined. The next phase of the program will be an operational test for several years to determine the potential for snowpack augmentation, its cost, and the required operating procedures.

TABLE II-1 -- Estimated Annual Water Yield, Platte River Study Area
1948-1968

Study Area	Study Area Gaged Inflow Minus Outflow	Irrigation Consumptive Use	North Platte River Main Stem Reservoir Evaporation	Reservoir Evaporation	Stock Pond Evaporation	Industrial Consumptive Use	Municipal Consumptive Use	Total Area Yield
	(ac-ft)	(ac-ft)	(ac-ft)	(ac-ft)	(ac-ft)	(ac-ft)	(ac-ft)	(ac-ft)
1. Saratoga	330,700	95,700	62,900 ²	6,000	230	790	980	497,300
2. Sweetwater River	75,000 ¹	5,250	---	2,600	10	830	---	83,690
3. Medicine Bow River	104,400 ¹	49,600	---	8,300	610	---	---	162,910
4. North Platte, Path- finder to Whalen Dam	84,800	112,100	38,000 ³	16,200	950	7,360	2,470	261,880
5. North Platte, Whalen Dam to State Line	- 94,200	144,100	---	12,900	440	---	---	63,240
6. Laramie River	- 51,300	166,900	---	25,900	460	---	1,590	143,550
Total N. Platte R.	449,400	573,650	100,900	71,900	2,700	8,980	5,040	1,212,570
7. South Platte River	8,900	3,500	---	3,000	---	780	3,680	19,860
8. Niobrara River	3,200	3,000	---	1,000	60	---	---	7,260
Total	461,500	580,150	100,900	75,900	2,760	9,760	8,720	1,239,690 ⁵

¹ Streamflow entering North Platte River.

² 35,100 acre-feet evaporation from Seminoe and 27,800 acre-feet evaporation from Pathfinder.

³ 8,400 acre-feet evaporation from Alcova, 27,200 acre-feet evaporation from Glendo, 2,400 acre-feet evaporation from Guernsey.

⁴ Included in Study Area 5.

⁵ The flow passing the State line into Nebraska and Colorado would be 1,769,590 acre-feet per year without development in Wyoming since 419,700 and 110,200 acre-feet per year flow into Wyoming from Colorado in the North Platte and Laramie River Basins respectively.

FLOODS

Flood damage, with certain specific exceptions, is not a major problem in the Platte River Basin of Wyoming. With the high storage control on the North Platte River, the flood damage potential along the main stem is rather minor. However, there is a possibility that a major flood in the North Platte River could cause flood damages in Casper, Douglas, and Torrington, even with this control. The majority of the main stem reservoirs were constructed without specific flood control space. Glendo Reservoir was constructed with 272,800 acre-feet of flood control space.

Many tributaries of the North Platte River have experienced flooding. Generally, the majority of the damage is to agricultural developments, highways and railroad crossings, with some damage to sparse urban developments.

In irrigated areas diversion structures, canals, and laterals frequently experience severe flood damage, mostly caused by spring snowmelt combined with local rainstorms. Tributaries which are especially susceptible to flooding are Horse, LaBonte, Wagonhound, Horseshoe, Box Elder, LaPrele, and Deer Creeks (79).

In recent years the most severe flooding on these tributaries occurred in the springs of 1965 and 1970. In 1965 the streams between Casper and Glendo which have their headwaters in the Laramie Mountains southeast of Casper reached flood peaks that exceeded the 50-year frequency. Up to 32 inches of snow fell in the drainage areas of these tributaries on May 7-9, 1965. When the rains began on May 13, there was a general cover of snow containing four to six inches of moisture above the 6,000-foot elevation. The rain, combined with the moisture in the snow, resulted in an estimated maximum of 10 inches of moisture in some areas (55). Flooding on Deer Creek in 1965 inundated many dwellings in the town of Glenrock and damaged oil well pumps on the floodplain. Floods on Box Elder, LaPrele, Wagonhound, LaBonte, and Horseshoe Creeks damaged ranch homes, destroyed bridges, eroded or deposited sediment on farm lands, and damaged or destroyed irrigation structures(55). The 1965 peak discharge on Deer Creek of 12,800 cfs exceeded the previous maximum recorded peak (1924) by 4.5 times (55). Preliminary estimates by the U. S. Geological Survey showed that in June of 1970 a peak of 14,000 cfs in Deer Creek flowed through the town of Glenrock causing considerable damage. In 1970 a peak of 18,000 cfs (USGS preliminary estimate) occurred on LaBonte Creek. This was the highest ever recorded on LaBonte Creek, exceeding the previous high of 8,770 cfs which occurred in May of 1965.

Another type of flood damage in the Basin results from flash floods caused by cloudbursts. An area which has been particularly susceptible to this type of flooding is in Goshen County near the large Interstate and Fort Laramie Canals. These canals cross a number of small intermittent tributaries which flow only in response to precipitation. Major storms in these small drainages have occasionally caused flows to exceed the capacities of the underpasses beneath the canals. Severe damage has thus occurred to the canals, to croplands above the underpass which were inundated by the backed-up water, and to croplands served by the canals which were without irrigation water while the canals were being repaired. Projects have been constructed on four such drainages for watershed protection and flood damage prevention under Public Law 566. Other P.L. 566 projects are being planned or contemplated in the Basin. (See Chapter IV, Flood Control).

The North Platte River could cause flood damages in the valley between Whalen Dam in Wyoming and Lake McConaughy in Nebraska. Three factors responsible for this risk are (79):

1. The upstream control and diversions are causing a lower peak and average flow than natural, with the result that the river is unable to keep a large channel clear of sediment, brush, and trees, and the channel capacity is thus reduced.
2. The lack of high flows has encouraged improvements on lands subject to floods.
3. There is a possibility that a greater flood runoff will occur than has previously been recorded.

WATER QUALITY¹

Quality of water refers to its physical and chemical characteristics and biological and radiological content. The goal of water quality management is to maintain water of adequate quality for multiple uses, both for present and future needs. Two water quality factors should be considered in every water development project. First, the water must be of adequate quality for the use for which it is intended. Second, if the water is not 100 percent consumptively used, the return flow quality must be considered.

Water Quality Standards

The Federal Water Quality Act of 1965 required that the states adopt water quality standards for all interstate waters. The water quality standards approved by the Wyoming State Board of Health were accepted and approved by the Federal Water Pollution Control Administration of the Department of the Interior (now the Water Quality Office of the Environmental Protection Agency or EPA) in November of 1968. The intent of the Interstate Water Quality Standards is to insure that all multiple use demands are met. This means that recreation and fish and wildlife propagation and overall aesthetic values are met, while at the same time municipal, industrial, and agricultural demands are met. These latter demands call for both a source of usable water and for an assimilative receptacle for the discharge or return flows of waste waters. A further criterion for quality levels in streams is to hold quality at such levels that conventional treatment techniques, such as sedimentation, filtration, and chlorination, would be the maximum treatment needed to enhance the quality to potable condition.

Within the North Platte, South Platte, and Niobrara drainages, the following streams are designated as interstate waters for which water quality standards have been established: North Platte River, Stretch I (upstream of Alcova Dam), North Platte River, Stretch II (Alcova Dam to U. S. Highway 87 bridge at Douglas), North Platte River, Stretch III (Highway 87 bridge at Douglas to Nebraska State line, including interstate canals), Laramie River, Horse and Lodgepole Creeks, and Niobrara River.

The water quality standards established for interstate streams are based on physical and chemical characteristics, biological content, and radiological content. Water quality standards for intrastate streams have not been established.

Generally, the quality of interstate waters in the Platte River Basin is within the limits of established standards.

Based on water use and existing conditions, ten basic standards and five variable standards have evolved. The following list of basic standards is summarized from "Water Quality Standards for Interstate Waters in Wyoming," published by the Wyoming Department of Public Health (now the Department of Health and Social Services):

1. Physical: Water should be essentially free of obvious and/or offensive pollutants such as particulates, taste, odor, and color, and the temperature should permit natural aquatic life.

¹ Contributed by the Sanitary Engineering Division of the State Department of Health and Social Services.

2. Chemical: Water should be free of toxic materials, and the dissolved oxygen and pH (measure of acidity or alkalinity) should permit natural aquatic life.

3. Bacteriological: The concentration of fecal coliform bacteria in water should be within the most probable number (MPN) limit set for the particular stream.

4. Radiological: Water should have a level of radioactivity below the limit set in the U. S. Public Health Service Drinking Water Standards of 1962.

Salinity (total dissolved solids) in water is becoming a controversial issue due to unknowns and variables affecting its degree of concentration. Where salinity increase can be attributed to specific discharges capable of control, specific control measures shall be instituted, and a specific numerical standard may be adopted. Where salinity increase is due to widespread irrigation or to natural accumulation of salts, the control is beyond present technology, and a numerical standard has no meaning. Where control remains beyond present technology, an interim approach with the following provisions is recommended:

1. A routine monitoring program should be implemented to determine any unreasonable increases that might be attributable to new specific sources capable of control.

2. An educational program should be established through the Agricultural Extension Service and the Soil and Water Conservation Districts as to the proper control and use of water and implementation of improved control methods as they are developed.

3. As the State has initiated a "State Water Plan" that must consider quality as well as quantity and uses, and as completion of the basic plan is projected for 1972, sufficient data should be available by that time to consider specific numerical standards for salinity.

In addition to the above basic standards which apply to all Wyoming interstate waters, the following special water quality standards have been established for designated interstate streams within the Basin.

A. North Platte River, Stretch I: Wastes or substances of other than natural origin shall not be discharged into these waters in amounts which (1) will cause organisms of the fecal coliform group to exceed 240 per 100 ml (MPN) as a geometric mean of the last five consecutive samples, nor exceed 750 per 100 ml in any one sample, or (2) will result in a pH value in these waters of less than 6.5 or greater than 8.5.

B. North Platte River, Stretch II: Wastes or substances of other than natural origin shall not be discharged into these waters in amounts which will result in a pH value in these waters of less than 7.0 or greater than 8.5.

C. North Platte River, Stretch III: (1) Wastes or substances of other than natural origin shall not be discharged into these waters in amounts which will cause organisms of the fecal coliform group to exceed 240 per 100 ml (MPN) as a geometric mean of the last five samples, nor exceed 750 per 100 ml in any one sample (this standard applies only to the waters of Glendo and Guernsey Reservoirs

which are designated as full-body-contact recreation areas), or (2) will result in a pH value in these waters of less than 7.5 or greater than 8.5. (3) The control of salinity will be carried out in accordance with the general policy outlined on page 46 of this report.

D. Laramie River: The basic water quality standards applying to all interstate waters in Wyoming are the only standards applicable to these waters at this time.

E. Horse Creek and Lodgepole Creek: Same as above.

F. Niobrara River: Same as above.

Historical Water Quality Data in the Platte and Niobrara River Basins

An informal cooperative program of physical and chemical monitoring in the Basin has been carried out since the inception of Wyoming's water pollution control program in 1956. The agencies involved in this program are the State Engineer's Office, the Wyoming Game and Fish Commission, the Department of Agriculture, the State Department of Health and Social Services, and the U. S. Geological Survey.

The State Department of Agriculture carries out the basic chemical quality-of-water program in cooperation with the USGS and the State Engineer's Office. Although the existing program does not cover all interstate waters, it is felt that it is adequate to provide a good control network for the major drainage basins. In the Basin, monthly sampling has been started on Horse Creek near Yoder and LaGrange and at the State line for the Niobrara River.

Personnel of the Game and Fish Commission play a very important part in the monitoring of streams within the State. Fishery management crews maintain a personal and continuous supervision of Wyoming waters and are aware of all conditions that may affect fisheries. In addition, the Game and Fish Commission has two men assigned statewide as pollution analysts, who are responsible for detailed study of water quality problems.

The State Department of Health and Social Services is responsible for the supervision of municipal and industrial waste water facilities and for the necessary bacteriological and radiological monitoring to determine compliance with the proposed standards. Bacteriological monitoring is done at the following locations:

- (1) North Platte River, Stretch I -- I-80 highway bridge
- (2) North Platte River, Stretch II -- county bridge $\frac{1}{2}$ mile north of Glenrock
- (3) North Platte River, Stretch III -- Douglas water intake above outlet
- (4) Glendo Reservoir -- above dam

Radiological monitoring is done at:

- (1) North Platte River -- Fort Steel Bridge
- (2) Medicine Bow River -- at Highway 487 crossing 1 mile north of the town of Medicine Bow
- (3) Little Medicine Bow River (four stations in the Shirley basin uranium mining district)
 - (a) north of the town of Medicine Bow
 - (b) 28 miles point (from Medicine Bow)

- (c) mid-point of river stretch
- (d) uranium mining company pond discharge
- (4) Sweetwater River at Sweetwater Station
- (5) Sweetwater River at Split Rock
- (6) North Platte River at Alcova
- (7) North Platte River at Douglas
- (8) Laramie River at Howell
- (9) North Platte River at State line

The State Department of Health and Social Services is increasing its surveillance of interstate and intrastate streams on a problem-oriented basis. Specific instances of such recent surveillance in the Basin have been at Crow Creek (Cheyenne), North Fork of the Little Laramie River, and Sugar Creek (Rawlins).

The Water Quality Office has a Missouri River Basin program sampling point on the North Platte River below Casper which is operated by the USGS.

Existing and Potential Water Quality Problems

The available data indicate that the water quality of the interstate streams of the Basin is in general agreement with adopted interstate standards. Table II-2 shows present municipal and industrial waste water sources which currently present little or no problem to Basin water quality. However, it is conceivable that future development of Basin water resources may deplete the receiving waters to such extent that pollution from these sources could cause problems.

It is recognized that irrigation return flows can, by virtue of the soil characteristics of the irrigated land, carry significant amounts of sediments and total dissolved solids (TDS or salinity) into the receiving stream. Other agricultural enterprises, such as feedlots, exist in the Basin but are presently of minor importance to water quality. There are two basic causes of salinity increases in a stream, and they need to be distinguished. These are the "salt loading" and "salt concentrating" effects. Salt loading is produced by the discharge of additional minerals from municipal, industrial, agricultural, or natural sources into a stream. The salt concentrating effect occurs as a result of the diversion and consumptive use of water. In this case, the salt load diverted and returned to the stream via return flows is the same, but the consumption of pure water and consequent loss of this water from the system increases the concentration.

Table II-3 shows a flow and TDS profile based on USGS streamflow and water quality records at selected sampling points along the North Platte River and its larger tributaries.

Table II-3 indicates a general increase downstream in TDS concentrations. There exists a significant measured increase in TDS between Alcova and Glenrock and again from Guernsey Dam to the State line. In the Alcova-Glenrock stretch this increase can be accounted for as follows:

(1) The main stem diversions in this stretch supply water to approximately 24,000 irrigated acres, many of which can be classified as generally high in salt levels due to comparatively new projects and to soil conditions.

(2) Tributary flows from Bates, Poison Spider, and Casper Creeks, which irrigate approximately 24,000 acres, could possibly result in high TDS levels from

TABLE II-2 -- Waste Water Treatment

A. Municipal Systems

<u>City</u>	<u>1970 Population</u>	<u>Treatment</u>	<u>Receiving Waters</u>
Encampment	321	Pond ¹	Encampment River
Saratoga	1,181	Pond, Imhoff Tank	North Platte
Rawlins	7,855	Ponds	Sugar Creek
Sinclair	445	2 Imhoff Tanks	Sugar Creek
Jeffrey City	700	Retention ¹	No discharge
Shirley Basin	300	Pond	Spring Creek (2 miles to Little Medicine Bow River)
Medicine Bow	455	Pond	Medicine Bow River
Hanna	460	Municipal Septic Tanks - 3 (Absorption)	Big Ditch Creek
McFadden	135	Community Septic Tank and Absorption System	Rock Creek
Brooks Sanitary District	1,000	Pond	Casper Creek
Mills	1,724	Pond	Casper Creek
Paradise Valley	1,764	Extended Aeration and Pond	North Platte
Casper	39,361	Aerated Primary	North Platte
Alcova	80	Pond	North Platte
Evansville	832	Pond	North Platte
Glenrock	1,515	Ponds - 2	North Platte
Douglas	2,677	Ponds - 2	North Platte
Glendo	210	Imhoff Tank and Rock Filter	North Platte
Guernsey	793	Pond	North Platte
Sunrise	200	Imhoff Tank and Filter	4 miles north of North Platte
Hartville	246	Septic Tank Sand Filter	4 miles north of North Platte
Camp Guernsey	2,000 (seasonal)	Pond	North Platte
Fort Laramie	197	Pond	North Platte
Lingle	446	Pond	North Platte
Torrington	4,237	Pond - 2	North Platte
Rock River	344	Discharge	Rock Creek
Laramie	23,143	Pond - 4 (Pond Aeration under Construction)	Laramie River
Summit Rest Area	-	Extended Aeration	Middle Fork, Crow Creek
Wheatland	2,498	Pond	Rock Creek (6 miles to Laramie River)
Cheyenne	40,914	Secondary Trickling Filter	Crow Creek
South Cheyenne Sanitary District	4,000 (est.)	Extended Aeration	Crow Creek
Cheyenne Little America	250 (est.)	Extended Aeration and Pond	Crow Creek
Albin	118	Imhoff Tank and Pond	Horse Creek tributary
LaGrange	189	Pond (Under Construction)	Horse Creek
Pine Bluffs	937	Imhoff Tank & Secondary Pond	Lodgepole Creek
Lusk	1,495	Extended Aeration	Niobrara River
Manville	92	Septic Tank	Niobrara River

B. Towns Without Public Systems

<u>City</u>	<u>1970 Population</u>	<u>Treatment</u>	<u>Adjacent Waters</u>
Riverside	46	Soil Absorption Systems	North Platte
Elmo	53	Soil Absorption	Big Ditch Creek
Elk Mountain	127	Soil Absorption	Medicine Bow River
Yoder	101	Soil Absorption	Horse Creek and Fort Laramie Canal
Hawk Springs	100	Soil Absorption	Horse Creek
Arlington	10 (est.)	Soil Absorption	Rock Creek
Centennial	100	Soil Absorption	Little Laramie River
Bosler	50	Soil Absorption	Laramie River
Chugwater	187	Soil Absorption	Chugwater Creek
Horse Creek	100	Soil Absorption	Horse Creek
Burns (Approaching construction stage)	185	Soil Absorption (Pond Under Planning)	Lodgepole Creek
Carpenter	100	Soil Absorption	Crow Creek
Hillsdale	80	Soil Absorption	Lodgepole Creek
Van Tassell	21	Soil Absorption	Niobrara River

C. Industrial Systems

<u>Company</u>	<u>Location</u>	<u>Treatment</u>	<u>Effect on Interstate Waters</u>
Atlantic Richfield Oil Refinery	Sinclair	Retention	None
Uranium Mining & Milling	Shirley Basin	Retention	None
American Oil Refinery	Casper	Retention	None
Texaco Oil Refinery	Evansville	Retention	None
Little America Oil Refinery	Evansville	Retention	None
Dave Johnston Powerplant	Glenrock	Cooling water return to North Platte River	Minor temperature effect
Phillips 66 Refinery (L.P. Gas)	Douglas	Pond	None
Sunrise Iron Mine	Sunrise	Retention	None
Holly Sugar Refinery	Torrington	Separation, retention, and screening	Minor addition of turbidity, B.O.D., and Coliform
Forest Products Company	Laramie	Retention and relocation of Laramie River	None
Husky Oil Refinery ²	Cheyenne	Serial ponds	None
Wycon Chemical (ammonia plant)	Cheyenne	Injected into Hygiene sandstone	None
Union Pacific Railroad ²	Cheyenne	Flotation and sedimentation	None
Geneva Steel Co. (Ore Mine)	Lander	Retention (bypass surface flow)	None

¹ "Pond" refers to stabilization ponds with treated discharge. "Retention" indicates no discharge.

² Discharges from these facilities do reach Crow Creek following treatment. However, agricultural use depletes the flow downstream.

return flow, in the inflow to the North Platte. High selenium content in soil and in return flows is a subject of current investigation.

(3) A population of approximately 50,000 in the vicinity of Casper can, by virtue of an estimated 148 pounds of TDS per capita per year, contribute 3,700 tons (or 1.8%) of the TDS accretion along this stretch.

TABLE II-3 -- Flow and TDS Profile for North Platte River and Major Tributaries

<u>Stream</u>	<u>Location</u>	<u>Flow¹ (cfs)</u>	<u>TDS¹ (ppm)</u>	<u>TDS¹ (Tons/A-F)</u>
North Platte	Northgate, Colorado	399	190	.26
North Platte	Above Seminoe Reservoir	1,070	235	.32
Medicine Bow	Above Seminoe Reservoir	144	713	.97
North Platte	At Alcova	1,179	309	.42
Sweetwater	Near Alcova	104	235	.32
North Platte	Near Glenrock	1,202	478	.65
North Platte	Near Orin	1,250	478	.65
North Platte	Below Guernsey Reservoir	1,398	471	.64
Laramie	Near Fort Laramie	81	463	.63
North Platte	State Line	572	529	.72

¹ Flow and TDS levels are time-weighted averages. However, quality data are from relatively recent records and may not reflect long-term trends.

The TDS concentration increase between Guernsey Reservoir and the State line is due in part to tributary inflow and also to the effects of the irrigation of some 84,000 acres of land in this reach.

There are minor water quality problems in the South Platte River drainage area in Wyoming. An environmental clean-up project has been identified for the reach of Crow Creek through Cheyenne in the Cheyenne Model Cities Program. The major concerns are pollution control and cleaning up the floodplain of Crow Creek through Cheyenne. Irrigation of 28,335 acres depletes nearly all the natural flow of the South Platte tributaries in Wyoming. For this reason, none of the streams has been designated as interstate, and no interstate stream standards apply. "Grab samples" for TDS determinations in Lodgepole Creek showing 272 ppm indicate that a negligible, if any, water quality problem exists.

No quality data are currently available on the Niobrara River, although a sampling station has been proposed at the State line.

In conclusion, when considering the water quality aspects of irrigation in the Platte River Basin, two basic facts have had continuing considerations:

- (1) The individual farmer or rancher has a legal right to use the water, and
- (2) For continuous irrigation, the return flows must carry a tonnage of salt equal to that applied to the land (salt balance). Therefore, in irrigation, some degradation of surface water quality will occur.

For municipalities and industries it is technically possible to provide waste water treatment such that no water quality deterioration occurs.

With continued growth of recreation in the Basin, proper facilities will also be required at campgrounds, picnic areas, and other such places in order to prevent localized pollution problems.

The effects on water quality of various potential developments in the Basin are discussed in Chapter V.

WATER RIGHTS

The Wyoming Constitution declares that the waters of all natural streams, springs, lakes, or other collections of still water within the boundaries of the State are the property of the State. Constitutional provisions allow the appropriation of water for beneficial uses and establish the Office of State Engineer and the Board of Control to supervise such appropriations. The Board of Control consists of the State Engineer and the Superintendents of each of the four administrative water divisions of the State. The State Engineer is President of the Board of Control and has general supervision of the distribution of water and of the officers connected with water distribution.

State Statutes establish the procedures for the appropriation of water for beneficial use. First, a permit to use water and construct works must be obtained from the State Engineer. After the diversion is completed and proof of beneficial use of water is made to the Board of Control, the Board will adjudicate the water right. Priority of appropriation is based upon the relative dates on which applications for permits were accepted in the State Engineer's Office. "First in time is first in right," is the basis of Wyoming water law.

The "Water Resources Inventory for Water Division Number 1," published in 1965 by the State Engineer, presents tabulations of water rights in the Basin. Table II-4 is a summary of data in that report, updated through December 31, 1970.

Total irrigated acreage in the Platte River Basin of Wyoming was determined by the Wyoming Water Planning Program during the summer of 1969. The irrigated lands were identified by field examination and mapped on aerial photographs. Irrigated lands totaled 552,760 acres, some 627,000 acres less than existing water rights. No attempt was made in this inventory phase of work to compare irrigated lands with water rights. The existence of more water rights than irrigated land is not unique to the Platte River Basin; a similar situation exists throughout the State.

The excess of water rights over actually irrigated lands presents a special problem in the area of the North Platte River drainage where irrigation is limited by U. S. Supreme Court decree to 168,000 acres. As shown in Table II-4 there are 325,847 acres with water rights in good standing in the North Platte River decree area. About 156,620 acres were identified as being irrigated in the decree area by the irrigation inventory. The large discrepancy between actual irrigation and water rights needs to be reconciled, especially in the decree area, to protect the diligence and investments of junior appropriators who may suffer because senior priority "paper rights" are activated and available water supplies and acreage limits are exceeded.

TABLE II-4 -- Tabulation of Adjudicated Acres and Permits in Good Standing
(December 31, 1970)

Section (1)		Adjudicated Acres (2)	Permits in Good Standing (3)	Total (2) & (3) (4)
North Platte River Basin	Colorado State Line to Pathfinder Dam			
	1. Main Stem North Platte River	12,888	719	13,607
	2. Medicine Bow River Basin	95,725	5,915	101,640
	3. Sweetwater River Basin	14,321	2,595	16,916
	4. Other Tributaries	148,741	10,708	159,449
	5. Under Seminoe High Water Line	195	---	195
	6. Under Pathfinder High Water Line	1,673	---	1,673
	Total	273,543	19,937	293,480
	Pathfinder to Guernsey Dam			
	1. Main Stem North Platte River ¹	42,901	9,638	52,539
	2. North Platte River Tributaries	108,444	30,538	138,982
	3. Main Stem under Glendo High Water Line	2,908	1,018	3,926
	4. North Platte River Tributaries under Glendo High Water Line	208	361	569
	Total	154,461	41,555	196,016
	Guernsey to Nebraska State Line			
	1. Main Stem North Platte River	89,298	0	89,298
	2. Minor Tributaries	6,591	1,868	8,459
	3. Horse Creek and Tributaries	65,029	3,848	68,877
	4. Laramie River and Tributaries	293,145	179,613	472,758
	Total	454,063	185,329	639,392
North Platte River Basin Total		882,067	246,821	1,128,888
South Platte River Basin		44,006	3,141	47,147
Niobrara River Basin		2,804	675	3,479
Grand Total - Study Area		928,877	250,637	1,179,514
Decree Area North Platte River		296,218	29,629	325,847
Non-Decree Area North Platte River		585,849	217,192	803,041

¹ Includes Kendrick Project - 23,134 adjudicated acres and 964 acres of permits in good standing.

COURT DECREES AND INTERSTATE COMPACTS

Development of irrigation in the Basin began in the 1860's, with the most rapid expansion from 1880 to about 1910. Pathfinder Reservoir went into operation in 1909, and the North Platte Project lands that were developed thereafter comprised the last large block of lands placed under irrigation until the Kendrick Project was settled beginning in 1946. The dependable water supplies of most streams in the Basin were utilized fairly rapidly. By 1910 the Laramie River was over-appropriated, and construction was begun of works intended to divert about 50,000 acre-feet of water per year from the Laramie River to the Cache la Poudre River in Colorado. During 1911 the State of Wyoming brought suit in the U. S. Supreme Court against Colorado to enjoin this diversion.

After Pathfinder Dam was constructed on the North Platte River, it was believed that water resources were available for further development. Negotiations were held among the States of Colorado, Wyoming, and Nebraska in an attempt to divide the excess water thought to be available. A series of drought years began in 1931, and severe shortages of water for irrigation occurred, including shortages of Pathfinder storage water. Construction of the Kendrick Project began in 1933. During October 1934 Nebraska brought suit in the U. S. Supreme Court against Wyoming over administration of the waters of the North Platte River. Colorado was later brought into the suit, and the United States intervened.

Both the Laramie River and the North Platte River court cases were very lengthy and costly processes. Agreements, or interstate compacts, dividing water uses among states, such as those agreed upon in other Wyoming river basins, usually provide a better, more amiable solution to interstate water problems. An interstate compact for the Upper Niobrara River was ratified by Wyoming and Nebraska in 1963 and by the U. S. Congress in 1969.

Laramie River Decree

The U. S. Supreme Court handed down its decree restricting the Colorado uses of the Laramie River in 1922, some eleven years after the proceedings began. A modification of this decree was submitted after the findings of a court-appointed commission were revealed in 1936. In 1957 a stipulation was agreed upon by both Colorado and Wyoming, and the Court amended the decree.

Under decree the State of Colorado can divert from the Laramie River and its tributaries 49,375 acre-feet of water each calendar year for use in Colorado. The return flow and remaining water of the Laramie River is allocated to Wyoming. Of the 49,375 acre-feet of water allotted to Colorado, not more than 19,875 acre-feet may be diverted out of the Laramie River Basin for use in the Cache la Poudre River Basin. The remaining 29,500 acre-feet of water may be diverted and used to irrigate lands within the Colorado portion of the Laramie River Basin. Not more than 1,800 acre-feet of the 29,500 acre-feet may be diverted in any calendar year after July 31 of that year.

North Platte River Decree

The Supreme Court proceedings that began in 1934 terminated in the decree of 1945. In 1953, partly because of the plans for construction of Glendo Dam, a stipulation amending the decree was agreed upon by the three states involved--Colorado, Wyoming, and Nebraska.

Under the North Platte River Decree, the State of Colorado is limited to the irrigation of 145,000 acres of land and the storage of 17,000 acre-feet of irrigation water from the North Platte River and its tributaries in any water year. The transbasin diversion for irrigation from the North Platte River and its tributaries in Colorado may not exceed 60,000 acre-feet of water in any 10 consecutive water years.

The State of Wyoming is limited to the irrigation of 168,000 acres of land, exclusive of the Kendrick Project, from the main stem of the North Platte River above Guernsey Reservoir and the tributaries of the North Platte River above Pathfinder Dam. Exclusive of Seminoe Reservoir, not more than 18,000 acre-feet of irrigation water may be stored in Wyoming on the North Platte River or its

tributaries above Pathfinder Reservoir in any one water year. The natural flow of the North Platte River, including the contribution of Spring Creek in the reach from Guernsey Dam to Tri-State Dam (1 mile beyond the State line in Nebraska), is divided 25 percent to Wyoming and 75 percent to Nebraska. Glendo Reservoir has the right to store in any water year, in addition to the evaporation, a maximum of 40,000 acre-feet of the natural flow waters of the North Platte River and its tributaries below Pathfinder Dam. These waters are divided 15,000 acre-feet to the water users in southeastern Wyoming below Guernsey Reservoir and 25,000 acre-feet of water to be used in the North Platte River Basin in western Nebraska. The storage in Glendo Reservoir for these lands, including carry-over storage, may not exceed 100,000 acre-feet.

The following priorities were established for the reservoirs in the North Platte River Basin, beginning with the highest: Pathfinder Reservoir, Guernsey Reservoir, Seminoe Reservoir, Alcova Reservoir, and Glendo Reservoir. The storage of water in these reservoirs is in accordance with the above priorities; however, water may not be stored in these reservoirs or diverted from the natural flow of the river through Casper Canal between and including May 1 and September 30 of each year, and these rights are junior to the French and State Line Canals. The return flow from the Kendrick Project is considered part of the natural flow of the North Platte River.

Upper Niobrara River Compact

This recently approved compact establishes an agreement between Wyoming and Nebraska for the utilization of the water resources in the Niobrara River west of Range 55 West of the 6th Principal Meridian. For surface waters the compact imposes restrictions for uses with priorities after August 1, 1957. The amount of storage in reservoirs with a priority before August 1, 1957, is limited to 500 acre-feet per year, and the time in which the water may be stored is restricted. These restrictions apply to storage from the main stem of the Niobrara River east of Range 62 West of the 6th Principal Meridian and from the main stem of Van Tassell Creek south of Section 27, Township 32 North, Range 60 West of the 6th P. M. Beginning August 1, 1957, domestic and stock water ponds are restricted to 20 acre-feet or less. After August 1, 1957, the period of the year that water may be stored in the main stem Niobrara River and Van Tassell Creek is limited, and all direct flow diversions are to be regulated on the basis of priority date, whether in Wyoming or in Nebraska. The compact recognizes that the use of groundwater for irrigation in the Niobrara River Basin may be a factor in the depletion of the surface flows of the Niobrara River. The apportionment of groundwater was delayed until such time as adequate information regarding groundwater is available.

AVAILABLE WATER RESOURCES

As previously indicated, under the present water uses and constraints, the surface water resources of the Basin appear to be largely utilized. It has been estimated that an average of about 2,000,000 acre-feet of surface water are diverted each year for irrigation in the Basin. There are, however, some water supplies that could be developed.

If the North Platte River Decree could be modified, water is physically available to improve the present water supplies on the main stem of the North Platte River and on many of the tributaries where irrigated acreage and water

storage are restricted. Water supplies can be developed on North Platte River tributaries not restricted in the decree. These possibilities are discussed in Chapter V.

The present water uses from the main stem of the North Platte River have an adequate water supply in most years. The Kendrick and North Platte Projects are provided storage water from the U. S. Bureau of Reclamation reservoirs.

Irrigation from most small streams in the Basin is generally limited to the snowmelt runoff season of the year, and water supply shortages begin in July of most years. Ranchers have adapted crops and irrigation methods to this water supply, but crop improvements and improved, more efficient irrigation methods are limited without storage reservoirs to regulate water supplies. Storage reservoirs have been constructed in many areas. These reservoirs assist many irrigators and irrigation districts in managing water supplies.

The surface water resources of the South Platte and Niobrara River Basins in Wyoming are fully utilized at the present. The annual runoff in both areas is small and in many streams undependable.

Further discussion of water supply needs is presented in Chapter IV, and potential projects and water development alternatives are discussed in Chapter V.

CHAPTER III

GROUNDWATER RESOURCES

GROUNDWATER RESOURCES

OCCURRENCE

The primary sources of groundwater are precipitation and the infiltration of surface water. The amount of underground storage space (porosity), the ability of the rock unit to transmit water (permeability), the depth to water, and the hydraulic gradient are characteristics which for the most part have been determined by past geologic environment.

Underground water, rather than collecting in large pools, usually occurs as fluid filling the very small pore spaces in the sediment or rock. If enough of these small spaces are interconnected, the saturated portion of the sediment or rock is an aquifer. Aquifers are found in unconsolidated sands and gravels, in sandstone and conglomerate, and in other rock types. The effectiveness of an aquifer can be increased by secondary porosity and permeability. For example, in limestone, solution cavities of tremendous volume can develop below the water table and can contain extensive quantities of groundwater. Fractures can create excellent aquifers in rocks which otherwise would not effectively transmit water.

In the interest of brevity the basic inventory data on the groundwater resources of the Basin are presented as maps and tables. Figure III-1 is a map showing the generalized surface distributions of the Quaternary, Tertiary, and pre-Tertiary rock units, and the regional groundwater potential of the three major time-rock units. The scale of this map does not permit showing the distribution of each individual aquifer or rock unit. As an aid to visualizing the distribution and correlation of aquifers within the Basin, Figure III-2 shows the three geologic regions and the township and range subdivision of the Basin. Figure III-3 shows the geologic basins and study areas superimposed on a map of Basin physiography. The three illustrations bring together the overall geologic panorama of the Basin and show that, among other things: (1) Quaternary and Tertiary sediments have extensive distributions within the Basin, (2) the Laramie Mountain Range and the Casper arch separate the High Plains from the other geologic regions, and (3) surface water divides do not coincide with groundwater divides.

Tables III-1 through III-8 describe the geologic formations. Stratigraphic units from the surface to the basement are correlated in Tables III-1, -2, and -3. The groundwater potential of each of the numerous formations is described in Tables III-4, -5, -6, -7, and -8.

QUALITY OF GROUNDWATER

Groundwater generally is classified, as to chemical constituents, by the amount of total dissolved solids in parts per million (ppm)¹. The U. S. Geological Survey uses U. S. Public Health Service standards (1962) for interstate common carriers as a guide for evaluating the suitability of domestic supplies.

¹ More recently also in milligrams per liter (mg/l).

TABLE III-1 -- Correlation of Quaternary and Tertiary Formations or Units in the
Platte River Basin of Wyoming

Time-Rock System	Time-Rock Series	Lithologic Unit or Formation (Thickness in Feet)			
		Granite Mountain and Wind River Mountain Areas	Intermontane Basins		High Plains
			North	South	
Quaternary	Recent and Pleistocene	Alluvium and windblown sand, ash and undifferentiated deposits. (0-100+)	Alluvium, windblown sand, terrace deposits, and landslide debris. (0-50)		Landslide material, alluvial fans, windblown sand, slope wash, flood-plain alluvium and valley fill, and terrace deposits. (0-300)
Tertiary	Pliocene	Bug formation (0-125)	(absent or unreported - a/u)	North Park formation (0-1,700)	Channel deposits (0-60)
		Moonstone formation (0-1,350)			Ogallala formation (0-330)
	Miocene	Split Rock formation	Arikaree formation (0-180)	Browns Park formation (0-1,200)	Unnamed deposits (0-30) ¹
		Arikaree formation (0-2,700)			Arikaree formation (0-1,000) ²
	Oligocene	White River formation (0-650)	White River formation (0-750)		White River group Brule formation (0-700)
					Chadron formation (0-800)
	Eocene	Ice Point conglomerate (0-200)	Wagon Bed formation (0-150)	(absent or unreported - a/u)	(absent or unreported)
		Bridger formation (0-700)			
		Igneous Intrusives			
		Laney shale member (0-300)			
		Cathedral Bluffs tongue (0-200)			
		Tipton tongue (0-100)			
	Paleocene	Niland tongue (0-275)	Wind River and Indian Meadows formations (0-8,000+)	Wind River and Hanna formations (0-500)	Wasatch formation (0-?)
		Luman tongue (0-75)			
		Red Desert tongue (0-1,300+)			
		Fort Union formation (0-3,000)			

¹ May include members of the Hemingford group (Sheep Creek and Marsland formations, top to bottom).

² Includes lateral equivalents of the Arikaree group (from top to bottom, Harrison, Monroe Creek, and Gering formations) of western Nebraska, and may also include a part of the younger Marsland formation locally in Goshen County.

(Formation thicknesses given in Tables III-1, -2, -3 are approximate and subject to revision.)

TABLE III-2 -- Correlation of Cretaceous Formations or Units in the Platte River Basin of Wyoming

Time-Rock System	Lithologic Unit or Formation (Thickness in Feet)				
	Granite Mountain and Wind River Mountain Areas	Intermontane Basins ¹		High Plains	
	Lance formation (0-2,700)	Lance formation (0-4,500?)	Medicine Bow formation	Lance formation (0-3,250?)	Laramie formation
C R E T A C E O U S	Mesteetse formation (0-650)	Lewis shale (2,000-3,000)		Fox Hills sandstone (0-550)	
	Mesaverde formation (0-1,100)	Mesaverde formation (1,200-3,500)		Pierre shale	
	Cody shale (3,500-5,000)	Steele shale (2,500-3,300)		Hygiene sandstone member	
	Niobrara formation (?)	Niobrara formation (425-700)		(2,500-5,700)	
	Frontier formation (600-1,000)	Frontier formation (400-?)	Carlile shale (?-400)	Carlile shale (460-540)	Benton shale (0-1,400)
	Mowry shale (250-500)	Mowry shale (100-300)		Mowry shale (0-250)	
	Muddy sandstone (0-75)	Muddy sandstone (0-?)		Muddy sandstone (0-100)	Newcastle sandstone
	Thermopolis shale (100-150)	Thermopolis shale (100-125)		Thermopolis shale (0-?) ³	Skull Creek shale (160-200)
	Cloverly formation (300-500) ²	Cloverly formation (100-250)		Cloverly formation (0-300)	Fall River sandstone
				Iryan Kara group	Lakota conglomerate

¹ The thickest interval of Lance through Steele is in the Hanna Basin and amounts to a maximum of about 14,000 feet.

² Includes the combined thicknesses of the Cloverly and underlying Morrison.

³ An undivided thickness of the Mowry-Thermopolis shale interval in Platte County is reported as 1,100+ feet.

TABLE III-3 -- Correlation of Pre-Cretaceous Formations or Units in the Platte River Basin of Wyoming

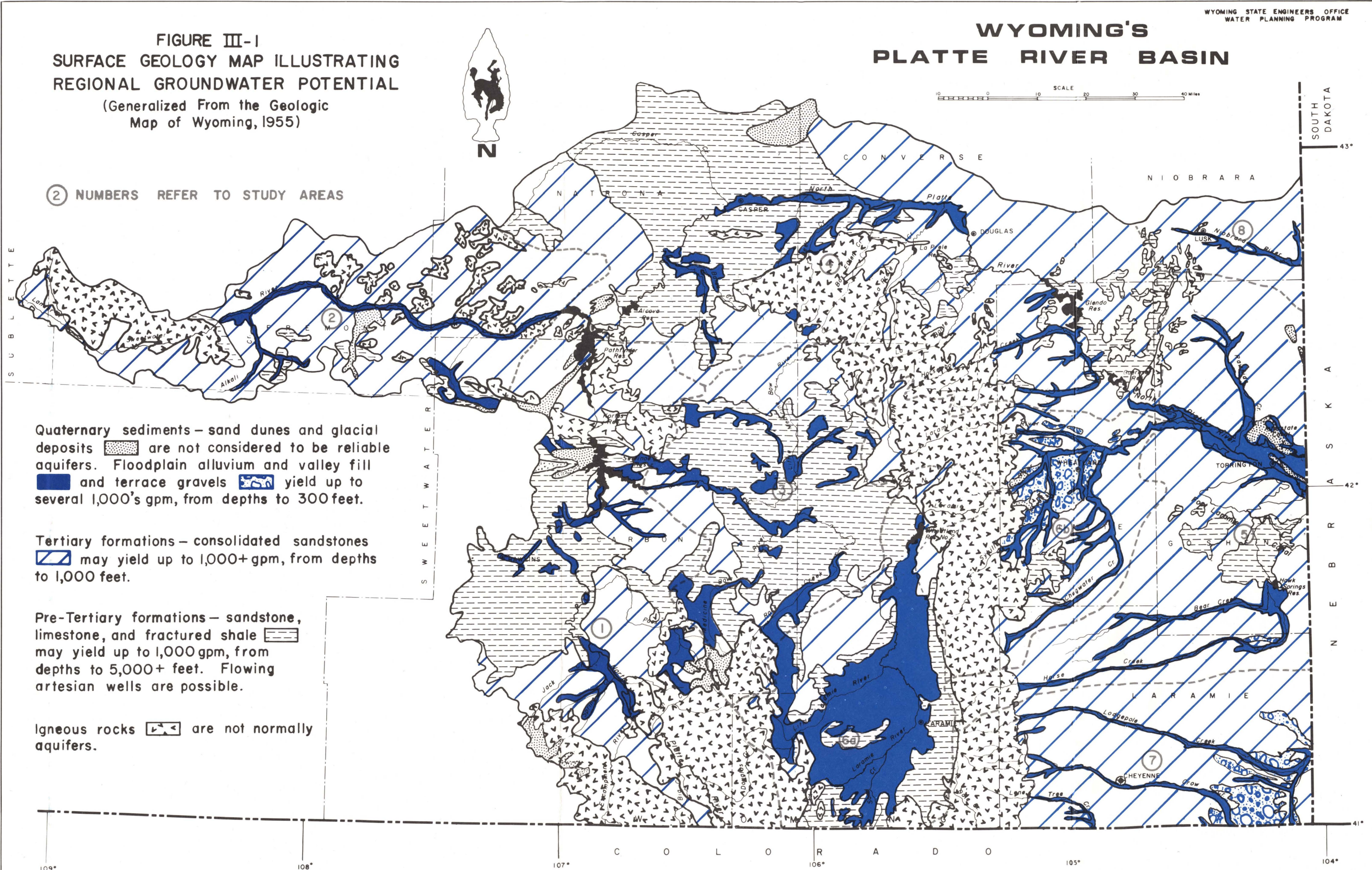
Time-Rock System		Lithologic Unit or Formation (Thickness in Feet)							
		Granite Mountain and Wind River Mountain Areas		Intermontane Basins		High Plains			
Jurassic	Morrison formation		Morrison formation (100-300)		Morrison formation (0-250)				
	Sundance formation (190-550)		Sundance formation (0-300)		Sundance formation (0-550)				
	Gypsum Spring formation (0-250)		(absent or unreported - a/u)		(absent or unreported - a/u)				
	Nugget sandstone (0-525)		Nugget sandstone (0-100?)						
Triassic	Chugwater group (1,000-1,300)	Popo Agie (0-350)	Chugwater group or formation (0-1,200)	Popo Agie (0-?)	Chugwater formation	Spearfish formation (0-800)			
		Crow Mountain sandstone (50-100)		Jelm formation (0-190)					
		Alcova limestone (2-25)		Alcova limestone (0-?)					
		Red Peak (700-900)		Red Peak formation (0-1,200)					
	Dinwoody formation (50-200)		Goose Egg formation (350-380)	Goose Egg formation (0-350)	Forelle limestone (0-80)	Dinwoody formation (0-300)	gypsum and red beds ¹		
					Satanka shale (140-300)	Minnekahta limestone (0-40)			
Permian	Phosphoria	Park City formation (200-400)		Owl Canyon (?)	Goose Egg formation (200-250)	Opeche shale ² (0-80)			
						Hartville formation	Casper formation	Minnelusa formation	
Pennsylvanian	Tensleep sandstone (200-600)		Casper formation (400-500)	Tensleep sandstone (? -800)	Casper formation (500-700)	Fountain formation (20-150)	Fountain formation	(0-1,050)	
	Amsden formation (0-400)			Amsden formation (0-150)					
Mississippian	Madison limestone (200-700)		Madison limestone (0-300)		Guernsey formation		Pahasapa formation and Englewood formation (0-200)		
Devonian	Darby formation (0-100?)		(absent or unreported - a/u)		absent				
Silurian	absent		absent (?)		absent				
Ordovician	Bighorn dolomite (0-100?)		(absent or unreported - a/u)		absent				
Cambrian	Gallatin limestone (0-365?)		Flathead sandstone (0-600)		Cambrian quartzite		Deadwood formation (0-60)		
	Gros Ventre formation (0-700?)								
	Flathead sandstone (50-500?)								
Precambrian									

¹ This unit in southeastern Wyoming may include all or part of the following sequence (top to bottom): Dinwoody formation, Ervay member, Freezeout shale, Forelle limestone, and Glendo shale.

² Beneath the Opeche shale and above the Hartville formation may sometimes be found an interval of Satanka shale and/or Lyons sandstone.

② NUMBERS REFER TO STUDY AREAS

Igneous rocks  are not normally aquifers.



WYOMING'S PLATTE RIVER BASIN

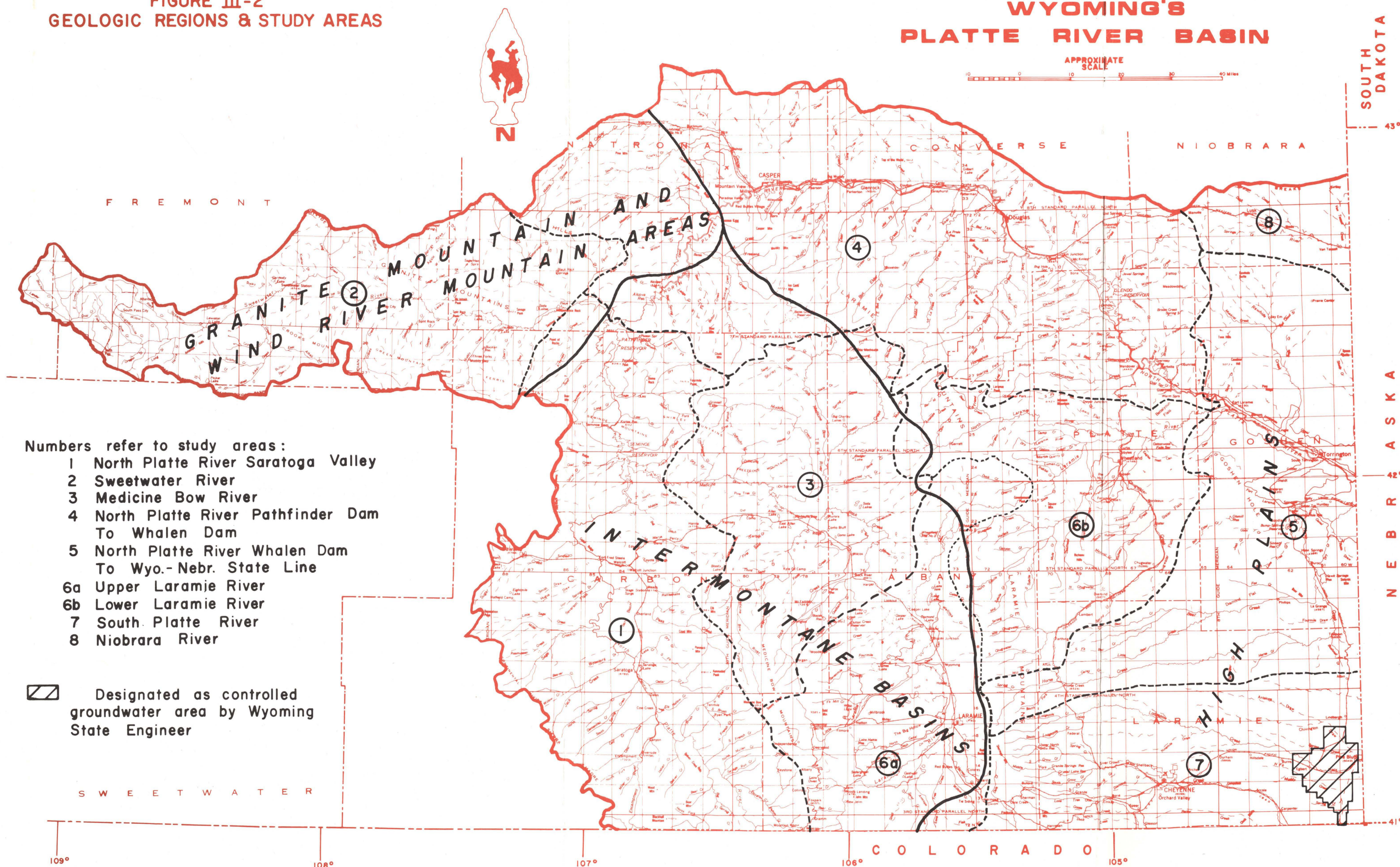


TABLE III-4 -- Lithology and Groundwater Potential of Quaternary and Tertiary Units in the Granite and Wind River Mountain Areas, Platte River Basin, Wyoming

Formation or Unit	Lithology	Groundwater Potential
Alluvium	Unconsolidated sand, silt, and gravel along the Sweetwater River and major tributaries; pediment gravels locally capping uplands; sand dunes.	Potential for small to moderate yields along major rivers and streams; quality may range from suitable for domestic to unsuitable for stock.
Bug formation ¹	Soft pale-green, pale-brown, and white claystone, tuff, limestone, sandstone, and conglomerate.	Unreported, but probably poor potential.
Moonstone formation ¹	Black shale overlying a middle unit containing uranium-bearing white shale, and a basal soft, poorly-cemented arkosic conglomerate and sandstone.	Reportedly can yield small supplies of good quality water to stock and domestic wells.
Split Rock formation/ Arikaree formation ²	Sandstone, clayey sandstone, and silty sandstone, poorly-cemented, with lesser amounts of conglomerate, claystone, limestone, tuff, and pumicite. Discharge from the Arikaree may make a significant contribution to the flow of the Sweetwater River (24).	Yields small supplies to stock and domestic wells; large supplies might be obtained where the saturated thicknesses are great, or the matrix permeability has been increased; water quality generally is good. The sandstone may be so porous and permeable as to drain rapidly, resulting in the water table being several hundred feet below the surface. Provides Jeffrey City municipal supply; yields 1,000+ gpm for industrial use from depths of 150-250 feet.
White River formation ³	Bentonitic and tuffaceous mudstone, with lenses of arkose and conglomerate and beds of tuff.	Generally a poor aquifer, with local exceptions.
Ice Point conglomerate ⁴	Angular reddish-brown rock fragments in a matrix of brown to golden-yellow poorly-cemented arkosic sandstone. Present in southwestern part of Granite Mountains area.	Unreported potential, but probably poor.
Wagon Bed/ Bridger formation ⁴	Pale-green and drab, yellow to gray bentonite mudstone, locally tuffaceous, with persistent zeolitic mudstone and sandstone beds; also includes volcanic sandstone and conglomerate, thin beds of uraniferous phosphate, laminated organic-rich shale, and oil-saturated sandstone some of which contains a commercial amount of uranium.	Generally a poor aquifer, but probably would yield small supplies locally; water quality would vary from poor to good.
Igneous intrusives	Volcanic eruptive debris and flows, clustered in an area of about 125 square miles in the Rattlesnake Hills.	No known potential.
Laney shale ⁵	Soft brown and green siltstone, shale, and claystone; may be typified by oil shale at the top and bottom and arkose in the middle.	Potential unreported, but has poor to good potential in other areas.
Cathedral Bluffs tongue/ Crooks Gap conglomerate ⁵	Conglomeratic arkosic sandstone and pebble conglomerate interbedded with a lesser amount of variegated mudstone, grading to a conglomerate of giant granite boulders embedded in pink to gray arkosic sandstone and siltstone.	Potential unreported, but elsewhere the Cathedral Bluffs tongue yields very small amounts of mineralized water and has a poor potential.
Wind River and Indian Meadows formations/ Wasatch and Battle Spring formations ⁶	Interbedded siltstone, sandstone, and conglomerate containing some carbonaceous shale and thin coal seams; locally contains large boulders in a soft sandstone and shale matrix.	Yields small supplies to stock and domestic wells, of poor to good quality. Large supplies have been developed elsewhere.
Fort Union formation ⁷	Conglomerate, sandstone, shale, and carbonaceous shale in lower part, grading into very fine-grained clastics in the upper part.	Sandstones yield small supplies generally unsuitable for domestic use and sometimes unsuitable for stock.

¹ Has only a local distribution, in east-central part of area.

² The USGS has abandoned the name Split Rock; Arikaree includes what formerly was called Split Rock formation. The Arikaree formation is present throughout the area, excluding the Wind River basin.

³ Only peripheral distribution, in the west and northwest; also reported in east, south of Wind River basin.

⁴ Peripheral distribution, in southwest, west, and northwest.

⁵ Present in southwest, adjacent to the Red Desert (Great Divide) basin.

⁶ Includes equivalents of Tipton, Luman, and Red Desert tongues. Wasatch and Battle Spring formations are present in the southwest, adjacent to the Red Desert (Great Divide) basin; the Wind River formation has a peripheral distribution in west and north-central parts; the Wind River-Indian Meadows interval is in the Wind River basin.

⁷ Present in the southwest, and in the Wind River basin.

TABLE III-5 -- Lithology and Groundwater Potential of Quaternary and Tertiary Units in the Intermontane Basin Area of the Platte River Basin, Wyoming

<u>Formation or Unit</u>	<u>Lithology</u>	<u>Groundwater Potential</u>
Alluvium	Unconsolidated sand, silt, and gravel along major streams and tributaries, terrace gravels, landslide debris, and sand dunes.	Along streams and tributaries yields adequate water for domestic and stock use; locally may be very thin or above water table and yield little or no water to wells. Terrace gravels generally are above the water table, and landslide debris hosts small springs but is not known to yield water to wells.
North Park formation	Fine-grained silty and clayey sandstone, with few thin beds of volcanic ash, limestone, and chert; may contain lenses of pebbles and conglomerates.	An extensive aquifer in Carbon County; yields sufficient water for domestic and stock use. One spring flows 1,300 gpm, another 500 gpm, and a third 100 gpm from this formation.
Browns Park/ Arikaree formations	Sandstone, gray, white, and brown, and fine grained; overlying a conglomerate interbedded with sandstone and volcanic ash. The Arikaree is light gray to white tuffaceous siltstone, sandstone, conglomerate, and limestone of local distribution, found as a ridge-cap in the northern part of the intermontane basin area.	Potential for wells unknown, but numerous springs discharge from this formation, with yields of 50 to 340 gpm, in Carbon County. The potential of the Arikaree is unreported, but probably poor.
White River formation	Tan to brown tuffaceous siltstone, sandstone, and conglomerate, over pink-tan siltstone and claystone, poorly to moderately-cemented. In the southern portion, restricted to valley-remnants.	Unreported potential, but probably poor.
Wagon Bed formation	Light tan to gray coarse-grained arkosic sandstone, claystone, and fresh-water limestone, of local distribution.	Unreported potential, but probably poor.
Wind River and Hanna formations	Gray medium- to coarse-grained arkosic sandstone, poorly-cemented, and green or gray-green claystone and siltstone. Uranium minerals are sometimes found in this formation. The lower Hanna formation may be yellowish-brown sandstone, yellowish-green sandy shale, coarse conglomerate, and coal.	Unreported potential, but probably would yield small to large supplies to wells. Unreported potential, but probably poor to fair.
Ferris formation	Equivalent, for the most part, to Fort Union sandstone, conglomerate, and shale. The lowermost portion is Cretaceous in age and overlies the Medicine Bow (Lance) formation. Reported in the Hanna basin and southern Carbon County. No equivalent of the Ferris is known to be present in the Laramie basin or the Shirley basin.	May yield small supplies of questionable quality water to wells.
Landslide debris	Principally large blocks of sandstone derived from Cretaceous sandstones. Reported locally in northern portion.	Unreported potential, but probably not an aquifer.

TABLE III-6 -- Lithology and Groundwater Potential of Quaternary and Tertiary Units in the High Plains Region of the Platte River Basin, Wyoming

<u>Formation or Unit</u>	<u>Lithology</u>	<u>Groundwater Potential</u>
Alluvium	Unconsolidated sand, silt, and gravel in the floodplain and underlying valley fill, and in terrace gravels and pediments; also includes alluvial fans, slope wash, and sand dunes.	Excellent potential in the floodplain-valley fill and terraces; probably fair to good potential in the pediments-alluvial fans, and poor to no potential in the slope wash and sand dunes. Yields from the floodplain-valley fill are in the range of several hundred to 3,000 gpm. Yields from terrace gravels are in the range of about 100 to 1,500 gpm.
Channel deposits	Sand and gravel, poorly to moderately-cemented, containing cobbles and boulders.	Not normally considered an aquifer.
Ogallala formation	Lenticular beds of sand and gravel, and silt, clay, and thin-bedded fresh-water limestone.	An extensively developed aquifer in Laramie County. Reported yields range from 150 to 1,800 gpm.
Unnamed deposits	Poorly consolidated cross-bedded deposits of clay, silt, sand, and gravel, occurring locally in Converse County.	Not an aquifer, but serve as small infiltration areas for recharge from precipitation.
Arikaree formation	Massive, loosely to moderately-cemented fine-grained sandstone, tan to gray, sometimes pinkish; contains layers and concretions of hard sandstone, and a basal coarse channel conglomerate.	Provides water to many domestic and stock wells and to irrigation wells. Yields of 10 to 1,000 gpm reported.
Brule formation	Mainly buff-colored, sometimes pale-green to pink or flesh-colored siltstone, with local fractures, fissures, and pipes.	Yields adequate water for domestic and stock purposes, and irrigation supplies from fissures, fractures, or pipes. Reported yields are in the range of 10 to 2,000 gpm.
Chadron formation	Medium- to coarse-grained brown sandstone, locally conglomeratic, and green silty clay and soft shale, sometimes containing channel deposits of loose to well-cemented sandstone.	Yields water to many domestic and stock wells. Some large yields from the Brule may actually be from the Brule-Chadron (White River group), and perhaps mostly from the channel deposits.
Wasatch formation	Dark-colored claystone and shale, drab-colored sandstone, and coal. Present only in the vicinity of the drainage basin boundary in Converse County, where it crops out and dips underground to the north.	Unreported potential, but probably poor because of a very limited extent in the Basin.
Fort Union formation	Sandstone, shale, and coal beds. The only place in the High Plains region where the Fort Union is known to be present is in a portion of Converse County in the vicinity of the drainage basin boundary. The formation crops out at the surface and dips underground to the north. Elsewhere this sequence is thought to have been removed by erosion prior to the deposition of younger formations.	Unreported potential, but may yield small supplies.

TABLE III-7 -- Lithology and Groundwater Potential of Cretaceous Units in the Platte River Basin

<u>Formation or Unit</u>	<u>Lithology</u>	<u>Groundwater Potential</u>
Lance formation and equivalents	White, gray, yellow, and brown sandstone, fine- to medium-grained; coarse-grained in the mountain areas. The sandstone is thin bedded to massive, cross bedded and lenticular, and includes beds of dark shale and claystone, and coal.	Yields small supplies to wells and springs in the High Plains region, and locally supplies many domestic and stock wells. The formation is deeply buried in much of Platte County and is of unknown potential there. Yields of 100 gpm per well are reported in Goshen County.
Meeteetse formation and equivalents	White, gray, and buff soft, fine- to medium-grained sandstone, interbedded with pale-green, yellow, black, and gray claystone, and thin coal seams (Meeteetse). The Lewis shale is dark gray and soft, interbedded with thin sandstone beds. In the High Plains region the Fox Hills sandstone is gray to yellow-brown, friable and silty, and interbedded with dark shale. The basal part of the Meeteetse formation and Lewis shale is equivalent to the uppermost Pierre shale.	The potential of the Meeteetse formation is unreported, but may be fair locally. The Lewis shale has poor to no potential. The Fox Hills sandstone yields small quantities of water to domestic and stock wells in the outcrop area in Niobrara County, from depths of 100-300+ feet. The Fox Hills probably would yield small ¹ supplies of water to wells locally in Goshen, Platte, and Laramie Counties, but the depth of the formation is a deterrent to development.
Mesaverde formation and equivalents	The Mesaverde is white, gray, and brown sandstone interbedded with gray carbonaceous shale and thin coal seams. The Pierre, Cody, and Steele are dark gray shales with sandstone beds and stringers.	Sandstones in the Mesaverde yield water; one well in Section 30, T.21 N., R.78 W. produces water with 726 ppm total dissolved solids from a depth interval of 2,015-2,133 feet. The shales have poor or no potential. The Pierre reportedly yields small supplies of poor quality water from sandstone and fractured shale.
Niobrara formation	Gray to black shale with beds of buff shaly limestone, and sandstone stringers.	Fractured zones reportedly can yield small quantities of water to wells, but overall potential considered poor.
Frontier formation and equivalents	Black and gray shales, enclosing sandstone members as much as 100+ feet thick.	Sandstones are water bearing; yields of 50 gpm have been reported.
Mowry shale	Dark gray to black shale.	Probably poor potential.
Muddy sandstone/ Newcastle sandstone	Predominantly light gray, fine- to medium-grained sandstone, in places coarse-grained and conglomeratic; thin-bedded to massive, lenticular, with siltstone and claystone interbeds.	Poor to fair potential; oil exploration wells have recovered water with total dissolved solids in the range 2,000-20,000 ppm; one test flowed water from a depth of 5,900 feet.
Thermopolis shale/ Skull Creek shale	Dark gray to black shale.	Probably poor potential.
Cloverly formation and equivalents	The Fall River sandstone usually is gray to pale yellow-orange, fine grained and thick bedded, and separated from the Lakota conglomerate by dark gray to black or variegated shale. The Lakota normally is medium grained to conglomeratic, light gray or white in color.	The sandstones yield water to wells. Most reported yields are small, but some are in excess of 100 gpm. The Cloverly reportedly yields the best quality water in some areas.

¹ The nomenclature commonly used by the U. S. Geological Survey is referred to: A small yield is up to 50 gpm; a moderate yield is 51 to 350 gpm; a large yield is more than 350 gpm.

TABLE III-8 -- Lithology and Groundwater Potential of Jurassic and Older Units
in the Platte River Basin

<u>Formation or Unit</u>	<u>Lithology</u>	<u>Groundwater Potential</u>
Morrison formation	Pale-green, maroon, and other shales, with thin beds of sandstone and fresh-water limestone.	Potential poor, but may be fair in or near outcrop areas.
Sundance formation	Pale-green glauconitic sandstone and shale, with gray, yellow, brown, and pink sandstone beds and greenish-gray sandy and limy shale.	One well in Section 34, T.19 N., R.88 W. reportedly flowed 28 gpm.
Gypsum Spring formation	Red shale and siltstone interbedded with gray earthy dolomite and massive white gypsum.	The formation is reported only in the western part of the Mountain area and has poor potential.
Nugget sandstone	White to buff, fine- to coarse-grained quartzitic sandstone. Salmon-red sandstone in the Granite Mountain area, where it may be entirely of Triassic age.	Probably fair potential. Reportedly yields very small quantities of water to wells; too quartzitic locally to yield large quantities.
Chugwater group and equivalents	Red color is the prominent feature of this unit, which is siltstone and shale, silty sandstone, and seams of gypsum or anhydrite. Popo Agie - siltstone, claystone, shale. Crow Mountain/ Jelm formation - sandstone. Alcova - thin-bedded, hard, purple-gray limestone. Red Peak - brick-red siltstone, silty sandstone, and shale. The Chugwater is equivalent to the Spearfish formation in eastern Wyoming.	Sandstones yield water to wells; yields of about 5-20 gpm are reported in the Laramie basin, on the edge of the Laramie Mountains. The Chugwater sandstones may be in hydraulic continuity with deeper formations through fractures.
Goose Egg formation and equivalents.	Predominantly reddish siltstone and sandstone interbedded with limestone, dolomite, and gypsum. Stratigraphic relationships between members of this unit are complex.	Groundwater potential unreported but probably poor. Sandstone intervals may be water bearing. The Phosphoria reportedly has yielded 30 gpm from a depth of 6,158-6,284 feet in Section 4, T.28 N., R.93 W.
Tensleep sandstone-Amsden formation and equivalents	The Tensleep is white to tan fine-grained sandstone, cross-bedded in part, with dolomite layers. The Amsden is red and green shale with beds of dense dolomite and sandstone, sometimes having 50 feet of sandstone (Darwin) at the base. The Casper equivalent is predominantly sandstone, pink to gray, with limestone, dolomitic limestone, and shale, in the upper part, and red or reddish-yellow quartzitic and arkosic sandstone at the base (Fountain formation). In the High Plains area the Hartville equivalent is primarily limestone with 100-120 feet of soft, white to yellow, porous sandstone (Converse sand) at the top, and beds of cherty dolomitic red sandstone, and thin beds of dolomite and breccia, throughout. The equivalent in the northern part of the High Plains area is the Minnelusa.	The Tensleep sandstone yields moderate quantities of water to springs and wells. Water quality reportedly is better in the outcrop areas. The Amsden probably will yield little or no water from the shale and dense dolomite; the basal sandstone could be water bearing and may locally yield moderate quantities of water. The Converse sand of the Hartville formation yields 75-175 gpm to wells.
Madison limestone and equivalents	White to bluish-gray and purple limestone and dolomite, cherty and hard. The Guernsey equivalent may have beds of purple, hard dolomitic shale and siltstone in the lower part. The Pahasapa-Englewood interval is a formation equivalent in the northern High Plains region.	Moderate to large quantities of water probably can be obtained from solution cavities in the limestone. A yield of 700 gpm has been reported from a well 269 feet deep, in Section 7, T.30 N., R.96 W.; the aquifer is thought to be the Madison.
Darby formation	Brown shaly and sandy dolomite, present as local remnants in the mountain areas.	Unreported groundwater potential, but probably nil.
Bighorn dolomite	Gray hard, silicious, massive dolomite, present locally in the mountain areas.	Unreported groundwater potential, but probably poor.
Gallatin limestone	Brown-gray, glauconitic, hard limestone.	Unreported groundwater potential, but probably poor.
Gros Ventre formation	Predominantly green shale.	Groundwater potential probably nil.
Flathead sandstone and equivalents	Brown and red-brown sandstone and quartzite.	May yield small to moderate quantities of water to springs and wells. A well in Section 17, T.21 N., R.87 W. has a reported yield of 150 gpm. The well is 416 feet deep.
Igneous and metamorphic rocks	A complex sequence of granite, gneiss, schist, and metasedimentary rocks.	This sequence makes up large parts of the mountainous recharge areas.

According to public health standards, good drinking water for humans contains no more than 500 ppm total dissolved solids. If no better water is available, not more than 1,000 ppm total dissolved solids is the upper limit for acceptable drinking water.

Animals reportedly can become accustomed to highly mineralized water. Water with less than 1,000 ppm total dissolved solids is considered good for stock; 1,000 to 3,000 ppm is fair, 3,000 to 5,000 ppm is poor but usable, 5,000 to 7,000 ppm is very poor and of questionable use, and more than 7,000 ppm is not advisable.

The U. S. Salinity Laboratory classifies irrigation water according to its salinity and sodium hazard. As a rule, the higher the salinity the less suitable the water for irrigation, because the application of water with high salinity tends to add salts to the soil. Because salinity is directly related to its specific conductance, the following classification has been established (29):

<u>Salinity hazard</u>	<u>Specific conductance (micromhos per centimeter)</u>
Low	100-250
Medium	250-750
High	750-2,250
Very high	greater than 2,250

The sodium hazard is directly related to the sodium-adsorption-ratio (SAR). For water whose specific conductance is 750, the following approximate relations between the SAR and sodium (alkali) hazard exist:

<u>SAR (approx.)</u>	<u>Sodium hazard</u>
0-10	Low
10-18	Medium
18-26	High
more than 26	Very high

The sodium hazard increases as specific conductance increases, even though the SAR value remains constant. Water in which the percentage of sodium² is appreciably greater than 50 percent is of limited suitability for irrigation.

Radioactive elements are not common as mineral constituents of groundwater, but the presence of mineable uraniferous ore bodies in the Wind River formation invokes the possibility of these elements being found in underground waters. Supplies are considered satisfactory by the Public Health Service standards if the concentration of radium-226 does not exceed 3 picocuries per liter, and strontium-90 does not exceed 10 picocuries per liter, without considering the total exposure of consumers to radiation (29).

Another quality consideration is the amount of sediment that is pumped with the water. Sand pumping reduces the efficiency of a well and causes premature abandonment which results in excess water costs. Unconsolidated aquifers and the

² Related to total concentration of calcium, magnesium, and sodium-potassium.

North Park, Ogallala, Arikaree, and White River formations have loose sands that may result in sand pumping from wells. Loose sands are also found in the Cloverly and Hartville formations.

Chemical analyses given in Table III-9 show only chemical character and not sanitary quality. Water quality (chemical) is attributed to the source of the groundwater, soluble minerals in the host material, the rate of percolation, and man's use of the land and the subsurface. The chemical nature of groundwater is influenced by many environmental factors. Climate and the composition of the soil and rock strata are two important factors influencing the quality of groundwater. Shales and clays may contribute large amounts of soluble minerals to water passing over or through the material, and groundwater that is withdrawn or discharges from aquifers in shales or clays usually has a very high amount of total dissolved solids. Other geologic factors, such as texture and porosity, and regional structure also influence the quality of the groundwater. A closely related factor is the proximity of the outcrop (recharge) area to the site of groundwater withdrawal or discharge.

Climate strongly influences the solution of minerals in the soil which eventually reach the water table, causes the concentration of dissolved minerals by evaporation, and greatly influences the natural movement of water, both into and out of aquifers, through resulting changes in natural surface water flows.

AVAILABILITY OF GROUNDWATER

In this report the availability of groundwater refers to the opportunity to obtain water of adequate quantity and quality at reasonable cost. Sedimentary deposition and structural configuration control the occurrence of groundwater, and therefore greatly influence its availability, in the geologic basins. Even though there is a close relationship between surface water and groundwater in parts of the Platte River Basin, it is apparent that the boundaries of geologic basins do not coincide with divides separating surface water drainage basins (Figure III-3). The availability of groundwater in the Basin is tabulated by study area and geologic time-rock sequence in Table III-10.

The availability of groundwater at a specific site, by means of a water well, depends upon (1) type of earth material in the aquifer, (2) depth to the water table or artesian pressure surface, (3) inclination of the water table, pressure surface, and/or the aquifer, (4) type of earth material above the aquifer, (5) thickness, porosity, and permeability of the saturated water-bearing interval, (6) natural recharge to the aquifer, (7) well location, (8) well design and construction, (9) well spacing pattern and water uses, and (10) method of lifting water to the surface. Of the above enumerated items, the one factor which most affects the availability of groundwater with time is the depth to water. Even though the static water level may vary only insignificantly from one year to the next, the pumping water level may vary greatly during times of water withdrawal. As drawdowns (differences between the static and pumping water levels in wells) become greater in wells in a particular locality, the availability of groundwater may be affected by institutional constraints.

TABLE III-9 -- Chemical Analyses of Groundwater - Reported in Publications of the U. S. Geological Survey
(results in parts per million except as indicated)

Well Locations Section- Township- Range	Interval or depth (feet)	Study Area	Date of collection	Temperature (°F)	Silica (SiO ₂)	Total Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	(Na + K)	Potassium (K)	Bicarbonate (HCO ₃)	Carbonate (CO ₃)	Sulfate (SO ₄)	Chloride (Cl)	Fluoride (F)	Nitrate (NO ₃)	Boron (B)	Dissolved Solids (residue at 180° C)	Hardness as CaCO ₃		Percent Sodium	Sodium adsorption ratio	Specific conductance (micromhos at 25°C)	pH
																				Calcium, Magnesium	Noncarbonate				
A L L U V I U M																									
2-12-62	104	7	6/26/64	—	46	0.04	46	9	14	5.2	183	0	16	5.4	0.8	12	0.08	260	152	2	—	0.5	364	7.8	
29-13-62	80	7	6/26/64	—	53	0.19	48	12	13	4.8	190	0	16	6.9	1.0	17	0.05	276	170	14	—	0.4	389	7.8	
11-14-60	85	7	10/7/47	51	55	0.10	53	10	33		222	—	44	8.0	0.6	5.5	—	302	173	0	29	—	423	—	
5-18-61	—	5	6/22/64	53	56	0.02	53	18	77	10	348	0	65	11	0.6	8.0	0.24	474	208	0	—	2.3	697	7.8	
28-20-61	35	5	9/28/49	55	51	0.02	75	12	23	6.4	320	0	29	9.2	0.2	2.8	0.10	390	237	0	17	—	533	7.7	
10-23-60	50	5	8/21/51	56	21	0.02	74	20	92		279	0	199	19	0.4	2.0	0.13	578	266	37	43	—	865	7.7	
10-24-61	63	5	9/7/51	58	35	0.03	93	17	43	9.4	264	0	154	12	0.2	19	0.09	528	302	86	23	—	751	7.4	
31-25-61	95	5	8/17/51	57	44	0.02	51	9.7	68	9.3	214	0	125	11	0.3	4.1	0.08	430	167	0	45	—	630	7.6	
22-26-64	62	5	8/20/51	56	27	0.03	88	23	53	6.7	286	0	170	16	0.2	11	0.09	540	314	79	26	—	805	7.4	
21-27-67	19	4	9/14/49	56	47	0.42	63	4.5	24	8.8	232	—	22	7.6	0.2	10	0.4	332	176	0	22	0.8	511	7.5	
27-28-68	12	4	8/20/53	61	44	0.03	64	6.7	34	3.8	287	—	14	4.5	0.4	0.4	0.03	326	187	0	28	1.1	486	7.3	
21-29-68	58	4	9/14/49	52	38	1.2	153	17	34	2.4	252	—	296	3.0	0.4	1.2	0.1	692	452	245	14	0.7	939	7.5	
25-29-87	20-35	2	10/6/65	48	28	0.29	44	9.0	29	5.1	163	0	61	16	0.2	0.1	0.04	273	147	13	28	6.9	400	8.0	
T E R R A C E D E P O S I T S																									
2-12-62	104	7	10/7/47	52	46	0.02	48	8.0	11	4.0	187	0	14	4.0	0.7	12	0.33	266	182	29	13	—	380	8.1	
30-13-61	83	7	9/26/47	53	47	0.02	45	11	10		163	0	29	9.0	0.8	2.2	—	234	158	24	13	—	335	8.0	
19-14-60	110	7	9/23/47	52	55	0.01	42	4.4	24		189	—	8.6	5.0	0.6	2.1	—	242	123	0	29	—	337	—	
18-23-68	24	6b	8/18/53	71	14	0.07	66	56	55	1.4	305	—	228	15	0.7	0.16	—	622	395	145	23	1.2	927	7.9	
2-24-61	112	5	8/23/51	57	26	0.02	102	22	40	11	310	0	155	13	0.2	14	0.06	540	343	89	20	—	808	7.3	
15-24-68	43	6b	8/19/53	55	22	0.05	96	42	52	0.9	327	—	204	14	0.6	28	0.20	668	414	146	21	1.1	948	7.7	
28-25-61	120	5	8/16/51	58	35	0.02	78	9.6	43	9.7	189	0	160	13	0.2	4.5	0.07	450	234	79	28	—	647	7.5	
34-25-68	21	6b	8/19/53	64	27	0.11	98	58	75	4.8	401	—	280	19	1.2	1.9	0.18	786	484	155	25	1.5	1,140	7.7	

TABLE III-9 -- continued

Well Locations Section- Township- Range	Interval or depth (feet)	Study Area	Date of collection	Temperature (°F)	SiO ₂	Total Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	(Na + K)	Potassium (K)	Bicarbonate (HCO ₃)	Carbonate (CO ₃)	Sulfate (SO ₄)	Chloride (Cl)	Fluoride (F)	Nitrate (NO ₃)	Boron (B)	Dissolved Solids (residue at 180° C)	Hardness as CaCO ₃		Percent Sodium	Sodium adsorption ratio	Specific conductance (micromhos at 25°C)	pH
O G A L L A L A F O R M A T I O N																									
23-13-64	300	7	5/2/62	54	57	0.03	54	13		9.7	218	0	11	6.4	0.4	8.4	—	286	186	7	—	0.3	407	7.4	
20-14-63	80	7	9/23/47	52	55	0.2	53	13		9.2	185	—	21	16	0.6	10	0.11	270	152	34	10	—	421	—	
27-14-68	250	7	8/11/64	52	30	0.07	47	5	5.9	2.1	169	0	6.0	2.5	0.4	6.8	0.03	189	138	0	—	0.2	294	7.6	
4-15-60	108	7	9/25/47	52	59	0.07	52	16		22	168	—	47	34	0.4	10	—	336	138	58	20	—	456	—	
2-16-68	459	7	4/14/61	40	23	0.34	43	5.5		7.8	162	0	8.0	1.5	0.8	1.8	—	175	130	0	—	0.3	278	7.9	
N O R T H P A R K F O R M A T I O N																									
30-18-83	Spring	1	9/19/50	49	40	0.06	54	4.5	9.4	6.6	190	—	16	4.5	0.3	1.4	0.05	242	153	0	11	—	331	7.9	
9-19-83	217	1	9/19/50	—	22	0.3	57	1.9	36	7	223	—	44	3.5	0.3	0.3	0.05	284	150	0	33	—	425	7.6	
16-20-84	Spring	1	9/18/50	47	33	0.06	137	27	71	6.6	198	—	373	46	0.1	1.1	0.35	820	451	289	25	—	1,080	7.9	
B R O W N S P A R K F O R M A T I O N																									
Combined flow from 19 springs, T.17 N., R.88 W.		1	10/23/51	52	32	0.27	53	3.8	14	2.7	179	0	33	2.0	0.1	1.2	0.04	237	295	1	17	—	345	7.8	
A R I K A R E E F O R M A T I O N																									
7-14-62	—	7	6/26/64	—	49	0.14	21	40	12	4.4	208	0	27	16	0.7	26	0.58	330	216	45	—	0.4	476	7.8	
20-17-60	—	7	6/27/64	—	—	—	—	—	16	—	184	0	19	—	—	—	—	294	170	19	—	0.5	408	7.4	
8-19-64	Spring	5	10/25/49	52	54	0.02	57	8.7	7.5	5.6	223	0	0.1	2.0	0.6	1.7	0.2	286	178	0	8	—	362	7.6	
34-20-65	—	5	11/7/51	—	48	0.26	43	11	11	3.8	182	8	1.0	5.5	0.8	11	0.17	252	154	0	13	—	340	8.4	
34-21-64	204	5	11/7/51	55	46	0.03	52	7.2	9.7	2.2	193	6	1.0	3.5	0.4	6.5	0.04	238	159	0	11	—	340	8.3	
13-24-68	560	6b	8/21/53	—	43	0.04	74	23	27	6.4	186	—	139	22	0.6	12	0.08	496	280	127	17	0.7	660	7.7	

TABLE III-9 -- continued

Well Locations Section- Township- Range	Interval or depth (feet)	Study Area	Date of collection	Temperature (°F)	Silica (SiO ₂)	Total Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	(Na + K)	Potassium (K)	Bicarbonate (HCO ₃)	Carbonate (CO ₃)	Sulfate (SO ₄)	Chloride (Cl)	Fluoride (F)	Nitrate (NO ₃)	Boron (B)	Dissolved Solids (residue at 180°C)	Hardness as CaCO ₃		Percent Sodium	Sodium adsorption ratio	Specific conductance (micromhos at 25°C)	pH
																				Calcium, Magnesium	Noncarbonate				

A R I K A R E E F O R M A T I O N -- continued

27-25-67	150	6b	8/19/53	56	52	0.27	91	33	32	6.7	263	—	172	16	1.4	19	0.09	604	362	146	16	0.7	807	7.7
19-27-63	300	5	11/21/51	54	56	0.09	25	1.6	37	16	164	4	16	6	0.4	9.6	0.04	260	69	0	47	—	339	8.4
31-27-68	100	4	8/20/53	55	17	0.01	44	2.4	51	1.2	194	—	42	17	0.3	6.3	0.06	288	120	0	48	2.0	453	7.8
6-28-85	—	1	10/5/65	52	44	0.05	31	4.7	12	3.7	132	0	10	4.5	0.4	2.0	0.02	176	97	0	20	0.5	249	7.2
8-28-88	—	2	10/5/65	50	48	0.05	137	52	36	9.0	346	0	328	12	0.3	0.4	0.17	831	556	272	12	0.7	1,100	7.4
31-29-86	220-250	2	10/5/65	50	56	0.02	38	8.5	13	5.6	165	0	27	5.3	0.4	0.0	0.20	248	130	0	17	0.5	330	8.1
2-29-92	145-161	2	1962	—	37	0.10	58	10	—	—	189	—	85	12	—	—	—	—	186	—	—	0.5	440	7.6
15-29-95	—	2	8/18/65	86	27	0.00	62	26	126	18	200	0	220	119	1.6	0.0	0.40	698	260	96	49	3.4	1,140	7.7
15-29-95	—	2	8/18/65	42	41	0.00	40	7.3	40	6.7	200	0	41	9.9	0.4	0.0	0.10	278	130	0	39	1.5	440	6.8
27-30-61	148	5	10/23/51	—	45	0.19	66	16	11	6.5	221	0	25	21	0.3	24	0.04	354	232	51	9	—	506	7.7
27-30-67	Spring	4	8/20/53	53	53	0.25	61	11	67	16	376	—	28	11	0.5	6.4	0.09	468	199	0	40	2.1	677	7.5
14-31-91	91-220	2	7/21/65	48	52	0.00	33	8.6	33	7.8	154	0	50	12	0.6	6.5	0.09	284	119	0	36	1.3	411	7.1
25-31-91	40-150	2	7/21/65	52	28	0.00	32	6.0	31	4.9	192	0	14	5.3	0.4	2.8	0.04	228	105	0	38	1.3	358	7.3

W H I T E R I V E R (W R) , B R U L E (B) , A N D C H A D R O N (C) F O R M A T I O N S

8-13-60	77.5 (B) 7	10/26/47	52	57	0	66	15	34	302	—	34	11	0.2	0.6	—	378	226	0	24	—	554	—	
8-14-60	80 (B) 7	9/23/47	52	66	0.02	35	14	23	176	—	33	8	0.6	3.0	—	251	144	1	28	—	338	—	
34-15-60	318 (WR) 7	5/ 2 /62	52	61	0.26	32	12	12	151	0	12	6.7	0.6	8.5	—	232	128	4	—	0.5	320	7.6	
6-15-69	182 (WR) 7	8/11/64	49	23	0.01	49	16	16	3.2	249	0	13	3.6	0.6	3.2	0.05	257	187	0	—	0.5	419	7.9
9-18-62	— (WR) 5	6/27/64	58	—	—	—	—	41	—	288	0	62	—	—	—	—	424	232	0	—	1.2	608	7.5
20-19-60	90 (B) 5	11/14/51	53	50	0.29	32	7.3	33	5.8	180	4	15	4	0.8	16	0.03	262	110	0	38	—	363	8.3
33-20-62	33 (B) 5	10/18/49	52	64	0.02	51	18	122	9.6	556	0	20	4.2	0.6	5.6	0.2	584	202	0	55	—	813	7.8

TABLE III-9 — continued

Well Locations Section- Township- Range	Interval or depth (feet)	Study Area	Date of collection	Temperature (°F)	Silica (SiO ₂)	Total Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	(Na + K)	Potassium (K)	Bicarbonate (HCO ₃)	Carbonate (CO ₃)	Sulfate (SO ₄)	Chloride (Cl)	Fluoride (F)	Nitrate (NO ₃)	Boron (B)	Dissolved Solids (residue at 180°C)	Hardness as CaCO ₃		Percent Sodium	Sodium adsorption ratio	Specific conductance (micromhos at 25°C)	pH
																				Calcium, Magnesium	Noncarbonate				

WHITE RIVER (WR), BRULE (B),
AND CHADRON (C) FORMATIONS — continued

17-21-60	124	(C) 5	10/30/51	53	10	0.02	1.8	0.6	198	3.8	456	33	13	9	1.4	1.1	0.43	518	7	0	97	—	824	8.9
33-22-60	85	(C) 5	10/30/51	57	12	0.06	2.5	0.9	206	4.4	469	20	26	23	1.6	0.7	0.42	539	9	0	97	—	876	8.6
21-22-66	200	(B) 6b	8/21/53	67	47	0.01	82	26	56	7.4	157	—	197	52	1.4	28	0.08	616	311	182	28	1.4	865	7.3
12-23-61	50	(C) 5	11/23/51	50	11	0.61	4	2.2	262	7.1	460	15	102	68	1.6	0.7	0.37	713	19	0	95	—	1,160	8.6
22-24-62	—	(C) 5	8/15/50	—	16	—	8.5	1.2	202	7.7	297	0	65	114	1.1	0.3	0.3	580	26	0	92	—	920	7.8
25-25-64	120	(B) 5	11/6/51	54	59	1.1	46	10	32	7.4	208	0	29	9	0.4	29	0.05	332	157	0	29	—	452	8.2
12-26-61	120	(B) 5	10/23/51	—	—	0.01	—	—	98	—	206	9	—	—	—	—	—	420	—	—	—	—	597	8.4
9-29-68	145	(B) 4	8/5/46	54	64	0.03	89	8.1	46	—	246	—	88	33	0.4	19	0.02	519	256	54	28	1.3	696	7.5
31-31-95	65-135 (WR)	2	7/21/65	50	44	0.00	35	7.3	17	3.4	180	0	5.8	5.3	0.3	3.8	0.02	216	119	0	23	0.7	318	7.3

F O R T U N I O N F O R M A T I O N

23-33-73	100	4	8/18/50	57	13	1.7	353	98	432	38	432	0	1,830	52	0.3	0.4	0.2	3,030	1,280	926	41	—	3,620	7.7
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L A N C E F O R M A T I O N

17-20-61	Spring	5	10/24/49	56	53	0.02	50	11	60	18	332	0	39	10	0.4	2.3	0.2	416	171	0	40	—	608	7.7
17-21-62	117	5	11/6/51	54	17	0.03	9.5	3.3	429	7	413	22	405	113	0.5	39	0.21	1,250	37	0	95	—	1,940	8.6
12-22-63	157	5	11/19/51	—	11	0.26	6	1.7	273	5.4	434	18	185	34	0.3	19	0.18	790	22	0	95	—	1,230	8.6
36-23-61	275	5	11/7/51	50	11	0.01	1.7	0.5	237	2.6	576	28	1.0	9.5	1.6	1.2	0.36	592	6	0	98	—	951	8.7
10-24-61	470	5	10/22/51	59	11	0.04	1.8	1.0	275	1.6	660	35	1.0	7.5	2.4	0.3	0.39	664	8	0	98	—	1,080	8.7

TABLE III-9 -- continued

Well Locations Section- Township- Range	Interval or depth (feet)	Study Area	Date of collection	Temperature (°F)	Silica (SiO ₂)	Total Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO ₃)	Carbonate (CO ₃)	Sulfate (SO ₄)	Chloride (Cl)	Fluoride (F)	Nitrate (NO ₃)	Boron (B)	Dissolved Solids (residue at 180°C)	Hardness as CaCO ₃		Percent Sodium	Sodium adsorption ratio	Specific conductance (micromhos at 25°C)	pH
C O D Y S H A L E																								
15-27-89	--	2	9/24/65	50	8.5	0.00	201	192	1,070	7.6	578	0	3.080	70	2.0	0.0	0.93	5,150	1,290	816	64	13	6,020	7.3
F R O N T I E R F O R M A T I O N (F) A N D B E N T O N S H A L E (B)																								
10-18-88	210 (F)	1	12/8/54	47	7.8	0.69	5.5	1.3	290	1	556	89	37	6.5	1.2	0	0.37	720	38	0	97	--	1,170	9.3
8-32-73	725 (B)	4	8/16/50	51	13	4.1	8.5	0.4	310	5.0	580	12	2.0	142	1	2.6	1.6	802	23	0	96	--	1,340	8.2
C L O V E R L Y (I N Y A N K A R A)																								
11-17-88	580	1	12/6/54	46	10	0.11	1.5	0.4	222	0.9	342	65	85	3	0.5	0	0.35	557	10	0	99	--	913	9.4
10-18-88	1,000	1	12/6/54	57	9.7	0.56	3.5	1.1	75	2.6	175	0	32	2	0.5	0.4	0.08	223	26	0	91	--	346	7.5
35-29-68	Spring	4	9/13/49	53	19	0.12	49	7.5	40	8	296	--	4	3.6	0.2	1.7	0.35	296	154	0	35	1.4	515	7.7
S U N D A N C E F O R M A T I O N																								
34-19-88	1,890	1	12/6/54	62	11	4.2	2.0	0	465	1.6	1,120	31	1	26	6	0.1	0.45	1,100	10	0	99	--	1,750	8.6
M I N N E K A H T A L I M E S T O N E A N D G Y P S U M A N D R E D S H A L E S E Q U E N C E																								
24-29-69	44-102	4	5/23/61	--	13	0.02	521	88	67	11	148	0	1,580	6.5	0.4	0.6	0.29	2,550	1,660	1,540	8	0.7	2,570	7.4
O P E C H E S H A L E																								
24-29-69	355-840	4	7/26/61	56	16	0	33	18	20	4.4	230	0	28	2.7	0.7	0.8	0.05	231	172	0	20	0.7	420	7.6

TABLE III-9 -- continued

Well Locations Section- Township- Range	Interval or depth (feet)	Study Area	Date of collection	Temperature (°F)	Silica (SiO ₂)	Total Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO ₃)	Carbonate (CO ₃)	Sulfate (SO ₄)	Chloride (Cl)	Fluoride (F)	Nitrate (NO ₃)	Boron (B)	Dissolved Solids (residue at 180°C)	Hardness as CaCO ₃		Percent Sodium	Sodium adsorption ratio	Specific conductance (micromhos at 25°C)	pH
<u>H A R T V I L L E F O R M A T I O N (H) , T E N S L E E P S A N D S T O N E (T)</u>																								
20-23-88	Spring (T) **		12/7/54	38	3.6	0.09	43	35	27	2.4	222	0	93	20	0.1	1.0	0.09	339	432	68	19	--	581	7.9
20-29-68	1,296 (H) 4		9/22/49	54	15	0.2	45	13	18	3.2	240	--	3.2	2.6	0.2	1.5	0.3	226	166	0	19	0.6	416	7.8
16-30-68	Spring (H) 4		8/20/53	60	22	0.12	63	22	45	7.2	192	--	146	29	1.0	3.8	0.09	440	249	92	28	1.2	689	7.7
24-29-69	355-385(H) 4		6/14/61	--	19	0.01	29	7.7	26	12	42	0	118	8.5	0.6	0.4	0.07	234	104	70	32	1.1	357	8.1
<u>M A D I S O N L I M E S T O N E (A N D T E N S L E E P)</u>																								
16-21-87	650	1	12/7/54	53	11	0.02	144	40	350	19	246	0	663	299	0.8	1.2	1.2	1,650	727	323	58	--	2,480	7.6
13-30-99	1,013- 1,500	2*	4/8/65	--	--	0.2	93	37	3	1	275	0	7	117	--	1	--	--	--	--	--	--	--	7.0
<u>C A M B R I A N R O C K S</u>																								
11-21-88	Spring	1	12/6/54	44	7.8	0.07	46	13	9.3	1.4	190	0	24	3	0	1.1	0.02	214	326	14	10	--	353	7.6
<u>P R E C A M B R I A N G R A N I T E</u>																								
16-30-90	--	2	7/21/65	46	25	0.00	20	5.2	66	4.6	206	0	36	7.1	1.0	1.3	0.14	252	71	0	65	3.4	405	6.7

* In Wind River Mountains, near Study Area 2.

** In Great Divide Basin, near Study Area 1.

TABLE III-10 -- Availability of Groundwater

Quaternary Sediments	Tertiary Sediments	Pre-Tertiary Sediments
<u>STUDY AREA 1. NORTH PLATTE RIVER SARATOGA VALLEY (INTERMONTANE BASIN)</u>		
Stream alluvium supplies water adequate for domestic and stock needs but only locally adequate for irrigation. The reported maximum thickness of the alluvium is less than 50 feet; therefore wells are shallow.	The North Park formation yields sufficient water for domestic and stock uses and reportedly supplies large yield (1,000+gpm) irrigation wells. Water is found at depths above 100 feet.	The Cloverly and Tensleep-Madison intervals are the better of numerous potential aquifers. Depth to aquifer is a deterrent to drilling except close to outcrop areas. Yields vary from small to large and may be artesian.
(See Tables III-1, -2, -3, -5, -7, -8)	The Browns Park formation reportedly supplies water to irrigation wells. The city of Rawlins pipes most of its water from springs issuing from the Browns Park formation.	The study area includes a portion of the Hanna basin (Figure III-3). The structural configuration of this basin has resulted in pre-Tertiary formations being steeply inclined towards the center of the basin, overlapped by younger Tertiary sediments.
<u>STUDY AREA 2. SWEETWATER RIVER DRAINAGE AREA (GRANITE MOUNTAIN AND WIND RIVER MOUNTAIN AREAS)</u>		
Small yields are readily available from floodplain alluvium at depths less than 100 feet below the surface.	The Arikaree probably would yield moderate to large supplies. Thus far wells have been drilled 40 to 850 feet deep, with an average depth of about 190 feet. Two wells near Jeffrey City have yields of 800 and 1,100 gpm. The Arikaree reportedly may have between 800 and 1,000 feet of water saturation.	Pre-Tertiary formations are present at relatively great depths except where exposed due to uplift. Several formations, including the Cloverly, Park City, and Madison, yield water through wells at the edge of the Wind River Mountains.
A significant part of the flow of the Sweetwater River is derived from groundwater. This conclusion is supported by the configuration of generalized water table contours as mapped by the USGS.	The White River and Wagon Bed formations are not utilized because water is available at shallower depths.	
(See Tables III-1, -2, -3, -4, -7, -8)	Adjacent to the Red Desert (Great Divide) Basin the Battle Spring formation may yield up to 1,000+gpm from wells 2,000-3,000 feet deep.	
<u>STUDY AREA 3. MEDICINE BOW RIVER DRAINAGE AREA (INTERMONTANE BASIN)</u>		
Floodplain alluvium is not at this time considered a significant aquifer, even though the alluvium of Rock Creek (in the Laramie basin, Figure III-3) is known to yield at least 25 gpm to shallow wells.	The study area includes portions of three geologic basins. These are the Shirley, Hanna, and Laramie basins.	Groundwater is available from numerous aquifers; depth to aquifer increases towards the centers of the geologic basins.
(See Tables III-1, -2, -3, -5, -7, -8)	In the Shirley basin the White River-Wagon Bed sequence overlies older formations along the western edge of the Laramie Mountains. The Tertiary cover elsewhere in the Shirley basin is the Wind River formation. The availability of groundwater in the White River-Wagon Bed sequence is not reliably known. Groundwater is available from the Wind River formation at shallow depths; several small-yield wells (10 gpm) have found water zones at depths of 10 to 500 feet.	The exposed rocks in that part of the Laramie basin in this study area are almost all pre-Tertiary in age. Groundwater is produced through wells 50 to 1,500 feet deep; the most important aquifers are the Cloverly formation and the Tensleep sandstone.
	The Hanna basin is similar to the Shirley basin in that Tertiary sediments overlie pre-Tertiary rocks which are steeply inclined towards the center of the basin. A few wells reportedly yield small quantities of water from the Hanna formation.	The Hanna basin contains an estimated total sedimentary thickness of 30,000 feet.

TABLE III-10 -- Availability of Groundwater (continued)

Quaternary Sediments	Tertiary Sediments	Pre-Tertiary Sediments
<u>STUDY AREA 4, NORTH PLATTE RIVER PATHFINDER TO WHALEN DAM (MOSTLY IN THE HIGH PLAINS, BUT ALSO IN THE OTHER TWO GEOLOGIC REGIONS)</u>		
Availability of groundwater in alluvium of the North Platte River is assumed to be good. The alluvium of Horseshoe Creek in Platte County supplies water for stock, domestic, and irrigation uses, but the adequacy of alluvial aquifers in tributary valleys is for the most part unknown. The alluvium thickness along the Platte River is about 80 feet, and alluvial aquifers should yield at least several hundred gallons per minute. (See Tables III-1, -2, -3, -4, -5, -6, -7, -8)	Formations in the western part (Arikaree remnants, White River, Wagon Bed, Wind River, Wasatch, Fort Union) are separated from those to the east (Ogallala, Arikaree, Brule, Chadron, Wasatch, Fort Union) by the Casper arch and the Laramie Range. The over-all potential of aquifers in the western part is not well known. Several water wells, 300 - 500 feet deep, with yields of about 20 gpm, may be producing from the lower part of the White River and/or the underlying Wagon Bed formation. The Wind River probably has a potential to supply small yields from shallow depths. In the east the Arikaree supplies water to numerous domestic and stock wells. Moderate yields might be obtained from fractured Brule in Platte and Converse Counties. Water might also be obtained from the lower part of the Chadron formation. The potential of the Wasatch is poor due to its very limited extent in the area. Several domestic and stock wells obtain water from the Fort Union formation.	The most important of the pre-Tertiary aquifers is the Casper (Hartville). In the vicinity of Glendo in Platte County the uppermost "Converse sand" reportedly has the potential to flow as much as 175 gpm through wells. A spring in Natrona County reportedly flows 7,500 gpm from the Tensleep sandstone. Depth to aquifer deters drilling to the Casper (Hartville, Tensleep) in much of the area.
<u>STUDY AREA 5, NORTH PLATTE RIVER WHALEN DAM TO STATE LINE (HIGH PLAINS)</u>		
Alluvium (including valley fill) supplies water to many wells but only where the gross saturated thickness of the permeable water-bearing material is sufficient (50 feet and greater) is it a reliable source of irrigation water, with yields of 1,000 to 3,000 gpm. The alluvium reaches a thickness of more than 200 feet in Goshen County and large-yield irrigation wells penetrate the entire thickness. Municipal water supplies for Torrington and Lingle and perhaps other communities are obtained through wells 50-100 feet deep in the alluvium of the North Platte River. Sand dunes are not significant aquifers. (See Tables III-1, -2, -3, -6, -7, -8)	Channel deposits are local cap rocks, topographically high and well drained. The Ogallala formation is present only near the mountain front and adjoins a much more extensive outcrop in Study Area 7. The Ogallala has a limited potential in Study Area 5 due to its local distribution. The Arikaree formation is at the surface in much of the area. The Arikaree has a wide distribution and stores a large amount of water, but matrix permeability generally is poor, and large intervals of water saturation are required for moderate to large yields. The Brule and Chadron yield water to domestic and stock wells. Near LaGrange in Goshen County yields of 800-900 gpm are obtained from fractured Brule. Here the Brule is overlain by a moderate thickness of saturated alluvium.	Pre-Tertiary formations are exposed in and adjacent to uplifted areas and in the Goshen Hole (Figure I-1). In much of the study area pre-Tertiary aquifers are at excessive drilling depths. The Lance formation, at localities where the water table is shallow, supplies water to a large number of domestic and stock wells. The town of Yoder reportedly obtains its municipal water from two wells 80-100 feet deep in the Lance formation.

TABLE III-10 -- Availability of Groundwater (continued)

Quaternary Sediments	Tertiary Sediments	Pre-Tertiary Sediments
<u>STUDY AREA 6A, UPPER LARAMIE RIVER DRAINAGE AREA (INTERMONTANE BASIN)</u>		
Even though floodplain alluvium covers much of the study area, the availability of groundwater in the alluvium is only fair. This is due to an undulating and sharply varying underlying bedrock surface which results in a regionally thin and locally absent alluvial zone of saturation. A number of wells in the alluvium supply stock and domestic water, and several irrigation wells reportedly yield amounts greater than 1,000 gpm. (See Tables III-1, -2, -3, -5, -7, -8)	Tertiary sediments are not widespread in this area. The White River formation occurs only as small isolated remnants along the edge of the Medicine Bow Mountains and is not considered an aquifer. The Wind River formation is the surface bedrock in the north-western part of the area and reportedly has at least three water zones. Well yields of 50-200 gpm are reported from depths of 15-200 feet. The Hanna formation (underlying the Wind River) probably would yield small supplies to wells.	Many wells produce water from the pre-Tertiary bedrock immediately underlying the veneer of floodplain alluvium. Wells in the Casper formation (Tensleep sandstone) at the edge of the Laramie Range yield 5-1,000 gpm from depths of less than 100 to 1,000 feet. Other formations which can yield water through wells are the Mesa-verde, Niobrara, Muddy, Cloverly, Chugwater, and Satanka. The effectiveness of these aquifers is enhanced by fractures in the outcrop (recharge) areas and artesian conditions due to the configuration of the geologic basin. Large-yield springs that provide municipal water to the city of Laramie appear to originate from pre-Tertiary sources.
<u>STUDY AREA 6B, LOWER LARAMIE RIVER DRAINAGE AREA (HIGH PLAINS)</u>		
Terrace gravels in the vicinity of Wheatland are significant aquifers. Well yields ordinarily range from 100 to 500 gpm with greater yields reported. Seven terraces have been mapped in the Wheatland Flats. The thickness of terrace deposits ranges from 5 to 85 feet, with an average of about 30 feet. Floodplain deposits are found along streams and consist mainly of sand and silt with admixtures of clay and gravel. Small, perhaps to moderate, yields of water can be obtained from alluvium of the floodplains. Other alluvial deposits associated with slope wash, landslide material, and alluvial fans are of very limited distribution. (See Tables III-1, -2, -3, -6, -7, -8)	The Arikaree formation is exposed in much of the area and underlies the terrace gravels. The Arikaree reportedly can support 1,000-gpm wells if the wells penetrate 500 feet of saturated aquifer. The best wells in the Arikaree are relatively shallow and produce from fractured sandstone. The Brule formation is at the surface in much of the area drained by Chugwater Creek and its tributaries, in T.20 N. through T.23 N. Both the Brule and Chadron formations are at the surface in T.23 N. adjacent to the Goshen County line, where the erosional lowland of the Goshen Hole extends into Platte County. The Brule supplies small quantities of water for domestic and stock uses. The Chadron may be capable of yielding small supplies.	The potential of pre-Tertiary aquifers has not been evaluated. Depths to aquifers will probably deter exploration of these formations.

TABLE III-10 -- Availability of Groundwater (continued)

Quaternary Sediments	Tertiary Sediments	Pre-Tertiary Sediments
<u>STUDY AREA 7, SOUTH PLATTE RIVER DRAINAGE AREA (HIGH PLAINS)</u>		
Alluvium is associated with flood-plains and terraces. Stream (flood-plain) alluvium generally is thin and not a good aquifer except in the Pine Bluffs lowland where it yields moderate to large supplies of water to wells. It also yields quantities sufficient for irrigation locally in the Lodgepole Creek valley. Elsewhere the alluvium supplies water adequate only for domestic and stock supplies. Terrace gravels yield up to 1,500 gpm to wells in the Carpenter-Egbert-Pine Bluffs area. (See Tables III-1, -2, -3, -6, -7, -8)	The Ogallala formation supplies hundreds of millions of gallons of water annually to municipal wells in the Cheyenne Well Field about 6 miles west of Cheyenne. Yields of 50 gpm probably can be obtained from the Ogallala at most locations and much greater yields have been reported. The Arikaree can supply at least small yields and even large yields locally. The White River (Brule) supplies large yields to wells in the Federal Well Field west and north of Cheyenne and is a principal aquifer in the Pine Bluffs area. Large yields (2,000 gpm) are attributed to joints, fissures, fractures, and pipes in the Brule.	The pre-Tertiary formations may reach an aggregate thickness of 12,000 feet along the axis of the Denver-Julesburg basin (Figure III-3). The Lance, Fox Hills, Cloverly, Sundance, and Casper formations probably would yield water to wells. Pre-Tertiary formations are not considered important aquifers because water is available in younger (shallower) formations.
<u>STUDY AREA 8, NIOBRARA RIVER DRAINAGE AREA (HIGH PLAINS)</u>		
Many stock and domestic wells obtain water from the floodplain alluvium. The extent and thickness of the alluvium are not adequate for supplying water for irrigation, and common practice has been to drill through the alluvium into the underlying Arikaree sandstone. (See Tables III-1, -2, -3, -6, -7, -8)	The Arikaree is relatively impermeable, but wells with yields of 1,100 gpm have been developed in fractured and fissured sandstone. The Brule formation (of the White River group) yields water to stock and domestic wells. Sources of large water supplies may exist in the Brule, but depths to water and yields are very unpredictable at present. The Chadron formation (lower member of the White River group) may yield water to wells. The White River group underlies the Arikaree formation and is not exposed in this study area south of the Hat Creek Breaks.	Sandstone of the Lance formation would be expected to yield small quantities of water to wells; the formation generally is too deep to be utilized for most purposes. Other formations probably would yield water to wells, but are at even more excessive drilling depths.

The quality of groundwater affects its availability for a specific use. Table III-11 is a summary of the quality of groundwater as it affects the availability of water supplies.

TABLE III-11 -- Summary of Water Quality as it Affects the Availability of Groundwater

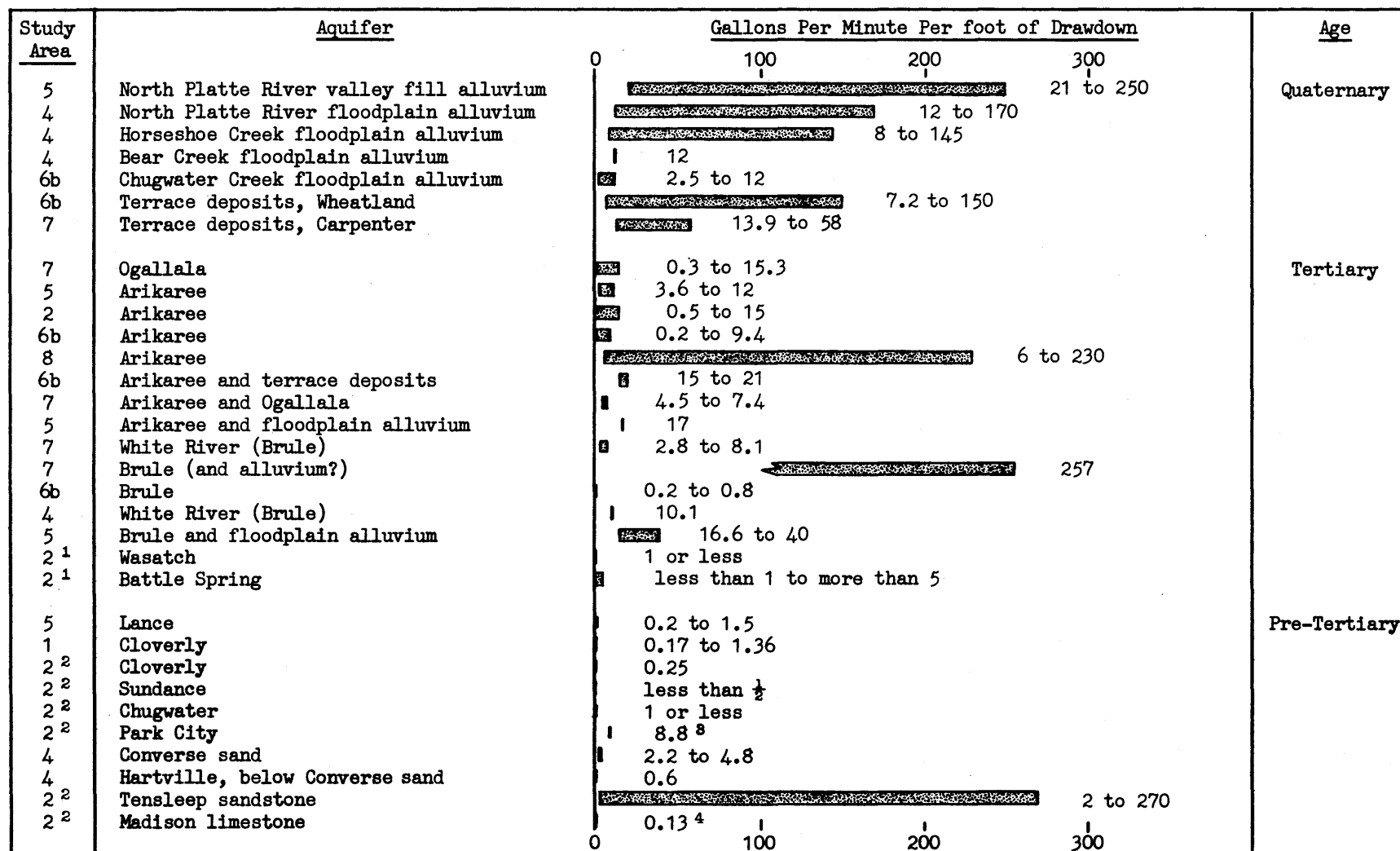
<u>Quaternary Sediments</u>	<u>Tertiary Sediments</u>	<u>Pre-Tertiary Sediments</u>
Stream Alluvium-- water quality generally is fair to good; the water generally is hard ¹ . Quality is susceptible to change due to man's activities, precipitation, and the movement of water between shallow aquifers and surface water drainages.	Ogallala -- water is satisfactory for most domestic and stock uses, although it may be hard. North Park -- water from springs that supply the city of Rawlins is considered of excellent quality. Browns Park -- water quality is fair to good.	Water quality is highly variable. The amounts of total dissolved solids range from about 200 to 100,000 ppm. Quality is usually good in proximity to outcrop (recharge) areas and deteriorates towards the interiors of the geologic basins. Very high concentrations of total dissolved solids are found in waters associated with accumulations of crude oil.
Terrace Alluvium-- water quality is similar to that of water in stream alluvium.	Arikaree -- water has the best overall quality of Basin aquifers, and is suitable almost everywhere for most uses. White River -- water quality is variable and locally is below acceptable standards for domestic use. Wasatch -- water quality reportedly varies from fair to poor. Battle Spring -- water quality is good. Wind River -- water quality is variable and ranges from good for domestic use to unsuitable for livestock. Fort Union -- water may have a limited use due to quality.	

¹ Hardness is a quality of water which influences the use of water for a specific purpose. Expressed as equivalent amounts of calcium carbonate, water that has less than 60 ppm is considered soft; 60 to 120 ppm is moderately hard; 120 to 200 ppm is hard; and more than 200 ppm is very hard.

Aquifers that are capable of supporting large-yield wells usually have thick saturated intervals. The exception to this is the thin interval of saturation that is at or near the surface and has more than normal effective permeability due to fractures, fissures, pipes, solution cavities, or lenses. A measure of the comparative ability of aquifers to supply water through wells is given by the specific capacities of wells, in gallons per minute per foot of drawdown (gpm/ft). Figure III-4 illustrates relative specific capacities of wells in the Basin, by study area and aquifer.

There are numerous reported springs in the Basin. The greatest known spring flow is 7,500 gpm from the Casper formation reported in Section 15, T.32 N., R.81 W. (Study Area 4). The source of the spring water probably is a system of interconnected solution cavities in the Madison and/or Casper (Tensleep).

FIGURE III-4 -- Relative Specific Capacities of Wells in the Basin, by Study Area and Aquifer
(From USGS Publications)



¹ Adjacent to Study Area 2, in Red Desert (Great Divide) Basin.

² Adjacent to Study Area 2, in Wind River Basin.

³ Probably in hydraulic connection with deeper source.

⁴ Much lower than would be anticipated.

Recharge to aquifers in the Basin is accomplished by precipitation, infiltration of surface water of natural drainages, infiltration of water diverted for irrigation and applied to the land, and underflow of groundwater into the Basin. Mining of the groundwater resource occurs when withdrawals from a particular aquifer in a defined area exceed the natural recharge to the area, over a period of several years. The same effect produced by mining over a period of years--declining water levels and reduced yields--can be produced by well interference in a much shorter period of time.

USE OF GROUNDWATER

Groundwater is used extensively in the Basin as domestic and stock, municipal, industrial, and irrigation water. The rural population and livestock are very dependent on the availability of groundwater. Municipalities use groundwater to a great extent. Industry has found it convenient and economical to develop groundwater resources. In some parts of the Basin the only available water for irrigation is groundwater. Most uses (excluding irrigation) require only low to moderate well yields and therefore are fairly certain of a constant water supply after proper construction and development of the source wells. Irrigation requires large yields, on the order of 500 to 1,000 gpm per well.

Domestic and stock wells are normally low-yield, intermittent producers. Water for domestic and stock uses is found at relatively shallow depths almost everywhere in the Basin. Some flowing artesian wells and springs are utilized for domestic and stock purposes.

About 78 percent of the total municipal population use a combination of groundwater and surface water; another 12 percent depend entirely on groundwater. Municipal water is used locally for industrial purposes.

Industry uses self-supplied groundwater in the secondary recovery of petroleum³, in the manufacture of cement, in the processing of uranium and iron ores, and for other purposes. Industry consumes an estimated 3,000 acre-feet of groundwater annually.

Irrigation accounts for the consumption of more groundwater in the Basin than all other uses combined. By the end of 1965 there reportedly were 545 wells in the Basin providing an original supply of groundwater to about 42,000 acres and a supplemental supply to about 31,000 acres. By the end of 1970 these figures had increased to about 68,500 acres using groundwater as the original supply and about 70,000 acres using groundwater as a supplemental supply. The number of irrigation wells had increased to about 1,000.

Table III-12 shows the new lands irrigated with groundwater in 1969 and 1970 with the assistance of DEPAD and Farm Loan Board⁴ loans. As a means of comparison,

³ Some of the groundwater used for this purpose is saline water that is produced with oil and would otherwise require disposal. The produced water used for this purpose is not included in the calculation of total amount consumed.

⁴ The Wyoming Department of Economic Planning and Development provides technical assistance to farmers seeking water development loans from the Farm Loan Board and has a loan program of its own.

the table also shows new acres by permits filed with the State Engineer's Office in 1970.

TABLE III-12 -- Acres Irrigated Using Groundwater as the Original Supply, by Study Area

Study Area	State Loan Program				Acres, by Permit Filings, 1970, in State Engineer's Office ¹		
	Acres (Original Supply)		Percent of Total		Original Supply	Supplemental Supply	Combined
	1969	1970	1969	1970			
1	---	---	---	---	1,286.3	626.7	---
2	---	---	---	---	---	---	---
3	---	---	---	---	480	40	---
4	---	---	---	---	494.1	422.7	---
5	923	1,245	27	28	4,769.1	4,177.4	840
6a	---	---	---	---	116	---	---
6b	780	631	23	14	2,555	500	---
7	1,142	1,739	33	39	6,519.6	1,518	---
8	600	824	17	19	1,586.4	---	---
Total	3,445	4,439	100	100	17,806.5	7,284.8	840

¹ Six percent of the total number of permits filed are for irrigation; 90 percent are for domestic and stock wells, and four percent are for other wells.

The total number of acres shown on permits almost always is greater than acres actually developed during the year of filing. The State's loan programs are presumed to be indicative of the overall effort, including that of private investment. It is estimated that in 1970 the loan programs were responsible for 75 percent of the new lands irrigated with groundwater. The number of new acres irrigated with groundwater annually in the Basin has increased, by estimate, from 4,600 acres in 1969 to 6,500 acres in 1970. The total for 1970, by study area, shows the following:

Study Area	New Acres Original Supply (numbers rounded)	Study Area	New Acres Original Supply (numbers rounded)
1	320	6a	30
2	---	6b	840
3	120	7	2,320
4	125	8	1,100
5	1,660	Basin Total	6,515

Study Areas 5 and 7 had the greatest amount of new development in 1970. Together these two study areas include almost all of Goshen and Laramie Counties. A very large percentage of the total amount of irrigated lands using groundwater as the original supply are in these same two counties. Based on records in the

State Engineer's Office, the total number of acres in the Basin using groundwater as an original supply, by county, are: ⁵

<u>County</u>	<u>Acres</u>	<u>County</u>	<u>Acres</u>	<u>County</u>	<u>Acres</u>
Albany	3,448	Fremont	44	Natrona	675
Carbon	1,565	Goshen	24,262	Niobrara	4,299
Converse	740	Laramie	29,212	Platte	4,282

A comparison of reported acres and mapped acres in the Basin shows that the actual numbers of irrigated acres in a season are less than the permit totals. Table III-13 is a summary of irrigation using groundwater as the original supply. The data were estimated from available information. The total estimated amount of groundwater consumed annually as the original supply by irrigation is approximately 71,000 to 95,000 acre-feet. Groundwater is also used as a supplemental water supply for about 70,000 permit acres of irrigated land in the Basin. The amount of water consumed for this purpose is estimated to be about 35,000 acre-feet per season. ⁶

TABLE III-13 -- Summary of Irrigation Using Groundwater as the Original Supply

Study Area	Acres Irrigated Using Groundwater as Original Supply, by Permits	Average Consumptive Use ¹ (Acre-Feet/Acre)	Estimated Annual Consumptive Use, Based on Permits (Acre-Feet)	Estimated Annual Withdrawal, ² Based on Permits (Acre-Feet)	Estimated Annual Withdrawal, ³ Based on 75% of Permit Acreage (Acre-Feet)
1	1,565	1.6	2,504.0	6,260.0	4,695.0
2	44	1.6	70.4	176.0	132.0
3	(If there is any irrigation using groundwater in this area, the acres are included in area 1 and/or area 6a)				
4	1,415	1.5	2,125.5	5,313.8	3,985.4
5	24,262	1.4	33,966.8	84,917.0	63,687.8
6a	3,448	1.5	5,172.0	12,930.0	9,697.5
6b	4,282	1.5	6,423.0	16,057.5	12,043.1
7	29,212	1.3	37,975.6	63,292.7	47,469.5
8	<u>4,299</u>	1.5	<u>6,448.5</u>	<u>10,747.5</u>	<u>8,060.6</u>
Totals	68,527	(1.4-Basin average)	94,685.8 ⁴	199,694.5	149,770.9

¹ In addition to normal effective precipitation.

² The amount of water actually applied to the land is greater than the amount consumptively used and depends largely on climatic factors and the method of applying the water.

³ The number of irrigated acres reported on a permit usually is greater than the number finally irrigated. The estimate of validity used here is based on random sampling.

⁴ Based on the estimate of 75 percent validity, the amount consumed is 71,014.5 acre-feet.

⁵ Through 1970.

⁶ Estimated, using 75 percent of permit acres and 2/3 acre-foot per acre late season water supplied for consumptive use in addition to effective precipitation.

An important consideration in obtaining groundwater for irrigation is the depth to water. Most unconsolidated aquifers are less than 100 feet deep. In the North Platte valley of Study Area 5, however, they are from 10 to 300 feet deep. Consolidated aquifers exist from depths of less than 50 to more than 10,000 feet in the Basin. Table III-14 shows the depth-ranges of irrigation wells, by study area, based on permit-acres and permits filed in 1970. More than 60 percent of the total 1970 permit acres are proposed to be irrigated from wells in the depth-range 50-299 feet.⁷

TABLE III-14-- Depth-Range of Wells Producing Groundwater for Irrigation,
Based on Permits Filed in 1970

Study Area	Permit Acres (1970) by Depth-Range of Wells								Total Permit-Acres (Original Supply)
	0-49'	50-99'	100-199'	200-299'	300-399'	400-499'	500-599'	600-900'	
1			1,195	91.3					1,286.3
2									
3								480	480
4	95.6	100	100		31.5	7	160		494.1
5		625	1,489.5	2,314.6	200		140		4,769.1
6a		13			103				116
6b		60	240	880	457	618		300	2,555
7		80	1,982.6	1,262	2,255	940			6,519.6
8			495	320	611.4	160			1,586.4
Total	95.6	878	5,502.1	4,867.9	3,657.9	1,725	300	780	17,806.5

POTENTIAL GROUNDWATER DEVELOPMENT

Groundwater will continue to be used extensively for rural domestic and live-stock supplies. Rural farm population is not projected to increase, so the amount of water consumed by this use probably will not increase. The amount of groundwater required for livestock will increase as the numbers of livestock increase.

A very large number of people in the Basin are supplied municipal water which is pumped from aquifers. Municipal populations are projected to increase, and water requirements will increase accordingly; small communities probably will not increase consumptive uses appreciably. Consumptive uses in large communities will increase due to the anticipated growth of populations and industries. Increases will in part be supplied by groundwater.

The industrial use of groundwater is projected to increase considerably in the uranium sector. The increase will occur in conjunction with operations in the Crooks Gap uranium district (Study Area 2) and the Shirley Basin uranium district (Study Area 3). In addition, the Gas Hills uranium district could expand into the Sweetwater River drainage area (Study Area 2) in the future. The districts are shown on Figure IV-4. The groundwater will be pumped from consolidated

⁷ About 58 percent are in the range 100-299 feet.

aquifers of Tertiary (and perhaps earlier) age. The amount pumped in each district conceivably could result in mining of the local groundwater resource by the year 2000. The annual consumptive use by the uranium industry is projected to be 10,000 acre-feet by the year 2000.

Between 1970 and 2000 the annual use of groundwater for waterflooding oil fields (Figure IV-3) is projected to decrease, and the use by cement and other industries is projected to remain fairly constant. The total amount of groundwater consumptively used annually by industry in 2000 A.D. is projected to be about 11,600 acre-feet (refer to Table IV-17).

The largest consumptive use of groundwater in the Basin is by agriculture for irrigation. If growth of agriculture occurs, the consumptive use of groundwater for irrigation may greatly increase because either the practical limit of surface water development has locally been reached or development is limited by legal constraints.

It is assumed that future irrigation will be accomplished primarily by sprinkler systems. A circular sprinkler covering 125 acres⁸ in the high plains reportedly requires a well yield of about 900 gpm. Sprinkler systems cost about \$200 to \$300 per irrigated acre to install, including the cost of developing the groundwater supply.

Much of the development of irrigation using groundwater is presently occurring in Study Areas 5, 6b, 7, and 8 (Figure III-2), and it appears that this trend will continue. Each of these areas is discussed individually.

Study Area 5 has more than 120,000 acres of irrigation of which approximately 20,000 acres are irrigated using groundwater as the original source of supply. The estimated annual withdrawal of groundwater for this use is between 60,000 and 85,000 acre-feet per year; about 25,000 to 35,000 acre-feet are consumed each year. Most of the groundwater withdrawn for irrigation is from the valley fill underlying the floodplain of the North Platte River and major tributaries. The groundwater available to wells in the valley fill of the North Platte River and major tributaries is not depleted by present irrigation because recharge is greater than consumption. During the irrigation season the underground water level in the valley fill rises due to the infiltration of diverted surface water. It has been estimated that the diversion and application of surface water for irrigation contribute about 200,000 acre-feet of water annually to the valley-fill groundwater reservoir (53). The water table rises about 5 feet during the irrigation season and declines approximately the same amount during the subsequent nonirrigation season. The net effect is a relatively unchanging natural groundwater level. The natural groundwater recharge, from precipitation and tributary underground inflow, amounts to an estimated 14,000 acre-feet per year (half the annual consumptive use). Natural recharge does not provide sufficient water to support long-term irrigation without lowering the groundwater level. Lining canals and laterals for the more efficient use of surface water will adversely affect groundwater recharge.

Several thousand acres of irrigated land in the study area are located south of the Platte River valley in the vicinity of LaGrange. A considerable portion

⁸ This is the approximate amount of level land that will be covered by a circular sprinkler pivoted at the center of a quarter section.

of this irrigated land is in the floodplain of Horse and Bear Creeks. Some of the irrigation water is obtained from the alluvium, but most is from the underlying Brule formation. Recharge is mainly from precipitation; therefore, expanding irrigation development may result in lowered water levels, requiring deeper wells to obtain a water supply.

The Arikaree formation yields water to several irrigation wells in the northern part of the study area (53). The amount of water in the Arikaree is very large; however, a considerable saturated thickness of the formation normally must be penetrated in order to develop a large-yield well. The better wells are found where secondary permeability is effective. Effective secondary permeability many times is due to fracturing of the bedrock.

In Study Area 6b numerous wells have been drilled into gravels which cap terraces above the valleys of the Laramie River and tributaries. The gravels are good aquifers but due to an elevated topographic position drain relatively rapidly. Natural recharge due to precipitation is small; much of the effective recharge has been due to seepage from canals and laterals. During the irrigation season water levels have been known to rise in wells as much as 5 feet; about the beginning of August, water levels decline until the next irrigation season. Recharge from irrigation water has been much greater than that from precipitation. When surface water has not been available for irrigation, water levels in wells have declined an average of 6 feet per year (47).

Wells of large capacity can be developed in the Arikaree formation. The average matrix permeability of the formation is low; several hundred feet of saturated sandstone must be penetrated by a well to obtain a large yield. In most of the Wheatland Flats area wells can reach water at depths of 40 to 100 feet and penetrate about 500 feet of saturated sandstone. The Arikaree is thought to have a thick interval of saturation north and east of the Wheatland Flats.

In Study Area 7 a large quantity of groundwater is used for irrigation. The majority of lands being irrigated are east and northeast of Cheyenne. The most recent irrigation developments are taking place in the Egbert-Pine Bluffs area in southeastern Laramie County, and in the vicinity of Albin 15 miles north of Pine Bluffs. Much of the irrigation water is pumped from the Brule formation of the White River group. Large yields are obtained from fractures in the Brule, which is recharged by direct precipitation, underflow from the west, and infiltration of surface water and groundwater.

In the future, most new lands probably will be developed away from major valleys and will therefore obtain groundwater from consolidated aquifers. In addition to the Brule, the Arikaree and Ogallala formations locally will yield large supplies of water. The area west of Cheyenne is being developed for municipal supplies, so water in the Ogallala formation in this area is not considered to be available for irrigation. In the eastern part of the study area, between Albin and the Carpenter-Egbert-Pine Bluffs area, the saturated thickness of the Ogallala-Arikaree interval is zero or negligible due primarily to the effects of erosion preceding and during the Quaternary period. One of the best places to prospect for large well yields is in T.16 N., Rgs. 64-66 W. where conditions are favorable for finding a combined Ogallala-Arikaree saturated thickness in excess of 350 feet (41). Even though a thick interval of water-saturation might be found, large yields might not be obtained without the added advantage of secondary permeability. Other important considerations are the depth to water and the feasibility of lifting water from a deep, permeable, thick interval of saturation.

At present, wells in the Pine Bluffs area experience declining water levels during the irrigation season and recovering water levels during the remainder of the year. Some wells can be pumped only intermittently during the irrigation season. The State Engineer has designated 53,000 acres in the Pine Bluffs area a "controlled (critical) groundwater area" (Figure III-2). This designation does not automatically curtail future groundwater development but does allow certain restrictions to be placed on the use of shallow groundwater in the area.

Study Area 8 relies almost entirely on groundwater to support expanding irrigation. The primary aquifer is Arikaree sandstone, which is exposed in much of the area and underlies the valley alluvium. At most places the Arikaree should be capable of yielding at least 5 gpm for each foot of drawdown (88). The more productive wells generally obtain water from fractures in the Arikaree formation along the river valley in the vicinity of Lusk. Reported well yields are in the range of 500 to 1,000 gpm. Increasing withdrawals for irrigation will require drilling more wells into the Arikaree formation, 100 to 600 feet deep. It may become necessary to explore the feasibility of obtaining large yields through wells drilled into aquifers below the Arikaree.

Other areas have the potential to supply groundwater for irrigation but not to the extent of the easternmost High Plains. Groundwater probably can be developed in the Saratoga Valley (Study Area 1) and the Sweetwater River drainage area (Study Area 2) if other factors are favorable. In both areas vast amounts of groundwater are stored in the uppermost 1,000 feet of consolidated formations.

The valley of the North Platte River below Pathfinder Reservoir and above the Laramie River juncture (Study Area 4) has a groundwater potential for some irrigation in the alluvium of the main stem and major tributaries. The potential may extend to the Tensleep-Madison interval in the vicinity of Glendo Reservoir.

In Study Area 6a the alluvium which veneers most of the valley is very thin and not adequate, except locally, for supporting large-yield wells. Expanded irrigation using groundwater will require deep bedrock wells, and exploration is required to locate the best sites. The quality of water in deep bedrock formations may not be satisfactory. Representative analyses of waters of Cretaceous, Jurassic, and Pennsylvanian ages show high amounts of TDS (3,200 to 74,000 ppm) and a range of 234 to 27,037 ppm sodium plus potassium (20).

Based on economic projections and a sampling of well completion filings in the period 1968-1970, it is estimated that by 2020 as many as 130,000 permit acres of land in the Basin may be irrigated using groundwater as the original source of supply.⁹ Groundwater may also be used as a supplemental supply for 175,000 permit acres.

The total estimated amount of groundwater projected to be consumed annually during the period 2000 to 2020 in the Basin is about 300,000 to 350,000 acre-feet. In the areas of greatest projected usage groundwater may be withdrawn at rates greater than natural recharge. In addition, as development progresses, more wells will be drilled at sites away from floodplains requiring well-depths greater than 300 feet.

⁹ Assuming other factors such as soil and economics are favorable.

DATA NEEDS AND ACQUISITION

The Platte River Basin is a region of intense groundwater use, which use is projected to continue and increase in the agricultural and industrial sectors and perhaps in other sectors as well. The greatest increase will take place in the High Plains due to the projected growth of irrigation with groundwater.

A considerable amount of groundwater data of the High Plains has been collected in the past by the USGS and others, and several detailed studies of areas in the High Plains are underway at present. Data for the other two geologic regions are sparse.¹⁰ The groundwater resources of the Basin, more specifically of the High Plains, should be inventoried as part of an ongoing continuous reconnaissance study augmented by detailed studies of specific areas. The first step in such a procedure has been accomplished by the implementation of a program to periodically measure groundwater levels in observation wells (Figure II-1) as part of an ongoing cooperative program between the State Engineer and the USGS.

Data should be collected on the geohydrology, including water quality, of the entire sedimentary rock section from the surface to the basement. Records of wells drilled for oil and gas can be perused for information. Additional data will be found in publications pertaining to oil and gas and uranium. Data such as well location, aquifer characteristics, changing water levels, well yield and annual withdrawal, and related information should be collected and kept current for all large-yield wells (350 gpm or more) in the Basin.

Artificial recharge to unconsolidated aquifers in the Basin may be technically feasible. A great deal of preliminary investigation and research is required even before a pilot program is attempted in the field. The possibility for artificially recharging certain aquifers within the Basin is not being overlooked.

¹⁰ A hydrologic atlas of the Sweetwater River drainage has been published (89) and an atlas of the Intermontane Basin Area is being prepared for publication by the USGS.

C H A P T E R I V

T H E E C O N O M Y A N D R E L A T E D W A T E R U S E S

THE ECONOMY AND RELATED WATER USES

AGRICULTURE

There are about 15,319,200 acres of land area and 114,400 acres of water area in the Platte River Basin. The total Basin area is about 15,433,600 acres or 24,115 square miles.

There are about 552,760 acres of irrigated land and 557,400 acres of dry cropland and summer fallow land in the Basin. Most other lands in the Basin are used for grazing, except inhabited areas, parks, recreation areas, Federal lands where grazing of livestock is not permitted for management purposes, and badlands and mountainous areas where access is too difficult to efficiently use the land for grazing.

Present Economy

The description of the agricultural economy of the Platte River Basin is based on county data which does not conform to the drainage boundary. Albany, Carbon, Converse, Goshen, Laramie, Natrona, Niobrara, and Platte Counties reasonably represent conditions in the Basin. Parts of Fremont and Sublette Counties lie within the Basin, but agricultural production in the Platte drainage area of these two counties represents only a small share of the production and income of these counties, and they are excluded from the analysis.

The Agricultural Census shows the value of all farm products sold in 1964 to be about \$62,260,445 in the Basin area (Table IV-1). Livestock and livestock products contribute about 79.1 percent of the value of all farm products sold, and crop sales amount to about 20.7 percent of total sales.

Beef cattle and sheep are the principal sources of cash income in the Basin. Cash crops are an important source of income in Goshen, Laramie, and Platte Counties. Goshen County is the State's leading producer of corn and ranks second in sugar beets and beans. Laramie, Goshen, and Platte Counties are the top dryland wheat-producing counties in the State.

There are 2,779 commercial farms and 484 part-time and retirement farms in the area or a total of 3,263 farm and ranch units.

The average gross sales of all farm products sold per farm varies from \$14,056 in Niobrara County to \$29,343 in Carbon County. The average sales per farm and ranch unit in the Basin are about 13.9 percent above the State average.

Operators of small farms and ranches and inexperienced operators have difficulty establishing economic units. These operators usually realize a low return on invested capital and in some cases do not have the capital resources to employ the technology and efficiency necessary to establish a sound economic unit.

The operators of well-managed larger farm and ranch units generally meet production costs and realize a moderate return on invested capital. A larger percent of the farm and ranch units in the Platte Basin are of economic size than in most other areas of the State.

TABLE IV-1 — Value and Distribution of Farm Products Sold, Number of Farms, Size and Sales Per Farm
1964 Census of Agriculture

County	Value of Products Sold			Number of Farms	Average Farm Size (Acres)	Average Sales Per Farm (Dollars)
	All Farm Products (Dollars)	All Livestock and Livestock Products (Dollars)	All Crops Sold (Dollars)			
Albany	4,717,680	4,572,213	125,378	232	7,746	20,335
Carbon ¹	7,042,356	6,677,052	340,413	240	12,022	29,343
Converse ¹	5,041,991	4,672,436	345,745	325	7,069	15,514
Goshen	18,659,863	11,666,895	6,988,681	909	1,474	20,528
Laramie	9,061,238	6,401,225	2,659,431	553	3,731	16,386
Natrona ¹	5,365,738	5,110,413	245,504	217	15,859	24,727
Niobrara ¹	4,259,081	3,939,010	317,601	303	5,252	14,056
Platte	8,112,498	6,234,894	1,847,789	484	3,027	16,761
Total	62,260,445	49,274,138	12,870,542	3,263	5,211 ²	19,081 ²
State Total	151,436,363	119,465,471	30,726,384	9,038	4,102 ³	16,756 ³
Area-Percent of State	41.1	41.2	41.9	36.1		

¹ A portion of the county is outside the Platte drainage.

² Average for Basin.

³ Average for State.

During the period 1950 to 1969 the index of livestock prices received increased from 280 to 323 or about 15.3 percent. The index of crop prices received declined from 233 to 220 or about 5.6 percent during the period. Wyoming Cooperative Crop and Livestock Reporting Service reports that from 1959-1968 beef marketed in Wyoming increased from about 287 million pounds to about 610 million pounds, an increase of more than 112 percent. The increase in beef production has stimulated increased feed grain and forage production in the Basin.

Cash receipts from farm marketing and realized gross income have increased substantially, but the rise in production costs has largely offset these gains. From 1950 to 1969 the index of prices paid increased from 256 to 373 or about 45.7 percent (Table IV-2).

During the past 20 years, despite year-to-year fluctuations in personal income, there has been no discernible trend in the total personal income originating in agriculture. The income of persons engaged in agriculture has improved because of a decline in the number of persons working in on-farm agriculture rather than from growth of the agricultural industry.

During the period 1930 to 1960 every county in the Basin showed a steady decline in farm population. Wyoming has experienced a steady downward trend in agricultural employment similar to the national trend in agriculture. However, the rate of decline has been lower in Wyoming than in the Nation or the states comprising the Rocky Mountain Region. Agriculture accounts for a larger share of total employment in Wyoming than in the United States or the Rocky Mountain Region and is the fourth largest industry in Wyoming as measured in terms of employment.

TABLE IV-2 -- Index of Parity, Prices Received and Prices Paid,
Selected Years 1950-1969. 1910-1914 = 100

Year	Parity ¹	Prices Received			Prices Paid		All Prices ³
		All Prices	Crop	Livestock	Production Items ²	Livestock	
1950	101	258	233	280	246	402	256
1954	89	246	242	249	255	302	278
1959	81	240	222	256	266	380	298
1964	76	237	239	236	270	312	313
1968	73	261	229	288	292	389	355
1969	74	275	220	323	304	436	373

¹ Parity -- ratio of index of prices received to index of prices paid, including interest, taxes, and wage rates.

² All commodities bought for use in production.

³ All Prices -- commodities and services, including interest, taxes, salaries, and wages.

Source: Agricultural Prices, Statistical Reporting Service. PR 1-3 (1970).

Dry Cropland

There are an estimated 326,900 acres of dry cropland and about 230,500 acres of summer fallow in the Platte Basin. This amounts to 557,400 acres or 3.64 per cent of the land area in the Basin.

Wheat is an important dryland cash crop in the Basin. Dryland hay, oats, and barley provide an important forage and feed-grain base for the livestock industry.

Irrigated Lands

The irrigated lands of the North and South Platte drainages were mapped during the irrigation season of 1969. The mapping of lands under irrigation in the Niobrara drainage was done in 1970. For the mapping program, irrigated land was defined as land watered for agricultural purposes by artificial means. These include sub-irrigated lands and seeped areas under ditches, as well as lands irrigated directly by ditches or sprinklers. Lands that are under ditches but clearly have not been irrigated for a number of years were excluded. However, lands classified as idle lands in the crop-distribution analysis were included. Idle lands are defined as lands not irrigated in an average water year and include those cropland acres from which a crop was not harvested during the crop year. The idle lands were deducted from the irrigated land total to determine the average annual irrigated acreage.

Table IV-3 is a tabulation of the irrigated land in the Platte River Basin in Wyoming. A total of 552,760 acres of irrigated land was mapped of which 24,840 acres were idle. The average area irrigated is about 527,920 acres.

TABLE IV-3 -- Tabulation of Irrigated Land in the Platte River Basin in Wyoming¹
(Acres)

<u>S T U D Y A R E A ²</u>		<u>Total Acres</u>		<u>Average Acres</u>
<u>Number</u>	<u>Drainage</u>	<u>Irrigated</u>	<u>Idle</u>	<u>Irrigated</u>
1	Platte above Pathfinder	88,320 ³	2,835	85,485
2	Sweetwater River	5,810 ³	30	5,780
3	Medicine Bow River	46,210 ³	2,035	44,175
4	Platte below Pathfinder, to Whalen	87,440	3,890	83,550
5	Platte below Whalen	120,150	1,935	118,215
6a	Upper Laramie River	104,745	8,140	96,605
6b	Lower Laramie River	67,090	3,935	63,155
7	South Platte River	28,335	1,860	26,475
8	Niobrara River	<u>4,660</u>	<u>180</u>	<u>4,480</u>
	Total	552,760	24,840	527,920

¹ Also includes irrigated lands in the Niobrara River drainage.

² See Figure II-4, page 39.

³ Land above the Pathfinder Dam in North Platte Decree Area. The North Platte main stem irrigated acreage from Pathfinder Dam to Guernsey Dam is about 16,280 acres. The total of irrigated land in the decree area is about 156,620 acres.

Source: Wyoming Water Planning Program.

The North Platte River Decree limits the amount of land that may be irrigated from the main stem of the North Platte upstream from Guernsey Dam and from the tributaries entering the North Platte River above Pathfinder Dam to a total of 168,000 acres. The recent mapping of irrigated lands reveals that about 156,620 acres are presently irrigated from these sources, and 11,380 acres of additional irrigated lands are permissible under the decree.

Economic Importance of Agriculture

Irrigated lands to provide a winter feed base for the livestock enterprise and grazing lands for summer forage are interdependent components of the ranch enterprise. The production of cash crops on irrigated land and dryland is more important in the Basin than in most other areas of the State. Some operators depend entirely on crop sales for cash income, but livestock and livestock products are the principal source of cash income.

Current normal crop distribution, yields, value of production, and net return to land are summarized in Table IV-4 for the irrigated lands in the Basin. The estimated gross annual value of crop and pasture production in the Platte Basin is about \$25,036,870. The net return to irrigated land in the Basin is

about \$3,684,300. Hay and feed grains are largely marketed through livestock. Cash crops provide a moderate to high net return to land and management.

TABLE IV-4 -- Platte-Niobrara River Basin--Summary of Current Normal Crop Distribution, Yield, Production, Value of Production, Production Costs, and Net Return to Irrigated Land

Crop	Acres	Yield Per Acre	Production	Price ¹	Value of Production (Dollars)	Production Costs (Dollars)	Net Return ² to Land (Dollars)
Alfalfa	100,000	2.7 ton	270,000	22.28	6,015,600	5,918,000	97,600
Other Hay	65,740	1.1 ton	72,315	22.28	1,611,180	1,952,850	- 341,670
Native Hay	156,000	.9 ton	140,400	22.28	3,128,110	3,676,860	- 548,750
Barley	10,425	43.0 Bu.	448,275	.98	439,310	516,350	- 77,040
Oats	7,050	55.4 Bu.	390,570	.68	265,590	344,810	- 79,220
Sugar Beets	20,000	15.5 ton	310,000	13.66	4,234,600	3,210,400	1,024,200
Beans	18,330	16.2 cwt.	296,950	7.08	2,102,400	1,448,990	653,410
Potatoes	3,300	155.0 cwt.	511,500	2.07	1,058,800	639,570	419,230
Corn (grain)	17,030	67.0 Bu.	1,141,010	1.23	1,403,440	1,104,220	299,220
Corn (silage)	22,370	13.0 ton	290,810	7.80	2,268,320	1,622,050	646,270
Pasture	107,675	3.1 AUM ³	333,800	4.00	1,335,200	918,470	416,730
Aftermath Grazing ⁴			293,580	4.00	1,174,320		1,174,320
Idle	24,840						
Total	552,760				25,036,870	21,352,570	3,684,300

¹ Average prices 1964 to 1968. Silage estimated at 35 percent of hay price.

² Gross value of production less fixed costs of production, operating costs, and all other production costs except interest on land investment.

³ Animal unit month grazing.

⁴ Aftermath grazing yields are estimated at 1.0 AUM for native and other hay, 0.5 AUM for alfalfa, and 1.25 AUM for small grain.

Source: Wyoming Water Planning Program and the University of Wyoming.

The University of Wyoming production cost data developed for the Agricultural Sector Study were used for estimating production costs. These figures include all costs of production, interest on invested capital, and labor costs, but not interest on land investment.

Secondary benefits stemming from or induced by irrigation are increased income to service industries in the community, local business establishments, and processors of agricultural products. A substantial amount of the net income of the irrigation enterprise is spent for family living and supports local business establishments and service industries. Farm and ranch operators are dependent upon imports for machinery, tools, and supplies. A major portion of crop-production costs, estimated at \$21,352,570, flows through local business channels. In many communities of the Platte Basin, irrigation and the associated livestock industry provide the major economic base for supporting local business activity.

The percent of local taxes generated by agriculture varies considerably between counties. The 1969 assessed valuation of the significant items used by agriculture is tabulated in Table IV-5. In the eight-county area, agriculture provides about 18.7 percent of the total assessed valuation. The percent of total valuation varies from 6.2 percent in Natrona County to 50.2 percent in Goshen County.

TABLE IV-5 — Assesed Valuation, 1969¹ Land, Improvements, Livestock, and Machinery

Item	C O U N T Y							
	Albany (dollars)	Carbon (dollars)	Converse (dollars)	Goshen (dollars)	Laramie (dollars)	Natrona (dollars)	Niobrara (dollars)	Platte (dollars)
Land								
Suburban	297,233	91,010	16,285	5,725	255,362	394,220	3,857	27,162
Irr. Land First Class		7,525	279,125	2,997,889	19,660		67,275	785,091
Irr. Land Second Class	46,955	536,226	351,360		239,734	266,997	11,305	381,315
Uncultivated w/ Water Rights	844,398	1,530,565	39,407	231,219	235,649	102,301	34,086	188,909
Irrigated Pasture	404,498	496,462	52,795	104,281	58,225	17,920	69,376	131,756
Dry Farmland		86,270	57,913	1,311,358	1,781,926	5,069	254,310	585,237
Grazing Land	3,624,378	3,337,866	4,662,540	2,774,122	3,483,783	3,632,611	3,300,910	2,126,656
Subtotal	5,217,462	6,085,924	5,459,425	7,424,594	6,074,339	4,419,118	3,741,119	4,226,126
Total Improvements on Land	3,782,698	1,746,320	1,585,943	3,212,124	4,730,864	2,468,259	1,448,984	1,728,459
Livestock								
Cattle	1,985,314	3,151,685	2,107,644	2,833,489	1,935,741	1,222,466	2,024,792	2,153,222
Horses	63,640	69,320	49,350	40,360	55,485	36,980	35,455	41,840
Sheep	145,397	650,625	592,133	64,760	73,095	705,672	281,547	60,339
Other Livestock, Dogs, Bees, Fur-Bearing, & Poultry	3,336	1,157	4,581	23,694	20,860	1,256	4,212	15,563
Subtotal	2,197,687	3,872,787	2,753,708	2,962,303	2,085,181	1,966,374	2,346,006	2,270,964
Machinery & Equipment ²								
Farm Machinery	39,025	105,675	67,709	555,890	192,254	28,075	102,181	206,231
Threshing Machines, Balers	34,351	57,030	82,451	304,259	126,354	22,900	47,435	115,910
Tractors	94,910	299,010	161,464	655,584	337,841	63,260	137,525	300,231
Engines, Gas & Steam	43,875	6,260	4,088	115	1,710	350	255	70
Saddles & Harness	8,807	17,085	11,435	5,450	4,036	6,275	5,275	6,065
Subtotal	220,968	485,060	327,147	1,521,298	662,195	120,860	292,671	628,507
Total Agriculture	11,418,815	12,190,091	10,126,223	15,120,319	13,552,579	8,974,611	7,828,780	8,854,056
Total Assesed Valuation	47,485,085	54,313,516	51,546,866	30,096,470	106,121,685	144,116,795	15,641,943	21,484,791
Agriculture—Percent of Total Assesed Valuation	24.0	22.4	19.6	50.2	12.8	6.2	50.0	41.2

¹ Parts of Carbon, Natrona, Converse, and Niobrara Counties are outside the Platte drainage. A portion of Fremont County is in the Platte Basin.

² Does not include motor vehicles or miscellaneous tools and equipment.

Source: State Board of Equalization.

Projections of Future Conditions

The enterprises of greatest potential for future expansion are livestock production, mainly beef, and the feed grains and forage crops needed to support the livestock industry. Sugar beets also have potential for future expansion of both acres and production. Wyoming's share of U. S. production as measured in terms of cash receipts from marketing is about 1.22 percent for beef and veal and 6.2 percent for lamb and mutton. The Wyoming share of U. S. beef and veal production, on the basis of live weight produced, is presently 1.32 percent and is projected to decrease to about 1.18 percent by 1980. However, the present share of cash receipts will be maintained for the period. The State's share of U. S. lamb and mutton production, based on live weight produced is presently 7.10 percent and is expected to increase to about 7.35 by 1980.

It is estimated that the projected increase in yields and a modest increase in irrigated lands will provide the feed grains and forage necessary for livestock producers in the Basin to approximately maintain their share of national production of beef, veal, lamb, and mutton.

The past national trend shows a sharp increase in per capita beef consumption and a decrease in lamb and mutton consumption. This trend is expected to continue. Projected national needs for lamb and mutton indicate that little or no expanded sheep production will be needed by 1980, but that moderate expansion will be needed for the years 2000 and 2020. However, beef will provide most of the predicted increase in meat production in the Basin.

To maintain Wyoming's share of national production of beef, lamb, and mutton will require some additional irrigated land along with increased productivity per acre. Projected changes in the status of irrigated lands and new lands projected for development are tabulated in Table IV-6.

TABLE IV-6 -- Status of Irrigated Lands and Projected Changes

<u>Present Use</u>	<u>Current Normal Acres</u>	<u>1980 Acres</u>	<u>2000 Acres</u>	<u>2020 Acres</u>
Irrigated	527,920	532,760	535,760	538,760
Idle	24,840	20,000	17,000	14,000
<u>Projected Developments (New Lands)</u>				
Corn Creek		11,000	11,000	11,000
Other Surface Water		11,000	11,000	11,000
Groundwater		21,240	54,240	84,240
<u>Total</u>	<u>552,760</u>	<u>596,000</u>	<u>629,000</u>	<u>659,000</u>

New irrigated land developments planned by the Bureau of Reclamation by 1980 include 11,000 acres under the Corn Creek Project.

About 11,000 additional acres of land including undeveloped lands in the decree area and the Glendo inundated water rights will be developed with other surface water by 1980.

Projected development of new lands utilizing groundwater as a source of irrigation supply are estimated at about 21,240 acres by 1980, an additional 33,000 acres by 2000, and 30,000 acres more by 2020 or a total increase of 84,240 acres. New irrigation from groundwater will occur throughout the Basin, with most of the developments projected for Goshen, Platte, Laramie, and Niobrara Counties. Most of the farmers and ranchers developing groundwater for irrigated lands are currently installing sprinkler irrigation systems.

Dry cropland is the major source of land for new irrigation developments which utilize groundwater as a source of supply. The Soil Conservation Service Conservation Needs Inventory data indicate there are about 416,000 acres of capability class II and III dry cropland in the Basin. There is also a large acreage of rangeland suitable for irrigation, and some of the new groundwater developments are being made on rangeland. Dry cropland and rangeland suitable for sustained irrigation are scattered throughout the Basin and are more than adequate to meet all projected developments. It is the availability of water (and economics), not land resources, that determines the rate of growth in the Basin.

Changes in crop distribution for 1980 were determined by the University of Wyoming as a part of the Agricultural Sector Study. Historical trends and Wyoming's share of national production were used to establish these changes in land use and crop distribution. Projections for the years 2000 and 2020 were made by the Wyoming Water Planning Program and are based on the availability of land and Wyoming's share of national production (Table IV-7).

The principal changes in projected crop acres are increases in alfalfa and corn. Minor increases are projected for small grains, sugar beets, and potatoes. Yield projections are based on data provided by the University of Wyoming, the

TABLE IV-7 -- Irrigated Lands, Yields, Distribution, and Production
in the Platte River Basin

<u>Current Normal and Projected Yields</u>					
<u>Crop</u>	<u>Unit</u>	<u>Current Normal Yield</u>	<u>1980 Yield</u>	<u>2000 Yield</u>	<u>2020 Yield</u>
Alfalfa	Tons/acre	2.7	3.3	4.2	5.2
Other Hay	Tons/acre	1.1	1.8	2.3	2.9
Native Hay	Tons/acre	.9	1.0	1.2	1.3
Barley	Bu/acre	43.0	64.0	80.0	96.0
Oats	Bu/acre	55.4	64.7	82.0	98.0
Sugar Beets	Tons/acre	15.5	17.5	23.0	29.0
Beans	cwt/acre	16.2	17.8	25.0	30.0
Potatoes	cwt/acre	155.0	250.0	350.0	450.0
Corn (grain)	Bu/acre	67.0	91.0	101.0	121.0
Corn (silage)	Tons/acre	13.0	15.0	22.0	25.0
Pasture	AUM/acre	3.1	3.3	3.8	4.5
Aftermath grazing					
Alfalfa	AUM/acre	.5	.5	.5	.5
Other Hay	AUM/acre	1.0	1.0	1.0	1.0
Native Hay	AUM/acre	1.0	1.0	1.0	1.0
Small Grain	AUM/acre	1.25	1.25	1.25	1.25
<u>Crop Distribution</u>					
		<u>Current Normal Acres</u>	<u>1980 Acres</u>	<u>2000 Acres</u>	<u>2020 Acres</u>
Alfalfa		100,000	142,000	165,000	185,500
Native Hay		156,000	156,000	156,000	156,000
Other Hay		65,740	43,850	43,000	43,000
Barley		10,425	11,960	14,000	16,000
Oats		7,050	7,770	9,000	10,000
Sugar Beets		20,000	21,800	24,000	26,000
Beans		18,330	18,000	18,000	18,000
Potatoes		3,300	3,600	4,000	4,000
Corn (grain)		17,030	23,100	27,000	30,000
Corn (silage)		22,370	31,000	35,000	39,500
Pasture		107,675	116,920	117,000	117,000
Idle		24,840	20,000	17,000	14,000
Total		552,760	596,000	629,000	659,000
<u>Crop Production</u>					
<u>Crop</u>	<u>Unit</u>	<u>Current Normal</u>	<u>1980</u>	<u>2000</u>	<u>2020</u>
Alfalfa	Ton	270,000	468,600	693,200	964,600
Other Hay	Ton	72,315	78,930	98,900	124,700
Native Hay	Ton	140,400	156,000	187,200	202,800
Barley	Bu	448,275	765,440	1,120,000	1,536,000
Oats	Bu	390,570	502,720	738,000	980,000
Sugar Beets	Ton	310,000	381,500	552,000	754,000
Beans	cwt	296,950	320,400	450,000	540,000
Potatoes	cwt	511,500	900,000	1,400,000	1,800,000
Corn (grain)	Bu	1,141,010	2,102,100	2,727,000	3,630,000
Corn (silage)	Ton	290,810	465,000	770,000	987,500
Pasture	AUM	333,800	385,840	444,600	526,500
Aftermath grazing	AUM	293,580	295,510	310,250	324,250

Source: University of Wyoming, the Great Plains Agricultural Council, Economic Research Service, and Wyoming Water Planning Program.

Great Plains Agricultural Council, and Economic Research Service. Current normal and projected yields were established for each land resource area and expanded to the Basin for average yields. Current normal and projected yields, crop distribution, and production are presented in Table IV-7.

Projected yield increases assume improved water management, additional land leveling, improved water supply resulting from improved efficiency, development of small storage facilities, and improved cultural and management practices. New technologies will facilitate increased agricultural labor productivity.

Additional capital will be required and the agricultural labor force will decline, but at a slower rate than in the past. Agri-Business will maintain a strong position in the local business community.

Water Resource Requirements

Present Water Uses and Needs

About 76% of the present consumptive use of water in the Basin is for irrigation. The variable consumption of water depends on kind of crop and climatic factors such as temperature, humidity, and radiation. Because of the limited precipitation in the North Platte report area, dependable crop production must rely on irrigation to provide the necessary water.

The climatic factors which determine consumptive use of water are closely related to physical features such as latitude and elevation. In order to estimate irrigation water use, the report area was subdivided into smaller study areas. The study areas are shown in Figure II-4, page 39.

Estimates of water consumed by grass for a full season vary from less than $1\frac{1}{2}$ acre-feet per acre in the Upper Laramie River area (Study Area 6a) to nearly $1\frac{3}{4}$ acre-feet per acre in the North Platte River area (Study Area 4) because of a longer growing season in the lower, warmer areas of the Basin. The present consumptive water use of irrigation in the Basin is approximately 651,000 acre-feet per year.

The total evaporation loss in the Basin from reservoirs and stock ponds is estimated to be 179,560 acre-feet annually. The evaporation from the six major main stem reservoirs (Seminoe, Kortes, Pathfinder, Alcova, Glendo, and Guernsey) is 100,900 acre-feet per year. The evaporation from other reservoirs is 75,900 acre-feet per year, and stock pond evaporation is estimated to be 2,760 acre-feet annually.

Most irrigation is by direct diversion from streams, and flood irrigation is the principal method of application. Sprinkler irrigation is gaining in popularity, and groundwater is the major source of supply for this type of irrigation. Automated sprinkler systems are extensively used in the eastern study areas.

Diversion requirements for irrigation depend upon the crop grown and the losses incurred in getting water from the source (point of diversion) into the root zone. Most diversion losses accrue to groundwater and eventually appear back in the stream as return flow. There has been little or no effort made to determine irrigation diversion efficiencies in the Platte River Basin, but it is apparent that the commonly used flood irrigation methods are inefficient in many areas

of the Basin. Diversions are made with maximum ditch capacities during the peak runoff period when water is plentiful but crop consumption is relatively low resulting in low efficiencies. Later in the season, when streamflows are reduced, irrigation efficiencies increase because the use of the available water supply is maximized. Late-season water shortages occur in many areas of the Basin, and irrigation practices and crops have largely been adapted to this situation. For example, the production of native hay and pasture is accomplished by irrigating until water supplies run short in late July or August, at which time the hay is harvested. Some areas have water shortages by mid-July that restrict yields of the native grasses. Improved water supply distribution would enhance present operations, and, if water availability could be extended through August, more profitable crops could be grown. An example of this may be seen in the North Platte Project area in Goshen County and to a lesser degree in the Wheatland Irrigation District, where the availability of storage water enables the production of cash crops such as corn and sugar beets.

Construction of reservoirs to store spring runoff for late-season use is an obvious solution to improving the water supply. This has been done on the main stem and some tributaries where feasible damsites exist. The principal reservoirs are listed in Table IV-8 and located on Figure IV-1. Nearly all the reservoirs in the Basin are used at least partly for irrigation. More reservoir storage is needed to provide late-season irrigation water. However, the North Platte River Decree limits the quantity of water storable in specific areas of the Basin. Some of the streams not affected by the decree may lack sufficient streamflow to firm up irrigation water supplies even with storage. In these cases, water supplies from adjacent areas may be required to supplement the local supply.

TABLE IV-8 -- Principal Reservoirs in the Platte River Basin
(Reservoirs of over 1,000-acre-foot capacity)

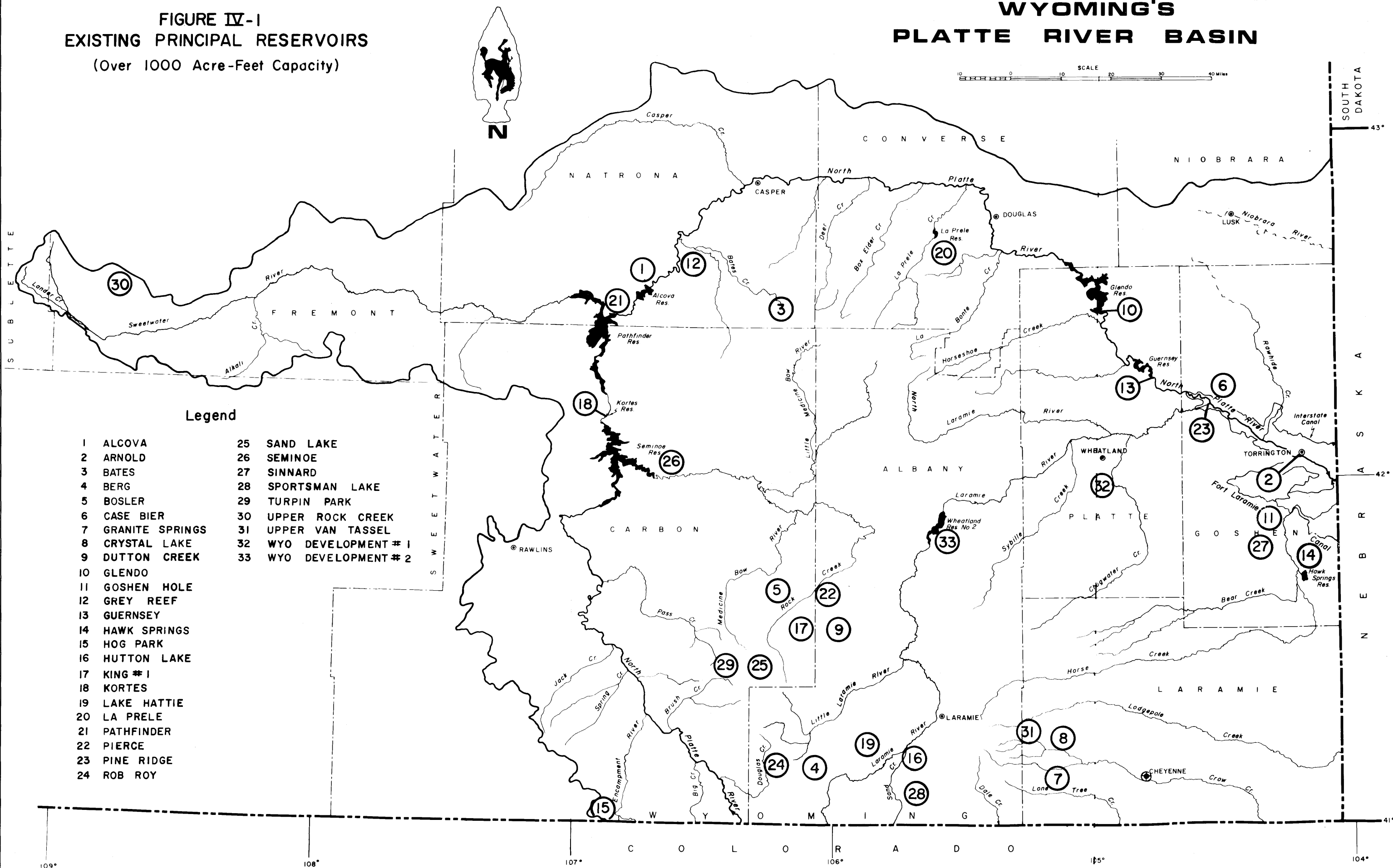
<u>Reservoir</u>	<u>Capacity Acre-Feet</u>	<u>Use</u> ¹	<u>Water Source</u>
Alcova	188,938	I,P	North Platte River
Arnold	1,134	FC	North Platte River
Bates	3,112	I	Bates Creek, Dry Forks
Berg	1,375	M&I,D	Douglas Creek
Bosler	1,605	I	Bosler Slough
Case Bier	1,459	FC	Case Bier Draw
Cheyenne No. 2 (Granite Springs)	7,367	Mun	Middle Crow Creek
Crystal Lake	4,513	M&I,P	Middle Crow Creek
Dutton Creek	2,645	I,S	Dutton Creek, Rock Creek
Glendo	795,196	I,P,FC,SC,Re-Reg	North Platte River
Goshen Hole	4,961	I	Horse Creek
Gray Reef	1,804	Re-Reg	North Platte River
Guernsey	45,288	I,D,P	North Platte River
Hawk Springs	16,735	I,S,D	Horse Creek, Hawk Springs
Hog Park	3,044	I,M&I	Little Snake River
Hutton Lake	2,500	I,Game Refuge	Sand Creek
King #1	2,216	I	Seepage Creek, Rock Creek
Kortes	4,765	P	North Platte River
Lake Hattie	68,500	I	Laramie River
LaPrele	20,000	I,D	LaPrele Creek
Pathfinder	1,015,886	I,D	North Platte River
Pierce	3,133	I	Rock Creek
Pine Ridge	2,208	FC	Pine Ridge Draw
Rob Roy	8,895	I,M&I	Douglas Creek
Sand Lake	1,105	I	Tributary Rock Creek
Seminole	1,010,825	I,D,FC	North Platte River
Sinnard	1,540	I,D	Dry Creek
Sportsman Lake	1,459	I,S	5-Mile Creek
Turpin Park	1,317	I,S	Turpin Creek
Upper Rock Creek	2,800	Ind	Rock Creek
Upper Van Tassell	1,868	Mun	North Fork Crow Creek
Wyoming Development #1	9,370	I,S,D	Sybilie Creek
Wyoming Development #2	98,934	I,D	Laramie River

¹ Includes uses listed on water right permits: I-Irrigation; M&I-Municipal and Industrial; P-Power; FC-Flood Control; SC-Silt Control; Re-Reg - Reregulation; Mun-Municipal; Ind-Industrial; D-Domestic.

FIGURE IV-1
EXISTING PRINCIPAL RESERVOIRS
 (Over 1000 Acre-Feet Capacity)

WYOMING'S
PLATTE RIVER BASIN

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Areas that need water supply and management improvements for existing development are as follows:

Study Area 1 -- Saratoga Valley: Approximately 30% of the irrigated lands in Area 1 receive a full-season water supply. All lands irrigated from the main stem of the North Platte River have a full-season water supply, while only about 20% of the lands irrigated from the tributaries receive a full-season water supply.

Study Area 1 is a part of the area in which the amount of water storable is limited by decree. Since Wyoming has nearly reached the limit, the primary methods of substantially improving crop yields will be better water management practices or streamflow augmentation.

Study Area 2 -- Sweetwater River: The Sweetwater River drainage is also part of the North Platte Decree Area. However, the limiting factor of irrigated lands in this study area is probably the poor quality of the soil and its inability to support anything more than native hay and grass. Approximately 21% of the irrigated lands receive a full-season water supply. Because of the decree no storage sites for improved irrigation water supplies have been investigated. One proposed plan of Green River development could put transbasin water into the Sweetwater River. The imported water and necessary reregulating reservoir could possibly supply supplemental water to irrigation on an interim basis until full use of this water is made by municipalities and industries.

Study Area 3 -- Medicine Bow River: Approximately 20% of the irrigated lands receive a full-season water supply. More than 3/4 of the irrigated lands mapped by the Wyoming Water Planning Program staff have been classified as meadow irrigation usually receiving adequate early-season water supplies. This type of irrigation is usually located at higher elevations and is devoted to raising native or grass-legume hay.

Study Area 4 -- North Platte River - Pathfinder Dam to Whalen Dam: Approximately 49% of the irrigated lands receive a full-season water supply. The main stem of the North Platte River is under the limitations of the North Platte Decree, and the acreage that may be irrigated by water diverted from the North Platte River is limited. The U. S. Bureau of Reclamation Kendrick Project, although it uses main stem storage water, is not part of the decree acreage limitation. Other proposed Bureau projects such as improvement of the existing LaPrele Project have been studied, but none has been authorized at the present time.

The Kendrick Project has a problem in that because of the lack of proper drainage some land is being seeped and is going out of production. If the drainage problem were to be eliminated, more efficient use could be made of the land.

The water supply for irrigation on tributaries would be improved by construction of reservoirs on these tributaries to retain some of the spring snowmelt runoff streamflows for later season use.

Study Area 5 -- North Platte River - Whalen Dam to Wyoming-Nebraska State line: Of the 120,150 acres irrigated in this area, about 84,100 acres are irrigated from the North Platte River. These lands are within the Bureau of Reclamation North Platte Project area and receive water from the main stem reservoirs. The majority of the remaining irrigated land in the study area receives a water supply

from Horse Creek and its tributaries. While there are only minor water shortages to the North Platte River irrigation, there are annual water shortages to the other irrigation, and further storage on tributaries would do little to alleviate the problem. Storage could be provided on the Lower Laramie River to improve the water supply for lands south of the Fort Laramie Canal. The potential Bureau of Reclamation Corn Creek Project includes this proposal.

Study Area 6a -- Upper Laramie River: Approximately 13% of the irrigated lands receive a full-season water supply. Meadow irrigation predominates in this study area. The main crops grown in this area are grass hay and pasture. The physical limitation of water supply, combined with the existing downstream water right priorities, essentially precludes the potential for any new water development in the area.

Study Area 6b -- Lower Laramie River: Approximately 46% of the irrigated lands receive a full-season water supply. The Wheatland Irrigation District receives storage water from two early priority reservoirs which control the administration of the river to a very large degree. Although these reservoirs supply storage water to the Wheatland area, there are water shortages to the project. Wells are used in the Wheatland Irrigation District, and a diversion from Rock Creek in the Medicine Bow drainage to the Laramie River helps reduce the average annual water shortage.

Study Area 7 -- South Platte River drainage: Approximately 44% of the irrigated lands receive a full-season water supply. The primary source of water for the cash crop acreage receiving a full water supply is groundwater. Surface water is used to the extent available, primarily to irrigate hay and pasture.

Study Area 8 -- Niobrara River: Approximately 86% of the irrigated lands receive a full-season water supply. The surface water supplies are not very reliable in this study area, and groundwater has been developed as the primary source of supply for agricultural purposes.

MINERAL RESOURCES AND INDUSTRIES

In 1969 Wyoming ranked 11th among the states in the value of mineral production as reported by the U. S. Bureau of Mines. Wyoming's mineral production and rank in national mineral production are increasing, and the present economy of the State is greatly dependent upon the mineral industries.

Wyoming has very little manufacturing to serve as a market for mineral products; therefore, the mineral industry relies on the production of raw materials that can be shipped to distant market centers and yet be competitive.

In September of 1968 Cameron Engineers of Denver, Colorado, was commissioned by the Wyoming Natural Resource Board and the State Engineer to study the existing mineral resources and industries of Wyoming and project to the year 2020 mineral development, water and utility requirements, employment, and the probable economic benefits to the State. The Cameron Report (16) is the basis for the following discussion on the mineral industries in the Platte River Basin.

Mineral resources of the Platte River Basin include coal, petroleum, uranium, and iron ore. The following discussion also includes brief sections on the cement and timber industries in the Basin.

Coal

Existing Conditions

Coal was first mined in Wyoming in 1868 by the Union Pacific Railroad at Carbon, Wyoming. Forty years later coal mining was Wyoming's leading industry, producing over 6 million tons in 1908.

The railroads were the largest consumers of coal in Wyoming until the conversion to diesel locomotives which began in 1953. Carbon, Sweetwater, and Sheridan Counties were most seriously affected by this conversion.

Though coal is now practically unused by railroads, coal production in Wyoming has increased since its low in 1958 because of the demand for powerplant fuel. Today over 79% of all coal mined in Wyoming is used in electric power generation.

Reserves and Present Development

A map of the coal resources in the Basin is shown in Figure IV-2. Table IV-9 shows the coal reserves of counties wholly or partly within the Basin.

TABLE IV-9 -- Coal Reserves in Counties Wholly or Partially Within the North Platte and Niobrara River Basins of Wyoming
(Millions of Tons)

<u>County</u>	<u>Estimated Original Reserves</u>	<u>Estimated Production Prior to 1950</u>	<u>Production 1950 to 1968</u>	<u>Estimated Unrecoverable</u>	<u>Remaining Reserves, 1968</u>
Albany	294				294
Carbon	4,944	58	9	27	4,850
Converse	4,154	4	10	3	4,137
Fremont	734	1	0	1	732
Natrona	193				193
Niobrara	14				14
Total	10,333	63	19	31	10,220

The Dave Johnston Fuel Recovery Pit near Glenrock in Converse County was the largest coal producer in Wyoming in 1968. The 1968 production of 1,387,630 tons was used exclusively in Pacific Power and Light Company's Dave Johnston Powerplant, the only coal-burning powerplant in the Basin. This plant, with a generating capacity of 420 megawatts, consumed 1,404,000 tons of coal in 1967 while operating at an average of 52% of capacity. The Pacific Power and Light Company is now installing an additional 330-megawatt generating unit at the Dave Johnston Plant. This unit is scheduled for operation by about 1972.

The Rosebud Mine near Hanna in Carbon County produced 432,057 tons of coal in 1968. Of this, 345,700 tons were shipped to Colorado for use as fuel in the Public Service Company of Colorado's Valmont Powerplant. The remainder was used for sugar beet processing and other industrial purposes. (Since publication of

the Cameron Report, the Iowa Public Service Company has begun mining coal in the Hanna area and shipping it to Sioux City, Iowa, for power generation. Present production is approximately 300,000 tons per year, and this is expected to increase to approximately 1.1 million tons per year by 1973).

The operators of smaller mines are having difficulty remaining in business due to the greater efficiencies possible in larger operations.

Economic Importance

In 1968 the coal industry in the Platte River Basin paid approximately \$976,500 in property and gross production taxes. A State severance tax was put into effect in 1969, and figures on income to the State from this tax were not yet available at the time the Cameron Report was published. The 1970 severance tax (based on 1969 production) on coal production in the Basin was approximately \$25,600. In addition, the coal industry pays sales, service, and use taxes. From July 1, 1966, to June 30, 1967, this amounted to \$6,300 for sales and service taxes and \$2,700 for use taxes on a statewide basis. The State received an income from royalties and rentals of coal lands in Wyoming totaling \$322,350 in 1967.

Growth Factors

Wyoming coal is used to produce power which is consumed both within and outside the State. Coal is also shipped out of the State for power generation elsewhere.

It has been estimated that by 1972 the total requirement for Wyoming coal for power generation will have increased from 1968's 3.04 million tons a year to 5.75 million tons a year, due to completion of the plants now under construction.

Nuclear power will be slow to replace fossil-fuel power in Wyoming because of an adequate supply of low-cost fuels. Cameron estimates that starting in 1990 and continuing through 2020, nuclear power will provide about 10% of the power production in the State.

The thickness and availability of the coal deposits in Converse County make them attractive for possible conversion to synthetic fuels. It appears likely that technological advancements will occur which will make synthetic fuels able to compete in markets now satisfied by natural oil and gas.

The projected growth of the coal industry in the Basin is shown in Table IV-10. The impact in the Basin is presented in terms of production, employment, payroll, capital investment, consumptive water requirements, and electric power requirements. It may be seen that the industry can have a pronounced effect on employment with a projected sevenfold increase by the year 2000 and nearly a ninefold increase by 2020. Capital investments would increase about 10 times by the year 2000 and 15 times by 2020. The locations of developments by the coal industry in the Basin as projected in the Cameron Report through the year 2020 are shown in Figure IV-2. Including present facilities, area number one (1) on the map will, according to the report, have five coal mines, three steam electric plants, and one synthetic liquid fuel plant. Area number two (2) will have three coal mines and two steam electric plants.

FIGURE IV-2
COAL RESERVES

(From U.S.G.S. Coal Investigations Map
C6 Coal Resources Map of Wyoming, 1951)

NUMBERS REFER TO FORECAST OF
DEVELOPMENTS BY 2020 DISCUSSED
IN TEXT

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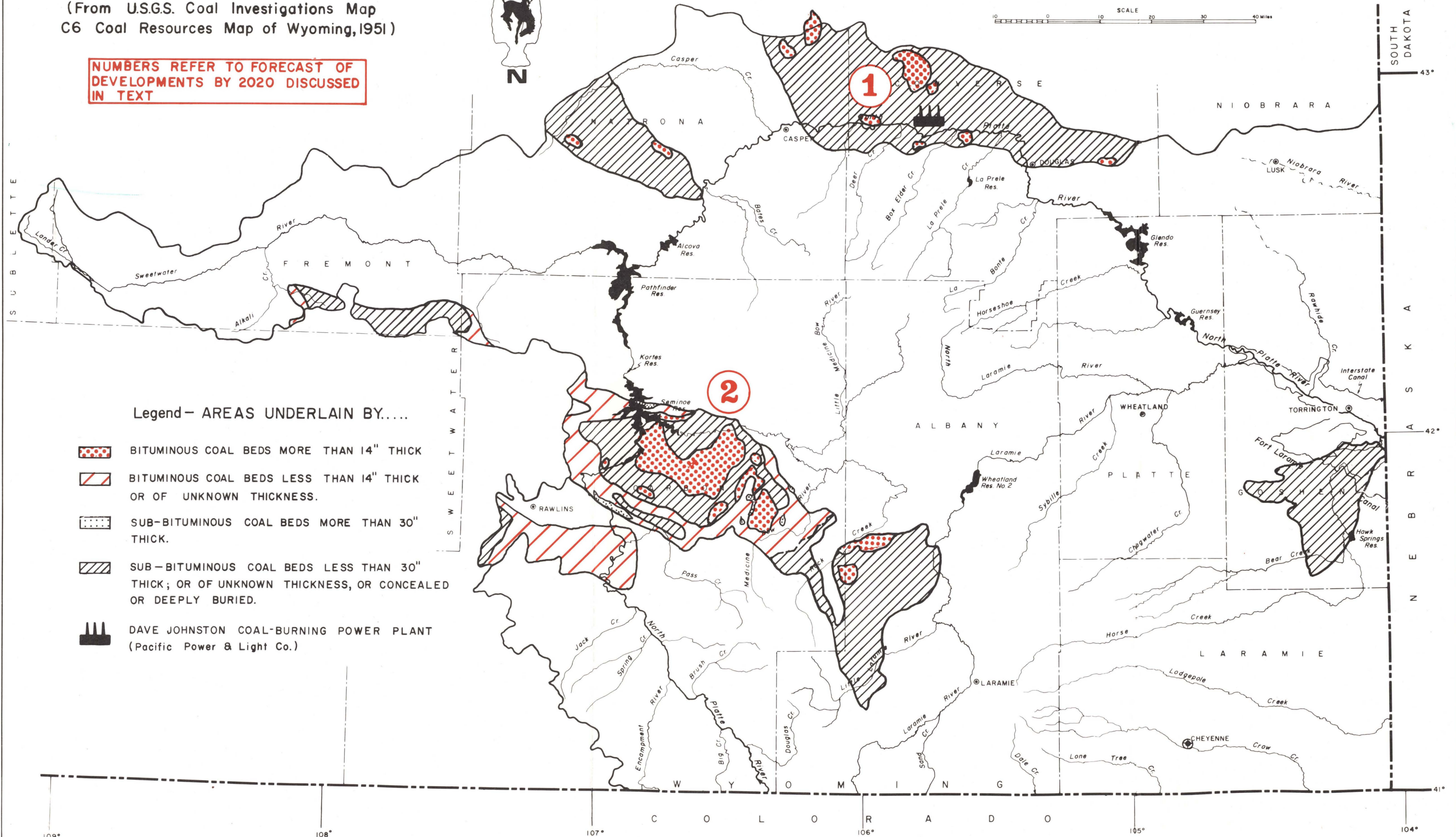


TABLE IV-10 -- Projected Growth of the Coal Industry in the
Platte River Basin

	1968 ¹	1980	2000	2020
<u>Steam Electric Plants</u>				
Number of Plants	1	2	5	5
Average Output, billion kwh	1.90	12.04	38.32	38.32
Value of Power, million dollars	5.71	36.12	114.96	114.96
Number of Employees	90	218	398	398
Annual Payroll, million dollars	.72	1.76	3.18	3.18
Capital Investment, million dollars	62	237	627	627
Water Required, thousand A-F/year	5	20	65	65
<u>Synthetic Liquid Fuels Plants</u>				
Number of Plants				1
Amount Produced, million barrels				27.38
Value of Fuel, million dollars				82.14
Number of Employees				200
Annual Payroll, million dollars				1.6
Capital Investment, million dollars				300
Water Required, thousand A-F/year				15
<u>Coal Mining Industry (for all purposes)</u>				
Number of Mines	2	3	6	8
Production, million tons	1.86	9.27	26.26	35.86
Number of Employees	81	280	720	855
Annual Payroll, million dollars	.73	2.52	6.48	7.69
Capital Investment, million dollars	5	23	68	98
Water Required, thousand A-F/year	-----	- N I L	-----	-----
Power Required, million kwh/year	5.6	34	106	178
<u>Basin Coal Industry - Summary</u>				
Number of Employees	171	498	1,118	1,453
Annual Payroll, million dollars	1.45	4.28	9.66	12.47
Capital Investment, million dollars	67	260	695	1,025
Amount of Coal Mined, million tons/year	1.86	9.27	26.26	35.86
Water Required, thousand A-F/year	5	20	65	80
Power Required, million kwh/year	5.60	34	106	178

¹ Figures in this column are for year 1967 where 1968 figures were not available.

Water Resource Requirements

Table IV-10 shows the present and future water requirements of the Platte River Basin coal industry. The present consumptive use of about 5,000 acre-feet per year is forecast to increase to 20,000 by year 1980, to 65,000 by year 2000, and to 80,000 by year 2020.

Oil and Gas

Existing Conditions

Crude oil seeps were known to the Indians and early travelers but were of little interest before the advent of the automobile. The discovery of the huge Salt Creek Field in Natrona County (in the Powder River drainage) in 1906 resulted in a period of rapid growth of both oil and natural gas production to a peak high in 1923. Through 1967 the Salt Creek Field had produced 454,000,000 barrels of oil, making it the largest field in the Rocky Mountain region and placing it well up among the all-time giant fields of the United States.

Although the rate of early growth varied, there was a period of sustained exploration and increased oil and gas production from 1933 to the early 1960's. Present Wyoming production is about 140 million barrels of oil and 270 billion cubic feet of gas annually.

Reserves and Present Development

Table IV-11 shows the 1967 estimated gross production and gross field value of crude oil, natural gas, and natural gas liquids by county in the Platte River Basin. Natrona and Niobrara Counties were not included in Table IV-11 because the production in these counties occurs largely outside the Basin boundary. The Basin totals are compared with Wyoming totals, which in turn are compared with the U. S. totals.

TABLE IV-11 -- Total 1967 Oil, Natural Gas, and Natural Gas Liquids Production and Gross Value for Counties Within the Platte River Basin and a Comparison With State and National Figures

County	<u>CRUDE OIL</u>		<u>NATURAL GAS</u>		<u>NATURAL GAS LIQUIDS</u>		<u>TOTAL VALUE</u>
	Gross Production	Gross Value	Gross Production	Gross Value	Gross Production	Gross Value	
	<u>1,000 barrels</u>	<u>\$ million</u>	<u>million cubic feet</u>	<u>\$ million</u>	<u>1,000 barrels</u>	<u>\$ million</u>	<u>\$ million</u>
Albany	463	1.10					1.10
Carbon	1,992	5.70	13,537	1.91	397	0.86	8.47
Converse	5,189	15.00	2,131	0.33	63	0.14	15.47
Goshen	8	0.02					0.02
Laramie	671	1.90					1.90
Platte River Basin	8,323	23.72	15,488	2.24	460	1.00	26.96
Wyoming	138,666	357.80	265,848	38.71	7,798	16.90	413.41
U. S. A.	3,037,579	9,375.70	18,380,838	2,899.00	644,493	1,180.00	13,454.70
Basin Share of Wyoming Production	6 %	6.6%	5.8%	5.8%	5.9%	5.9%	6.5%
Wyoming Share of U. S. Production	4.6%	3.8%	1.4%	1.3%	1.2%	1.4%	3.1%

Figure IV-3 shows the locations of the petroleum reserves in the Basin.

There are five crude oil refineries in the Basin, compared with nine in the entire State. However, approximately 70% of the crude oil produced in Wyoming is processed out of the State.

The major by-product industry in Wyoming is the Wycon Chemical Company's ammonia and fertilizer plant in Cheyenne.

Economic Importance

The oil and gas industry provides a significant payroll in Wyoming. In terms of taxes paid, the industry is the State's most important. In 1968 it paid slightly more than 30% of all property taxes collected in Wyoming.

Benefits to the State accrue in the form of a production tax, a conservation tax, a severance tax, ad valorem property taxes, sales and use taxes, State

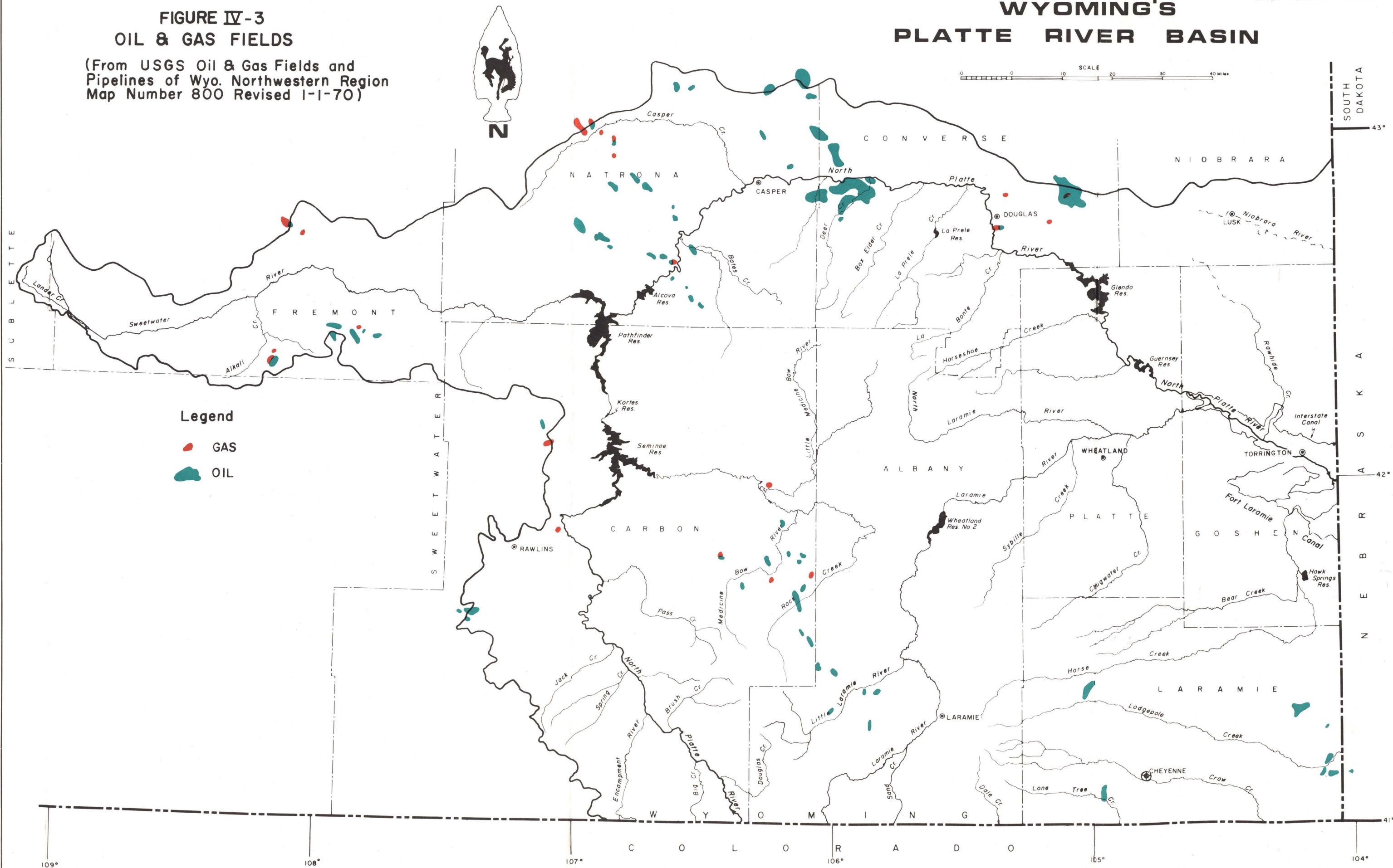
FIGURE IV-3 OIL & GAS FIELDS

(From USGS Oil & Gas Fields and
Pipelines of Wyo. Northwestern Region
Map Number 800 Revised 1-1-70)

WYOMING'S PLATTE RIVER BASIN

Legend

- GAS
- OIL



royalties, the State's share of Federal royalties, private interest royalties, and lease bonuses and filing fees. Gross production and ad valorem property taxes paid by the oil and gas industry in the Basin in 1968 (based on 1967 production) amounted to approximately \$2,163,500. The 1970 severance tax (based on 1969 production) on oil and gas production in the Basin was approximately \$208,000. Figures on other taxes paid by the oil and gas industry are not readily available on a county basis. Other benefits to the State are payroll unemployment taxes and vehicle registration and license fees.

Growth Factors

The oil and gas industry is extractive with an apparent finite limit of the resources. It must be recognized that the industry will decline and may in time pass out of existence.

Several factors may have an effect on the future of the industry. Some of these are:

1. It is assumed that no market constraint on production will be enacted because of the petroleum-deficient situation in the United States. It appears that the domestic deficit will become more severe in the future.
2. Any significant change in economic parameters such as changes in prices, taxes, or import policies will affect the rate of discovery and production.
3. Any increase in the price of crude oil that encourages discovery and production will also hasten the development of alternative sources of liquid fuels such as coal and oil shale.
4. A decrease in the cost of exploration, or the development of new techniques would result in an increased rate of discovery.

The average crude oil production rate is projected to remain at its present level through 1972 and then decline until the year 1990, after which it will remain constant through the forecast period (Table IV-12).

The production rate for natural gas is forecast to remain at about its present level through 1980, then decline gradually to about one-quarter of its present rate by the year 2000, after which it will remain constant.

Water Resource Requirements

Table IV-12 shows the 1967 and estimated future water requirements of the Platte River Basin oil and gas industry. Total water consumed by the industry in 1967 was 6,050 acre-feet. Statewide, the largest demand for water for the petroleum industry is in the waterflood production of crude oil. In the Platte River Basin, however, the largest single demand is in the refinery industry, which consumes about 4,000 acre-feet per year. The Wycon Chemical Company's ammonia and fertilizer plant, which consumes about 1,000 acre-feet of fresh water per year, is the industry's second largest water consumer in the Basin. Water for the Wycon Plant is self-supplied groundwater with a standby hook-up to the Cheyenne municipal water system.

Nearly all the water used in refineries is supplied directly from the Platte River or from wells in the Platte River floodplain. It is common practice to use water produced along with the oil for waterflood operations. However, in practically all such operations, additional water is obtained from underground aquifers.

TABLE IV-12 -- Projected Trends of the Petroleum Industry
in the Platte River Basin

	1967	1980	2000	2020
<u>Crude Oil</u>				
Production, million barrels	9.03	5.10	2.10	2.10
Value, million dollars	23.30	13.16	5.42	5.42
Employment	200	140	70	70
Annual Payroll, million dollars	1.80	1.26	.63	.63
Water Required, A-F/year	1,000	800	400	400
Power Required, million kwh/year	25.82	19.99	13.28	13.28
<u>Natural Gas</u>				
Production, billion cubic feet	14.61	14.40	5.80	5.80
Value, million dollars	2.13	2.10	0.85	0.85
Employment ¹	92	92	62	52
Annual Payroll, million dollars ¹	0.83	0.83	0.56	0.47
Water Consumed, A-F/year	- - - - N E G L I G I B L E - - - -			
Power Required, million kwh/year	0.12	0.12	0.06	0.06
<u>Natural Gas Liquids</u>				
Production, million barrels	0.06	0.04	0.02	0.02
Value, million dollars	0.11	0.07	0.04	0.04
Water Consumed, A-F/year	120	110	45	45
Water Diverted, A-F/year	140	130	50	50
Power Required, million kwh/year	0.02	0.02	0.02	0.02
<u>Refineries</u>				
Refinery Runs, million barrels	34.70	25.00	10.00	10.00
Employment	1,130	875	350	350
Annual Payroll, million dollars	10.17	7.88	3.15	3.15
Water Consumed, A-F/year	3,930	2,830	1,130	1,130
Water Diverted, A-F/year	3,400	9,700	3,900	3,900
Power Required, million kwh/year	77.30	48.00	25.00	25.00
<u>Other (Including Service Supply and By-Products)</u>				
Employment	843	520	400	400
Annual Payroll, million dollars	7.59	4.68	3.60	3.60
Water Consumed, A-F/year	1,000	1,000	1,000	1,000
Power Required, million kwh/year	36.43	35.84	35.82	35.82
<u>Total Petroleum Industry in the Platte River Basin</u>				
Employment	2,265	1,627	882	872
Annual Payroll, million dollars	20.39	14.65	7.94	7.85
Water Consumed, A-F/year	6,050	4,740	2,575	2,575
Power Required, million kwh/year	139.69	103.97	74.18	74.18

¹ Includes natural gas liquids.

Uranium

Existing Conditions

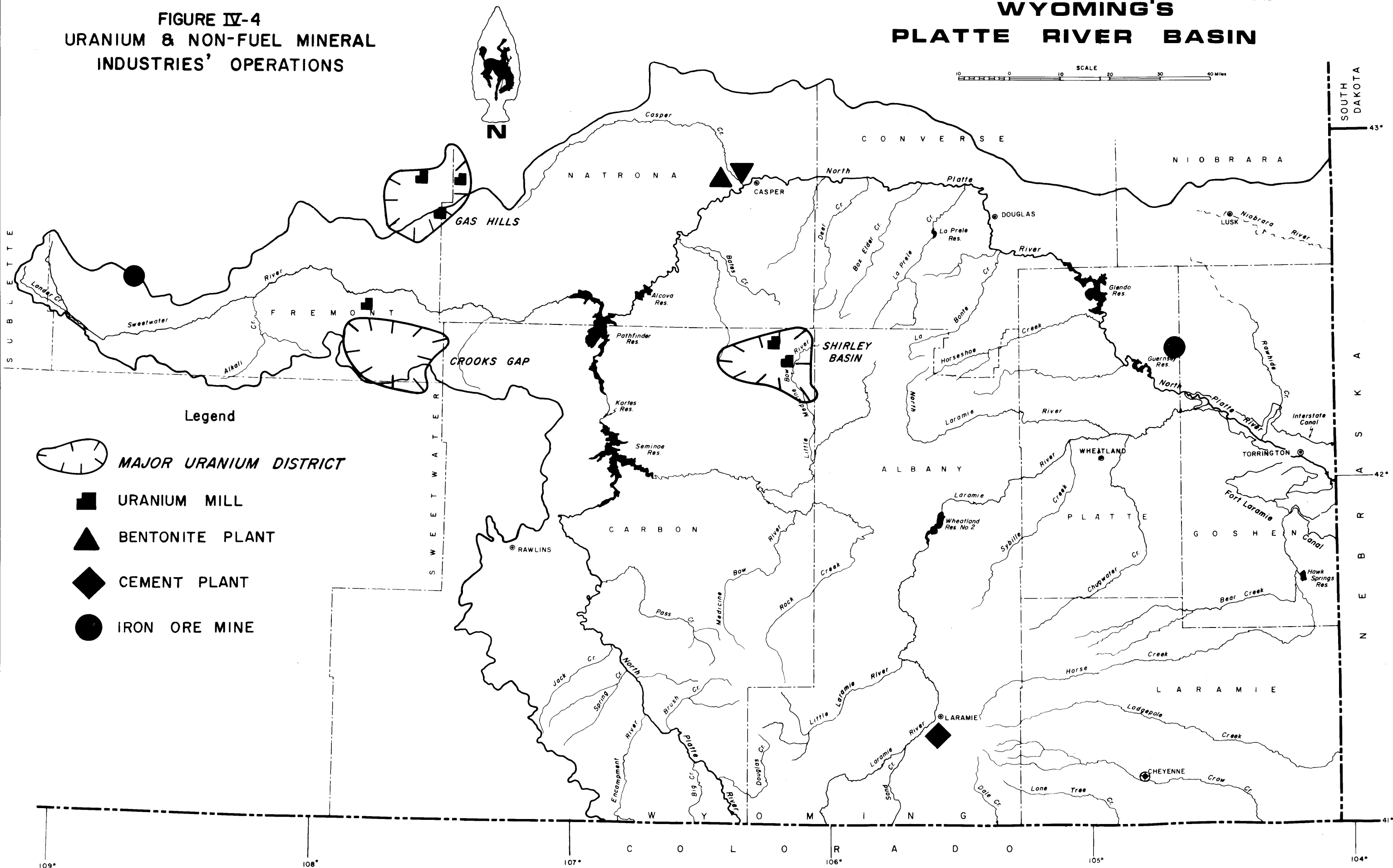
Interest in Wyoming uranium remains high because much of the ore is at a depth that permits open-pit mining. In Wyoming approximately 77% of the ore comes from open-pit mines, compared with only 30% for the entire United States. Figure IV-4 shows the locations of the active major uranium districts in the Basin.

The Platte River Basin has been particularly prominent in the development of Wyoming's uranium industry. Uranium was first discovered in Wyoming at the Silver Cliff Mine at Lusk in 1918. Following other discoveries around the State,

FIGURE IV-4
URANIUM & NON-FUEL MINERAL
INDUSTRIES' OPERATIONS

WYOMING'S PLATTE RIVER BASIN

WYOMING STATE ENGINEERS OFFICE
WATER PLANNING PROGRAM



production was first attained in Converse County in the Cheyenne River drainage in 1953. Later that year uranium was discovered and developed in the Crooks Gap area in the drainage of the Sweetwater River--a tributary of the North Platte River. The latest of the major uranium producing districts to be developed was the Shirley Basin in northeastern Carbon County. A major claim-staking rush followed word of this discovery in 1957.

The announcement by the Atomic Energy Commission that it would provide market only for those ore reserves developed prior to November 24, 1958, greatly reduced exploration activities since at that time the AEC was the only market for uranium ore.

The development of the nuclear power industry in the early 1960's and the transfer of the uranium industry from a government to a private market have revived exploration and production activities.

Reserves and Present Development

With the uranium industry in the midst of a transition from a government market to a competitive private market, most individual companies are reluctant to provide information pertaining to ore reserves. For this reason the AEC will not subdivide the total reserve figure for the State into districts. However, as of January 1, 1968, the AEC reserve for Wyoming was 52,931 tons of contained U_3O_8 or 35.8% of the national total of 148,000 tons of U_3O_8 . These figures are for uranium mineable at \$8 per pound price.

Wyoming presently ranks first in the United States in tons of ore reserves and second only to New Mexico in tons mined per year.

Economic Importance

The gross value of Wyoming concentrates sold to the AEC and to private and foreign interests since the inception of the industry in the early 1950's was \$372,000,000 through 1968. Of this total, only \$13,000,000 worth of concentrates was sold to private or foreign interests. The 1968 production value of \$46,274,000 ranks uranium second in the Wyoming mineral sector, being exceeded only by the value of oil and gas.

Virtually every community in the Basin has felt the effect of a recent upsurge in uranium exploration. Casper, because of its proximity to the Shirley Basin and southern Powder River Basin, and because of petroleum activity, has become important as an industrial service and supply center. Douglas, in Converse County, will benefit from Humble Oil's uranium complex now under construction about 25 miles northwest of Douglas in the Powder River Basin. A community has even developed at the mining area in the Shirley Basin.

A large part of the State's gross production value since 1953 has been a direct benefit to Wyoming in the form of payrolls, consumption of locally produced fuels and sulfuric acid, utilities, and an appreciable part of royalty and profit revenues. The industry also pays a property tax, a severance tax, production taxes, and sales and use taxes. In 1969 the taxable production of uranium in the Basin was approximately 1.05 million tons. With an assessed valuation of about \$7.9 million, taxes levied amounted to about \$487,900 excluding severance taxes. The 1970 severance taxes (on 1969 production) totaled about \$79,000.

Growth Factors

The use of uranium as a generator source, a process which presently is an inefficient use of the resource, will continue to increase until the advent of the breeder reactor. With the efficiency which will then be possible, most of the market for newly mined uranium will be eliminated.

Although uranium from the Basin will be in demand as a powerplant fuel, the market will be largely out of State. This is due to the abundance of low-cost coal in Wyoming, which indicates that the Basin and the State may be among the last regions of the country to utilize nuclear-generated electricity.

Developments in the uranium industry, scheduled for the immediate future, which will have significant impacts on the Basin include:

1. The commencement by Utah Construction Company of construction of a uranium mining and milling facility in the Shirley basin.
2. The commencement by Humble Oil Company of construction on a \$20-million uranium mine and mill 25 miles northwest of Douglas. The complex, though outside the Basin, will have great impact on both Casper and Douglas.
3. The increasing of production by Kerr-McGee Corporation of ore from an open-pit operation in the Shirley Basin, with the ore to be treated at the Petro-tomics mill.

The projected growth of the uranium industry in the Platte River Basin is shown in Table IV-13.

TABLE IV-13 -- Projected Growth of the Uranium Industry in the
Platte River Basin of Wyoming

	<u>1967</u>	<u>1980</u>	<u>2000</u>	<u>2020</u>
Uranium Ore Mined, million tons	0.74	7.1	9.2	3.7
U ₃ O ₈ Produced, thousand tons	1.58	6.00	10.00	0.55
Employment	923	3,900	5,650	1,450
Annual Payroll, million dollars	7.38	31.20	45.20	11.60
Water Consumed, acre-feet per year	667	5,172	10,000	4,000
Power Required, million kwh per year	16.90	128.75	247.50	83.00

Water Resource Requirements

The present and potential water requirements of the uranium industry in the Platte River Basin are shown in Table IV-13. Essentially all the water requirement is for use in milling operations, since little water is used in the mining of uranium. Groundwater presently supplies all five of Wyoming's mills; this practice will probably continue.

Cement

Existing Conditions

The Wyoming cement industry presently consists of one plant operated by the Monolith Portland Midwest Company located a few miles southwest of Laramie (Figure IV-4).

Reserves and Present Development

The product manufactured by the Monolith plant is portland cement. This is the product obtained by pulverizing clinkers consisting of hydraulic calcium silicates, to which no additions have been made subsequent to calcination other than water and/or untreated calcium sulfate.

Most of the necessary raw materials, including limestone, shale, and gypsum, are mined at company quarries near the plant. Iron oxide is obtained as a residue from an Allied Chemical plant in Denver which roasts iron pyrite to produce sulfur dioxide for conversion to sulfuric acid.

Although raw materials are abundant near the plant, other factors act to limit cement production. Transportation costs limit the market area to within a radius of about 250 miles. There are 1 million people for every cement plant now operating in the United States. Wyoming has a population of about 332,000, and there are six competing cement plants located in adjacent states within the Wyoming marketing area. Cement consumption is dependent on construction activities, and therefore is highly affected by economic activities.

Present production at the Wyoming Monolith plant is about 1 million barrels per year and from all indications will continue at this rate.

Economic Importance

The Monolith plant employs about 100 people. Several additional people are engaged in quarrying operations and are employed by the Wyoming Construction Company, a subsidiary of Monolith. The total labor force amounts to about 0.2 man-hours per barrel of cement produced. The plant paid about \$750,000 in wages in 1968.

The present value of the plant is about \$3 million, but it would require approximately \$8-10 million to replace it. The Monolith plant paid \$37,254 in property taxes in Albany County in 1968. The average plant price per barrel (376 pounds) of cement in 1967 was \$3.12.

Growth Factors

A new 2½-million-barrel-per-year cement plant being constructed at Lyons, Colorado, will be the seventh competing plant in the market area. This will help to limit growth in the market for cement from the Monolith plant, and production capacity of the plant is not expected to be increased. Around 1980 the Monolith plant will probably be rebuilt or improved.

The projected growth of the cement industry in Albany County, and thus in the Basin, is shown in Table IV-14.

TABLE IV-14 -- Projected Growth of the Cement Industry in the
Platte River Basin
(all the Basin cement industry occurs within Albany County)

	<u>1968</u>	<u>1980</u>	<u>2000</u>	<u>2020</u>
Cement Produced, million barrels per year	1.0	1.0	1.0	1.0
Employment	100	100	100	100
Annual Payroll, thousand dollars	750	750	750	750
Industry Taxes, thousand dollars	37	42	42	42
New Investment, million dollars	0	4	0	0
Power Required, million kwh per year	25	25	25	25
Water Consumed, acre-feet per year	153	153	153	153

Water Resource Requirements

The Monolith plant is a "wet process" plant and uses about 50 gallons of water for each barrel of cement manufactured. The projected water requirements for the industry are shown in Table IV-14. All the water is presently obtained from company wells in the Laramie River drainage, and this practice will probably continue.

Iron Ore

Existing Conditions

The total tonnage of iron ore available to the United States iron and steel industry has remained fairly constant at 145 million short tons per year in recent years. Wyoming produces about 1.4% of the Nation's requirements, all of which is produced in the Platte River Basin (see Figure IV-4).

Reserves and Present Development

Many types of iron-bearing minerals occur in Wyoming; three types of iron-bearing ores are mined commercially at the present time in the Basin. The U. S. Steel Corporation mines magnetic taconite near Atlantic City in Fremont County. CF & I Steel mines hematite near Sunrise in Platte County. Titaniferous magnetite is mined in Albany County and is marketed as heavy aggregate.

Known reserves of magnetic taconite near Atlantic City are estimated at 300 million tons of 30-percent iron ore, sufficient for about 75 years of operation at the present mining rate. Estimated reserves of hematite ore at the Sunrise facility are small but could last 30 years at the present mining rate. Huge reserves of titaniferous magnetite occur in the Laramie Range area of Albany County. Reported occurrences total about 178 million tons, but total reserves are probably much larger than this.

Titaniferous magnetite is a dense, massive, hard rock which is sold as a heavy aggregate for specialized applications where weight or mass are important.

It is not used as an ore from which metallic iron is extracted. Both of the other Wyoming iron ores, magnetic taconite and hematite, must be beneficiated in order to produce concentrates possessing the required chemical and physical properties for iron blast furnace feed material. Two modern iron ore mining and beneficiation facilities, one at Atlantic City and one at Sunrise, constitute Wyoming's present iron ore industry.

In 1967, 3,971,477 short tons of magnetic taconite were mined by U. S. Steel at Atlantic City, 727,360 short tons of hematite were mined by CF & I Steel at Sunrise, 41,350 short tons of titaniferous magnetite were mined by Plicoflex, and 5,806 short tons of the magnetite were mined by the U. P. Railroad. Ore usable for steel industry consumption amounted to 1,479,010 short tons of taconite concentrates and 540,441 short tons of hematite concentrates in 1967.

Economic Importance

Total employment in the Basin's steel industry in 1967 was 765 persons. The total annual payroll that year was \$6.83 million, and total capital investment in the industry has been about \$70 million (excluding magnetite production). Total 1967 taxes levied on the Basin iron ore industry were \$1,353,774.

TABLE IV-15 -- Projected Growth of the Iron Ore Industry in the Platte River Basin

	<u>1967</u>	<u>1980</u>	<u>2000</u>	<u>2020</u>
Mine-run Ore, million short tons/year				
Taconite	3.97	4.70	7.25	9.40
Hematite	0.73	0.80	0	0
Titaniferous Magnetite	0.05	0.05	0.65	0.65
Basin Totals	4.75	5.55	7.90	10.05
Usable Ore Concentrates, million short tons/year				
Taconite Pellets	1.48	1.75	2.70	3.50
Hematite Concentrates	0.54	0.60	0	0
Titaniferous Magnetite	0.05	0.05	0.65	0.65
Basin Totals	2.07	2.40	3.35	4.15
Employment	765	885	1,350	1,650
Annual Payroll, million dollars	6.12	7.08	10.80	13.20
Capital Investment, million dollars	70.2	82.7	150.0	185.0
Water Consumed, acre-feet per year	949	1,115	1,609	2,058
Electric Power Required, million kwh per year	26.3	31.0	675.0	685.0
Natural Gas Required, million cubic feet per year	1,433	1,673	2,205	2,626

Growth Factors

Low delivered price and high grade of foreign iron ores are major factors contributing to their popularity in the United States. Imports of iron ore are projected to rise from 37% of supply in 1965 to over 50% by 1982.

The chief markets for Wyoming ores are in Utah and Colorado. The distance of these markets from seaports will shield Wyoming ore producers from foreign competition. Therefore, production of iron ore in Wyoming will depart from the national trend and will increase rather than decrease.

The projected growth of the iron ore industry in the State and therefore within the Basin is shown in Table IV-15. Production of hematite is forecast to end after 1980 due to depletion of reserves.

Water Resource Requirements

The iron ore industry is not a heavy user of water. All of CF & I Steel Corporation's present requirement of 119 acre-feet per year comes from wells at the mine site. The U. S. Steel facility near Atlantic City consumes only 830 acre-feet per year. This water comes from Rock Creek, a tributary of the Sweetwater River. Water required in the mining of titaniferous magnetite is negligible and will remain so until about the year 2000, after which the requirement will be approximately 90 acre-feet per year. This will probably be supplied from Chugwater Creek.

Timber

Existing Conditions

Most of the demand for Wyoming wood products prior to 1950 was by the railroads for ties. Since 1950 the need for dimension lumber has been the major factor in the industry.

Production in Wyoming amounts to about 0.2% of the Nation's output of forest products.

Reserves and Present Development

A breakdown of the timber reserves and resources in the Platte River Basin is not readily available. On a Statewide basis there are 95 wood product firms in operation, and over one-half are lumber producing sawmills. A 1962 survey revealed that there are 4.7 million acres of commercial timber in the State, containing more than 28 billion board feet of live saw timber. According to the Cameron Report, the inventory increases yearly because new timber growth is exceeding removal by all causes.

Wyoming's forests are comprised almost exclusively of softwood trees. Ownership of commercial forest land in Wyoming is largely public, and most of it grows at an elevation of between 7,000 and 10,000 feet. The timber resources of the Platte River Basin are largely within the Medicine Bow National Forest.

Economic Importance

In 1968 there were 323 employees in the timber industry of the Platte River Basin. This is nearly 30% of the State's total for the industry.

Growth Factors

Table IV-16 shows the projected developments in the timber industry in the Platte River Basin. The demand for timber products in the United States is expected to more than double by the year 2020. The allowable timber cut in national forests in Wyoming is limited by the need to protect recreation and watershed values. Improved forest management could lead to substantial increases in allowable-cut figures in the future. Better yields can be realized by proper thinning, re-seeding, and protection from fire, insects, and disease.

TABLE IV-16 -- Projected Growth of the Timber Industry in the
Platte River Basin

	<u>1968</u>	<u>1980</u>	<u>2000</u>	<u>2020</u>
Employment	323	412	412	540
Annual Payroll, million dollars	2.58	3.30	3.30	4.32
Electric Power Required, million kwh per year	3.15	6.76	8.52	10.65
Water Consumed, acre-feet per year	0	50	50	100
Capital Required, New Facilities, thousand dollars	1,000	0	0	2,000

Lumber will continue to be the most important product of the Wyoming timber industry for at least the next 50 years. Little or no increase is expected in the use of Wyoming timber for such wood products as ties, posts, and poles. The projected 1980 lumber production could theoretically be achieved with the State's present sawmill capacity of approximately 200 million board feet annually. In reality, however, some expansion of present facilities will be necessary. This will include the construction of a new sawmill in Albany County and one in Carbon County between the years 2000 and 2020. Each new mill will cost approximately \$1 million and will produce 20 million board feet of lumber annually.

(Not reported by Cameron are the recent efforts to stop clear cutting and other forestry practices. Should these efforts be successful, the projected growth shown in Table IV-16 would be correspondingly reduced.)

Water Resource Requirements

Table IV-16 shows the water requirements of the timber industry in the Platte River Basin through year 2020. The Basin's timber industry is not a heavy user of water. At present, total water consumption by all firms in the State's timber industry is less than 200 acre-feet annually.

Summary of Water Requirements for Industrial Purposes

Table IV-17 shows a summary of the projected industrial consumptive water requirements in the Platte River Basin. The requirements increase from 12,820 acre-feet in 1967 to nearly 7 times that quantity, or 88,890 acre-feet by 2020. The greatest increase is by the coal industry. In 1967 the coal industry used 5,000 acre-feet, or less than one-half the Basin industrial requirement. This will increase to 80,000 acre-feet per year in 2020, or nearly 99% of the industrial requirement in the Basin. Nearly all the water is supplied from surface water supplies.

TABLE IV-17 -- Industrial Water Projections, Platte River Basin

	<u>1967</u>	<u>1980</u>	<u>2000</u>	<u>2020</u>
	(Thousand Acre-Feet Per Year)			
Coal Industry				
Carbon	0	0	30	30
Converse	<u>5</u>	<u>20</u>	<u>35</u>	<u>50</u>
Total	5	20	65	80
Petroleum Industry ¹	6.05	4.74	2.58	2.58
Uranium ²	.67	5.17	10.0	4.0
Cement ²	.15	.15	.15	.15
Iron Ore				
Fremont	.83	.98	1.52	1.97
Platte ²	.12	.13	0	0
Albany	<u>nil</u>	<u>nil</u>	<u>.09</u>	<u>.09</u>
Total	.95	1.11	1.61	2.06
Timber	nil	.05	.05	.10
Total Surface Water Consumed	9.76	23.86	67.79	83.29
Total Groundwater Consumed	<u>3.06</u>	<u>7.36</u>	<u>11.60</u>	<u>5.60</u>
Total Water Consumed	12.82	31.22	79.39	88.89

¹ Refinery water requirements are assumed to be supplied from surface water. Groundwater is assumed to supply the remainder of the petroleum industry.

² Supplied from groundwater.

Summary of Industrial Economic Factors

Table IV-18 is a summary of present and projected economic factors.

TABLE IV-18 -- Projection of Economic Factors of Industry in the Platte River Basin

	<u>1967</u>	<u>1980</u>	<u>2000</u>	<u>2020</u>
Total Number of Industrial Employees	4,547	7,422	9,512	6,065
Approximate Annual Payroll, million dollars	38.67	61.25	77.65	50.19
Capital Investment, million dollars	290.96	658.5	1,261.5	1,377
Electric Power Required, million kwh per year	216.64	329.48	1,136.20	1,055.83

MUNICIPAL, DOMESTIC, AND STOCK WATER USE

Municipal water is provided largely by municipally operated water systems, although water in some smaller communities is supplied from small, privately owned systems. Table IV-19, extracted from data collected in a survey conducted by the University of Wyoming, gives the sources of municipal water supply and the 1970 population of the majority of towns in the Basin. Where 1970 population figures were not available, 1960 figures are given. It may be seen from the table that groundwater serves as at least a partial source for approximately 90% of the population of the municipalities shown.

TABLE IV-19 -- Municipal Water Supplies in the Basin

Town	Drainage Basin ¹	1970 Population	Type of Water Supply System		Source of Supply			Remarks
			Municipal	Private	Surface water	Ground-water	Combination	
Albin	2	118	X			X		
Burns	2	183	X			X		
Carpenter	2	100(1960)		X		X		
Casper	1	39,361	X				X	
Cheyenne	2	40,914	X				X	Groundwater system is peak standby
Chugwater	1	187	X			X		Springs with standby intake on N. Platte
Douglas	1	2,677	X		X			Served by Hanna
Elk Mountain	1	127	X			X		
Elmo	1	53	X		X			
Encampment	1	321	X		X			
Evansville	1	832	X				X	
Ft. Laramie	1	197	X			X		
Foxpark	1	150(1960)		X		X		
Glendo	1	210	X			X		
Glenrock	1	1,515	X				X	
Guernsey	1	793	X			X		
Hanna	1	460	X		X			Springs above Rattlesnake Creek
Hartville	1	246	X		X			
Hawk Springs	1	125(1960)		X		X		
Hillsdale	2	100(1960)		X		X		
LaGrange	1	189		X		X		
Laramie	1	23,143	X				X	
Lingle	1	446	X			X		
Lusk	3	1,495	X			X		
Manville	3	92	X			X		
Medicine Bow	1	455	X			X		
Mills	1	1,724	X			X		
Mountain View	1	1,641	X				X	Served by Casper
Orchard Valley	2	1,015	X			X		
Paradise Valley	1	1,764	X			X		
Pine Bluffs	2	937	X			X		
Rawlins	1	7,855	X		X			
Rock River	1	344		X	X			
Saratoga	1	1,181	X		X			
Sinclair	1	445	X		X			
Sunrise	1	300(1960)	X			X		
Torrington	1	4,237	X			X		
Wheatland	1	2,498	X			X		
Yoder	1	101	X			X		
Total		138,531						
Population Served by:								
a. Municipal systems			137,523					
b. Private systems ²				1,008				
Population Served by:								
a. Surface water					13,582			
b. Groundwater						17,543		
c. Combination							107,406	

¹ The numbers in this column refer to the drainage basin in which the corresponding town is located. These basins are numbered as follows: (1) North Platte River Basin, (2) South Platte River Basin, (3) Niobrara River Basin.

² These figures do not include rural population.

Source: Municipal Water and Sewerage Systems in Wyoming--A Source Book of Data, University of Wyoming, WRRI, R. Keith Schwer, February 1968, and Wyo. Department of Health and Social Services, Sanitary Engineering Services, 1971 Inventory Records.

The term "water consumption" is often used in connection with municipal water usage to mean treated water delivered into the municipal distribution system. In this report the terms "diversions" from a water source, "returns" to a water source, and "consumptive uses," which are the diversions less the returns, are used.

A diversion of approximately 1 acre-foot per year normally is required to serve five people. This is equivalent to an average diversion of 180 gallons per day per person, commonly abbreviated as 180 gpcd (gallons per capita per day). Approximately one-half the annual municipal water diverted is consumptively used, and the balance may be considered a "return."

Domestic and stock water is supplied from lakes, streams, ponds, ditches, water wells, and reservoirs. Since these are private supplies, little factual data exist concerning domestic and stock water uses in the Basin. The quantity of domestic water consumed in the Basin is small compared with other uses.

It is estimated that there are approximately 490,000 head of cattle in the Basin and approximately 700,000 head of sheep. Assuming consumptive water use rates of 15 gallons per day for cattle and 15 gallons per day per each five sheep, the present total water consumption by both in the Basin is approximately 10,500 acre-feet per year.

If the developments in the mineral industries occur as forecast in the Cameron Report (16), many of the municipalities in the Basin, particularly the larger cities, will experience fairly rapid growth between now and year 2020. The Basin population projection is given in Table IV-20. The figures were interpolated from studies by the University of Wyoming (Demographic Study of Wyoming, Population in Transition, 1969) and the Cameron Engineer's report (Wyoming Mineral Industries--Review and Forecast, 1969). The estimates assume an increase in population of 3.59 persons for each employee added to the labor force. The primary growth counties in the Basin will be Albany, Laramie, and Natrona. The growth centers will be in the cities and larger towns, with Casper, Cheyenne, and Laramie showing the greatest increases.

TABLE IV-20 -- Population Projection for that Portion of the Counties
Within the Platte River Basin

<u>Area</u>	<u>1970</u>	<u>1980</u>	<u>2000</u>	<u>2020</u>
North Platte River Counties ¹	81,700	97,100	138,000	181,900
Laramie River Counties ²	32,900	37,400	53,900	73,500
South Platte River (Laramie County)	<u>56,400</u>	<u>73,700</u>	<u>126,300</u>	<u>198,400</u>
Total	171,000	208,200	318,200	453,800

¹ Carbon, Converse, Fremont, Goshen, Natrona, Niobrara, and Sublette Counties.

² Albany and Platte Counties.

Some cities in the Basin are aware of the possibility of growth and have taken steps to insure that their municipal water supplies will be adequate to meet this growth. The city of Cheyenne, for example, developed a city water

supply plan in 1961. This plan (5), which involves using water from Douglas Creek in the North Platte drainage and replacing it with Little Snake River water from the Colorado River Basin, is designed to furnish an adequate water supply for Cheyenne at least through the year 2020. The city of Laramie is included with Cheyenne in the permit for diversion of Douglas Creek water and replacement with Little Snake River water. The estimated average yield of the Cheyenne-Laramie water rights from the Little Snake River is 31,000 acre-feet per year. Not all the proposed collection system is constructed, however, and the yield of the presently constructed facilities is estimated to be about 7,000 acre-feet per year. The remainder of the system will be constructed as the water is needed. Projections show that it will be many years until all available capacity of the Little Snake diversion system will be required for Cheyenne and Laramie. If Laramie constructs facilities to use any Douglas Creek water, Laramie's priority date will be the same as for Cheyenne. It is projected (6) that it may be 30 or 40 years before Laramie has need of any of this water, and at that time the city will have to decide whether it is more economical to purchase more Laramie River water rights, as it has done in the past, or proceed with the Douglas Creek and Little Snake River diversions. A contractual arrangement between the cities of Laramie and Cheyenne reserves this option.

It may be possible to construct the facilities to the full capacity in the near future and make the water from the extra capacity available to others on an interim basis until another transbasin diversion from the Green River to the North Platte River is constructed. This assumes, of course, that another diversion will be an element in the State's future water plans. The advantages of this early construction include:

1. The water rights of Cheyenne and Laramie to the Little Snake River water would be perfected.
2. A new water supply would be available in the Platte River Basin, and the Green River transbasin diversion would be committed.
3. A stage-development plan for construction of the Green River to North Platte River transbasin diversion would be possible.

A report on the city of Casper water works facilities was prepared in 1969 (11). The conclusion reached in this report was that Casper should turn to the North Platte River for future water supplies to insure adequate quality and quantity. The Casper water supply presently comes from alluvium deposits of the North Platte River. Even with artificial recharge, this source will not meet projected demands, and quality of groundwater in this area is a problem because of hardness, the presence of iron, manganese, sulfates, and selenium. Casper and other towns in the North Platte River valley may want to purchase water from a Green River transbasin diversion if it is undertaken.

A comprehensive plan for water and sewerage for each county in the State is being prepared by various consulting firms for the Planning Division of the Department of Economic Planning and Development through an FHA grant. The function of these reports is to provide a basic plan for municipalities with populations less than 5,500 persons to insure adequate water supplies and waste disposal facilities to meet future demands.

Although Table IV-19 indicates that groundwater is the principal source for municipal water supplies in the Basin, the preceding discussion suggests that the

larger cities will turn more and more to surface water supplies. Since the reliable surface water supplies of the Basin are now appropriated, this will probably involve buying other water rights, as in the case of Laramie, or using water from transbasin diversions as Cheyenne has done.

Table IV-21 shows the projected municipal, domestic, and stock water requirements in the Platte River Basin through the year 2020. Nearly all the increase in water use will be in municipal water systems, with some increase in stock water use and little or no increase in rural domestic uses. The projected diversions from Douglas Creek to Cheyenne are subtracted from the municipal water since this water is replaced by Little Snake River water and thus represents no depletion of Platte River water. By 2020 Laramie may be utilizing the remaining Little Snake River to North Platte River diversion capacity, but this is not shown.

TABLE IV-21 -- Present and Projected Municipal, Domestic, and Stock Water Requirements in the Platte and Niobrara River Basins of Wyoming

	<u>1970</u>	<u>1980</u>	<u>2000</u>	<u>2020</u>
Basin Population	171,000	208,200	318,200	453,800
Municipal and Domestic				
Diversions, A-F/year	34,200	41,640	63,640	90,760
Consumption Use, A-F/year	17,100	20,820	31,820	45,380
Cheyenne Use ¹				
Diversions, A-F/year	8,000	11,000	19,600	28,000
Consumption, A-F/year	4,000	5,500	9,800	14,000
Basin Municipal and Domestic				
Diversions, A-F/year	26,200	30,640	44,040	62,760
Consumption, A-F/year	13,100	15,320	22,020	31,380
Stock Water Depletion	10,500	11,600	14,100	16,600
Total Depletion	23,600	26,920	36,120	47,980

¹ Based on DEPAD population projections through year 1990, estimated for 2000 and 2020.

RECREATION AND FISH AND WILDLIFE ¹

Outdoor recreation, including fishing and hunting, is of increasing economic importance in the Basin. The location of the Basin with respect to the major population areas of both Wyoming and Colorado will influence the growth of the recreation industry in the Basin. Fishing, hunting, boating and other water sports, and other recreational activities all have potential for growth in Wyoming's Platte River Basin.

¹ The information in this section was extracted from the Wyoming Game & Fish Commission report for completion of the Platte River Comprehensive Framework Study.

The following discussion on recreation and fish and wildlife in the Basin utilizes data current as of January 1, 1970.

Fish

There are over 4,700 miles of streams in the Basin which have been classified on the basis of present conditions of aesthetics, availability, and productivity, according to the following categories:

Class 1 -- Waters of nationwide importance.

Class 2 -- Waters of statewide importance.

Class 3 -- Waters of importance to large areas less than statewide.

Class 4 -- Waters of importance to small areas such as counties.

Class 5 -- Waters of potential importance to fisheries, now polluted or otherwise seriously limited or degraded.

Of the classified streams in the Platte River Basin, 98 miles are presently of national importance, with another 275 miles considered to be of statewide importance. Although trout populations exist and a fisheries management plan for trout stocking is in effect, the sport fisheries of the Niobrara River drainage are of minor value.

The area also contains over 75,600 acres of natural lakes, reservoirs, and farm ponds. The natural lakes are composed of alpine lakes (elevation over 7,500 feet) and lowland lakes. A similar classification separates alpine and lowland reservoirs. Farm pond classification pertains to waters which are 5 acres or less in surface area and are categorized as trout, mixed, and non-trout ponds.

Tables IV-22 and IV-23 summarize the classified streams and bodies of water in the Platte River Basin of Wyoming, each with its annual fishing use and capacity.

TABLE IV-22 -- Estimated Use and Capacity of Streams for Sport Fishing
in the Platte River Basin of Wyoming

<u>Streams-Cold Water</u>	<u>Miles</u>	<u>Annual Fisherman Days-Use</u>	<u>Annual Fisherman Days-Capacity</u>
Class 1	98.3	59,210	134,390
Class 2	275.0	21,870	68,017
Class 3	1,594.4	54,200	154,318
Class 4	2,395.3	13,024	35,633
Class 5	<u>364.9</u>	<u>481</u>	<u>1,260</u>
Total	4,727.9	148,785	393,618

TABLE IV-23 -- Estimated Use and Capacity of Lakes and Impoundments for Sport Fishing in the Platte River Basin of Wyoming

<u>Type</u>	<u>Number</u>	<u>Acres</u>	<u>Annual Fisherman Days-Use</u>	<u>Annual Fisherman Days-Capacity</u>
Alpine Lakes	89	930.7	5,269	21,052
Alpine Reservoirs	17	849.0	3,283	13,616
Lowland Lakes	66	6,658.0	19,815	73,610
Lowland Reservoirs	119	66,742.6	172,580	578,869
Trout Farm Ponds	289	466.1	4,264	4,264
Mixed Farm Ponds	2	4.7	5	5
Non-Trout Farm Ponds	16	36.5	152	152
Total	598	75,687.6	205,368	691,568

Alpine lakes and reservoirs in the Basin are confined to the Snowy Range area and the southern area of the Wind River Mountains. They provide populations of one or more cold-water species of trout such as cutthroat, golden, rainbow, and brook. Brown trout are incidental to some of these waters. Some are planted on an annual or biennial basis to maintain a satisfactory level of fishing, whereas others maintain themselves by natural reproduction.

The lowland lakes and reservoirs provide populations of both cold- and warm-water species of fish such as the walleye, largemouth bass, bluegill, perch, black bullhead, crappie, sunfish, rainbow, cutthroat, brook, and brown. Some are stocked on an annual or biennial basis whereas others are stocked according to pressure and need. The lakes and reservoirs providing warm-water populations require limited stocking.

All of the trout species realize at least limited natural reproduction in the various streams. Brown trout are self-sustaining in most of the Class 1, 2, and 3 streams, such as the Upper North Platte River and the Big and Little Laramie Rivers. Naturally reproducing populations of rainbow are confined to Class 1 and 2 waters, such as the Upper North Platte River and Douglas Creek. Brook and cutthroat trout are confined mostly to Class 3 and 4 waters, such as the headwater streams. In some situations of heavy fishing pressure or limited natural reproduction, these populations are supplemented by additional planted trout.

Current Fisherman Use and Harvest

Fishing pressure in the Platte River Basin is relatively heavy compared to most other areas of the State. The proximity to population centers, such as Cheyenne, Laramie, and Casper in Wyoming, and the northeastern population centers of Colorado, is accountable for this intense pressure. The estimated number of fishermen in 1969 was 179,010, who spent an estimated 506,818 fisherman days in the activity. Their estimated harvest was 2,011,641 fish. These figures probably underestimate total pressure, as they do not include data on pioneer, youth, and military license holders.

In order to provide for the fishing demand, the Wyoming Game and Fish Commission has purchased lands or easements or entered into agreements with public and private landowners to provide public access on 56.6 miles of streams and nine

lakes and reservoirs in the Platte River Basin. Saratoga Lake, Johnson Creek Reservoir, and Douglas Fishing Lake were provided by the Game and Fish Commission by constructing dams.

Economic Importance of Sport Fishing

An economic study was completed by the Statistics Department of the University of Wyoming in 1966, based upon a random sample of the 1965 license holders. This survey indicated that fishing generated a total income of \$9,175,534 to the seven counties within the Platte River Basin. The survey further indicated that the resident fisherman spends an average of \$220 per year and the nonresident fisherman spends \$142 during his stay in Wyoming. An updated study will be completed in December 1971 by the University.

Wildlife

Wildlife is dependent upon water as a factor in its habitat. For this reason, wildlife must be considered along with fish in the economics of water resources and their development.

There are three principal types of wildlife habitat in the Platte River Basin: forested mountains, sagebrush-grassland plains, and juniper. Some floodplains and lower benches along the streams are irrigated and provide habitat for upland game, furbearers, and other wildlife species.

Elk summer in the mountain and forest areas, but winter habitat is scarce in some areas because man has invaded the winter range. The Wyoming Game and Fish Commission operates and maintains four big game winter ranges to supplement native winter range. Mule deer reside in nearly all areas of the Basin. Their summer range is plentiful in the higher elevations; however, the winter range is also utilized by livestock on both public and private lands. Moose habitat is primarily limited to the upper reaches of the Sweetwater drainage. Antelope habitat mainly consists of the plains areas of the Basin with some utilization of the lower areas of the forest lands. Bighorn sheep and black bear habitat is located in the higher elevations; however, much of their habitat areas are unoccupied.

Habitat for small game and upland game birds is very diversified. Wild turkeys are restricted to localized areas which provide adequate food, water, and escape cover. Pheasant habitat is found in the irrigated and dry farmlands, the highest value being located in the Wheatland and Torrington areas. Sage grouse are primarily found in the sagebrush-grassland community for a major portion of the year; however, movements to irrigated meadows sometimes occur in the summer months. The mountain grouse (blue and ruffed) inhabit the forest areas in good numbers. Most of the forest lands and adjacent foothill areas appear to offer suitable mountain grouse habitat. Chukar and Hungarian partridge and sharp-tail grouse habitat is very limited.

Waterfowl habitat consists of nearly 7,000 acres of wetlands and associated uplands developed for ducks and geese. Of more importance is the large number of permanent streams (over 4,700 lineal miles) and about 76,000 acres of natural lakes and man-made impoundments. A very large number of the impoundments are small private stock water or erosion control structures. The area surrounding Pathfinder Reservoir has been designated a National Wildlife Refuge.

The only improved waterfowl management areas under continual management are two State facilities located near Torrington, Wyoming. One area is centered about Springer Reservoir, an impoundment of about 800 acres created by diversion flows from Horse Creek. The other area of approximately 1,600 acres has been created with water diverted from Dry Creek. Water control is possible on both areas.

Current Hunter Use and Harvest

The figures in Table IV-24 were obtained from annual harvest reports of the Wyoming Game and Fish Commission. The current harvest represents the estimated kill for the Basin, and the hunter days include both successful and unsuccessful hunters. It is estimated that the total hunting capacity in the Basin is over 263,000 hunter days.

TABLE IV-24 -- Estimated Number of Hunters, Hunter Days, and Harvest
in the Platte River Basin - 1969

<u>Category</u>	<u>Hunters</u>	<u>Hunter Days</u>	<u>Harvest</u>
Big Game	54,507	139,055	40,706
Upland Game	20,348	58,012	103,403
Waterfowl	4,105	21,329	17,618
Total	78,960	218,396	161,727

Economic Importance of Hunting

An economic study was completed by the Statistics Department of the University of Wyoming in 1966, based upon a random sample of the 1965 license holders. This survey indicates that hunting generated a total income of \$10,997,446 to the seven counties within the Platte River Basin. Hunting expenditures, shown in Table IV-25, were for such items as transportation, food, commercial lodging, arms and ammunition, camping equipment and trailers, guides, and other miscellaneous items.

TABLE IV-25 -- Hunting Expenditures in Platte River Basin - 1965

<u>County</u>	<u>Resident</u>	<u>Nonresident</u>	<u>Total</u>
Albany	\$ 379,864	\$ 304,437	\$ 684,301
Carbon	976,371	1,069,810	2,046,181
Converse	178,002	206,760	384,762
Goshen	889,653	66,741	956,394
Laramie	2,718,662	5,741	2,724,403
Natrona	3,421,103	496,887	3,917,990
Platte	238,742	44,673	283,415
Total	\$8,802,397	\$2,195,049	\$10,997,446

Water Sports and Boating

The Platte River Basin offers tremendous opportunity for water sports and boating. According to Outdoor Recreation in Wyoming, Volume III (13), Alcova Reservoir, Pathfinder Reservoir, Glendo State Park, and Seminoe State Park, all on the North Platte River, ranked 2nd, 4th, 7th, and 9th in the boating areas of the State used by Wyoming residents. Lake Hattie, in the Laramie River drainage, ranked 10th. For out-of-State boaters, Glendo State Park ranked first in popularity of boating areas in the Basin and 5th in the State, followed by Seminoe (8th), Guernsey (11th), Pathfinder (12th), and Alcova (13th).

The same report indicates that the most popular boating activity of Wyoming boaters was fishing (65%), followed by water skiing (20%) and pleasure cruising (15%). Out-of-State boaters devoted 76% of their boating time to fishing, 16% to pleasure cruising, 7% to water skiing, and 1% to other pursuits.

The Platte River Basin contains many opportunities for water-based recreation. There are many examples of recreation uses of reservoirs that were constructed for other primary purposes. The Bureau of Reclamation has reported an average recreation use of 939,000 visitor days for the years 1967-69 on the seven irrigation and power reservoirs on the North Platte River. These reservoirs include Seminoe, Kortez (including the "Miracle Mile" reach of the North Platte River below the reservoir), Pathfinder, Alcova, Gray Reef, Glendo, and Guernsey. There are fishing and other types of recreation on the Cheyenne municipal reservoirs, including Hog Park, Rob Roy, Owen, Granite Springs, Crystal, and North Crow (Van Tassell). Other examples include the Teton Well Reservoir public fishery on Sage Creek and the many privately owned irrigation reservoirs throughout the Basin.

The North Platte River reservoirs are operated to provide continuous minimum streamflows in the river to help water quality and fisheries management while producing hydropower and providing irrigation water. This operation is made possible by the existence of Glendo Reservoir. Non-irrigation season releases from upstream reservoirs are stored in Glendo Reservoir for later delivery to the irrigators who own the water. Gray Reef Reregulating Dam smooths out "peaking power" releases from Alcova and provides for a minimum flow in the river of not less than 330 cfs. No absolute minimum flows are provided below Pathfinder or Glendo Reservoirs, however. Power releases from Kortez Reservoir are now maintained on a continuous basis at a minimum rate of 500 cfs to maintain the excellent fishing in the North Platte River between Kortez and Pathfinder Reservoirs. According to a Bureau of Reclamation feasibility report the fish and wildlife benefits exceed the cost of the peaking power foregone in the operation. Kortez had been used to produce peaking power, and water releases were alternately high and low during the daily cycle of operations. At the present the flows are provided by agreement and have no legally required status, but a bill has been introduced in the U. S. Congress to provide for a continuation of the present operation.

The 41st Wyoming Legislature designated the area surrounding the Cheyenne Granite Springs and Crystal Reservoirs a State Park. This designation will enhance the recreation opportunities of the area. Other State Parks in the Basin, administered by the Wyoming Recreation Commission where water-based recreation is important, include Guernsey, Glendo, and Seminoe. The Natrona County Parks and Pleasure Grounds Commission administers facilities at Alcova, Gray Reef, and Pathfinder Reservoirs.

Future Demands and Desires

Sport Fisheries

Increasing populations in and adjacent to Wyoming's Platte River Basin will influence utilization of the area by fishermen, especially if the present environmental quality of the aquatic habitat is maintained.

The principal factors affecting future capacity of the fishery are a projected large increase in outdoor recreational pursuits, a potential reduction in quantity and quality of habitat, a steady reduction in free public access and an ever-increasing competition for land and water from other resource development programs. All these point to the need for increasing multipurpose land and water resource management to insure that soil erosion, stream siltation, and stream pollution will not adversely affect the fishery habitat of this region.

It is estimated that the level of angler use (as of 1968) will have increased approximately 12% by 1980 and 43% by 2000. It is felt that these figures are modest and could be altered drastically by future industrialization of the Basin and continued growth of cities in southeastern Wyoming and northern Colorado. Projections obtained from the Wyoming Recreation Plan indicate an estimated increase from 1967 to 1985 of 28%.

It is estimated that the cold-water stream fisheries of the Platte River Basin could sustain an average of approximately seven times the fishing pressure they presently receive. The sevenfold increase appears to be justified since there are only a limited number of stream fishing sites, such as the Upper North Platte fishing area above Saratoga, that are being used to near capacity. Other areas, such as the North Platte River below Gray Reef and the Platte River in the Douglas area, could support an estimated 15 times the fishing pressure they presently receive.

By the same token, the large and small impoundments and natural lakes have an even greater potential capacity for fisherman use. It is estimated that fishing pressure could be increased to 10 times the present fisherman use and still maintain the present level of fishing success. Lakes such as Crystal and Granite Reservoirs could support only about double the present fishing pressure, while Seminoe Reservoir may be capable of supporting 20 times the existing pressure.

There are a considerable number of acres of water in this area which are considered unsuitable trout habitat; however, exotic species of fish, capable of surviving in the unique habitat conditions of these lakes, may someday be successfully introduced.

Big Game

The demand for hunting opportunities within the Basin is expected to increase substantially during the next 30 years. Resident demand should parallel an increase in statewide population growth. Nonresident demand will continue to show percentage increases exceeding national population growth figures. Hunting license limitations will continue to be the means to provide proper game management.

Hunting within the Basin is expected to increase 15% by the year 1980 and 32% by the year 2000. By 2000 the demand for big game hunting will exceed

capabilities by approximately 10%. These figures are based on present habitat conditions.

The capacity to increase big game species is dependent upon the quality and quantity of habitat available. The acquisition of additional key game ranges and better protection of existing habitat will assist in the preservation of present populations and provide for additional means of expanding the future carrying capacity. Some water development programs have proven beneficial to the pronghorn. Where water is a limiting factor, stock pond construction or guzzlers have allowed the antelope to utilize more range.

Small Game

Harvest of fur animals is very light, but the potential demand for outdoor recreation may bring about an increased use of this resource.

The recreational potential of upland game birds could expand since the resource is not at present being fully utilized. Under-harvested populations suffer substantial winter loss. Greater use of this upland game resource may result from publicizing the need and opportunity for sportsmen to hunt in this Basin.

The capacity to provide additional hunting for waterfowl is based upon the size of the populations during any one season and the length of time that substantial numbers may stay in the Basin during the fall migration. The prospects for increased numbers of ducks appear to be good, and with a medium-grade habitat there is a prospect of increasing the number of waterfowl wintering in the Basin. Any liberalization of seasons and bags will entice participation in waterfowl hunting.

Water Sports and Boating

The future increases in participation in water-oriented recreation are shown in Figure IV-5. Projected 1985 increases over 1967 participation include boating-38%, swimming-38%, and water skiing-67%. The largest increased uses will occur on water bodies nearest population centers because of their convenience.

A system of wild and scenic rivers has been established by the Federal Government to preserve sections of the rivers of the Nation in their free-flowing states. The Wyoming position regarding scenic rivers is given in An Outdoor Recreation Plan For Wyoming, October 1970:

"The State of Wyoming has taken the position that it is the State's responsibility to administer the rivers within its boundaries, and that development of scenic rivers programs and other similar programs affecting the waters of Wyoming should be under the jurisdiction of the State. Portions of the following rivers are under consideration for designation as scenic rivers: the Upper Green, Snake, Platte, Clarks Fork, Shoshone, Wind, and Tongue, (Upper Sweetwater², and Upper Popo Agie²)."

A scenic river designation for a reach of a given stream in Wyoming would have to be made by the Wyoming Legislature. In considering a scenic river

² Added by Wyoming Recreation Commission since October 1970.

designation, conflicts with potential economic developments should be evaluated. Where there is no conflict, a scenic designation may best insure maintenance of quality environmental standards, continued public access, and proper management of the recreation values of the desired section of the stream.

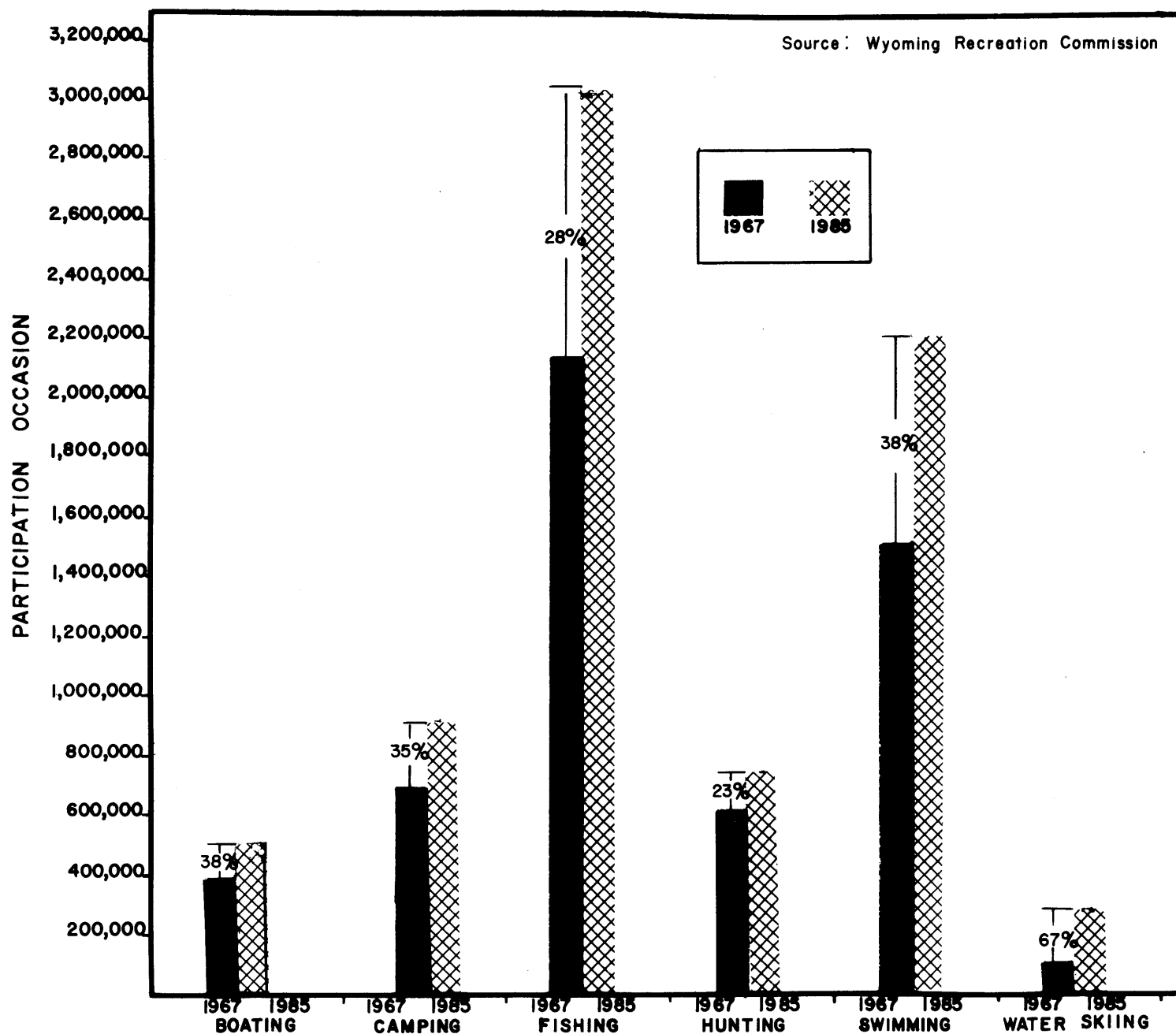
Water Resource Requirements

The present consumptive uses assigned directly to recreation and fish and wildlife activities are small. Other present uses for recreation are nonconsumptive, although some stock pond evaporation could probably be assigned to wildlife use. Forty-five reservoir permits have been issued by the State Engineer for recreation and fish and wildlife in the Basin. A very large number of existing reservoirs are used for recreation, even though this use is not listed on the permit. The reason recreation use is not listed is usually because recreation was not the primary intended use when the permit application was submitted. In most cases the applicant was unaware of the recreation potential that his reservoir would have.

Future recreation water demands will be met primarily in conjunction with providing water for other purposes.

The Wyoming Game and Fish Commission has suggested several provisions and considerations for inclusion in water development projects regarding recreation and fish and wildlife, including the following:

1. All reservoirs should have minimum pools of sufficient depth and size to maintain a permanent fishery. Conditions requiring a minimum of stocking effort to produce a quality fishery should be maintained.
2. Storage capacity should be adequate for continuous downstream releases in sufficient quantity to sustain the stream trout fishery.
3. If there are alternate sites available for reservoir construction, consideration should be given to selecting the site which is least detrimental to the stream fishery and game habitat.
4. Funds for fisheries management purposes such as fish screens, rough fish control, or silt settling basins for water quality control should be included as part of the project costs.
5. Reservoir functions and operations, including downstream water releases, should be planned on a cooperative basis with appropriate State and Federal agencies.
6. Water conservation practices such as lining ditches, using overhead sprinklers, and the efficient application of water should be a consideration in any project planning to reduce water quality deterioration.
7. Cost of land necessary for public access to streams and lakes to replace present public use areas should be included in project funding.
8. Cost of land to replace big game wintering areas should be included in project funding.
9. Big game migration routes should be protected by providing bridges across canals.



PARTICIPATION ESTIMATES FOR SELECTED RECREATION ACTIVITIES
WYOMING FOR 1967 and 1985

Figure IV-5

Opportunities to improve fish habitat in the Basin have been identified by the Game and Fish Commission. Several watershed improvement projects proposed under P.L.566 would include reservoir construction, and minimum pools and minimum streamflow releases are recommended to provide or enhance the fishery. A minimum pool for Guernsey Reservoir and elimination of the annual flushing of the reservoir has been proposed, but this conflicts with the operation of the reservoir for irrigation and power, the purposes for which the reservoir was constructed. Another proposal is an enlarged minimum pool for Glendo Reservoir. This proposal is currently under study. Guaranteed minimum flows in the North Platte River below the Bureau of Reclamation reservoirs will insure the present fishery enhancement, and the Game and Fish Commission recommendations cited above apply to any project proposals. Inclusion of minimum flows below Pathfinder and Glendo Dams could enlarge the stream fishery by approximately 20 miles.

HYDROELECTRIC POWER

The electrical energy requirements of the Basin are supplied by interconnected power systems with part of the power generated by six federally operated hydroelectric plants on the North Platte River and the remainder by the Pacific Power and Light Company's coal-fired Dave Johnston plant. The Dave Johnston plant, as discussed in the previous section on Mineral Resources and Industries, has an installed capacity of 420,000 kilowatts, and another 330,000-kilowatt unit is under construction. Power produced at this plant is consumed largely within the Basin.

The combined generating capacity of the six hydroplants is 181,200 kilowatts, as shown in Table IV-26.

TABLE IV-26 -- Installed Generating Capacity of the Six Reclamation Hydroplants on the North Platte River, Wyoming

<u>Plant</u>	<u>Installed Capacity (kilowatts)</u>
Seminole	32,400
Kortes	36,000
Fremont Canyon	48,000
Alcova	36,000
Glendo	24,000
Guernsey	4,800
Total	181,200

The six hydroplants collectively generate an average of 670 million kilowatt-hours per year. The seven Bureau of Reclamation reservoirs on the North Platte River in Wyoming are operated mainly for irrigation and power production.

Distance from the Basin to large power use centers is a deterrent to additional hydropower development in the near future. However, there are potentials for development in the Basin which should be recognized as they may become feasible should present economic conditions or evaluating criteria change.

One possible development which has been studied by the USBR is the enlargement of Seminoe Reservoir. This would enable the storage of spring runoff which would otherwise spill. This additional stored water would permit irrigation releases through the chain of hydroplants under schedules in which generation would more nearly conform to the varying power requirements of the North Platte Power System.

In the event that water is imported to the Basin, as in the proposed Green River-to-North Platte diversion, this enlargement would provide for storage and regulation of the imported water and for power generation through the use of this water.

Investigations indicate that maximum additional head of 15 feet might be placed on the Seminoe Powerplant turbines without causing excessive stresses. A 15-foot increase in the height of the dam would increase the reservoir capacity by 340,000 acre-feet to 1,350,825 acre-feet. The Bureau of Reclamation is also making plans to update the generating units at Seminoe from their present capacity of 36,000 kilovolt amperes (KVA) to 45,000 KVA.

Another proposal for development is for pumped storage sites at Kortes and Alcova. At Kortes, the USBR studied plant sizes of 50, 75, 100, 150, and 250 mw, but their criterion that pumped storage peaking power must be applied to area loads only limited the Kortes plant to 100 mw. Plant sizes of 50, 75, 100, 150, and 250 were also studied at Alcova. The 100-mw plant proved infeasible, but revision of criteria used in engineering studies and estimates may prove potential development at Alcova feasible. The larger-sized plants at Alcova and Kortes would be most desirable. The proposed sites are ideally suited for pumped storage. Both proposals would require construction of a power tunnel and an off-stream forebay.

With the projected increase in steam-electric generation shown in Table IV-10 as a base load, there will be little difficulty in marketing the peaking power from pumped storage plants. Transmission facilities needed to market the power over the interconnected system would be minimal.

A third proposal for hydroelectric development which has been studied by the USBR is the enlargement of the existing power capacity of the Guernsey plant by 10,000 kw to a total capacity of 14,800 kw. Enlargement of the powerplant would enable power generation with releases of water which otherwise must bypass the plant because of its limited capacity. In a previous 10-year period 61.9% of all water released from Guernsey Reservoir bypassed the generating units. The development of additional hydroelectric power at Guernsey is not economically justified under current evaluation procedures.

FLOOD CONTROL

As was mentioned in Chapter II, flood damage is not a major problem in Wyoming's Platte River Basin. Although there is a high degree of storage control on the North Platte River, the majority of these reservoirs were built without specific flood control space.

The Corps of Engineers, in a study conducted in the mid-1950's, concluded that 875,000 acre-feet of flood control space were needed on the main stem of the

North Platte River in Wyoming. This storage space was recommended to be apportioned as follows: 200,000 acre-feet above Seminoe, 400,000 acre-feet below Alcova but above Glendo, and 275,000 acre-feet in Glendo Reservoir. Glendo Reservoir was subsequently constructed with 272,800 acre-feet of flood control storage space. The Corps said flood control space is also needed on the Laramie River and possibly on Bates Creek, but no determination was made of capacity requirements for either.

In Goshen County, near the Interstate and Fort Laramie Canals, damage has resulted from flash floods caused by cloudbursts. These large canals cross a number of small draws and plains tributaries which flow only in response to precipitation. Major storms in this area have caused the flows in these small drainages to exceed the capacities of the underpasses which carry the flows beneath the canals. The resulting flooding has caused severe damage to the canals, to croplands above the underpasses which were inundated by the backed-up water, and to irrigated croplands which were without water while the canals were being repaired.

Projects have been constructed in Goshen County on four such drainages for watershed protection and flood damage prevention under Public Law 566. These are:

1. Pine Ridge--Case Bier Watershed
2. London Flats--Bovee Watershed
3. Angell Draw Watershed
4. Arnold Drain Watershed

Other P.L.566 projects being planned or contemplated in the Basin are:

1. Bates Creek. A Preliminary Investigation Report on the Bates Creek Watershed was printed by the SCS in June 1961. Three reservoir sites were studied, varying in size from 6,000 to 7,650 acre-feet, with many variations on flood control and irrigation water storage. The project apparently was considered too expensive and has not been undertaken.

2. Horseshoe Creek. A Preliminary Investigation Report on the Horseshoe Creek Watershed was released by the SCS in September 1970. Floodwater damage to crops and personal property in the watershed has occurred eight times during the last 5 years. The proposed reservoir would provide 500 acre-feet of sediment storage, 5,500 acre-feet of irrigation storage (supplemental supply to 2,000 acres below the structure and 500 additional acres above the structure which could receive a full water supply by exchange with downstream water users), and 4,500 acre-feet of flood control storage. Alternative plans were also presented but were rejected because of economic infeasibility.

3. Deer Creek. A Field Examination Report on the Deer Creek Watershed was printed by the SCS in May 1969. The severe flood of 1965 motivated the watershed investigation application. The application listed four major problems: flood damages, shortage of irrigation water, unsatisfactory municipal water supply, and shortage of recreation resources.

Agricultural flood damages have consisted of streambank erosion, loss of irrigation structure sites, floodwater damages to crops and fences, and sediment damages to cropland and irrigation facilities. County roads and wooden bridges have been washed out.

In the town of Glenrock about ten homes, the town water intake, an athletic field, and the city park are subject to frequent flooding.

Consideration was given to channel improvement as a possible solution; it was felt that costs would be prohibitive. A reservoir site on Deer Creek above Deer Creek Canyon has been found physically feasible and could provide for full development of the watershed's resources. This would feature storage for floodwater retardation, a full water supply for about 3,500 acres and for recreation.

At this time land ownership problems prevent any further progress on the reservoir project. It has been recommended that the town of Glenrock be encouraged to proceed with the construction of levees to provide a limited amount of local flood protection.

4. Upper North Laramie. A Watershed Work Plan for the Upper North Laramie Watershed was printed by the SCS in October 1967. The objectives of the plan are to provide flood protection for cropland along the North Laramie River, to fully utilize existing water supplies, to develop recreation, and to provide supplemental irrigation water for 1,745 acres of cropland. A reservoir was studied with 115 acre-feet of sediment storage, 405 acre-feet for recreation, 2,425 acre-feet for irrigation, and 1,689 acre-feet of storage between the principal and emergency spillways. Developments have been prevented due to litigation over land.

5. Lower North Laramie River. The SCS studied a potential for a flood control and water management project, but the costs were found to be high.

6. Spring Canyon. There is a proposed flood damage prevention project on Spring Canyon (including Willy Draw) near the town of Lingle. The SCS is presently working on a work plan for this watershed.

7. Encampment River. Interested parties near the headwaters of the Encampment River applied for assistance from the SCS in 1967. The application listed four major problems: continuous changes of the stream channel, bank erosion, need for municipal water, and need for recreation storage. At present little progress is being made on this study. Some municipalities within the Encampment River drainage have periodically experienced flood damage.

8. Casper Area. Several tributaries of the North Platte River which rise near Casper Mountain flow through or near the city of Casper. At flood stages these tributaries have caused considerable damage in the Casper area. The city of Casper applied through the Wyoming State Engineer to the U.S. Army Corps of Engineers for assistance in identifying these flood hazards. The result of this request is a three-part report which defines flood hazard areas and shows by maps the approximate areas that would be inundated. Volume I of the report deals with Garden Creek, Volume II with Sage Creek, and Volume III (not yet published) with the North Platte River in Casper. Two potential floods are used in these reports:

- A. Intermediate Regional Flood: a flood having a 1-percent probability of occurrence in any year or an average frequency of occurrence in the order of once in 100 years (62).
- B. Standard Project Flood: the flood that may be expected from the most severe combination of meteorological and hydrological conditions that are considered reasonably characteristic of the geographical area in which the drainage basin is located, excluding extremely rare combinations (62).

Improvements to control floods are not discussed or proposed in these Corps of Engineers' Reports. Flood hazard information is provided for the guidance of local officials in planning the use and regulation of the floodplain and as public information. At the present, through a request by the residents and officials in Casper and the subsequent bill that was introduced into the United States Senate, the Committee on Public Works of the United States Senate directed the Corps of Engineers to conduct an investigation of these flood problems. On March 1, 1971, a public meeting was conducted by the Corps of Engineers to obtain the public opinion concerning alternative means of preventing the flood problems. These alternatives included do nothing, evacuate overflow areas, floodplain zoning, flood insurance, diversions, levees, channels, dams, or any combination of these.

The Corps of Engineers plans to conduct a preliminary investigation of the creeks in this area using the suggestions obtained at this public meeting. The tributaries of special interest are Garden, Glendale, Eastdale, and Sage Creeks which flow through developed portions of the city.

9. Cheyenne Area. A report has been written for the city of Cheyenne by the U. S. Corps of Engineers identifying the floodplains of Crow and Dry Creeks as they flow through the city. Volume I defines the flood characteristics of Dry Creek, and Volume II deals with Crow Creek. The floodplain information contained in this report describes the areas inundated by an intermediate regional flood and a standard project flood.

SUMMARY OF WATER RESOURCE REQUIREMENTS

The present water uses and projected demands for water in Wyoming's Platte River Basin have been discussed in detail in previous sections of this chapter. The present consumptive uses for irrigation, industrial, municipal, domestic, and stock water uses total about 688,000 acre-feet per year. In addition to these consumptive uses, reservoir and stock pond evaporation consumes about 180,000 acre-feet of water per year.

Table IV-27 presents a summary of present and projected consumptive uses in the Platte River Basin, Wyoming. The 50-year projection conforms with other projections made in this report.

TABLE IV-27 -- Summary of Present and Projected Consumptive Water Uses in the Platte River Basin, Wyoming

<u>Water Uses</u>	<u>(1,000 Acre-Feet Per Year)</u>			
	<u>Present</u>	<u>1980</u>	<u>2000</u>	<u>2020</u>
Irrigation	651	864	918	968
Industrial	13	31	79	89
Municipal, Domestic, and Stock	<u>24</u>	<u>27</u>	<u>36</u>	<u>48</u>
Total	688	922	1,033	1,105

Water supplies to meet the projected future water needs of the Basin will be developed from the available ground and surface water resources in the Basin and from transbasin diversions of water from other river basins. The most likely source of transbasin water for the Platte River Basin is the adjoining Green River Basin of Wyoming. If water is not imported to the North Platte River it is likely that irrigated lands will be taken out of production, resulting in some reduction in the future use of water for irrigation as shown in Table IV-27.

CHAPTER V

POTENTIAL SOURCES OF WATER TO
MEET REQUIREMENTS AND ALTERNATIVES
OF DEVELOPMENT

POTENTIAL SOURCES OF WATER TO
MEET REQUIREMENTS AND ALTERNATIVES
OF DEVELOPMENT

SUMMARY OF WATER REQUIREMENTS

Projections of future water needs in the Basin were presented in Chapter IV and summarized in Table IV-27. The total present consumptive water uses of 688,000 acre-feet per year are projected to increase to 1,105,000 acre-feet per year by the year 2020.

Irrigation is the largest projected increased use, increasing from 651,000 acre-feet per year to 968,000 acre-feet per year by the year 2020, or 1.5 times the present use. Much of the new water use will have to come from groundwater sources. Of the 106,240 acres of new irrigated land projected, 84,240 acres would use groundwater, and the remainder would use surface water. Supplemental water for existing irrigation can be provided where water supplies are available.

Municipal, domestic, and stock water use is projected to double from the present consumptive use of 24,000 acre-feet per year to 48,000 acre-feet per year by the year 2020. The use of water diverted from the Little Snake River in the Colorado River Basin for use in Cheyenne and Laramie is excluded in these figures. About one-half the increase is projected for municipalities along the North Platte River, and the remainder would be in cities and towns not adjacent to the river.

Industry is projected to need 6.8 times the present consumptive use of 13,000 acre-feet per year, or 89,000 acre-feet per year by the year 2020. Analysis of the industrial water projections for the State indicates several areas with a significant potential future water demand. The location of these potential water demands can, in some instances, be associated with a specific coal field, uranium district, or other area of concentration of potential future mineral industrial activities.

In Wyoming's Platte River Basin two coal fields and three major uranium districts have been identified (see Figures IV-2 and IV-4). Future water needs of the uranium industry have been projected to be met with groundwater resources. The uranium industry water needs appear to be within the availability of groundwater in the mining districts.

Development of the coal resources will require large quantities of water for plant processes and cooling in the electric power and synthetic fuels industries. Two centers of coal activity have been identified in the Platte River Basin. One is in the area between Casper and Douglas, Wyoming, north of the Dave Johnston Steam Electric Plant on the North Platte River. The second is the Hanna coal mining district located southeast of Seminoe Reservoir. An analysis of the water needs projections shows that an additional 15,000 acre-feet of water per year will be required by 1980 in the vicinity of the Dave Johnston Steam Plant, and by the year 2020 an additional 45,000 acre-feet over the present use will be required in that vicinity. In the Hanna coal fields a total of 30,000 acre-feet of water requirements per year have been projected for the period 1980-2000.

POTENTIAL SOURCES OF WATER

Surface Water

Surface water supplies available for future development are limited because appropriations have developed the full supply in many areas of the Basin, and a U. S. Supreme Court decree has restricted new water uses on the North Platte River system in Wyoming. Chapter II presents the details of the water rights and other legal constraints on Wyoming's Platte River Basin surface water supplies. Basically, under the North Platte River Decree Wyoming is restricted from irrigating more than 168,000 acres from the main stem of the North Platte River above Guernsey Reservoir and from the North Platte River tributaries above Pathfinder Dam. The decree also limits irrigation storage in the area above Pathfinder Dam to not more than 18,000 acre-feet in any water year. There are, however, potentials for surface water developments on the tributaries of the North Platte River below Pathfinder Dam. Investigations regarding these potential water supply developments are discussed in detail in a later section of this chapter.

Groundwater

Groundwater resources are located throughout the Basin. Groundwater is presently providing a large portion of the stock, domestic, and municipal water supplies. Numerous industries and a sizeable amount of the presently irrigated acreage are currently using groundwater. In the future, groundwater will become increasingly important as a source of water supply in the Basin.

Of the 106,240 acres of new irrigated land projected for the Basin in the next 50 years, it is estimated that about 84,240 acres will use groundwater as a primary source of water supply. Groundwater will also provide supplemental water to some lands with an original surface water supply. Though groundwater is abundant throughout much of the Basin, additional information is required to define the local water resources and the ability to sustain irrigation development. Administrative controls may be required in certain areas to properly manage the resource.

Groundwater is available for future municipal and industrial water supplies. For industries whose water needs are not great, groundwater may be the most logical water supply because it is more readily available than surface water. An example is the uranium industry that uses groundwater in areas of scarce surface water supplies. For other projected industrial needs a groundwater supply is an alternative to using newly developed surface water supplies or to the conversion of irrigation water use to industrial use. Chapter III provides the details of the groundwater resources of the Basin and the potentials for development.

Improved Water Uses

Improved efficiency in existing water uses will enhance many present operations. Improvements in water uses usually occur when they appear justified for economic reasons.

Irrigation efficiencies may be improved through the use of ditch linings, pipelines, sprinkler systems, and improved field irrigation methods. In many areas ditch and lateral water losses and operation and maintenance costs could be reduced by consolidating several parallel ditches into one system. Reservoirs

that would store the high spring runoff could improve irrigation efficiencies by making water available to crops during the peak consumptive use period.

Most industries in the Platte River Basin are currently utilizing recirculating water systems. Most of the diverted water is for makeup and cooling. Practically all process water diverted by present industry is consumed. New industries contemplated in the Basin will likely consume all diverted water to avoid stream pollution and to comply with interstate water quality standards.

Change of Use of Irrigation Water Rights

Wyoming statutes provide for the change of use of water rights to higher, preferred uses. The preference order is: (1) drinking (domestic and stock) water; (2) water for municipal purposes; (3) "Water for the use of steam engines and for general railway use, water for culinary, laundry, bathing, refrigerating (including the manufacture of ice), for steam and hot water heating plants, and steam power plants;" (4) industrial purposes. Also implied are preferences: (5) irrigation and (6) hydropower. The statute (Section 41-3, Wyoming Statutes, 1957) provides for the condemnation of irrigation rights for the first three preferred uses (except steam power plant use). Irrigation water rights may be purchased by industry and changed to preferred uses.

Changes of water rights to preferred uses must be approved by the Board of Control. The underlying principle used by the Board of Control and the State Engineer in considering changes is that only the historic use may be transferred to the new use. This provision stems from the necessity to protect the rights of others. Protection of other water rights usually necessitates restrictions by the Board of Control upon the amount of the water right transferred and upon the season of use. For example, the historic use of a direct flow irrigation water right located above a reservoir on a stream system is seasonal. Conversion of the water right to a year-round use could impose a burden on the water resources that was not historically imposed. The winter use could deplete the water supply that would normally be stored in the reservoir during the nonirrigation season. Under this condition the winter use would not be allowed.

Industrial water supplies developed from change of use of irrigation water will likely require at least a part-year supply from storage, groundwater, unappropriated winter streamflows (if available), or transbasin diversion. The Board of Control would have to examine each transfer of use separately to determine the conditions of the change of use.

The cost of a water supply obtained from change of use of a water right is difficult to estimate without analyzing a specific instance. Irrigation water rights are property rights which attach to the land. A water right purchase would be between the M & I interest and the property owner, and prices would be based upon negotiations. A cost of a water right transfer (perhaps a secondary cost) is the loss of the economy associated with the farm and agricultural use in terms of expenditures in the community by the irrigators and the decrease in taxes from the land. If the new industry or water use is in the same locality as the irrigation, then the secondary cost may be offset by secondary benefits of the new industry or use. If, however, the new industry is far removed from the community near the irrigation water use, there may not be an accompanying economic offset to these secondary losses. If new water supplies are provided for M & I purposes, the result is an increase in the total economy.

Weather Modification

As mentioned in Chapter II, streamflows may be artificially augmented in the future. It has been found that snowfall, which would not ordinarily occur, can be induced from clouds over mountains by "cloud seeding." An increase in precipitation of 10 percent has been estimated for areas affected by precipitation management operations. Such operations are in the research and developmental stages, and the areas where precipitation management operations might be performed are presently unknown. The streams which would be benefited and the total amounts of increased water supplies will be difficult and costly to determine. At this time it would appear that benefits of precipitation management would accrue as supplemental water in an area or stream system in general for the existing water rights and users within the area. Weather modification may provide water for new development, but this possibility is so indefinite it precludes explicit projection at this time. It has been suggested that a conservancy district including all water users should be the entity to repay costs of weather modifications since the operations would improve water supplies for everyone in general.

Imported Water

Analysis of the State's water resources and availability of water supplies under interstate compacts reveals that considerable water is available for use in Wyoming's Green River and Bighorn River Basins. Based on past and current studies, the water supplies available in these river basins exceed their foreseeable total water needs, indicating that water could be diverted into the Platte River Basin. Diversion from the Yellowstone River Basin into the Platte River Basin would require approval of the States of Montana and North Dakota under the Yellowstone River Compact. Approvals of other states are not required to utilize Green River water in the Platte River Basin.

POTENTIAL SURFACE WATER PROJECTS

Since the time of the earliest settlement in the Basin, the surface water supplies have been developed and utilized. Water shortages and the desire to expand irrigation have prompted many private, State, and Federal investigations of surface water development potentials. Many of the potentials that have been identified in the past are not now realistic projects because of economic reasons, the limitations imposed by the North Platte River Decree, or the physical lack of water available for further development.

Investigations by the Bureau of Reclamation, Corps of Engineers, and Soil Conservation Service were reviewed to define the current potentials for surface water development and are summarized as reported. Additional studies were made by the Wyoming Water Planning Program to identify potential projects not considered in the past or project variations not considered in other studies. The studies are preliminary and were done to identify alternatives. The State studies considered two water supply needs: (a) the needs of presently irrigated lands for supplemental, or late season, irrigation water, and (b) development of new M & I water supplies. Flood control, minimum reservoir pools, and minimum streamflows below potential dams can be provided in most instances, and the studies include these provisions.

The water supply criteria used in the State studies include:

1. Supplemental irrigation water needs were based upon crop consumptive needs plus conveyance and field losses.

2. Storage requirements for irrigation were estimated on the basis of supplying a full-season water supply 8 years in 10. This is an essentially full water supply and is comparable to criteria commonly used by other agencies. For these studies no consideration was given to possible exchanges of water for upstream uses. Such possibilities should be identified if and when detailed project studies are undertaken.

3. M & I water supplies and storage requirements were determined from the firm yield that could be provided from streamflows surplus to existing irrigation uses. Primary consideration was given to providing supplemental irrigation water in the potential reservoir projects. Studies of alternative uses of the surplus water, however, considered development of M & I water supplies only.

4. Minimum pool requirements to provide fishery and recreation in potential reservoirs were assumed to be a pool with a surface area of about 25 percent of the area of the reservoir when the active space is full.

A primary need on tributaries of the North Platte River below Casper is flood control. The active storage capacity of potential reservoirs on the tributaries would provide incidental flood control, but reservoir capacity specifically for flood control purposes should be provided. Construction of flood control projects has been primarily done by the Federal Government because of the cost-sharing programs available. The Corps of Engineers and the Soil Conservation Service include flood control as a primary project purpose. The authority for SCS projects, P.L. 566, restricts the total reservoir capacity to 25,000 acre-feet or less in watersheds of 250,000 acres or less. Flood control provisions can be incorporated into a Bureau of Reclamation project.

Costs and benefits of potential irrigation projects in the non-decree areas were not calculated for these preliminary studies. Reasons for not doing so include: (1) the purpose of the studies is only to determine alternatives, (2) the desires for supplemental irrigation water need to be determined prior to initiation of detailed studies, (3) field data will be required for such detailed studies, and (4) a recently authorized U. S. Department of Agriculture river basin survey requested by the State will include investigations of small projects in greater detail than these preliminary studies. Benefits were estimated for potential irrigation projects in the decree area to determine the desirability of reopening the decree.

For multipurpose reservoirs involving municipal and industrial water, the total costs and annual costs allocated to the M & I portion of the reservoir were determined.

North Platte River Decree Area Above Pathfinder Reservoir

In the Saratoga Valley (Study Area 1, Figure II-4), Sweetwater River (Study Area 2), and Medicine Bow River (Study Area 3), approximately 140,340 acres are currently being irrigated. It is estimated that about 75 percent of these lands are irrigated with short-season water supplies. Most of these lands are on the

tributaries of the North Platte River where the largest percentage of runoff occurs from April through June. Water supplies could be improved by constructing small reservoirs on the tributaries to store the spring runoff and distribute it to the lands in the latter part of the growing season. Such reservoirs would permit higher water use efficiencies and improved crop types. Another way of improving irrigation efficiencies would be to construct sprinkler systems. Without storage, however, late-season water supplies may not be available to sprinkler systems.

Water supply investigations were conducted for 120,000 acres of land for which water supplies are physically available for water supply improvements. About 88,000 acres currently receive a short water supply, and about 32,000 acres presently have a full water supply. With an additional 136,000 acre-feet of storage about 77,000 acres could receive a full-season water supply, and the remaining 43,000 acres could receive an improved water supply amounting to $\frac{1}{2}$ to $2\frac{1}{2}$ months of additional water deliveries.

No specific damsites were identified in the study because the North Platte River Decree restricts irrigation storage in this area of the North Platte River Basin to not more than 18,000 acre-feet per year. The State Engineer's records show that the presently constructed reservoir space in the decree area totals about 25,300 acre-feet. Recently, storage in these reservoirs has averaged approximately 11,300 acre-feet per year, although a full 18,000 acre-feet were stored in one recent year. This would indicate that the possibility of constructing new reservoirs in Study Areas 1, 2, and 3 for improved irrigation water supplies is very limited, if practical at all, without changing the U. S. Supreme Court Decree on the North Platte River.

It was calculated that \$662,700 in benefits could be derived annually from increased crop yields if additional storage is provided in the decree area above Pathfinder Reservoir. The costs of providing the storage were not included in the calculation, so repayment costs would have to be considered in estimating the actual net return to the ranchers. The 120,000 acres which would benefit from this storage would realize annual increased benefits of \$5.52 per acre less the annual repayment costs of providing the storage.

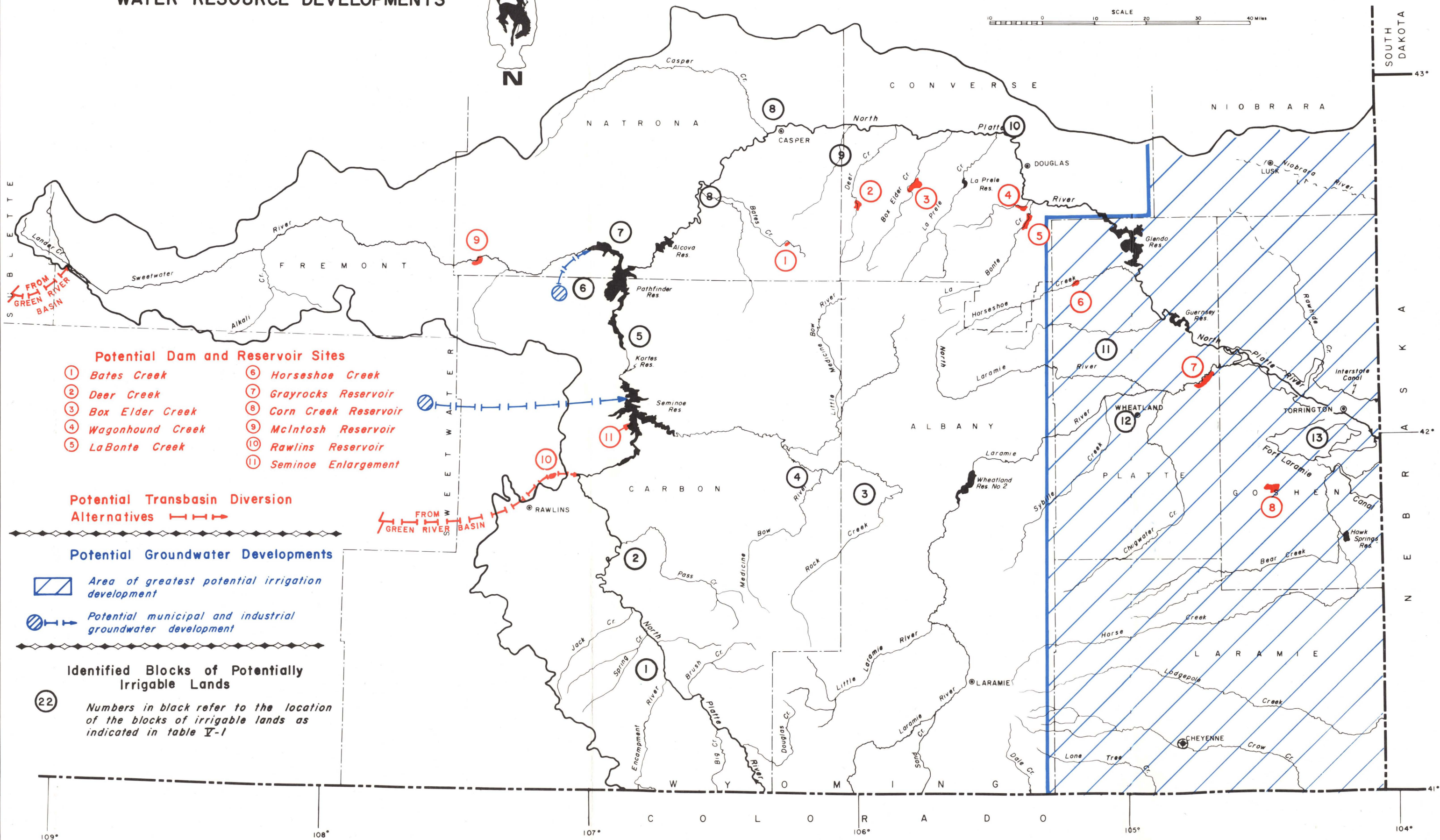
Bates Creek

Bates Creek drains 395 square miles and enters the North Platte River approximately 30 miles upstream from Casper, Wyoming, in Study Area 4. Irrigation water shortages have prompted investigations by the Wyoming Natural Resource Board, the Bureau of Reclamation, and most recently, the Soil Conservation Service. The SCS conducted a preliminary investigation study on Bates Creek in 1961 and identified three alternatives of reservoir development to improve the irrigation water supplies from the stream.

About 4,000 acres are irrigated from Bates Creek. The SCS study showed the potential for providing a full water supply to 2,000, 3,000, and 4,000 acres. The largest alternative was an 8,000-acre-foot reservoir located at the Bates Creek Damsite shown on Figure V-1. With this reservoir, carry-over storage can be utilized to furnish the 4,000 acres with a full-season water supply. There would also be flood control and fish and wildlife benefits in the project. The estimated cost in 1961 was \$851,000, and the project appeared feasible at that time. The project was not constructed because of opposition by a large ranch

FIGURE V-1
POTENTIAL PROJECTS AND ALTERNATIVE
WATER RESOURCE DEVELOPMENTS

WYOMING'S PLATTE RIVER BASIN



interest. A reevaluation of project benefits and costs considering today's costs and interest rates would be necessary to determine economic feasibility at the present time.

Deer Creek

Deer Creek enters the North Platte River at the town of Glenrock, which is approximately 25 miles east of Casper in Study Area 4. Deer Creek has an average annual discharge of 32,000 acre-feet per year at the mouth from a drainage area of 212 square miles. There are about 7,700 acres of adjudicated irrigation water rights and about 3,300 acres of water right permits in good standing. At present only about one-third of the acreage with rights is being irrigated.

Flooding has inflicted serious damage to irrigated lands, diversion structures, canals, oil well equipment, and to homes in the city of Glenrock. The Glenrock City Council is presently attempting to get assistance for a study to determine alternative ways to prevent flooding within the city.

A damsite in Deer Creek Canyon (Figure V-1) has been included in several investigations. A reservoir at the site could provide a water supply, recreation, and flood control. There is sufficient surplus water in Deer Creek to provide supplemental water for the approximately 3,750 acres of adjudicated water rights below the damsite (about 3,330 acres are presently irrigated) and develop a 9,500-acre-foot-per-year M & I water supply. Based on preliminary studies, 12,600 acre-feet of storage are required for supplemental irrigation and 46,200 acre-feet for M & I storage. The flood control storage requirement would depend upon the degree of protection desired and the channel capacity of Deer Creek. A multipurpose reservoir might be sized as follows:

Flood Control	11,000 acre-feet
M & I Storage	46,200
Irrigation Storage	12,600
Minimum Pool	16,000
Total Capacity	85,800 acre-feet

The estimated cost of the dam and reservoir is \$9.5 million. Lands inundated by the reservoir would include 1,420 acres of ranchland including 114 acres of lands with adjudicated water rights. In recent considerations by the SCS of a flood control facility on Deer Creek, it was found that a reservoir was not desired by ranch interests in the area.

As an alternative, the water supply surplus to the existing direct flow water rights could be developed exclusively for M & I purposes. A firm water supply of 13,100 acre-feet per year could be developed with 36,000 acre-feet of storage.

Box Elder Creek

Box Elder Creek enters the North Platte River approximately 10 miles east of Glenrock. With a drainage area of 202 square miles, Box Elder Creek has an average annual discharge of 26,500 acre-feet of water at the mouth.

There are 10,100 acres of adjudicated irrigation water rights from Box Elder Creek and permits for another 6,580 acres. The present irrigation covers about 53 percent of the adjudicated water rights and about 32 percent of the total water rights.

A potential reservoir site was selected at the head of Box Elder Canyon (see Figure V-1). There are 5,110 acres of adjudicated water rights below the damsite, of which 3,400 acres are actually irrigated. Water supply studies indicate that the potential reservoir could develop surplus spring streamflows to use either for supplemental irrigation water or for an M & I water supply. Storage could also be provided for flood control and recreation. An essentially full water supply could be provided for the 3,400 presently irrigated acres. A 17,000-acre-foot reservoir could have 12,500 acre-feet of active, irrigation storage and 4,500 acre-feet of inactive storage for recreation.

There is not enough water to provide a full-season supply to all 5,110 acres of land with adjudicated water rights. However, a reservoir could provide a water supply through July for this amount of land.

The water presently surplus to the direct flow irrigation water rights could be developed by a reservoir for a firm M & I water supply. The amount of M & I water supply available depends upon a definition of the irrigation water rights. If the irrigation demand is equivalent to the direct flow rights on the 5,110 acres with adjudicated rights, then 5,600 acre-feet per year of M & I water supply could be developed with 34,000 acre-feet of storage. If the irrigation demand is equivalent to the direct flow rights for the 3,400 acres of actually irrigated lands, an M & I water supply of 8,500 acre-feet per year could be developed with 45,000 acre-feet of storage.

LaPrele Creek

LaPrele Creek enters the North Platte River about 10 miles northwest of Douglas, Wyoming. LaPrele Creek has a drainage area of 177 square miles and an average discharge of 5,700 acre-feet per year at the mouth. Adjudicated irrigation water rights from LaPrele Creek total 21,785 acres, and there are unadjudicated permits for an additional 1,676 acres. About 60 percent of the total water right acreage is presently irrigated, about 9,100 acres of which are in the LaPrele Project.

The LaPrele Project was originally planned in 1905 to irrigate 27,000 acres of land. Plans included the LaPrele Dam and Reservoir with a 20,000-acre-foot capacity. In 1909, at the time the LaPrele Dam and the conveyance system were constructed, the project plans were enlarged to include 40,000 acres of land north of the North Platte River. A hydropower plant was planned for use with LaPrele Dam along with a pumping plant to serve the lands north of the North Platte River. These two facilities were never put into operation. The project was operated until 1918 without using the reservoir. The Douglas Reservoirs Water Users Association then acquired the system, and the project was later accepted by the Federal Government as complete under the Carey Act. The Douglas Reservoirs Water Users Association has operated the project since 1923.

Leakage from LaPrele Reservoir has been severe since the beginning of the operation of the reservoir. This leakage and deterioration of concrete in the LaPrele Dam have prevented full utilization of the reservoir. Consequently, project water supply shortages prompted the construction of transbasin diversions from four small streams in LaPrele Creek.

Rehabilitation of the project has been investigated by the Bureau of Reclamation since the early 1950's. The 1969 Concluding Report issued by the Bureau

included a plan for a new dam, rehabilitation of the distribution system, and construction of a drainage system. The new dam would be downstream from the old one and would provide 43,000 acre-feet of storage. The project would supply supplemental water to 7,230 acres. The Bureau reported the project to be economically infeasible and not justified for construction under the normal Bureau of Reclamation program.

The safety of the existing LaPrele Dam has been questioned throughout the years. A flood in LaPrele Creek in 1970 nearly overtopped the dam and raised further questions concerning the adequacy of spillway capacity. Due to these safety questions, the State Engineer has restricted the use of the dam. Emergency funds are being sought in Congress, and there are considerations for rehabilitation of the dam using loan moneys.

The water supply to the LaPrele Project will be reduced unless the dam is rehabilitated. With a reduced water supply the economy of the area surrounding Douglas will be seriously affected. The existence of the LaPrele Dam in its present condition also threatens loss through flood damage.

A diversion of water from Box Elder Creek into LaPrele Creek has been investigated by the State and by the Bureau of Reclamation. The water would be expensive, and without reservoir regulation the diversion may not enhance the LaPrele Project extensively. Another possibility for increased water supplies for the area is development of groundwater. Exploration is required, however, to determine the groundwater potential. Again, storage is likely to be required, and replacement or rehabilitation of LaPrele Dam appears to be essential.

Wagonhound and LaBonte Creeks

Wagonhound Creek enters the North Platte River about 6 miles south of the town of Douglas, and LaBonte Creek enters the river about 1 mile further downstream.

Wagonhound Creek has a drainage area of 112 square miles and an average annual discharge of 4,430 acre-feet per year at the mouth. Adjudicated water rights total 4,286 acres and another 312 acres are under permit. The Douglas Reservoirs Water Users Association has a small diversion into LaPrele Creek from the headwaters of Wagonhound Creek. About 44 percent of the water right acreage using water from Wagonhound Creek is presently irrigated.

LaBonte Creek has a drainage area of 287 square miles and an average annual discharge of 30,090 acre-feet at the mouth. This amount of water suggests a potential to develop a fairly sizeable water supply. There are 10,058 acres of water rights from LaBonte Creek, about 51 percent of which are presently irrigated.

The Bureau of Reclamation identified a potential reservoir of 4,500 acre-feet active capacity on Wagonhound Creek that could provide supplemental irrigation water. Flood control could be provided with additional storage. On LaBonte Creek, two irrigation reservoir potentials were identified. Both alternatives are located near the headwaters. The farthest upstream potential is below LaBonte Canyon, where a 14,200-acre-foot reservoir could be constructed. Three miles downstream a 9,500-acre-foot reservoir potential exists. Private lands would have to be acquired for right-of-way for any of these potentials. Apparently there has been little past support for developing these potentials.

The Water Planning Program investigated potentials to develop the fairly large water supply indicated to be available in the lower reaches of LaBonte Creek. Storage is required to develop the water, and dam and reservoir sites are few. A potential damsite exists on LaBonte Creek 2 miles upstream from the mouth of the stream. Studies show the site to be a good water development potential, but extensive relocations would be required. Right-of-way problems may preclude the development. The reservoir would inundate ranches and require relocation of three oil and gas pipelines and two transmission lines. A reservoir greater than 33,000 acre-feet capacity would inundate the historical sites of the LaBonte Stage Station and Camp Marshall. Since the relocation of the pipelines and transmission lines would also clear the way for a dam and reservoir on Wagonhound Creek, alternatives include the use of a damsite there.

A maximum development on LaBonte Creek could develop a firm water supply for M & I purposes of 25,300 acre-feet per year. A 113,500-acre-foot reservoir having M & I space of 94,000 acre-feet and a minimum pool of 19,500 acre-feet would develop the maximum water supply and also provide for recreation. A reservoir of this capacity would inundate 810 acres of irrigated land, 2,990 acres of dryland, and the buildings of three ranches. The total cost of this alternative is estimated to be \$9,410,000 including right-of-way and relocations. About 170 acres are irrigated below the damsite for which a regulated water supply could probably be provided.

A reservoir on Wagonhound Creek could develop a 3,200-acre-foot-per-year M&I water supply with a 26,300-acre-foot M & I storage pool. If a recreation pool of 5,000 acre-feet were provided, the total reservoir capacity would be 31,300 acre-feet. The Wagonhound Dam and Reservoir would be rather costly with an estimated construction cost of \$4.5 million. About 130 acres are irrigated below the damsite for which a water supply improvement might be provided.

The most economical water supply would be a 64,400-acre-foot reservoir on LaBonte Creek. If the storage were allocated 57,000 acre-feet to M & I and 7,400 acre-feet for recreation, a 21,800-acre-foot-per-year M & I water supply could be provided. A reservoir of this size would inundate the buildings of one ranch, 685 irrigated acres, and 1,876 acres of dryland. The estimated reservoir cost is \$6,930,000.

Although there is apparently only limited access to the previously mentioned historical sites, consideration was given to preserving them by limiting the size of LaBonte Reservoir to 33,000 acre-feet, with 28,000 acre-feet for M & I space. This would enable an M & I water supply of 15,400 acre-feet per year to be developed at a total project cost of about \$5,385,000. A reservoir on Wagonhound Creek interconnected with LaBonte Reservoir could raise the M & I water supply to 19,800 acre-feet per year from a combined total storage capacity of 45,000 acre-feet, 38,000 acre-feet of which would be active M & I capacity. The combined total cost would be about \$8,792,000.

Reduction or elimination of the minimum pools in all but the maximum development alternative would enable larger M & I water supplies than shown. If a project is desired, detailed planning, cost-benefit, and repayment analyses will reveal the best alternative.

Horseshoe Creek

Horseshoe Creek enters the North Platte River $4\frac{1}{2}$ miles southeast of Glendo, Wyoming. At the mouth, Horseshoe Creek has an average discharge of 16,860 acre-feet per year. The drainage area is 212 square miles.

There is a total of 8,134 acres with water rights, 7,759 of which are adjudicated. Present irrigation covers 51 percent of the acreage with water rights.

The Bureau of Reclamation investigated the potential for projects on Horseshoe Creek to develop new irrigation using the water rights from lands that were inundated by Glendo Reservoir. The SCS has recently investigated the potential to provide flood control and irrigation storage. The SCS investigation proposed a dam at the Horseshoe Creek Damsite shown in Figure V-1 to provide a supplemental irrigation water supply to 2,000 acres below the reservoir and to 500 acres above the reservoir by exchange. The total reservoir capacity would be 10,500 acre-feet with 500 acre-feet allocated to sediment storage, 5,500 acre-feet to irrigation storage, and 4,500 acre-feet to flood control. The estimated project cost is \$1.7 million, and the SCS has recently reported the project to be economically feasible.

The available water supply could be used for M & I purposes. Upstream water supplies are limited because most of the available water supply is required for prior irrigation water rights. As previously indicated, there is a considerable water supply available at the mouth of Horseshoe Creek, consisting largely of irrigation return flows. Only one dam and reservoir site potential near the mouth of the stream was found in the preliminary investigations. Approximately one-half the irrigation on Horseshoe Creek would be inundated by a reservoir at the site, and the Burlington Northern Railroad runs through the site, requiring a relocation that is of doubtful feasibility. Because of these right-of-way problems, no further consideration was given to the potential.

Glendo Inundated Water Rights

When Glendo Reservoir was constructed, the Wyoming Legislature passed a law enabling the transfer of the 3,276 acres of adjudicated water rights inundated by the reservoir to other lands so that these water rights might remain in use. The Bureau of Reclamation had acquired the water rights from purchases of lands for right-of-way for Glendo Reservoir. The Bureau conducted investigations of potential projects to utilize these water rights in the Sage Creek and Cassa-Horseshoe areas. The proposals have not been accepted, however, and no project has yet been undertaken to utilize the water rights.

A bill was introduced in the last U. S. Congress to transfer the ownership of the water rights to the State of Wyoming. The State could then develop one or more projects to put these water rights to use. The water rights were for lands within the area where the 168,000-acre U. S. Supreme Court acreage limitation is in effect. For the purpose of this report it is assumed that these lands will be developed by private individuals as part of the increase in irrigated lands to bring irrigation in the decree area up to the 168,000 acres allowed by the decree (see page 100).

Laramie River

The Laramie River drains an area of 4,547 square miles and flows into the North Platte River 7 miles downstream from Whalen Dam near Fort Laramie, Wyoming. About 4,600 acres of land in Colorado and about 172,000 acres of land in Wyoming are irrigated at the present time from the Laramie River and its tributaries. Wyoming water rights include 293,000 adjudicated acres and 180,000 acres under permits.

Appropriations for irrigation on the Laramie River and its tributaries have long exceeded the available water supply in the drainage. Drought conditions in the 1950's prompted investigations of the possibilities of importing water into the Laramie River Basin from Douglas Creek, Rock Creek, and the Medicine Bow River, all tributaries of the North Platte River (4). Water from the Little Snake River drainage in the Colorado River Basin would be used to replace the North Platte River water. Construction costs would include those for the Little Snake collection and diversion facilities and the cost of facilities from the North Platte tributaries to the Laramie River. The costs were found to be too great for the water to be used for irrigation.

The Wheatland Irrigation District diverts water from the Laramie River below the Wheatland Reservoir No. 2 (see Figure V-1) in two canals constructed in 1886 and another canal constructed in 1895. Storage water is provided in Wheatland Reservoirs No. 1 and No. 2 (see Figure IV-1), with a combined capacity of about 108,300 acre-feet. Reoccurring droughts and the need for distribution system rehabilitation resulted in a request for a study by the Bureau of Reclamation to improve the project. A feasibility report by the Bureau was issued in 1964. Water supply improvements suggested in the report included a canal lining program, groundwater wells within the district, Rock Creek (Ringsby Ranch) diversion of water to the Laramie River, volumetric water deliveries to the farmers, and replacement of Wheatland No. 2 Reservoir (capacity 98,900 acre-feet) with the Dodge Canyon Reservoir (250,000 acre-feet). The Wheatland Irrigation District has implemented several of the suggested programs out of an immediate need for water supply improvement. Dodge Canyon Reservoir and lining of the main canals are the remaining elements of the Bureau project not undertaken. Water supply studies show that a severe drought will still cause extreme water shortages in the district. Additional reservoir storage would help alleviate these water shortages.

Two watershed improvement projects have been investigated by the SCS on the North Laramie River. The Upper North Laramie River project would include land treatment measures and construction of a 4,600-acre-foot reservoir to provide storage for irrigation, recreation, and flood and silt control. About 1,750 acres of irrigated land would receive supplemental irrigation water from the project. The estimated project structural costs as of 1967 were about \$326,000, and the project is economically feasible. At the time of this writing, project construction is held up by pending litigation involving a test of the constitutionality of the Wyoming Watershed Improvement District law. The Lower North Laramie River P. L. 566 watershed project was investigated in 1962. About 2,800 acres could receive supplemental irrigation water from a potential reservoir with 5,100 acre-feet of irrigation storage located near the Albany-Platte County line on the stream. Although the project was shown economically feasible under a change of farming practices, the project was not constructed.

Corn Creek Project

Return flows from irrigation in the Wheatland Irrigation District, lower Laramie River, and Chugwater Creek areas result in an average flow of 58,900 acre-feet per year in the Laramie River just above its confluence with the North Platte River. The Goshen Irrigation District has a water right to divert a portion of this flow. Water supply studies show, however, that surplus water is available for other uses. This surplus could be developed by the potential Grayrocks Reservoir (Figure V-1) or by other means into a water supply for the Corn Creek Project or perhaps for other uses.

The Corn Creek Project is located in central Goshen County. The Bureau of Reclamation is investigating the possibility of providing a full water supply for 11,000 acres of new land and a supplemental water supply for 9,500 acres of land presently irrigated from Horse Creek, Hawk Springs Reservoir, and several other water sources. Additional new land could be irrigated if investigations reveal a large enough water supply. The current Bureau plan is to divert the surplus Laramie River water into the potential Corn Creek Reservoir for project use and to utilize a portion of Wyoming's allocation of the Glendo Reservoir irrigation storage water. The feasibility report on the project is scheduled for fiscal year 1974.

Seminoe Reservoir Enlargement

Seminoe Reservoir can be enlarged by raising Seminoe Dam. The Bureau of Reclamation has found that the dam could be raised 20 feet, and the maximum reservoir elevation could be raised 15 feet without causing excessive stresses on the units in the powerplant. The 15-foot raise would increase the storage capacity in the reservoir from 1,010,825 to 1,350,825 acre-feet. This 340,000 acre-feet of additional storage capacity might be utilized for several purposes including storage of surplus North Platte River streamflows, regulation of imported water, flood control, and enhanced regulation of water for irrigation, hydropower production, and recreation. A Bureau of Reclamation operation study based on the water years 1928-1956 shows that 79,000 acre-feet per year of North Platte River water are surplus to the existing uses.

The Supreme Court decree governing the uses of the North Platte River might have to be modified to enable construction of the enlargement, depending upon the uses to be made of the enlargement.

At this writing, authorization is being sought from Congress to enable the Bureau of Reclamation to analyze the feasibility of enlarging Seminoe Dam and Reservoir.

Other Surface Water Potentials

The irrigation on many streams that have not previously been named could probably be improved with reservoir storage for water supply regulation. Among other streams, Muddy Creek, located west of Casper, Cottonwood Creek, located west of Guernsey Reservoir, Chugwater Creek, Bear Creek, and Horse Creek all provide a water supply for a significant irrigated acreage. Water rights greatly exceed the acreages actually irrigated on these streams, and dependable water supplies are over-appropriated. Field investigations and determination of desires for improvements, however, may reveal the existence of potential projects for water supply improvements.

POTENTIAL GROUNDWATER DEVELOPMENTS

Data from groundwater investigations indicate that a considerable water resource exists underground in the Basin. This resource and details of the potentials for groundwater development are described in Chapter III.

Groundwater will supply a large part of the stock and domestic water in the future as it has in the past. Many communities will find groundwater the most feasible source of water to meet future demands.

As shown on Figure V-1, the High Plains region of southeastern Wyoming has a considerable potential for developing groundwater supplies for irrigation. The advent of automated sprinkler systems and the need to improve agricultural management to keep up with the economic times has stimulated interest in developing irrigated lands in this area. Groundwater supplies and sprinkler irrigation now enable irrigation of lands with good soils formerly thought not irrigable because of varying terrain and lack of water supply. The aquifers and development conditions vary widely throughout the area. Groundwater supplies must be located by test hole exploration, and water supplies and pumping lifts must be estimated. Water is now being pumped from depths formerly thought to be excessive for irrigation. These physical factors and others, as well as economic factors, are governing the development of new irrigated lands by private landowners. This type of development with its variable conditions would seemingly not lend itself to project-type construction; therefore, new irrigation of this type will probably be private undertakings.

A potential also exists in other areas of the Basin for developing groundwater supplies for irrigation, but not to the extent probable on the High Plains. Private developments may find adequate groundwater in the Saratoga Valley and the Sweetwater Valley.

Groundwater resources are limited to natural recharge and the amount of water that is in storage in the aquifers at the present time. The annual withdrawals for lands irrigated with groundwater will increase from the estimated present pumpage of approximately 150,000 acre-feet per year to 395,000 acre-feet per year by 2020. Increased emphasis on groundwater investigations needs to be made to insure that enough data are available to assist in making the decisions that will be required to manage the groundwater resources.

Two areas have been identified with a potential for large-scale groundwater developments for M & I water. Good quality water is available in the Arikaree formation underlying the Sweetwater River Basin and in the Battle Spring and other formations in the Great Divide Basin. Recharge of the groundwater aquifers is limited to that amount of precipitation that can infiltrate into the formations. The map of mean annual precipitation (Figure I-4) shows the precipitation in these areas is 7 to 14 inches. Potential recharge to groundwater is perhaps 5 percent of the total precipitation. Development of large quantities of water on a continual basis will undoubtedly result in groundwater mining in these areas. In the case of the Arikaree formation in the Sweetwater River Basin, the available data indicate that a large percentage of the streamflows in the Sweetwater River accrues from groundwater. A large groundwater development would likely reverse the groundwater gradient and deplete the streamflow in the river with the resulting effect that senior water rights on the Sweetwater River would be adversely affected. There are, no doubt, ways of compensating for these effects, and for small industrial uses or short-term uses, pumping of groundwater may provide a portion of Wyoming's future water needs.

To adequately estimate the cost of groundwater development, a great deal of data not yet available would be required. On the basis of existing information, an estimate was made of the costs of providing 35,000 to 70,000 acre-feet per year of M & I water through the use of well fields in these two areas. It was assumed that the water would be pumped in several batteries of wells and conveyed by pipeline to the North Platte River. Many other assumptions were required, including well depths, pumping levels, well capacities, and the period that

sustained yield could be obtained. Apparently these aquifers might supply water into the North Platte River for \$30 or less per acre-foot over a period long enough to be economically attractive.

Detailed investigations are required before a project-type groundwater development to provide firm M & I water supplies can be undertaken. A very large volume of groundwater is in storage, but the long-term yield and the required facilities to obtain the water must be determined from accurate information. Depletion of the groundwater resource seems inevitable for the annual volumes under consideration, and the time over which the depletion can be economically and physically sustained is of prime concern. Perhaps it is in the best interest of the State to keep this water as a reserve for the future.

POTENTIAL TRANSBASIN DIVERSIONS

A potential transbasin diversion from the Green River Basin into the Platte River Basin was included in the alternatives identified for the utilization of Wyoming's Green River water available under the Colorado River Compacts. The projected Green River Basin M & I water needs included 105,000 acre-feet (16) of uses in coal industries associated with coal districts lying in the Green River and Great Divide Basins east of the Green River. One of the coal districts is located in the eastern part of the Great Divide Basin just outside of the Platte River Basin near Rawlins, Wyoming. A pipeline conveying water from the Green River near Green River City easterly into the Great Divide Basin coal fields could logically and economically be extended to deliver water into the North Platte River for M & I purposes. Another potential diversion route was identified from the Upper Green River Basin into the Sweetwater River Basin and then to the North Platte River (see Figure V-1).

The amount of water available for diversion into the North Platte River Basin will depend upon the projects constructed to use water in the Green River Basin and upon the amount of water ultimately made available to Wyoming under the Colorado River and Upper Colorado River Compacts. The amount of Green River water estimated to be available for diversion to the Platte River Basin was found to vary from 39,000 acre-feet per year under conditions of maximum irrigation development in the Green River Basin to approximately 272,000 acre-feet for conditions of minimum irrigation development in the Green River Basin and maximum water availability to Wyoming. Considering the marginal economics of new irrigation in the Green River Basin, the most likely water supply available to the Platte River Basin from the Green River is at least 93,000 acre-feet per year.

It appears that the future M & I water needs of the Platte River Basin could be met with a transbasin diversion in the range of the 93,000 acre-feet per year. If more Green River water is available it could be brought into the North Platte River and rediverted into northeastern Wyoming to satisfy future water demands by the coal industry in that area.

The facilities required to transport water from the Green River into the North Platte River will be very costly. Therefore, it appears that a stage-development plan will be attractive. There are many ways in which stage development could proceed. Four alternatives are identified below:

1. A transbasin diversion from tributaries of the New Fork River appears to lend itself to developing small water supplies and then expanding into

larger supplies as needs develop. Water could be carried in the Sweetwater River for a small transbasin diversion and conveyed alongside the Sweetwater River in a conveyance system for larger diversions in order to protect the stream and minimize the conveyance losses.

2. A pipeline from the Green River near Green River City could be constructed across the Great Divide Basin into the North Platte River, sized to convey water needed for the short-term time period. As water demands in the Green River and Great Divide Basin coal fields and in the Platte River Basin increase, parallel pipelines could be constructed to provide the stage development.

3. The first stage of development could be the completion of the Cheyenne diversion facilities from the Little Snake River into the Encampment River, a tributary of the North Platte River. The diversion could be increased from the present capacity of 7,000 acre-feet per year to 31,000 acre-feet per year. Water in excess of the needs of Cheyenne and Laramie could be sold on an interim basis. Water sales contracts would necessarily require provisions to revert the water supplies to the cities as the cities need the water. As the water needs of the cities increase, additional facilities would be constructed to develop new transbasin diversions from the Green River Basin that might include those described in 1 and 2 above. The Green River diversion would provide additional M & I water from the North Platte River and allow the Little Snake River water to revert to Cheyenne and Laramie.

4. Groundwater could be developed in conjunction with numbers 1, 2, and 3 as a stage in the development.

Control of the imported water in the North Platte River Basin would appear to be possible in the existing reservoir system. However, Bureau of Reclamation hydrologists contend that additional storage space is required in the North Platte River system to regulate the imported water. This contention appears reasonable for larger importations of water. Alternative ways to control imported water would include enlargement of Seminole Dam, construction of a reservoir on the Sweetwater River, construction of an off-stream reservoir near Rawlins if a pipeline were routed in that vicinity, or construction of reservoirs on North Platte tributaries to provide "exchange" control on the tributaries.

Costs of the transbasin diversions from the Green River to the North Platte River are estimated to be \$45 per acre-foot for 39,000 acre-feet per year developed along with an irrigation project in the Green River Basin, \$75 to \$81 per acre-foot for delivery of about 93,000 acre-feet from near Green River City into the North Platte River, and \$48 per acre-foot for 207,000 acre-feet delivered from near Green River City to the North Platte River above Seminole Reservoir.

It can be seen that the costs of a major transbasin diversion are too high to utilize the imported water for strictly irrigation purposes under current conditions. It may be possible, however, in the process of stage development, or after the M & I project is paid out, to utilize some of the developed water for irrigation. For example, a groundwater development in the Sweetwater or Great Divide Basin might be undertaken as the first stage in the transbasin diversion development. This groundwater could then be retired from M & I use if a pipeline from the Green River were constructed that would replace the groundwater use and increase the amount of water imported into the Platte River Basin. It might be reasonable in this case to convert the groundwater system to a reduced pumping

level that would irrigate lands that could be easily developed in the vicinity. Another example would be the use of water for irrigation in an interim period between the development of a transbasin diversion and the ultimate total use of that diversion for M & I purposes. Under this type of use the irrigation would be a means of recouping a part of an investment in the interim period. Probably the majority of the cost of water would have to be subsidized for the irrigators.

The locations of blocks of irrigable land that have been identified by the Bureau of Reclamation are shown on Figure V-1. Within these blocks of land the irrigation associated with imported water could be developed. The acreage in these blocks is listed in Table V-1.

TABLE V-1 -- Identified Blocks of Potentially Irrigable Lands ¹

<u>Land Block Number and Name</u>	<u>Acres</u>
1. Encampment Unit	20,000
2. Pass Creek Flats Unit	37,500
3. Omoc Unit	10,600
4. Halleck Unit	4,000
5. Sage Creek Basin	3,700
6. Arkansas Basin	17,000
7. Horse and Fish Creek Area	38,000
8. Kendrick Unit No. 2	16,500
9. Muddy Creek Area	20,000
10. Sage Creek Area	10,000
11. Dwyer Junction Area	19,000
12. Wheatland Unit	2,900
13. Goshen Park Unit	15,600

¹ Identified by USBR.

There is keen competition for water in the Colorado River Basin, primarily in the lower reaches in the drainage. Although Wyoming has been allocated the beneficial consumptive use of 1,043,000 acre-feet per year from the Green River and its tributaries, water supplies and the compact requirement to deliver water to the Lower Colorado Basin may limit Wyoming's allocation to something less than one million acre-feet per year. As described in detail in Wyoming Water Planning Program Report No. 3, "Water & Related Land Resources of the Green River Basin, Wyoming," a significant amount of water is available for a transbasin diversion into the Platte River Basin within Wyoming's allocation. The political pressure of large downstream populations and water uses may preclude some Wyoming uses if the actual use of this water is prolonged too far into the future.

ALTERNATIVE WATER RESOURCE DEVELOPMENTS

The objective of this report is to illustrate the possible alternatives of water resource development that will meet the projected future water needs of the area. Many future water needs can be met by multipurpose projects. Without planning and cooperation among water users, however, projects may be constructed for single purposes.

Most projected irrigation water needs will require action on the part of individuals. This is because the largest amount of irrigation water development will likely be individual groundwater developments. The alternatives available to these individuals appear to depend upon economic considerations, water rights, water management considerations, and limitations of available water supplies.

Previous sections of this chapter described the identified potentials to develop supplemental irrigation water. The decisions required to undertake any of the projects or alternatives appear to also depend upon considerations of economics, water rights, and cooperation with other purposes such as flood control, recreation, and M & I water supplies.

Modification of the U. S. Supreme Court Decree restricting the uses of the North Platte River could enhance irrigation in Wyoming. Such a modification might include an expansion of irrigated lands or an increase in the amount of storage allowable in Wyoming above Pathfinder Dam, or both. A modification would require negotiations with Colorado and Nebraska to determine the basis for the considerations. An importation of water into the North Platte River would appear to enhance the opportunity for favorable consideration of a decree modification.

There are several alternatives for the development of water supplies for municipal and industrial purposes. Inclusion of other functions, such as recreation, fish and wildlife purposes, flood control, and water quality management, in projects would appear to hinge on decisions by the State to insure their inclusion in water resources development. Three alternatives of water resource development in the Basin appear to be available: (1) no water resource development; (2) development of Platte River Basin water resources only; and (3) the importation of water into the Basin.

Alternative 1

The "no development" alternative assumes that not developing water resources will suppress other development in Wyoming. In this case, economic growth will occur differently from the projections in this report. However, unless economic growth is specifically prohibited, it would seem that growth will occur according to projections insofar as Basin water resources will allow.

Assuming that a "no development" alternative means prohibiting new water projects such as dams, then municipal and industrial growth would result in a decline in irrigated agriculture because of transfers of water uses from irrigation to M & I uses. Groundwater developments for irrigation may offset the agricultural decline, but probably not in the same areas of the Basin where water rights uses are changed. Thus, economic gains in one area of the Basin could be accompanied by economic losses in another area.

This alternative would result in difficult water rights considerations by the Board of Control and State's courts. The ability of the State to participate in, or influence the nature of, future water and related development could also

be restricted. Another result of a "no water development" alternative would be to eliminate additional dams and reservoirs to control water resources for water management, flood control, recreation, and related functions.

Alternative 2

Development of the Basin water supplies would require construction of many of the surface and groundwater projects previously described. To meet the irrigation projections in this report, the Corn Creek Project would be constructed, the acreage irrigated from the North Platte River would be brought to the limit allowed in the North Platte River Decree, and individuals would develop irrigated lands with groundwater. Supplemental irrigation water supplies could be developed by using groundwater and by the surface water projects previously described. Municipal and industrial water supplies could be provided by construction of dams on North Platte River tributaries below Pathfinder Dam and the M & I groundwater projects west of the North Platte River.

The development of M & I water on the tributaries will require the resolution of many problems, not the least of which include obtaining rights-of-way for the dams and reservoirs, and accomplishing the relocations that would be required. Water rights on the tributaries would have to be clarified. Multipurpose functions to be included in the projects would require definition, and the economic costs and benefits and means of repayment would have to be determined. Reservoir project purposes could include irrigation and M & I water supplies, flood control, and fish and wildlife and recreation storage. Project operations could include maintenance of minimum streamflow for fishery and water quality purposes.

Development of one or both of the potential M & I groundwater projects discussed herein will require extensive investigation to determine the amount of water available, the recharge of the water resources, the development procedures, estimated depletion rates, and the economic life of the project. On the basis of the available information, the pumpage of 35,000 acre-feet or more per year will deplete the groundwater resources. It seems inevitable that a source of water will be required in the future either for recharge of the aquifers or for replacement of the water supply. Change of use of water rights or importation of water would be required. Change of use of water rights would result in a reduction in the economic activity projected in this report. The use of groundwater to develop large M & I water supplies seems, in reality, to be a step in Alternative 1 or 3.

In Alternative 2, importation of water into the Platte River Basin of Wyoming would be put off into the future, or not undertaken.

Alternative 3

Importation of water into the North Platte River could meet the future M & I water requirements identified by analysis of the projections in this report. Locally available water supplies and irrigation projects could meet the supplemental and future irrigation water requirements. A transbasin diversion from the Green River into the North Platte River would require considerable detailed planning of staged development. Flood control, recreation, fish and wildlife, water quality, and other water management measures would necessarily be a part of planning the transbasin diversion and other projects included in this alternative.

Alternative 3 would put to use a portion of Wyoming's allocation of the Green River under the Colorado River Compacts that would not otherwise be used. This alternative meets the directive given to State Water Planning by the Legislature. The 39th Legislature directed: "The State Engineer is hereby directed to initiate studies to plan the development of these waters [Green and Bighorn Rivers], including, but not limited to, transbasin diversions within the State wherever shown feasible as projects of the State of Wyoming." (Wyo. Stat. Sec. 41-512.7 (Supp. 1971)). The 41st Legislature declared (Wyo. Stat. Sec. 9-160.36 (Supp. 1971)):

"It is hereby declared to be in the public interest and to be the policy of Wyoming to foster and promote, by all reasonable means, the maximum development of the state's human, industrial, mineral, agricultural, and recreational resources. It is in the public interest to utilize said water resources, as expeditiously as it is feasible, to protect Wyoming's water resources from further encroachment by downstream states. It is in the public interest to make maximum, practical, beneficial, and multiple use of Wyoming's water resources, first in the drainage of origin and next in other drainages within the state."

The same statute directed the Department of Economic Planning and Development, in consultation with a committee of legislators and State agency representatives (including the State Engineer), to undertake a feasibility study for:

"...the necessary facilities to make maximum, practical, beneficial, and multiple use of Wyoming's water in the Green River and Great Divide Basins and to the degree that there is water in excess of the present and foreseeable uses in the Green River and Great Divide Basins, for the maximum, practical, beneficial, and multiple use of Wyoming's Green River water in other river basins within the state."

Alternative 3, then, would appear to be the one directed for further consideration by the Legislature.

ENVIRONMENTAL CONSIDERATIONS

The environmental impacts of the water resource development alternatives described in this report could be both beneficial and adverse. A detailed assessment of environmental impacts is not warranted until a definite plan or set of alternatives is identified for feasibility studies. An objective in detailed planning should be to identify specific environmental impacts of alternatives to provide water supplies. The environmental, social, economical, and financial considerations can be weighed to determine the best water resources development alternatives to pursue.

Future irrigation developments will, for the most part, occur on land presently used for livestock grazing and dry farming adjacent to presently irrigated lands. Besides enhancing the farm and ranching environment, these developments might provide additional habitat for big game, upland game, and waterfowl. Adverse impacts might include interference with game migration patterns and elimination of a portion of the habitat for some wildlife species.

The environmental changes occurring from change of use of water rights from lower to higher preferred uses cannot be generalized. Any specific water right

change could have beneficial or adverse impacts. The location and nature of the present use must be known for comparison with the proposed higher preference use. Once these specific factors are determined, the effect of the change on the environment could be assessed.

The development of reservoirs to provide water supplies could have both beneficial and adverse environmental impacts. Each reservoir site would require evaluation to determine impacts and the best way to minimize adverse environmental effects. Beneficial impacts at a reservoir site could include new recreation and fishing opportunities, waterfowl habitat, and other wildlife enhancements. The maintenance of minimum flows below reservoirs could provide a stream fishery not formerly available because of low flows or dewatering of streams. Flood control could protect the natural environment from flood damage and thereby enhance the recreation and wildlife habitat downstream from reservoirs, as well as protect the human environments. Adverse effects of reservoirs might include reduction of wildlife habitat in the reservoir area and inundation of a section of a stream. Additional environmental impacts of water resource developments could be the beneficial or adverse effects on the aesthetic qualities of an area.

Diversions of water into the North Platte River from the Green River could enhance the fishery and recreational values in the North Platte River system. If the North Platte River reservoirs could be maintained at higher levels, both fishery and other water-based recreation would be enhanced. Waters added to the North Platte River above Seminoe Reservoir could enable favorable reservoir and river manipulation in the entire North Platte Reservoir system to the advantage of all water-based recreational development in this drainage. Diversions into the Sweetwater River from the Green River could have benefits to the fishery habitat. Advantages to habitat in the Sweetwater River, however, would be contingent on flow release patterns that would not deteriorate the natural stream channel by erosion or through man-made rechannelization to handle the increased flow expected with the diversion.

The recommendations of the Game and Fish Commission on page 142 in Chapter IV should be followed wherever possible in order to minimize the adverse impacts of water resource developments on the natural environment and game and fish resources.

Water Quality Considerations

Water uses are required to comply with the water quality standards adopted by the State. The Wyoming water quality standards are summarized in Chapter II. Treatment of effluents will be required for any new water uses that would otherwise cause the quality of water in interstate streams to fall below the standards required for physical, chemical, bacteriological, and radiological characteristics. Future industrial water uses are most likely to be 100 percent consumptive and should therefore have little, if any, effect on water quality. Municipalities will be required to provide sewerage treatment to comply with health regulations and water quality standards. The projected increases in surface water irrigation will cause an increase in the salinity of the North Platte River. Increased groundwater irrigation uses will also increase the total dissolved solids in aquifers somewhat.

The primary effect of water resources development on water quality in the Basin will be on the salinity of the North Platte River. Analysis shows the

effect to be small, and the salinity will either increase or decrease depending upon the alternatives undertaken.

Salinity in a stream may be increased in two ways--salt loading and salt concentrating. Salt loading results from the discharge of additional soluble minerals from the soil or from other sources into the stream. Salt concentration results from the consumptive use of water, such as reservoir evaporation, or a use in which diverted water is partially consumed and the remaining water then carries the diverted salts back to the stream.

In Alternative 1, a decrease in irrigated agriculture is likely to accompany an increase in M & I water use. No analysis has been made of the effects of this change. However, it can be said that any salt loading occurring from irrigation that would be retired would cease. The total dissolved solids (TDS) of the irrigation water at its point of diversion would have to be known and compared with the TDS at the point of diversion of an M & I water use before further comparison can be made.

Future water needs would be met by Platte River Basin water supplies in Alternative 2. The effects of development on the salinity of the North Platte River at the stream gage below Guernsey Reservoir were estimated to provide an indication of the effects of M & I water development. The table below gives the data.

Alternative 3 assumed that the future Platte River Basin M & I water needs would be met by importation of water. The effects on the water quality are also shown in the table below.

It can be seen that the water quality of the North Platte River would be affected very little under any of the circumstances presented.

<u>Alternative</u>	<u>North Platte River below Guernsey Reservoir</u>	
	<u>Annual Weighted Average</u>	
	<u>Total Dissolved Solids</u> (ppm)	<u>Increase (Decrease) in TDS</u> (ppm)
Present Conditions	471	0
Alternative 1	(N o t e s t i m a t e d)	
Alternative 2		
M & I water from:		
A. In-basin surface water, 38,000 A-F/Yr. Battle Spring formation (180 ppm TDS), 47,000 A-F/Yr.	465	(6)
B. In-basin surface water, 38,000 A-F/Yr. Arikaree formation (420 ppm TDS), 47,000 A-F/Yr.	476	5
Alternative 3		
M & I water imported from:		
A. Green River (360 ppm TDS), 93,000 A-F/Yr.	466	(5)
B. Green River (480 ppm TDS), 93,000 A-F/Yr.	478	7

It was projected earlier in this report that an additional 22,000 acres will be irrigated with surface water supplies along the North Platte River by the year 2020. The concentrating effect of this new irrigation would increase the salinity in the water entering Nebraska by about 3 percent. The soil characteristics where the new irrigation develops will determine whether salt loading will occur. Sufficient data are not available to determine the present salt loading from the irrigation from the North Platte River and its tributaries, nor to estimate conditions with more irrigation. It is estimated, however, that salt loading could increase the salinity in the water entering Nebraska by another 2 to 7 percent.

WATER RIGHTS CONSIDERATIONS

Previous descriptions of potential water sources and potential projects contain many references to water rights and clarification of water right matters. The general statement can be made that any future water development must have water rights established in accordance with Wyoming water laws. Before some of the surface water projects could be undertaken certain water right questions must be resolved. This can be done through consultation with the State Engineer and the Board of Control.

One example of the type of question which must be resolved involves the use of water for future municipal purposes in the portion of the North Platte River Basin in Wyoming governed by the United States Supreme Court Decree of 1945. Section X of the Decree says: "This decree shall not affect or restrict the use or diversion of water from the North Platte River and its tributaries in Colorado or Wyoming for ordinary and usual domestic, municipal and stock watering purposes and consumption." What is "ordinary and usual municipal use"? What restrictions, if any, should be imposed on future diversions for this purpose?

Another question that must be resolved, not only in this Basin but throughout the West, involves the so-called "Federal Reservation Doctrine." Under this "Doctrine" it is contended that the United States impliedly reserved water sufficient for use in accordance with the purposes for which lands were reserved and as of the date of withdrawal of the lands. Since most of the water supply in this Basin, as well as throughout the West, arises on National Forest lands, any future use of this so-called reserved water on forest lands could have far-reaching effects on existing and potential future water uses.

COST COMPARISONS

The construction costs of the irrigation developments used in this report are found to vary with the individual irrigation system, water supply, and other site conditions. The capital costs of providing supplemental water to presently irrigated lands were found to be in the same range as new irrigation developments. This range is \$100 to \$300 per acre. Annual costs per acre depend upon the interest rates and loan repayment periods that can be obtained and the operation and maintenance costs of the irrigation system.

Construction costs were estimated for facilities included in Alternatives 2 and 3 for delivering M & I water supplies to the North Platte River. The cost estimates shown below were based on cost-curve data to obtain preliminary comparisons. Annual costs were calculated in order to include costs of repayment

of capital plus interest, operation, and maintenance. Secondary costs, such as effects on tax structures, effects on the environment, etc., are not included in the costs shown. The difficulty of quantifying such costs without specific projects being involved makes it impractical to attempt to include them. When feasibility studies of specific proposals are undertaken, these secondary costs and benefits should be evaluated. As described earlier, the costs of water development for Alternative 1 are largely secondary costs and the costs of purchases of water rights. These costs were not calculated. A summary of the estimates is given in Table V-2.

TABLE V-2 -- Summary of Costs of M & I Water Delivered to the North Platte River

<u>Alternative</u>		<u>Approximate Annual Repayment Cost per Acre-Foot</u>
2A	38,000 A-F/Yr. surface water (from Table V-3) 47,000 A-F/Yr. Battle Spring formation ¹	\$32
2B	38,000 A-F/Yr. surface water (from Table V-3) 47,000 A-F/Yr. Arikaree formation ¹	\$22
3	M & I water needs (93,000 A-F/Yr.) supplied from water imported from Green River	\$76 ²

¹ Costs until replacement of the groundwater resource is required. Costs include wells, pumping equipment, collection pipelines, pipeline from well field to the North Platte River, electrical transmission system, and pumping energy. Annual water cost estimated to be \$29 per acre-foot from the Battle Spring formation, and \$11 per acre-foot from the Arikaree formation.

² Supplied from Lower Green Reservoir and Great Divide pipeline. Other alternatives range in cost from \$75 to \$89 per acre-foot.

The basis for estimating the costs of "surface water" in Alternative 2 was the assumption that supplemental irrigation water would be provided in the potential surface water projects previously described. Water supplies surplus to the irrigation needs were identified on Deer, LaBonte, and Wagonhound Creeks. Table V-3 gives a summary of the estimated reservoir costs and the cost of M & I water delivered from the reservoirs to the North Platte River, conveyed in the streams. Additional expenditures would be required by the M & I water users for diversion and conveyance facilities from the North Platte River to the places of use.

TABLE V-3 -- Summary of Alternative 2 M & I Surface Water Costs

<u>Reservoir</u>	<u>Total Storage Capacity (Acre-Feet)</u>	<u>Allocated M & I Storage Capacity (Acre-Feet)</u>	<u>Total Cost of Dam & Reservoir (\$ Million)</u>	<u>Annual Cost per Acre-Foot of Storage Capacity (\$)</u>	<u>Annual M & I Water Delivery (Acre-Feet)</u>	<u>Approximate Annual Repayment Cost (\$)</u>
Deer Creek	85,800	46,200	9.50	8.90	9,500	43
LaBonte Creek	113,500	94,000	9.41	6.70	25,300	25
Wagonhound Creek	31,300	26,300	4.53	11.60	3,200	95
Total Annual Delivery and Average Cost					38,000	36

The estimated costs of groundwater supplies include the annual costs of wells, pumps and motors, collection system pipelines, electrical transmission lines, pipeline from the well field to the North Platte River, pumping energy, and operation and maintenance. These estimated costs are based on assumed well yields and assumed specific capacities of wells. Before any development project requiring large-scale groundwater withdrawals is undertaken, the potential underground reservoirs should be evaluated by exploration drilling and aquifer testing.

C H A P T E R V I

S U M M A R Y , C O N C L U S I O N S , A N D
R E C O M M E N D A T I O N S

WATER & RELATED LAND RESOURCES OF THE PLATTE RIVER BASIN, WYOMING

S U M M A R Y , C O N C L U S I O N S , A N D R E C O M M E N D A T I O N S

SUMMARY

The Platte River Basin, in the southeastern quarter of Wyoming, is a mountains and plains region of varying climate. Included in the area of study are the North Platte, South Platte, and Niobrara River Basins. Most of the plains receive 9 to 16 inches of precipitation, while the mountains receive 20 to 40 inches annually. The annual snowfall is 35 to 65 inches over the plains and much more over the mountains. Figure V-1 shows the area and the potential water development alternatives in the Basin.

LOCATION AND
CLIMATE

The streams with dependable water supplies rise in the mountains and derive most of the annual runoff from the spring and early summer snowmelt. Water demands by crops are greatest in July and August, and storage is required to provide irrigation water for the late growing season. The estimated streamflow originating in the Platte River Basin in Wyoming under natural conditions is about 1,240,000 acre-feet per year. Adding the measured inflow to the State, the undepleted streamflow that would be leaving the State under natural conditions is estimated to be about 1,770,000 acre-feet per year. On the average, 580,150 acre-feet of surface water are consumed by irrigation, 9,760 acre-feet by industry, 8,720 acre-feet by municipal and domestic uses, and 179,560 acre-feet by evaporation. The depleted streamflow leaving Wyoming in Platte River streams and the canals of the North Platte Project is about 992,000 acre-feet per year.

STREAMFLOW

Flood damage is not a major problem in the Basin, with certain exceptions. A major flood on the North Platte could cause damages in Casper, Douglas, and Torrington. Along tributaries agricultural developments, towns, highways, and railroad crossings have experienced flood damage. That part of Goshen County crossed by the Interstate and Fort Laramie Canals is susceptible to damage by flash floods from the small drainages that cross the area.

The quality of interstate waters in the Basin generally is within the limits of established standards. Municipal and industrial waste water sources present little or no problem to water quality in the Basin. Irrigation return flows may in some areas carry significant amounts of dissolved solids into receiving streams, but no practical problems of

WATER QUALITY

significance are being caused by these return flows. Other agricultural enterprises presently have a minor effect on water quality.

WATER RIGHTS

Water rights are based on the law of appropriation and "first in time is first in right." Priority of appropriation is based upon the date on which the application for permit was accepted in the State Engineer's Office. An application for a permit must be submitted to the State Engineer for approval before water uses are made.

The total of lands with adjudicated rights or permits in good standing in the Basin is about 1,180,000 acres. The total of actually irrigated lands identified by field examination in 1969 is 552,760 acres. The excess of water rights over actually irrigated lands presents a special problem in the North Platte River drainage area, where irrigation is limited by a U. S. Supreme Court decree.

Appropriations of water for irrigation began in the 1860's, and the dependable water supplies in the Laramie River were appropriated by 1910 and in the North Platte River by 1930. Interstate disputes over regulation of these streams were litigated in the U. S. Supreme Court.

DECREES AND COMPACTS

Under the Laramie River Decree, the State of Colorado can divert from the Laramie River and its tributaries 49,375 acre-feet of water each calendar year for use in Colorado, of which 19,875 acre-feet per year may be diverted out-of-basin. The return flow and remaining river water are allocated to Wyoming.

The North Platte River Decree limits irrigation in the State of Wyoming on the main stem of the North Platte River above Guernsey Reservoir and the North Platte tributaries above Pathfinder Dam to 168,000 acres of land, exclusive of the Kendrick Project. Exclusive of Seminole Reservoir, not more than 18,000 acre-feet of irrigation water may be stored in Wyoming on the North Platte River or its tributaries above Pathfinder Reservoir in any water year. The natural flow of the North Platte River from Guernsey Dam to the Tri-State Dam (1 mile beyond the State line in Nebraska) is divided 25 percent to Wyoming and 75 percent to Nebraska. Glendo Reservoir has a right to store, in addition to evaporation, 40,000 acre-feet of the natural flow of the North Platte River and its tributaries below Pathfinder Dam. Of this storage, 15,000 acre-feet are for irrigation in Wyoming below Guernsey Dam, and 25,000 acre-feet are for irrigation in Nebraska. The storage in Glendo Reservoir, including carry-over, may not exceed 100,000 acre-feet.

The North Platte River Decree provides that "ordinary and usual domestic, municipal, and stock water" uses and consumption are not affected or restricted by the orders in the

decree. Questions to be considered are: What is "ordinary" municipal use? Is it unlimited?

The Upper Niobrara River Compact is an agreement between Wyoming and Nebraska for the regulation of Niobrara River water west of Range 55 West (6th P.M.). The compact limits the storage and storage season for large reservoirs and limits the size of stock water ponds. The apportionment of groundwater was delayed until adequate information about groundwater becomes available.

About 2,000,000 acre-feet of surface water, including re-use of return flows, are diverted annually for irrigation. Under present water uses and constraints, the surface water resources of the Basin are nearly fully utilized, although limited water developments are possible on North Platte River tributaries below Pathfinder Dam.

Groundwater is available at depths less than 500 feet. The most significant aquifers are found in rocks of Quaternary and Tertiary ages. Major sources of groundwater are alluvium and terrace deposits and consolidated sandstones. The availability of groundwater is influenced by quality as well as quantity. Groundwater is classified by the amount of total dissolved solids in parts per million, by hardness (as calcium carbonate) in parts per million, and by its salinity and sodium hazard if it is to be used as irrigation water. Radioactive elements are not common as mineral constituents of groundwater, but the presence of mineable uraniferous ore bodies creates the possibility of these elements being found in underground waters.

GROUNDWATER

The Ogallala formation provides water satisfactory for most domestic and stock uses; the Arikaree appears to have the best overall quality. The quality of water in the White River locally is below acceptable standards for domestic use. Water in the Fort Union may be limited in use-capability due to high iron, sulfate, and dissolved solids content. Water quality in pre-Tertiary aquifers is highly variable; generally, quality is better near outcrop areas and deteriorates towards the interiors of the geological basins.

Groundwater is used extensively in the Basin as domestic, stock, municipal, industrial, and irrigation water. The largest use is irrigation, which accounts for the consumption of more groundwater in the Basin than all other uses combined. By the end of 1970 there were about 1,000 irrigation wells in the Basin providing an original water supply to approximately 68,500 permit acres, based on information submitted to the State Engineer's Office. From random sampling, it is estimated that in many instances lands actually irrigated are about 75 percent of the reported amounts. Based on this estimate, groundwater is the original supply for between 51,000 and 68,500 acres. A very large percentage of the total amount of

irrigated lands using groundwater as the original supply is in Goshen and Laramie Counties. The total estimated amount of groundwater consumed annually as the original supply by irrigation is approximately 71,000 to 95,000 acre-feet. Another 35,000 acre-feet are consumed as a supplemental supply for approximately 70,000 acres.

On the basis of economic projections and a sampling of well completion statements, it is estimated that by the year 2020 as many as 130,000 acres of land in the Basin may be irrigated using groundwater as the original source of supply. Another 175,000 acres may be using groundwater as a supplemental supply. The estimated total amount of groundwater projected to be consumed in the Basin during the period 2000-2020 is 300,000 to 350,000 acre-feet annually.

AGRICULTURE

The agricultural enterprises of greatest potential for future expansion are livestock production and the feed grains and forage crops needed to support the livestock industry. To maintain Wyoming's share of national production of beef, lamb, and mutton will require some additional irrigated land along with increased productivity per acre. Dry cropland is the major source of land for new irrigation developments which will utilize groundwater as a source of supply.

COAL

The projected growth of the coal industry in the Basin, as stated in a study by Cameron Engineers, will show a sevenfold increase in employment by the year 2000 and nearly a ninefold increase by 2020. Capital investment will increase about 10 times by the year 2000 and 15 times by 2020. The present consumptive use of water by this industry (5,000 acre-feet per year) is forecast to increase to 65,000 acre-feet per year by 2000 and to 80,000 acre-feet per year by 2020.

OIL AND GAS

The oil and gas industry provides a significant payroll in Wyoming and provides a major tax base for the State. The industry has an apparently finite limit of resources and may pass out of existence. In 1967 the industry consumed 6,050 acre-feet of water.

URANIUM, CEMENT, IRON ORE, TIMBER

The Basin has been prominent in the development of Wyoming's uranium industry. Uranium ore is produced in the Crooks Gap area in the Sweetwater River drainage and in the Shirley Basin. Groundwater presently supplies all the uranium mills. The cement and iron ore industries use water from both surface and underground sources. The timber industry may consume small quantities of water in the future.

MUNICIPAL, DOMESTIC, AND STOCK WATER

The present population served by municipal water systems is 138,531 people. Municipal and domestic water diversions are presently about 34,200 acre-feet per year, about one-half of which is consumptively used. The City of Cheyenne imports water from the Colorado River Basin, making the present municipal and domestic depletion from Platte River sources 13,100

acre-feet per year. The present annual stock water consumption is approximately 10,500 acre-feet. The projection for the year 2020 estimates a total annual consumption by municipal, domestic, and stock uses of approximately 48,000 acre-feet, compared to approximately 24,000 acre-feet in 1970.

Outdoor recreation is of increasing importance in the Basin. Fishing pressure in the Basin is relatively heavy, but sufficient capacity exists to provide for the estimated pressure for at least the next 50 years. The total annual hunting capacity is estimated to be more than 263,000 hunter-days. The Basin offers many opportunities for water sports and boating. The present consumptive uses assigned directly to recreation and fish and wildlife activities are small. Future increases of recreation water demand will be met primarily in conjunction with providing water for other purposes.

RECREATION

Electrical energy requirements are supplied by interconnected power systems with part of the power generated by six Federally operated hydroelectric plants on the North Platte River and the remainder by Pacific Power and Light Company's coal-fired Dave Johnston plant. The combined generating capacity of the six hydroplants is 181,200 kilowatts. The Dave Johnston plant has an installed capacity of 420,000 kilowatts; another 330,000-kilowatt unit is under construction. In the future, pumped-storage hydropower developments may complement coal-fired steam-electric powerplants developed in the Basin.

HYDROPOWER

Flood damage is not a major problem in Wyoming's Platte River Basin. There is a large amount of storage control on the North Platte River, but only Glendo Reservoir has a specific storage allocation for flood control. The Corps of Engineers has recommended that additional flood control space be provided on the North Platte River above Glendo Reservoir. Some tributaries of the North Platte River, principally those entering the river below Alcova Dam, have a history of causing flood damages. Considerations for flood control should be included in any future projects on these streams.

FLOOD CONTROL

A summary of present and projected consumptive uses of Platte River Basin surface water and groundwater is as follows:

WATER-USE SUMMARY

<u>Water Uses</u>	<u>1,000 Acre-Feet Per Year</u>		
	<u>Present</u>	<u>2000</u>	<u>2020</u>
Irrigation	651	918	968
Industry	13	79	89
Municipal, Domestic, and Stock	<u>24</u>	<u>36</u>	<u>48</u>
Total	688	1,033	1,105

Reservoir and stock pond evaporation presently consumes an additional 180,000 acre-feet per year.

POTENTIAL
SOURCES OF
WATER

Water supplies to meet the projected future water needs of the Basin will be developed from groundwater and surface water resources in the Basin and from transbasin diversions of water from other river basins. The increased use of irrigation water will be for the development of 106,240 acres of new irrigated land, 84,240 acres of which will use groundwater. Future water needs of the uranium industry have been projected to be met with groundwater resources. Coal developments near the Dave Johnston steam-electric plant and in the Hanna district are projected to require an additional 75,000 acre-feet of water by the year 2020.

Surface water supplies available for development are limited. Groundwater will become increasingly important as a water supply. Improved efficiency in existing water uses will provide water for additional uses. Change of use of irrigation water rights might provide water for industry. Weather modification may artificially augment streamflows in the future, but amounts of water and uses are not now predictable because such operations are in the process of research and development. Water could be imported into the Platte River Basin from either the Green River Basin or the Bighorn River Basin, or from both.

POTENTIAL
SURFACE WATER
DEVELOPMENTS

The potentials for developing surface water supplies to improve existing water uses and future water needs were identified. Storage project potentials include several sites in the North Platte River Decree area above Pathfinder Reservoir and sites on Bates Creek, Deer Creek, Box Elder Creek, LaPrele Creek, Wagonhound and LaBonte Creeks, Horseshoe Creek, Laramie and North Laramie Rivers, and Seminole Reservoir Enlargement (see Figure V-1). Where desired and feasible, water supply improvements may be possible on other streams that are over-appropriated. Modification of the U. S. Supreme Court decree on the North Platte River could enhance irrigation in Wyoming. A modification might enable more storage in Wyoming above Pathfinder Reservoir and additional irrigated acreage. Other potential surface water projects include the use of Glendo inundated water rights and the Corn Creek Project. These projects could provide water supplies for irrigation, municipal, industrial, recreation, and fish and wildlife purposes. Flood control and water quality management could also be included as project functions.

POTENTIAL
GROUNDWATER
DEVELOPMENTS

A considerable potential for developing groundwater supplies for irrigation exists in Laramie, Platte, Goshen, and Niobrara Counties in southeastern Wyoming. Other parts of the Basin also have a potential but not to the extent probable in southeastern Wyoming. The annual groundwater withdrawals for irrigated lands will increase from the estimated present pumpage of approximately 150,000 acre-feet to 395,000 acre-feet per year. Groundwater may be developed for large-scale M & I uses. Two aquifers where a potential for such development exists are the Arikaree formation in the Sweetwater

River drainage and the Battle Spring formation in the Great Divide Basin. Such developments will deplete the aquifers in time, and the water uses dependent upon the groundwater will have to be curtailed or replaced with other water supplies.

Surplus water from the Bighorn River Basin or the Green River Basin could be imported into the Platte River Basin to meet future M & I water needs. The Bighorn River is subject to the terms of the Yellowstone River Compact, and diversion of water from the Yellowstone River tributaries into the Platte River Basin requires approval of the States of Montana and North Dakota. No approvals are required to utilize Green River water in the Platte River Basin. It appears that the future M & I water needs of the Platte River Basin could be met with a transbasin diversion from the Green River. Such a diversion could be stage-developed and could provide water supplies for Green River Basin uses as well as for Platte River Basin uses. Although the cost of imported water in the Platte River Basin appears to preclude irrigation use, irrigation might be developed on an interim basis, or as a result of stage development.

POTENTIAL
TRANSBASIN
DIVERSIONS

Three alternative approaches for the future water resource development in the Basin are:

ALTERNATIVE
WATER RESOURCE
DEVELOPMENTS

1. No development -- it is assumed that "no development" means no dams or other major facilities would be constructed to develop water supplies for new uses. Unless economic development were suppressed, however, M & I water needs could be met from transfers of water uses from irrigation to M & I. This alternative requires consideration and approval by the State Engineer, Board of Control, and, perhaps, the courts of the State. The ability of the State to participate in or influence future water development could be restricted. M & I growth would occur at the expense of agriculture.

2. Development of Basin water resources only -- requires construction of many of the projects previously mentioned and utilization of groundwater resources. Depletion of groundwater may result in a curtailment of the use or in a requirement to replace the water supply by transfer of water rights or water importation.

3. Importation of water into the Basin -- could meet future M & I water requirements and put to use a portion of Wyoming's unused compact allocation of water of the Green River. Alternative 3 meets the directive of the legislature to make maximum use of Wyoming's allocated water resources.

The environmental impacts of the water resource development alternatives described in this report could be both beneficial and adverse. Each proposed development should be examined closely to determine its effect on the environment.

ENVIRONMENTAL
CONSIDERATIONS

Proponents of both economic development and environmental protection should cooperate to insure that (1) developments do not occur which will cause undue environmental damage, and (2) developments which do occur cause maximum enhancement (or minimum damage) to the natural environment. In all cases, water resource developments must comply with Wyoming's water quality standards and regulations.

COST
COMPARISON

Very preliminary cost estimates of potential water developments were made for comparative purposes. The capital costs of providing supplemental water for irrigation were found to be in the same range as the cost for new land developments, ranging from \$100 to \$300 per acre. Construction and repayment costs were estimated for delivering M & I water into the North Platte River. The costs of M & I water in Alternative 1 are largely secondary costs and the cost of water rights purchases. These were not estimated. Comparative estimates of the annual costs for Alternatives 2 and 3 include the costs of repayment of capital plus interest, operation, and maintenance. It was assumed for Alternative 2 that water rights and right-of-way problems could be resolved to enable construction of reservoirs on Deer, LaBonte, and Wagonhound Creeks, and that groundwater resources would support an economical development before being depleted. It was also assumed that supplemental water would be provided in reservoir projects for the existing irrigated lands which could be served by the reservoirs. The estimated annual repayment cost per acre-foot of M & I water in Alternative 2 is \$22 to \$32, depending upon which aquifer is used as a source of groundwater. Alternative 3 cost was based on supplying M & I water from the potential Lower Green River Reservoir through a pipeline into the North Platte River. The estimated annual cost per acre-foot for this water is \$76.

CONCLUSIONS

1. Economic expansion will occur in Wyoming's Platte River Basin in the future. Development of water supplies is required for this expansion.
2. If Wyoming is to maintain its national position in livestock production, additional irrigated land will have to be brought into production. The Platte River Basin has the potential for expansion of irrigation through its suitable climate and soils, but water is a limiting factor. Surface water development potentials for irrigation are limited because of the North Platte River Decree and full utilization of available water in many areas. Groundwater resources can provide for expanded irrigation, but continuing groundwater investigations are needed to provide proper management of groundwater.
3. M & I water supplies can be obtained from four sources: (1) change of use of water rights; (2) surface water developments on North Platte River tributaries not affected by the decree; (3) groundwater; and (4) imported water. Large-scale groundwater developments for M & I water supplies will result in depletion of the water supplies. If economic projections are valid, water will ultimately have to be imported into the Basin.
4. The benefits associated with potential projects and alternatives of development are variable and depend upon desires for flood control, irrigation water, M & I water, recreation, and other purposes.
5. Comparison of alternatives on the basis of estimated water costs alone may not indicate the best future course for water utilization. Other considerations should include: (1) the desirability of a decline in irrigated agriculture, as indicated in Alternative 1; (2) the desirability of mining groundwater resources when unused renewable surface water resources are available; (3) the desirability of putting to use water resources which are presently unused and in the future may not be available to Wyoming because of becoming committed to downstream uses.
6. Importation of water into the Platte River Basin from the Green River (Alternative 3) would meet the directives from the Wyoming Legislature to "make maximum practical, beneficial, and multiple use" of Wyoming's water. If transbasin diversion into the North Platte River is to be undertaken, detailed planning is required to determine the best plan for stage development to meet future water needs.
7. Water resource development will have beneficial and adverse impacts on the environment. Proper project planning can result in maximizing beneficial impacts while minimizing adverse impacts.

RECOMMENDATIONS

1. In formulating a State Water Plan, water needs of the Platte River Basin should be considered in conjunction with the water needs of the State of Wyoming.
2. Public opinion should be ascertained regarding the desired levels of development in the Platte River Basin, the economic impact of the alternatives, and the best alternative(s) to follow.
3. Detailed feasibility studies of the desired project-components of the alternatives should be undertaken to evaluate engineering and economic factors such as direct and indirect project benefits, construction costs, and recreational and environmental values.
4. Sources of financing, such as Federal funds, State loans and bonds, and others, should be reviewed. State laws should be reviewed to determine what legislation would be desirable and necessary for State financing of water development projects.
5. The best plan should be determined from public opinion, feasibility studies, and financial considerations.
6. Short-range and long-range goals should be established and implementation procedures outlined.
7. The type of State or other organization required to administer the construction of water development projects should be determined and established.
8. Soil and water conservation practices in the Basin should be promulgated and implemented through programs of the U. S. Department of Agriculture and others. The possibilities of improving water supplies by watershed management, water management, and flood control measures should be investigated.

CHAPTER VII

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