NEBRASKA SOIL AND WATER
CONSERVATION COMMISSION

STATE WATER PLAN
PUBLICATION NUMBER 201

Big Blue River Basin

SEPTEMBER 1968

STATE OF NEBRASKA

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Report Prepared By The Planning Division

James Owen, Chief, Planning Division
Ralph Waddington, Head, Comprehensive Planning

NEBRASKA SOIL AND WATER
CONSERVATION COMMISSION

Planning Division

COMPREHENSIVE REPORT
ON
LAND AND WATER RESOURCES
OF
THE BIG BLUE RIVER BASIN

September, 1968

Counsel and guidance were received from the following groups who reviewed the report for clarity, accuracy and completeness.

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State of Nebraska
Soil and Water Conservation Commission

P. O. BOX 94725
STATE CAPITOL
LINCOLN, NEBRASKA 68509

Mr. Henry Klosterman, Chairman
Big Blue River Watershed Planning Board
David City, Nebraska

Dear Mr. Klosterman:

We are transmitting a comprehensive report describing the land and water resources of the Big Blue River Basin in fulfillment of the request by your organization. This report discusses the characteristics and resources, as well as the needs and problems, and presents recommendations for your consideration and action.

The report incorporates the investigations, proposals, and data provided by various agencies and represents a broad spectrum in the water resource planning field.

The proposals and alternatives indicated provide measures for implementation which your group should consider in future development of the water resources of the basin. Our Commission looks to the Blue River Watershed Planning Board for your leadership and guidance in carrying out the provisions of this plan. We stand ready to cooperate with you in this endeavor.

Respectfully submitted,

J. R. Pringle

James R. Pringle, Chairman
Nebraska Soil ~~and Water~~
Conservation Commission

JRP:REW:smh

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BASIN STREAM NETWORK

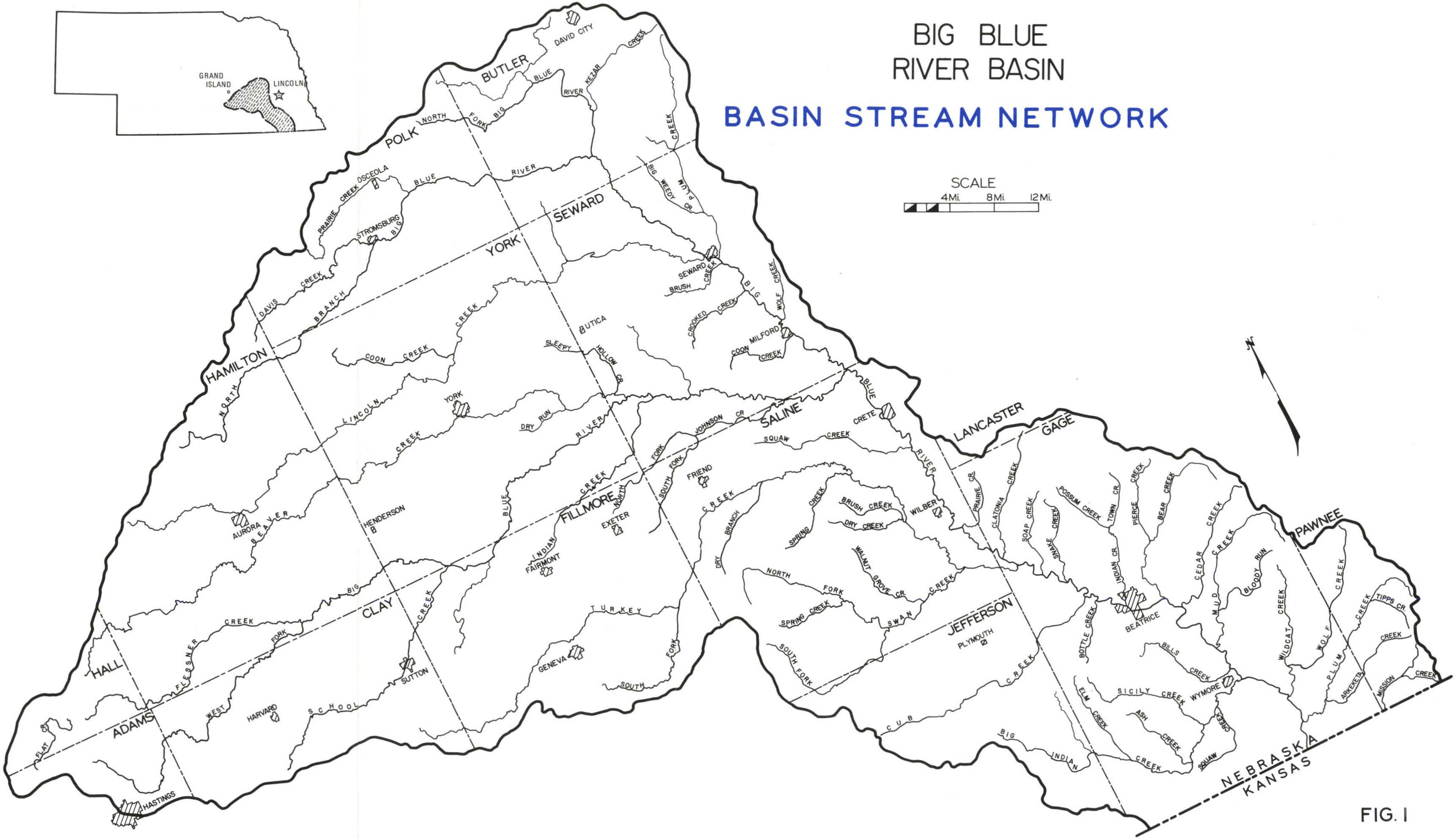

FIG. 1

INTRODUCTION AND SUMMARY

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INTRODUCTION

INITIATION

In March, 1961 the Big Blue River Watershed Planning Board requested the Nebraska Soil and Water Conservation Commission investigate the soil and water resource development potentials of the basin. The investigation and this report are the results of a cooperative effort between federal and state agencies. The study was requested by local people as a result of concern over problems and needs evident within the basin. Some of these are ground water depletion caused by continued irrigation development, soil erosion, flooding, and a desire to stimulate the economic development of the area.

AUTHORITY

The State Soil and Water Conservation Commission has the responsibility (Nebr. Rev. Stat. § 2-1507) to plan, develop, and encourage a comprehensive program of resource development, conservation, and utilization of the soil and water resources of the state. This program is to be carried out in cooperation with appropriate federal, state and local organizations.

PROCEDURE

Agencies cooperating in the study were asked to inventory the soil and water resources and needs of the basin and to propose developments to meet these needs. These were then combined by the Planning Staff of the Commission in preparing this preliminary report. Recommendations made as a part of this report are not to be regarded as the final elements of a plan but suggest actions which appear essential to meet a portion of the presently foreseeable needs. Development of additional needs will likely dictate revisions of, or additions to, some parts of the plan.

Federal agencies are required to consider any proposed development from a multiple purpose basin wide aspect and to formulate plans with this objective in mind. Most state agencies are concerned with only one or two aspects of basin-type development. The Soil and Water Conservation Commission acted as coordinator in consolidating the different plans and reports into this comprehensive report.

Agencies furnished the requested information by a variety of means. Those agencies that had previously investigated parts of the basin transmitted the results of those investigations while others undertook a new study of the topic assigned to them. Sources of data and information used in preparation of the report are listed in the bibliography and are available for use by anyone interested in specific topics.

ACKNOWLEDGEMENT

The Nebraska Soil and Water Conservation Commission wishes to thank all those who supplied data, suggestions and other assistance in the preparation of this report.

Agencies and departments who contributed included:

FEDERAL:
- Department of Agriculture
  - Soil Conservation Service
  - Economic Research Service
  - Forest Service
- Department of Commerce
  - Environmental Science Services Administration
- Department of Defense
  - Corps of Engineers
- Department of Health, Education and Welfare
- Department of Interior
  - Bureau of Reclamation
  - Fish and Wildlife Service
  - Bureau of Outdoor Recreation
  - Federal Water Pollution Control Administration
  - Geological Survey

STATE:
- Department of Health
- Department of Water Resources
- Game and Parks Commission
- University of Nebraska
  - Conservation and Survey Division
  - Agricultural Extension Service

LOCAL:
- Blue River Watershed Planning Board
- Soil and Water Conservation Districts

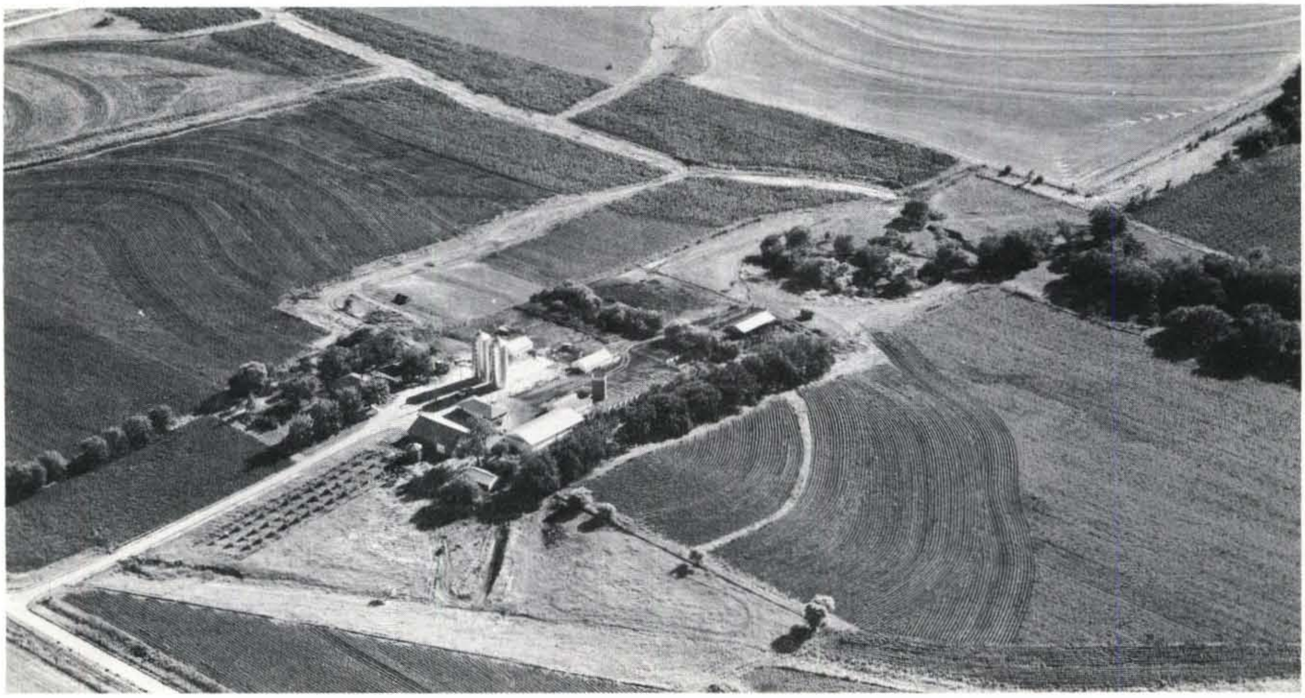
SUMMARY

RESOURCES

The Big Blue River Basin of Nebraska has large acreages of deep productive soils; highly variable but generally adequate rainfall; and somewhat erratic streamflow. The major industry in the basin is diversified agriculture and related agriculturally oriented enterprises. This area is predominantly agricultural in nature and has experienced a declining population similar to the national trend of farm population.

The climate is generally conducive to growth of most feed-grain crops. However, there are severe extremes in both summer and winter temperatures. Severe summer storms are not infrequent and often inflict significant damage.

Ground water storage reservoirs are quite extensive in the upper and central parts of the basin. The ground water table is currently declining in localized areas of high concentration of irrigation wells in York and Hamilton Counties. The main source of irrigation water has been from ground water but excessive rates of water level decline in certain areas indicate that better water management is needed to reduce the amount of ground water removed from storage in keeping with optimum use of this resource.



NEEDS

The primary needs evidenced in the basin are: flood control in the lower reaches of the streams; stabilization of the ground water table in the upper and central basin; erosion control throughout the basin; drainage of certain depressional areas in the upper and central basin; stabilization of the economy; and provision of more recreation opportunity, especially water oriented recreation.

Flooding is prevalent along the first flood plain of the mainstem and lower reaches of major tributaries. Adequate flood control reservoir sites are sparse in the basin because of the gently undulating topography and broad stream valleys.

Surface water irrigation in areas of overdevelopment of the ground water supply in order to stabilize the ground water reservoir has been proposed. More information is needed on the recharge potentials or the applicable methods of recharge. Research in this field should be initiated.

Erosion control by land treatment measures and structural methods is needed in most areas of the basin.[6] Drainage of depressional ponds (pot-holes) in the upper and central regions would bring about better land use and water from these areas could be more effectively used, possibly for ground water recharge, instead of being lost to evaporation. This drainage problem is typical of regions which have broad undulating areas with surface soils of low to moderate permeability.

Surface water quality control is essential to the public health and welfare. Pollution control needs should be evaluated in line with Nebraska water quality control standards.

PROPOSED DEVELOPMENT

Potential project-type irrigation development has been investigated in four areas within the basin. Available water supply for these projects would irrigate about 43,000 acres. The area showing the most promise for development is the Sunbeam Unit near Goehner and Dorchester encompassing about 30,000 acres. This development would not correct the water table decline experienced in the upper and central parts of the basin.

Nineteen flood control reservoir sites have been investigated but none have been proposed for construction. Five reservoirs have been selected as warranting further study for flood control purposes. All reservoirs studied would incorporate storage for multiple purposes. A local protection project has been authorized for Beatrice. [9]

Total watershed measures to control flow from small drainage areas and achieve a degree of drainage of the depressional regions have been investigated. Several appear feasible for further study and development.

Recreation facilities, including public hunting and fishing areas, are needed for nearly all regions of the basin. Provisions for water oriented recreation and fish and wildlife should be considered for incorporation into land and water resource development projects. The State of Nebraska and participating local groups should explore the possibility of acquiring storage in any significant structures for recreational purposes. Most water storage projects require non-federal participation for part of the recreation and fish and wildlife allocations.

(6) – Refers to Bibliography source number

RECOMMENDATIONS

More statewide investigation needs to be made in locating water surplus and water deficient areas. Alternate storage sites and proposals can then be determined in the event water is ever imported for irrigation.

A more detailed analysis of the functions involved should be made to determine the optimum development based on need, feasibility, practicality, and desirability.

More research into recharge methods and results should be made before any proposal is initiated. Adequate information on total project effects should be available before any one project is promoted ahead of another.

Further study of the surface and ground water laws of the State needs to be implemented. Basin studies, such as this one, providing a comprehensive study of the needs and resources pertaining to surface and ground water should be completed to provide necessary background information.

A complete flood control program should be implemented as soon as possible. This would include: flood plain regulation; flood proofing; watershed projects; and flood control programs.

Land treatment measures and programs need to be accelerated. Sediment deposition and occurrence is a major problem in the basin.

A more complete water quality data collection program should be developed to ensure the maintenance of presently adequate water supplies and the improvement of those found inadequate or unsafe.

A more aggressive educational program in the area of irrigation water management should be pursued.

Recreation and fish and wildlife conservation facilities should be considered for incorporation into all state and federal development projects.

BASIN CHARACTERISTICS

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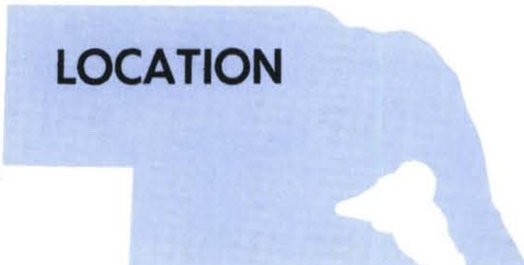
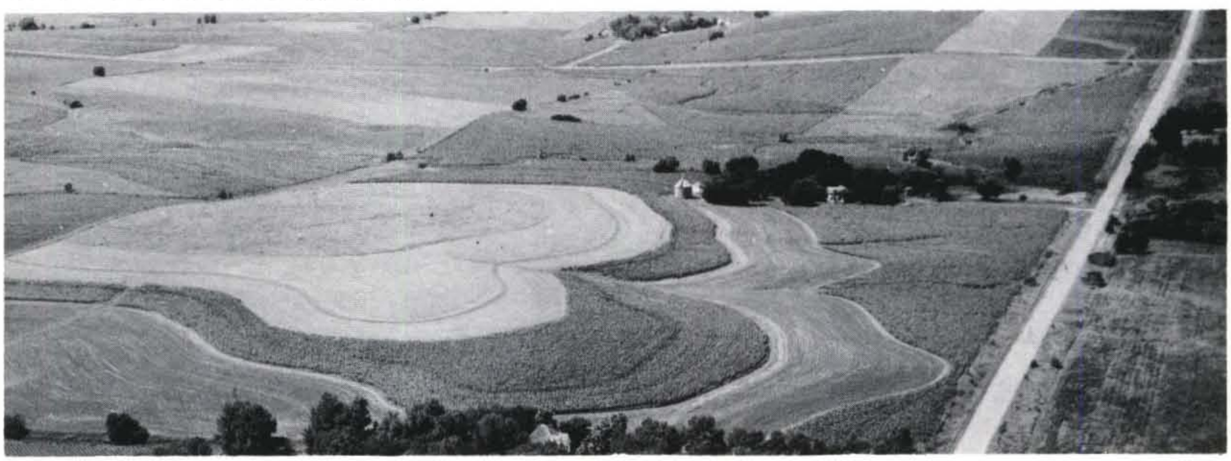
The Big Blue Basin is located in south central Nebraska and northeast Kansas and is a part of the Kansas River Basin. The Big Blue River joins the Kansas River near Manhattan, Kansas. The states of Kansas and Nebraska are presently negotiating a compact to control the use of streamflow in the Big Blue River. This report is concerned with only that portion lying in Nebraska. The Nebraska portion of the basin extends west to Hastings, north to David City and east to near Burchard.

LOCATION



The area of the Nebraska portion of the basin totals 4,560 square miles or approximately 2,920,000 acres. The greatest length west to east is about 130 miles while the maximum north-south distance is approximately 100 miles.

The northern part of the basin is about 55 miles west of Omaha, Nebraska and the southern edge is some 85 miles northwest of St. Joseph, Missouri. Lincoln, Nebraska is only 12 to 15 miles east of the basin.



TOPOGRAPHY

The upper basin is generally composed of loess plains with some areas so flat that they have no defined drainage pattern. The broad plains of the upper basin transcend into dissected tablelands near the center of the basin. The main channels are quite narrow and shallow but are bounded by fairly wide, high terraces. These high terraces are rarely inundated. (6)

The lower portion of the basin includes undulating loess hills which have a more highly developed drainage pattern. This area and the escarpment areas of the upper basin are subject to severe sheet and gully erosion.

The overall slope of the basin is toward the southeast with most streams flowing eastward or southeast.

Elevations range from 1,970 feet above mean sea level near Hastings to approximately 1,340 feet where the river leaves the state.

SOILS

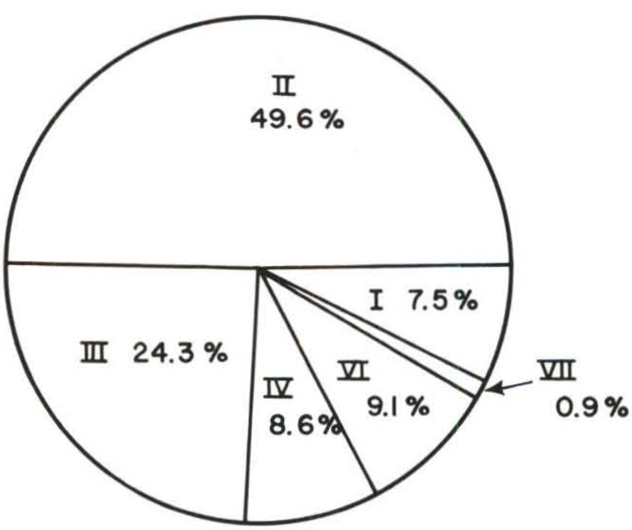
Soils in the basin range from deep loess to shallow soils developed on residual limestone and shale. (6) The upper basin is composed predominantly of deep, friable soils with a medium textured topsoil. The permeability of these soils is generally good. Portions of Clay and Fillmore Counties have soils with thick, fine textured subsoils with a slow rate of infiltration. About 14 percent of the upper basin is deficient in surface drainage and soils here have a well developed claypan. (6) This type of claypan soil severely reduces percolation of precipitation into the ground water aquifer.

The lower basin is characterized by deep soils of rolling loess-capped hills over glacial till. The top soil is friable and partly underlain with a moderately heavy to heavy claypan subsoil with fair to poor permeability. Limestone and sandstone outcrops may be found on the lower slopes adjacent to principal drainageways in the lower basin. These soils are quite shallow and have limited agricultural use.

Alluvial soils cover much of the valley along the main stem of the Big Blue River. These soils are mostly silt loams and silty-clay loams with some gravel outcrops. Several terraces occur in the valley along the mainstem. They are located for the most part above present day flood-crest levels.

Capability of soil types in the basin is shown in Figure 2. Capability refers to the soils' limitations or hazards of use under existing conditions. Factors of slope, soil depth, drainage, and erosion are considered in determining the soil capability. The Big Blue Basin has a high percentage of high quality lands (class 1 and 2) having only slight use limitations.

SOIL CAPABILITY CLASS
BIG BLUE RIVER BASIN /1



CLASS — LIMITATIONS

I – No limitations in use
II – Slight limitations in crops and practices
III – More serious limitations in crops and practices
IV – Very severe limitations on cultivation requiring careful management
V – Limitations because of excess water
VI – Unsuited for cultivation; largely range, woodland with careful management

(Amount of class V land in the basin is insignificant)

/1 – Agricultural land only

SOURCE: Soil Conservation Service

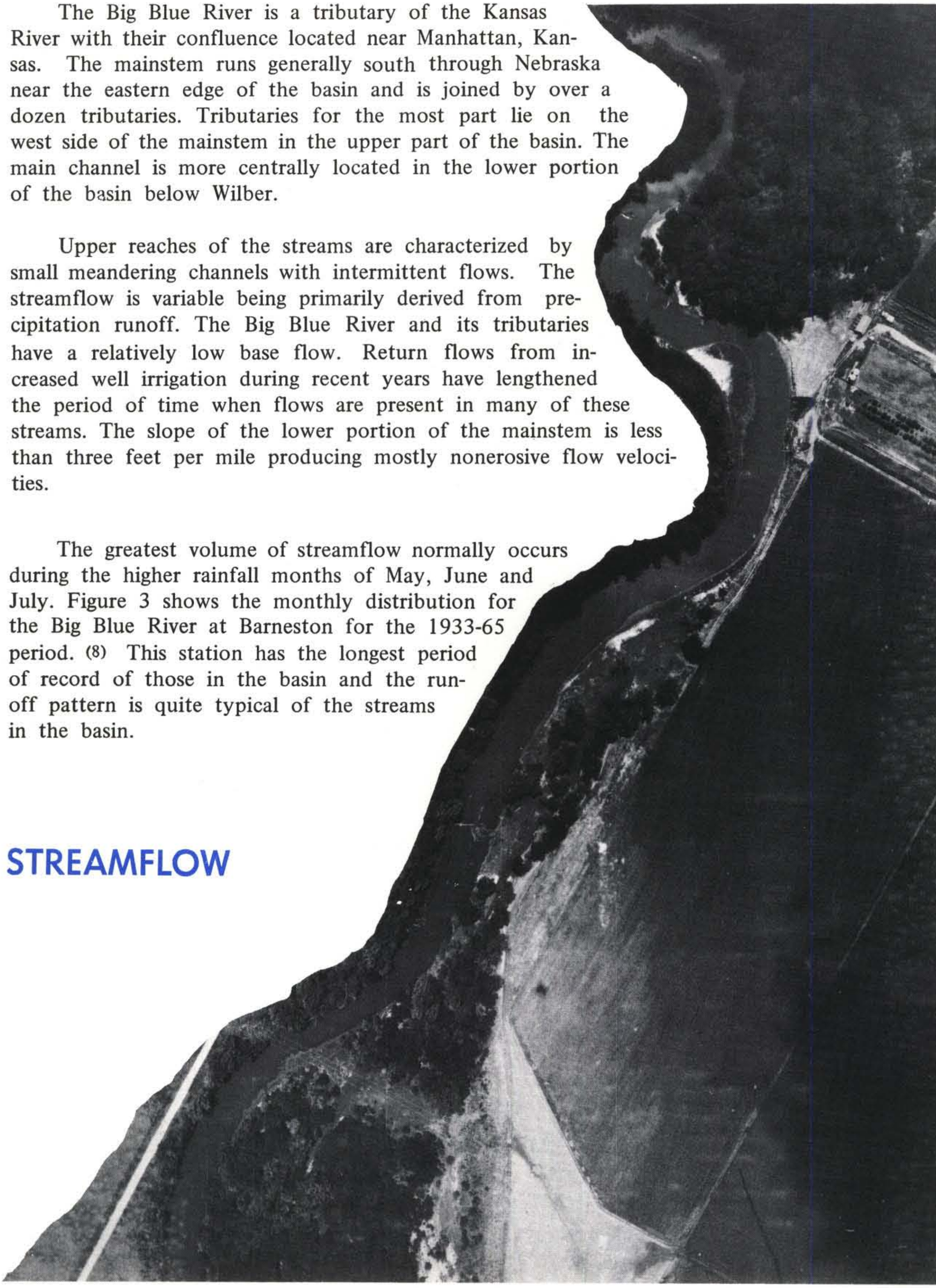
FIG. 2

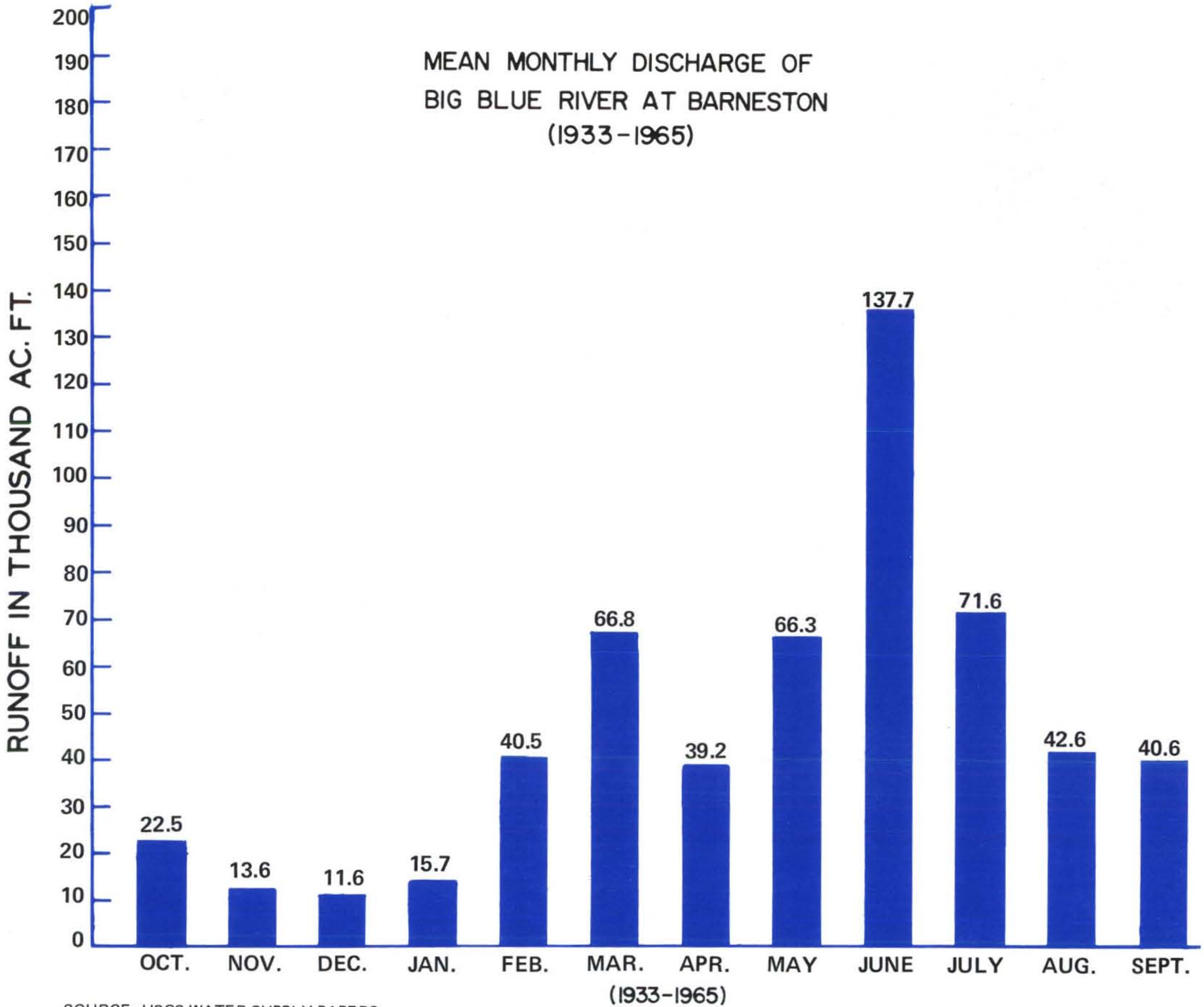
STREAMFLOW

The Big Blue River is a tributary of the Kansas River with their confluence located near Manhattan, Kansas. The mainstem runs generally south through Nebraska near the eastern edge of the basin and is joined by over a dozen tributaries. Tributaries for the most part lie on the west side of the mainstem in the upper part of the basin. The main channel is more centrally located in the lower portion of the basin below Wilber.

Upper reaches of the streams are characterized by small meandering channels with intermittent flows. The streamflow is variable being primarily derived from precipitation runoff. The Big Blue River and its tributaries have a relatively low base flow. Return flows from increased well irrigation during recent years have lengthened the period of time when flows are present in many of these streams. The slope of the lower portion of the mainstem is less than three feet per mile producing mostly nonerosive flow velocities.

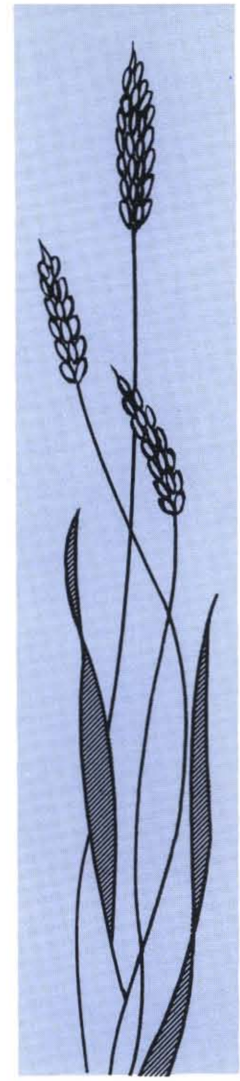
The greatest volume of streamflow normally occurs during the higher rainfall months of May, June and July. Figure 3 shows the monthly distribution for the Big Blue River at Barneston for the 1933-65 period. (8) This station has the longest period of record of those in the basin and the runoff pattern is quite typical of the streams in the basin.





SOURCE: USGS WATER SUPPLY PAPERS

FIG. 3



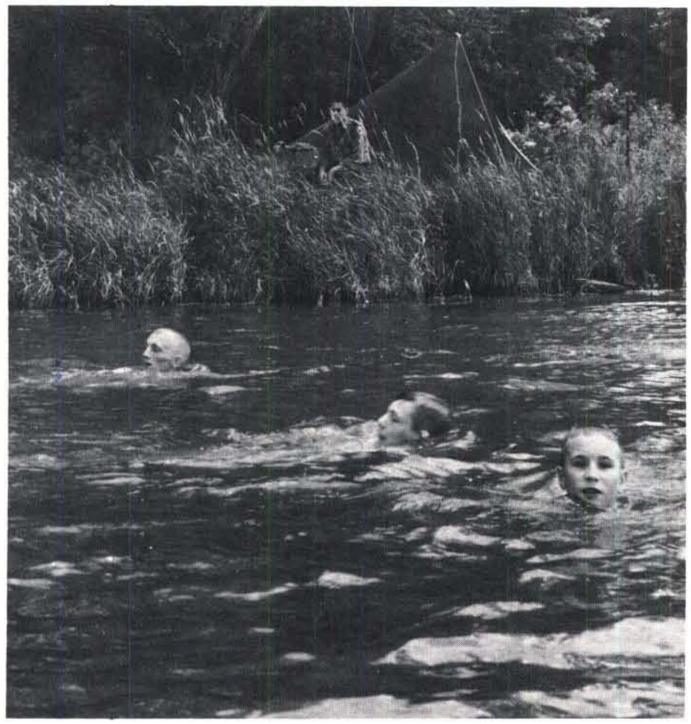
VEGETATION

Grass was the native vegetation of the uplands area and trees were present along the stream valleys. Timber plantings were introduced in the uplands by the early settlers and additional shelter belts have been added in more recent years.

Some 80 percent of the basin is in cropland thus reducing the natural vegetative cover. Farmers in the basin using good tillage practices leave most of the crop residue on or near the surface providing good cover conditions. On steeper, less fertile and more droughty soils, crop growth frequently is not dense enough to produce an adequate amount of crop residue to make good vegetative cover. Only about three percent of the land in the basin is of this type, but these lands often lie in close proximity to streams and watercourses making them major sediment contributors.

Nearly every farm contains small tracts of pasture and rangeland. An increase in undesirable annual grasses and weeds has resulted from the overutilization of many of these grazing areas. About sixty percent of the grassland in the basin has fair to poor rainfall retention characteristics.

Woodlands within the basin vary widely in cover and hydrologic characteristics. The practice of woodland grazing normally reduces the ability of such lands to retain precipitation. Much of the woodland and vegetation adjacent to the stream creates debris which partially blocks streams and increases flooding during periods of high flows.



CLIMATE

The climate of the Big Blue Basin is characterized as a sub-humid continental type having extremes of high and low temperatures. It is typical of the interior of large continents in middle latitudes and is comprised of light rainfall, hot summers, cold winters and great variations in both temperature and precipitation from year to year and day to day. Precipitation occurs mainly in the form of rain but some heavy snowfalls have been recorded.

Severe weather is not unknown to the basin and damaging hailstorms occur in local areas nearly every year. Tornadoes cause less frequent but significant damages.

The average wind speed is about 12 miles per hour with winds in the western part tending to be somewhat higher in velocity than those in the eastern part. March and April normally are the windiest months. Prevailing winds are from the south during the spring and summer and mostly north to northwest in the late fall and winter.

Temperature

The normal annual temperature over the basin is about 52 degrees F. The lowest temperature recorded in the basin was -33 degrees F. and the highest was 117 degrees F. (10) Temperatures above 100 degrees F. have occurred in the months of April through September.

The growing season ranges from 170-200 days with the latest frost date in the spring occurring about April 20 and earliest fall frost about October 20. (6)

Precipitation

Precipitation varies from an average of about 25 inches in the western part of the basin to 30 inches in the eastern part. Extremes of less than 12 inches in 1934 and over 48 inches in 1951 were recorded at some stations.[10] Precipitation occurs predominantly as rainfall and over 80 percent falls during the growing season from April through October. While the annual rainfall is favorably distributed with regard to the growing season, the monthly distribution within the season is poor. Little precipitation has been recorded during some months while others have received as much as 16 inches. The average precipitation for June, which is usually the month of highest rainfall, is about 4.5 inches in the eastern half of the basin.

Snowfall averages about 27 inches annually and occurs predominantly from December through March. The maximum annual snowfall recorded in the basin was 65 inches at York in 1960.

Precipitation figures for several stations in the basin were used to derive the isohyets shown on Figure 5. The stations of Beatrice, Hastings and York were felt to be representative of the basin and climatological data for them are tabulated in the following table.

TABLE I

CLIMATOLOGICAL DATA

TEMPERATURE [1] (Degrees Fahrenheit)				PRECIPITATION [2] (Inches)				
Mean	**Max.**	**Min.**		**Mean**	**Max.**	**(Year)**	**Min.**	**(Year)**
51.8	117	−33	Beatrice	28.58	48.40	(1951)	15.96	(1955)
51.1	116	−30	Hastings	24.94	45.45	(1965)	13.88	(1943)
51.7	114	−31	York	26.98	36.04	(1965)	14.82	(1934)

1/ Temperature data for at least 64 year period ending in 1960
2/ Mean precipitation for at least 68 year period ending in 1960
Maximum and Minimum precipitation for 1931 – 1965 period

SOURCE: ESSA, Department of Commerce

Historical precipitation for York, near the center of the basin, is shown for the 1931-65 period in Figure 4.

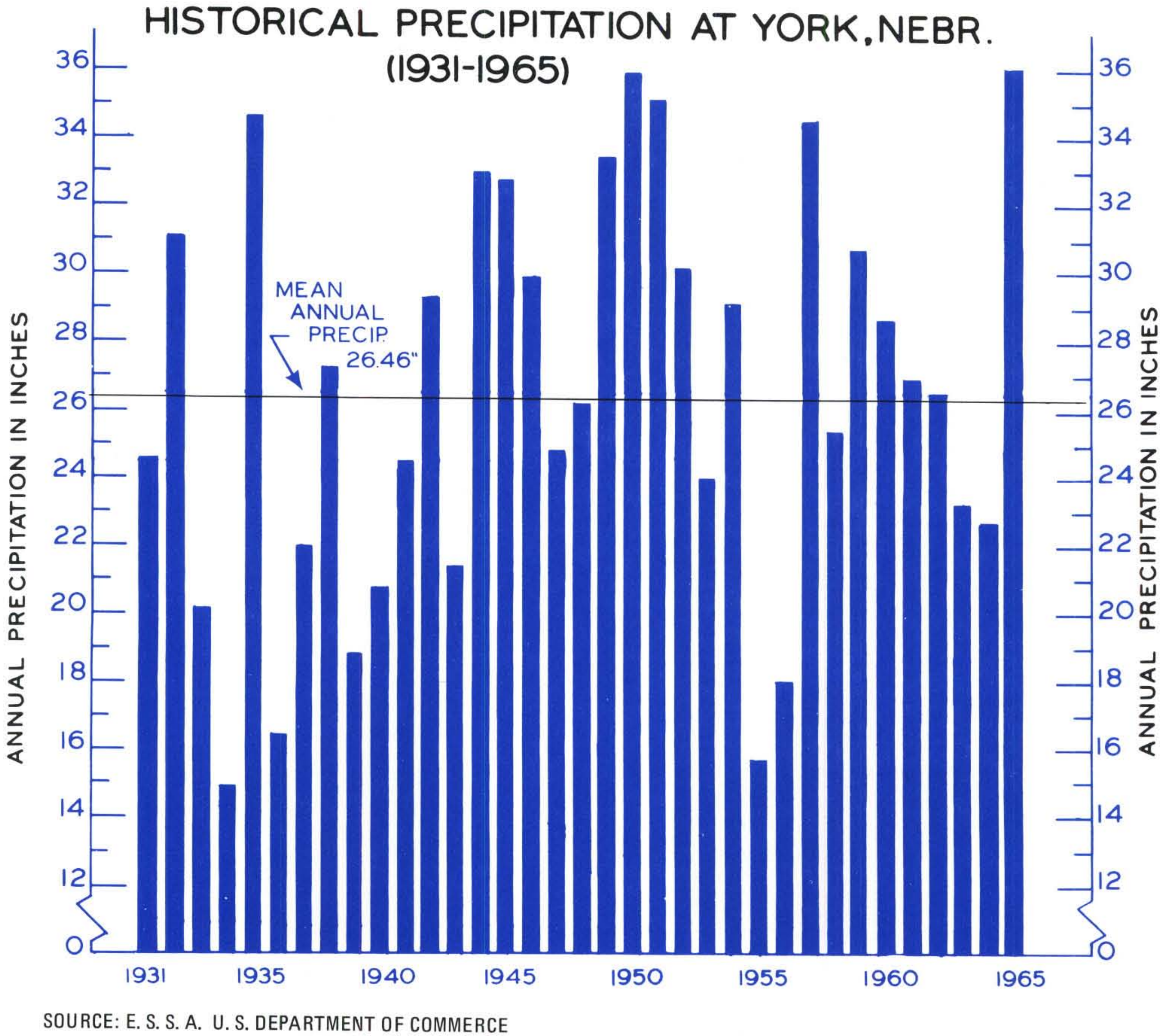

HISTORICAL PRECIPITATION AT YORK, NEBR.
(1931-1965)
ANNUAL PRECIPITATION IN INCHES
MEAN ANNUAL PRECIP. 26.46"
36
34
32
30
28
26
24
22
20
18
16
14
12
0
1931
1935
1940
1945
1950
1955
1960
1965
SOURCE: E. S. S. A. U. S. DEPARTMENT OF COMMERCE

FIG. 4

POPULATION

Population of the Big Blue River Basin reached its maximum of approximately 140,000 in 1890 and has since declined to an estimated population of 108,000 in 1966. Historic population data from 1870 to 1960 are shown in Table 2.

The 1960 Population Census shows that nearly 107,700 people lived in the Big Blue River Basin of which over 32 percent resided in the six urban areas of Aurora, Beatrice, Crete, Hastings, Seward, and York. Another 31 percent lived on farms and the remaining 37 percent lived in rural non-farm areas or in communities of less than 2,500 population. (11)

TABLE 2
POPULATION DATA
BIG BLUE BASIN

YEAR	TOTAL	URBAN TOTAL	RURAL TOTAL	FARM	NONFARM
1870	8,406				
1880	76,374				
1890	140,450	20,407	120,043		
1900	132,821	15,836	116,985		
1910	135,579	21,634	113,945		
1920	131,783	24,660	107,123		
1930	131,622	29,900	101,722		
1940	120,610	28,335	92,275	56,903	35,372
1950	111,760	32,345	79,415	45,000	34,415
1960	107,684	33,988	73,696	33,831	39,865
1966*	108,000				

* Derived from urban and county population estimates published by the Bureau of Business Research, University of Nebraska.

SOURCE: U.S. Department of Commerce, Bureau of the Census, and U.S. Census of Population

GENERAL ECONOMY

Historically, agriculture has been the primary factor in the economy of the Big Blue River Basin and represented directly 33 percent of the 1960 employment.

As a result, the general economic conditions of the area have fluctuated with the agricultural economy. Dry land farming has been the dominant type of agriculture. However, extensive private irrigation development has taken place in the upper parts of the basin in recent years. This irrigation has significantly stabilized the economy of this area. Wheat, corn and livestock have been the primary sources of farm income, with livestock producing an increasingly larger share of total farm income in recent years.

Manufacturing is somewhat limited in the basin and is confined primarily to agriculturally related industries or the production of items for local use. The urban communities serve principally as trade and service centers for the surrounding agricultural areas.

Transportation facilities are generally adequate as most towns are served by one or more of the five main or branch line railroads, and over 1,000 miles of hard-surfaced highways serve the area. Seventy miles of the Interstate Highway System (I-80) traverse the northcentral part of the basin. The rural areas are served by a relatively good farm-to-market network of state, county, and local roads. Commercial bus and truck transportation serves many communities within the basin. Hastings, York, and Beatrice have municipal airports and commercial air transportation serves several points in and adjacent to the basin. The state and federal highway system is shown in Figure 6.

The usual public utilities are available in most communities although public water, gas and sewage facilities are not available in some of the smaller towns. Telephone and electric power services are available to nearly all farms.

The basin is located within easy shipping distance of three central livestock markets–Omaha, St. Joseph and Kansas City. Local auction rings and buying stations are also located throughout the basin. Most towns have either privately owned or farmer cooperative grain elevator facilities. Many of the cooperatives also provide production items for their farmer members at a reduced cost.

FIG. 5

BIG BLUE RIVER BASIN

MEAN ANNUAL PRECIPITATION

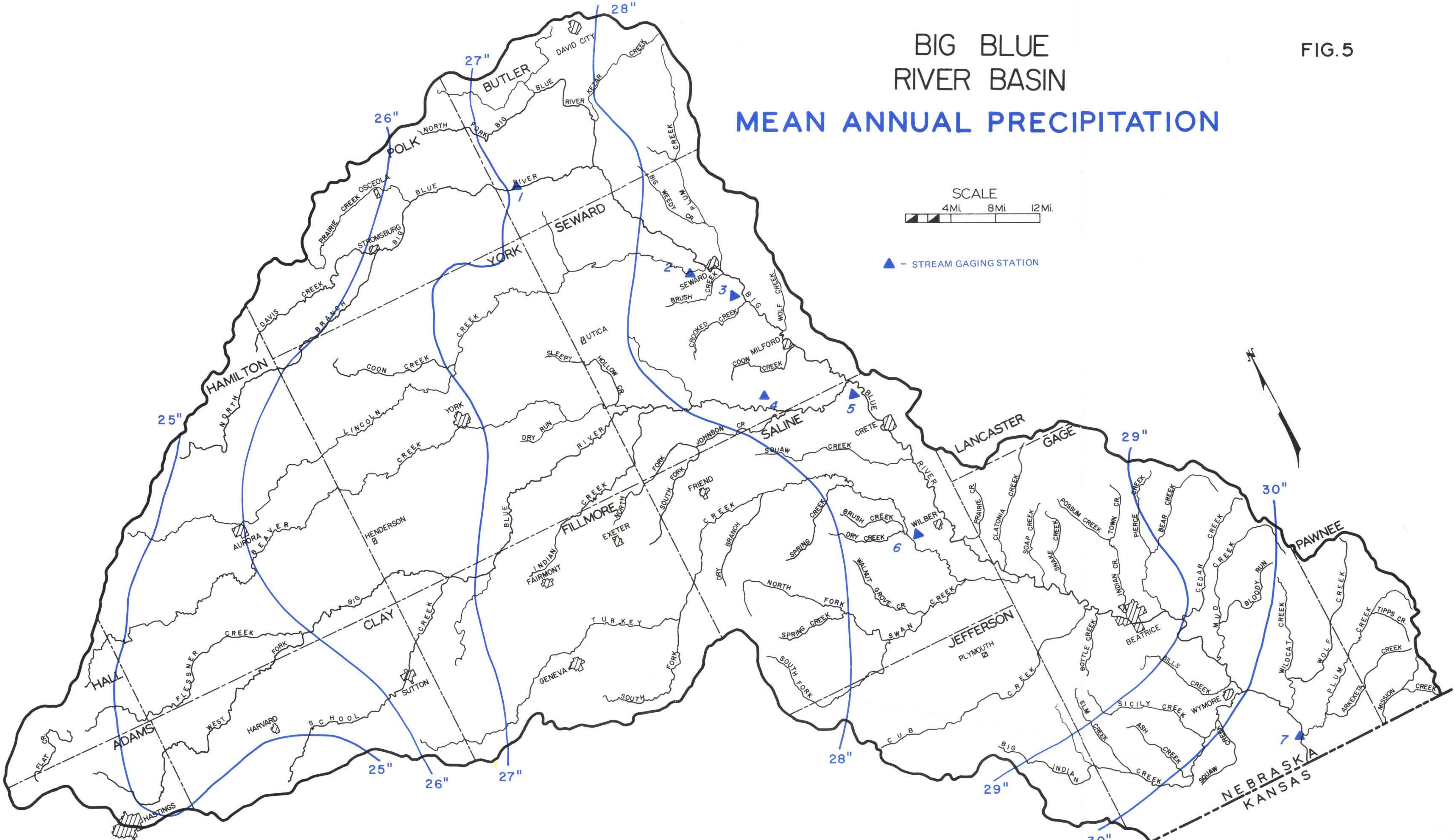
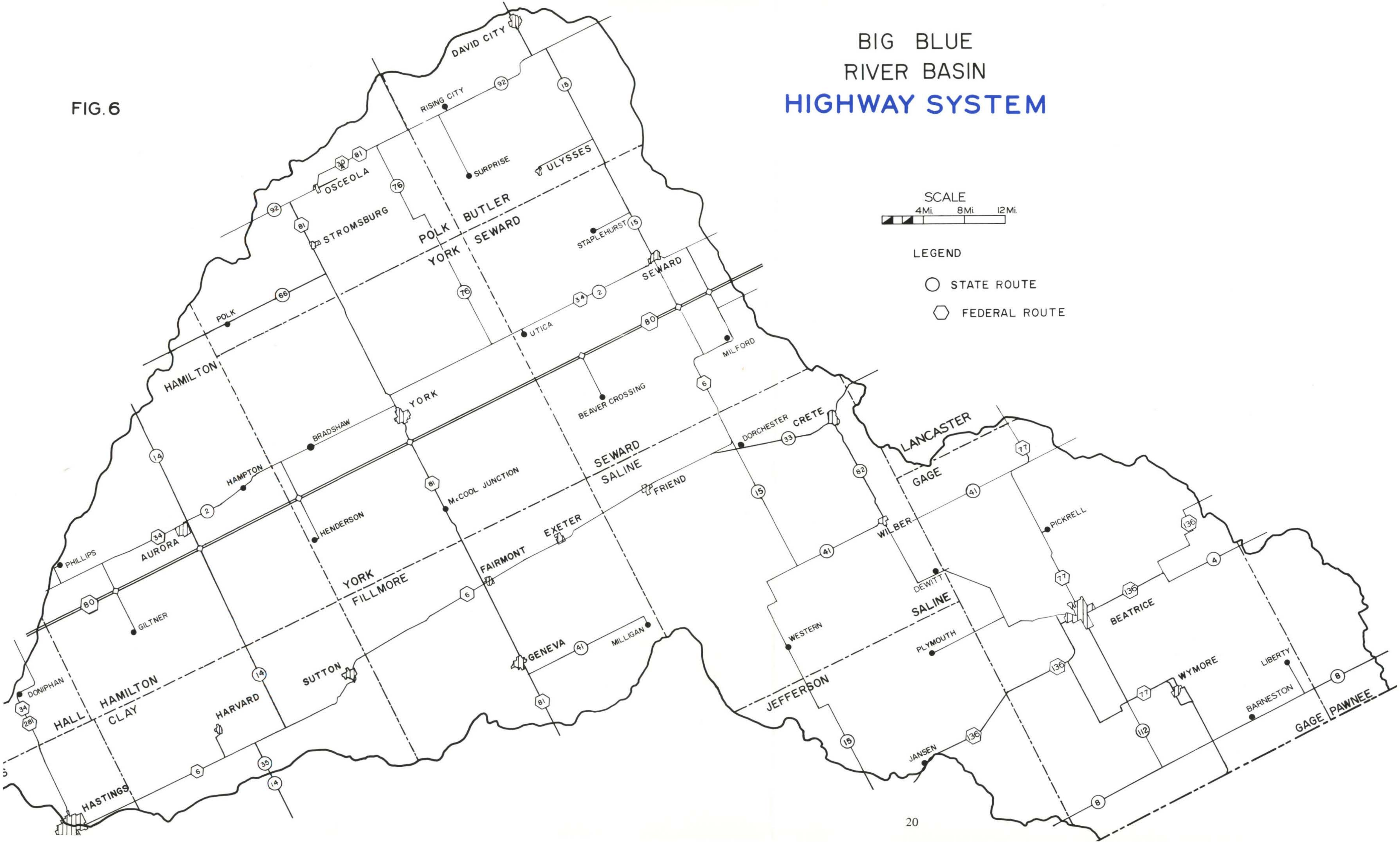


FIG. 6

BIG BLUE RIVER BASIN
HIGHWAY SYSTEM



BASIN RESOURCES

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LAND

Ninety-six percent of the basin's total land area of 2,920,000 acres is devoted to agriculture. Eighty-three percent of the agricultural land is in crops, 12 percent in pasture, two percent in woodland, and the remaining three percent is in other agricultural uses. (6)

Land resource areas are composed of geographically associated land resource units, usually several thousand acres in extent, that are characterized by particular patterns of soil (including slope and erosion), climate, water resources, land use and type of farming. The two land resource areas within the Big Blue Basin are designated as the Central Loess Plains and the Nebraska Kansas Loess Drift Hills and are shown on Figure 7.

Central Loess Plains

The Central Loess Plains Area comprises nearly 83 percent of the basin and lies in the central and western portions of the basin. This nearly level to gently rolling plain is overlain with loess soil and is generally quite adaptable to irrigation. Private systems utilizing ground water have been developed to irrigate about 25 percent of the cropland. Wheat and grain sorghums are the major dryland crops while corn is the most important irrigated crop.

Woodland occupies 22,400 acres of land or approximately one percent of the total resource area.

Nebraska and Kansas Loess Drift Hills

The Nebraska and Kansas Loess Drift Hills Area comprises 17 percent of the basin and lies along the extreme eastern portion. The soil in this area is comprised of a variable thickness of loess over glacial drift and is typified by narrow stream valleys separated by broad undulating ridges. The irrigation potential appears to be somewhat limited in this area. Rainfall is generally adequate for the production of wheat, corn, feed grains, and hay. Seventy percent of this resource area within the basin is in cropland, 20 percent in pasture and four percent in woodland.

Land use within the Resource Areas described is summarized in Table 3.

TABLE 3
MAJOR LAND USE BY LAND RESOURCE AREAS
BIG BLUE BASIN

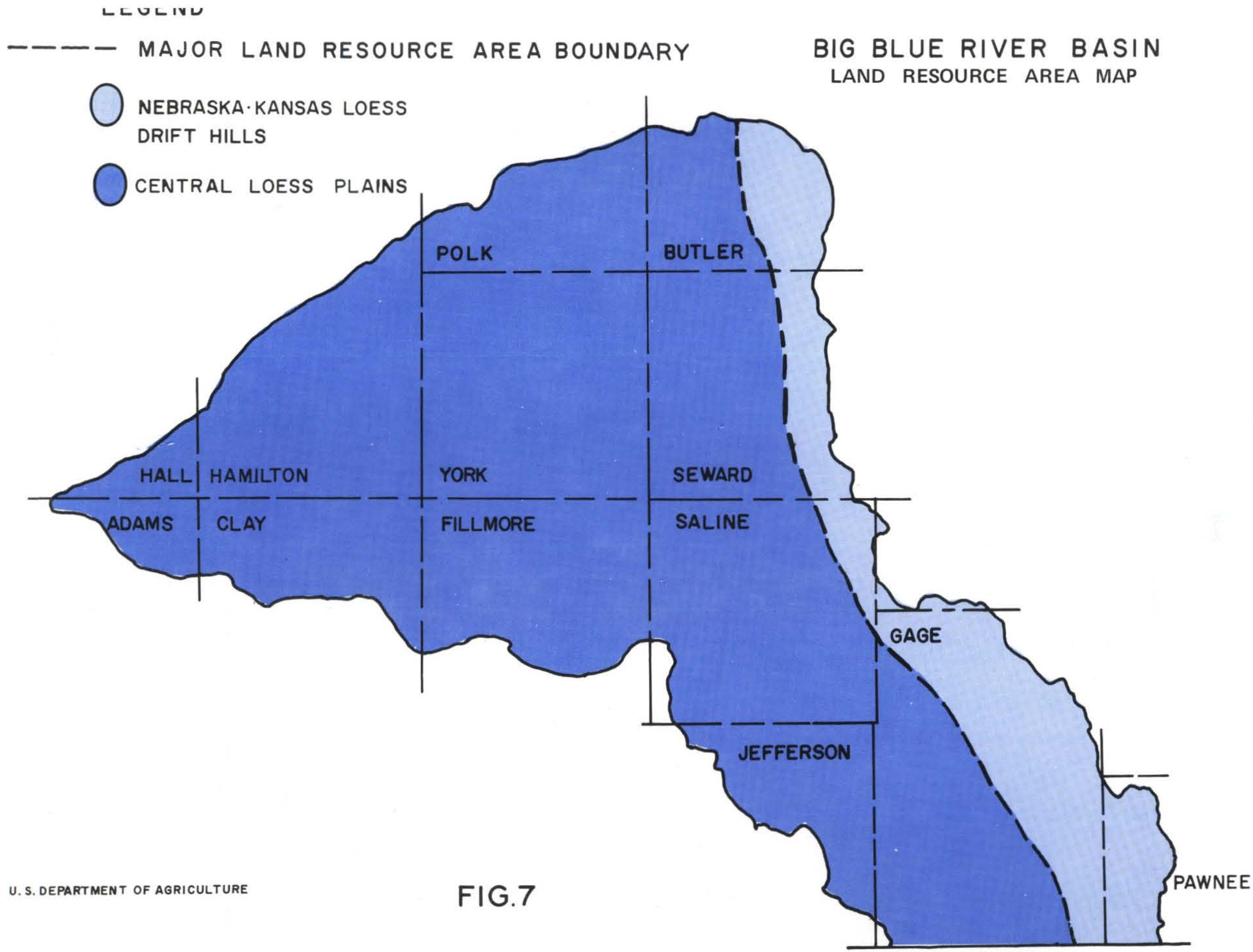
Land Use	CENTRAL LOESS PLAINS		NEB–KAN DRIFT HILLS		BASIN TOTAL	
	Acres*	Percent Of Area Total	Acres*	Percent Of Area Total	Acres*	Percent Of Total Land
Cropland	1,991.5	82.5	350.3	69.2	2,341.8	80.2
(nonirrigated)	(1,510.6)	(62.6)	(341.3)	(67.4)	(1,851.9)	(63.4)
(irrigated)	(480.9)	(19.9)	(9.0)	(1.8)	(489.9)	(16.8)
Pasture	237.2	9.9	97.5	19.3	334.7	11.5
Woodland	22.4	.9	19.1	3.8	41.5	1.4
Other Ag. Land	73.5	3.0	19.3	3.8	92.8	3.2
TOTAL Ag. Land	2,324.6	96.3	486.2	96.0	2,810.8	96.3
Nonagricultural Land	88.9	3.7	20.4	4.0	109.3	3.7
TOTAL AREA	2,413.5	100.0	506.6	100.0	2,920.1	100.0

* Numbers are in thousands of acres.

SOURCE: U. S. Dept. of Agriculture, Conservation Needs Inventory, 1958

Several major differences between these two land resource areas are apparent. The Central Loess Plains Area has a higher percentage of cropland, a much higher percentage of irrigated land, and a lower percentage of pasture and woodlands.

Nonagricultural land represents only 3.7 percent of the total land area in the basin. This land is primarily composed of urban areas, roads, highways, and railroads.



SOURCE: U. S. DEPARTMENT OF AGRICULTURE

FIG.7

WATER

The water resources of the Big Blue Basin consist of variable surface water supplies and ground water supplies of considerable magnitude. Interest by basin residents in control and conservation of the ground water supply is increasing.

Ground Water

Ground water is the primary source of irrigation water for the nearly half-million acres of land being irrigated in the basin. The best sources of ground water are the Quaternary age deposits of sand and gravel having high permeability. The bedrock materials underlying the aquifers are mostly impermeable in nature. Some bedrock in the southeastern part of the basin is somewhat permeable but yields water too highly mineralized for most uses. The geology of the basin reflects the influence of glaciation periods. The glaciation extended only into the eastern parts of the basin but the advance and retreat of four major glaciations are reflected in the underlying deposits throughout the basin. The most permeable deposits in the basin are generally the sand and gravel layers of the Illinoian age (the third major glaciation). The thickness of these layers is variable and ranges from a few feet to about 200 feet. Gravel layers of other glaciation periods also occur but normally are separated by glacial drift or clay lenses. These sand and gravel layers occasionally occur in a continuous strata, resulting in an aquifer several hundred feet thick. (1)

The thickness of the water bearing material has a bearing on the yield of water from the aquifer, however, the porosity and transmissibility primarily determine the actual amount of water available.

Porosity refers to the void space in the water bearing material and is usually expressed as a percentage of the total volume. Effective porosity, or specific yield, is the part of this water filled void space which can be removed by gravity. Much of the water contained in an aquifer is bound by surface tension to the surrounding material and is thus unavailable. The degree of this retention establishes the specific yield.

Transmissibility is a measure of a material's ability to transmit water. The coefficient of transmissibility refers to the amount of water in gallons per day passed through a one-foot vertical strip of aquifer when the slope of the water table is 45 degrees. Transmissibility is sometimes expressed in units of gallons per day per mile of aquifer under a gradient of one foot per mile. Figure 11 shows areas having transmissibility rates of 20,000 to 200,000 gallons per day per mile. These quantities can be roughly converted to gallons per minute yield of wells by dividing by 100, assuming that the static water level is 100 feet above the base of the permeable section and the drawdown while pumping is about 30 feet.

The depth to the water table is generally less than 100 feet but in some localized areas it is as much as 150 - 200 feet. Most stream valleys in the central and western part of the basin are less than 40 feet above the water table. Water table depths have been steadily increasing in some areas of the basin with the increased withdrawal and use of ground water for irrigation. The amount of ground water in storage in the basin has been estimated by the Conservation and Survey Division of the University of Nebraska based on test holes drilled throughout the basin. This analysis shows as much as 60 feet of water in storage in aquifers beneath broad areas adjacent to some of the tributaries in the central and northwest parts of the basin. However, many of the uplands in the lower parts of the basin are underlain by aquifers containing as little as four feet of water. Again, it is emphasized that the amount of water in storage is not a direct indication of availability since specific yield and transmissibility of these aquifers determine the amount of ground water that can be withdrawn. (1)

GROUND WATER QUALITY

Ground water quality is not a problem in much of the basin. However, some ground water aquifers in the lower central part of the basin near Wilber and DeWitt are highly mineralized. This condition is believed to be the result of the mineralized water in the Dakota sandstone moving up into the sands and gravels above. In addition, ground water of poorer quality is generally found in areas of lower transmissibility. Wells in these areas must penetrate deeper aquifers which contain more highly mineralized waters in order to get sufficient yields. In a few instances, iron, manganese and nitrate concentrations are greater than the limits of the 1962 Public Health Service drinking water standards. In the area of the basin below Crete, ground water supplies may be more highly mineralized and exceed the upper limits for sulfates, nitrates and total dissolved solids set by the U. S. Public Health Service as drinking water standards. The ground water in most of the basin is quite high in calcium carbonate, an indication of hardness. This does not constitute a health hazard but indicates a factor affecting some of the uses. Figure 12 shows dissolved solids content of the Big Blue Basin ground water.

Salinity is measured in terms of conductivity or the ability of water to carry an electric current. The higher the salt content, the greater is the water's ability to carry a current. Water classified low or medium in salinity hazard can be used for irrigation on most soils unless internal drainage is restricted.

Results of a number of salinity tests made throughout the basin are shown in Table 4.(12) Most of the wells sampled yielded water which could be used without salinity hazards resulting. The majority of those indicating some salinity hazard could be controlled by water management and leaching techniques. Parts of Saline and Lancaster Counties are known to have high salinity ground water.

TABLE 4
SALINITY OF GROUND WATERS IN THE BIG BLUE BASIN*

COUNTY	LOW	MEDIUM	HIGH	VERY HIGH
Adams	1	26	0	0
Butler	0	11	5	0
Clay	0	45	0	0
Fillmore	0	43	10	0
Gage	0	10	0	0
Hall	0	31	17	0
Hamilton	3	64	7	0
Jefferson	0	8	2	0
Lancaster	0	5	4	0
Polk	0	28	3	0
Saline	0	10	2	0
Seward	0	35	1	0
York	0	71	0	0

* No. of samples falling into appropriate USDA classifications based on conductivity.
SOURCE: The Nebraska Water Quality Survey, 1965 Extension Service, etal.

Potassium, calcium, magnesium, sulfur and other essential nutrient elements are present in substantial quantities in the ground water. When soils deficient in these elements are irrigated with such waters, fertilization benefits can be achieved. The boron content of the ground water is generally not high enough to be toxic to plants.

Sodium adsorption ratio (SAR) is used to evaluate sodium or alkali hazard. This ratio is the sodium content in relation to the magnesium and calcium content. If the sodium content is high, it will tend to replace the calcium in clay and result in an alkali problem in some soils. Definite alkali hazards exist in areas of Lancaster, Gage, Polk, Seward, Saline and Butler Counties.(12) Figure 13 shows the ranges in sodium content of the ground water by county in the Big Blue Basin.

Some irrigation wells sampled during 1961 contained concentrations of more than 20 ppm nitrate-nitrogen. The wells in the Big Blue Basin showing highest concentrations were located in Seward and Fillmore Counties. A follow-up study was done in 1962 to determine the change in nitrate levels. The concentration of nitrate-nitrogen decreased from July, 1961 to August, 1962 in all but one of the original irrigation wells resampled.(12) Nitrogen is a necessary nutrient for plant growth and can have very beneficial results when it is available in irrigation water. However, any nitrate-nitrogen concentration above 10 ppm is considered by health officials to be unsafe for human consumption. Nitrate-nitrogen concentration of 10 ppm is essentially equivalent to a nitrate concentration of 45 ppm.

A special study was done throughout Seward County during 1960 to 1963 to observe changes in nitrate-nitrogen concentration and to determine the correlation with fluctuations in ground water levels.(12) Changes in ground water levels occur each year with the highest levels normally occurring during the spring. At the end of the irrigation and growing season ground water levels are usually at their lowest. The study was inconclusive but generally indicated the nitrate level was highest in the fall following the irrigation season.

The chemical constitution of the waters of the basin seldom cause serious problems of corrosion or incrustation.

USE OF GROUND WATER

Ground water is the major source of water supply for irrigation, industrial and domestic use. Of these, irrigation is by far the greatest user of ground water in the basin and has contributed greatly to the economy of the area. The greatest concentration of irrigation wells, as illustrated in Figure 14, is in Hamilton and western York Counties, areas experiencing a measurable and somewhat progressive decline in ground water levels. Observation well records compiled by the U. S. Geological Survey and the Conservation and Survey Division show a general decline in Hamilton and western York Counties of about eight feet since1953. Similar declines have been recorded in southwestern Polk and parts of Clay and Fillmore Counties. (See Figure 15.)

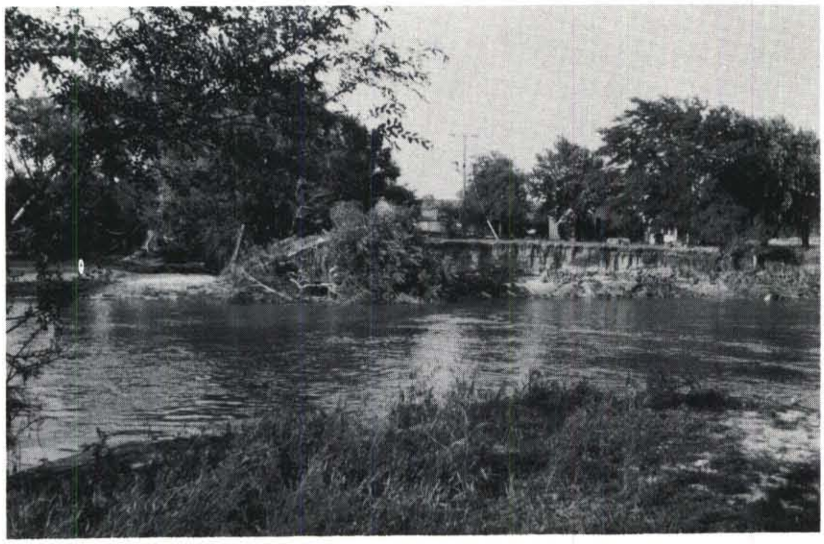
Ground water development may be expressed in terms of the relation of ground water withdrawn from storage under average climatic conditions to the average amounts of water added to ground water from precipitation sources. This relationship does not imply that there would be no lowering of ground water levels if the withdrawal did not exceed the rates of recharge because it is improbable that the irrigation wells could intercept all of the recharge to the basin under the physical relationships that exist.

Irrigation well densities (Figure 14) combined with a conservative estimate of the average annual withdrawal of ground water indicates certain areas are removing ground water from storage at a rate three to four times the average annual rate of recharge from precipitation. This is true of York and Hamilton Counties where some 240,000 of the counties' 689,000 acres are irrigated (1) with average annual withdrawals of about three times the 85,000 acre feet of estimated average annual recharge in these two counties and relates directly to the lowering of the water table as shown in Figure 15.

The average annual recharge to ground water from precipitation throughout the entire basin varies from a few tenths of an inch in much of the rougher land in the eastern and southeastern parts of the basin to about one and one-half inches in the western part of the basin and averages about three-fourths inch (.06 ft.) for the entire basin. This amounts to an average annual increment of about 175,000 acre feet although some of it occurs in areas of low transmissibilities and is not available for withdrawal. The annual withdrawals required to irrigate the nearly 500,000 acres which are presently being irrigated varies from small amounts in years of high precipitation to 700,000 acre feet or more in the low precipitation years, and probably averages 350,000 acre feet or more. This is at least twice the average annual rate of recharge for the entire basin.

Ground water conservation districts were organized in York County in November, 1966 and Hamilton County in August, 1967. Fillmore and Clay County irrigators are considering the formation of similar districts. These districts have the authority to develop a program for the conservation of ground water, provide for additional data collection programs, levy up to one mill for financing their activities, and can institute regulatory measures if and when necessary.

Surface Water

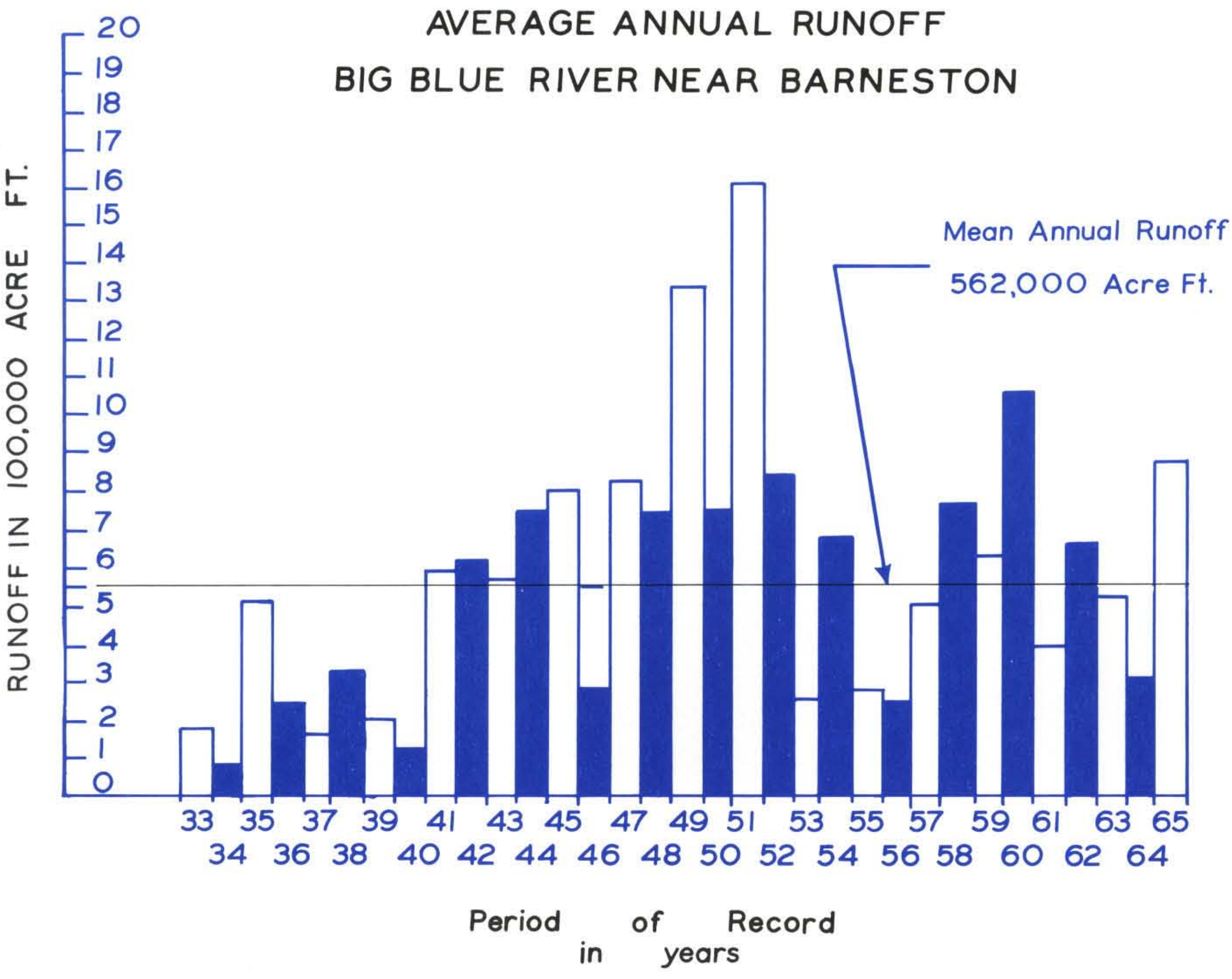


Streamflow of the Big Blue River near the Nebraska-Kansas line averages some 561,000 acre feet annually.(8) The gaging station on the Big Blue River at Barneston, Nebraska has been in operation since June, 1932 and has the longest period of record of stations in the basin. The variation in annual runoff for this station is shown in Figure 8. Gaging station locations are shown on Figure 5 and Table 5 shows pertinent data collected at these sites. The long-term average annual runoff at the lower gaging station is less than ten percent of the average annual precipitation. This indicates a considerable amount of precipitation is lost to evaporation and transpiration. The average runoff per square mile increases measurably downstream reflecting the accretion due to increasing precipitation, somewhat steeper topography, and some interception of the ground water aquifers. Diversions for existing water rights and ground water pumping deplete the surface water.

Analysis of available data shows that fifty percent of the time the base flow at the state line is only one-third of the average annual discharge in cubic feet per second. This means that during the remaining fifty percent of the time, over eighty percent of the annual flow volume occurs. This indicates quite variable runoff with much of it occurring as flood flow. Records show a total, as of December 31,1964, of some 50,000 acres in the Big Blue Basin had surface water rights for irrigation using stream bank pumps. Surface water rights for irrigation in the basin total over 400 cubic feet per second.(2) A reconnaissance field survey by the Department of Water Resources indicates that only about 50 percent of the land with water rights is being actively irrigated. Reasons for the lag in this irrigation are the uncertainty of the water supply and the fact that the flood plain is subject to quite frequent flooding. There are also power rights of nearly 2,000 second feet of which four plants with a total appropriation of 1,650 second feet are still in operation. Power rights in the basin date back to 1860 while the earliest right for irrigation purposes was secured in 1895. Few irrigation rights were secured until the dry period of the thirties, and an additional surge in the procurement of surface water rights for irrigation took place in the late fifties. There are over 500 appropriators using surface water from the Big Blue River for irrigation. Table 6 shows the extent of these rights by stream and the approximate acreage involved.

The increase in ground water pumping has apparently had little effect upon the streamflow partly because most of the stream channels in the upper basin are above the water table and increased irrigation return flows have offset any decrease caused by the ground water pumping.

The Conservation and Survey Division of the University of Nebraska has estimated that some 91 percent of the total precipitation in the basin is lost to evapo-transpiration, that about three percent ultimately supports streamflow as ground water discharge, and six percent is direct runoff under normal conditions. The nine percent of precipitation resulting in total runoff compares to a yield of around six percent for the Salt Creek area and 15 percent or more for the Loup River Basin.(1)



SOURCE: USGS

FIG. 8

TABLE 5
STREAMFLOW DATA

Gage No.	Streamflow Station	Drainage Area sq. mi.	Period Of Record	Annual Runoff in Acre-Feet			Flow In Cubic feet/second	
				mean	max.	min.	max. /2	min./3
1	North Branch – Big Blue River at Surprise	345	Apr. '64 Sept. '65	40,510 /1	–	–	10,900	0
2	Lincoln Creek near Seward	426	Oct. '53 Sept. '65	33,380	75,510	7,000	10,100	1.3
3	Big Blue River at Seward	1,099	Oct. '53 Sept. '65	76,740	149,000	10,250	15,300	0
4	West Fork -Big Blue River near Dorchester	1,206	Aug. '58 Sept. '65	138,300	229,800	67,200	11,200	28
5	Big Blue River near Crete	2,716	March '45 Sept. '65	252,700	494,200	83,590	27,600	13
6	Turkey Creek near Wilber	460	Oct. '59 Sept. '65	63,200	122,900	21,380	7,300	0.2
7	Big Blue River at Barneston	4,444	June '32 Sept. '65	561,100	1,600,000	83,240	57,700	1 /4

SOURCE: U. S. Geological Survey, Water Supply Papers
1/ - One year of record
2/ - Instantaneous
3/ - Mean daily
4/ - Affected by power plant regulation

TABLE 6
ACREAGE UNDER IRRIGATION WITH SURFACE WATER RIGHTS*
BIG BLUE BASIN

STREAM	SECOND FEET	ACRES
Big Blue River	163.40	17,050
West Fork Big Blue River	123.18	14,550
Turkey Creek	79.99	8,220
Lincoln Creek	30.37	3,680
Swan Creek	15.70	1,680
Indian Creek	9.86	1,140
Beaver & Bill's Creeks	11.47	1,060
Bear Creek	10.90	760
Cub, Crooked & Clatonia Creeks	7.99	940
School, Squaw & Sicily Creeks	5.87	560
Wolf Creek	4.86	430
Middle, Pierce, Spring & Plum Creeks	5.74	450
TOTAL	469.33	50,520

* Records to September 30, 1964
SOURCE: Department of Water Resources (2)

SURFACE WATER QUALITY

The quality of the surface waters in the Big Blue River Basin varies greatly during the year. Studies conducted by the Nebraska State Department of Health indicate that the best quality of water exists in the late winter and early spring before the spring runoff occurs. The Big Blue River may rank as the most polluted interstate river in Nebraska if we consider silt as a pollutant. The U. S. Geological Survey conducted measurements of the suspended sediment in the Big Blue River near Crete during water-year 1962 (October 1, 1961 to September 30, 1962.) Figure 9 shows the monthly variation in suspended sediment that passed the Crete gaging station. The mean discharge for the year was 383 cubic feet per second. The maximum discharge of 5,430 c.f.s. occurred in March and the effect of this can be observed in the total suspended sediment discharge for March. In addition to the high load of suspended solids, the Big Blue River receives municipal and industrial wastes from every community located along the river.[13]

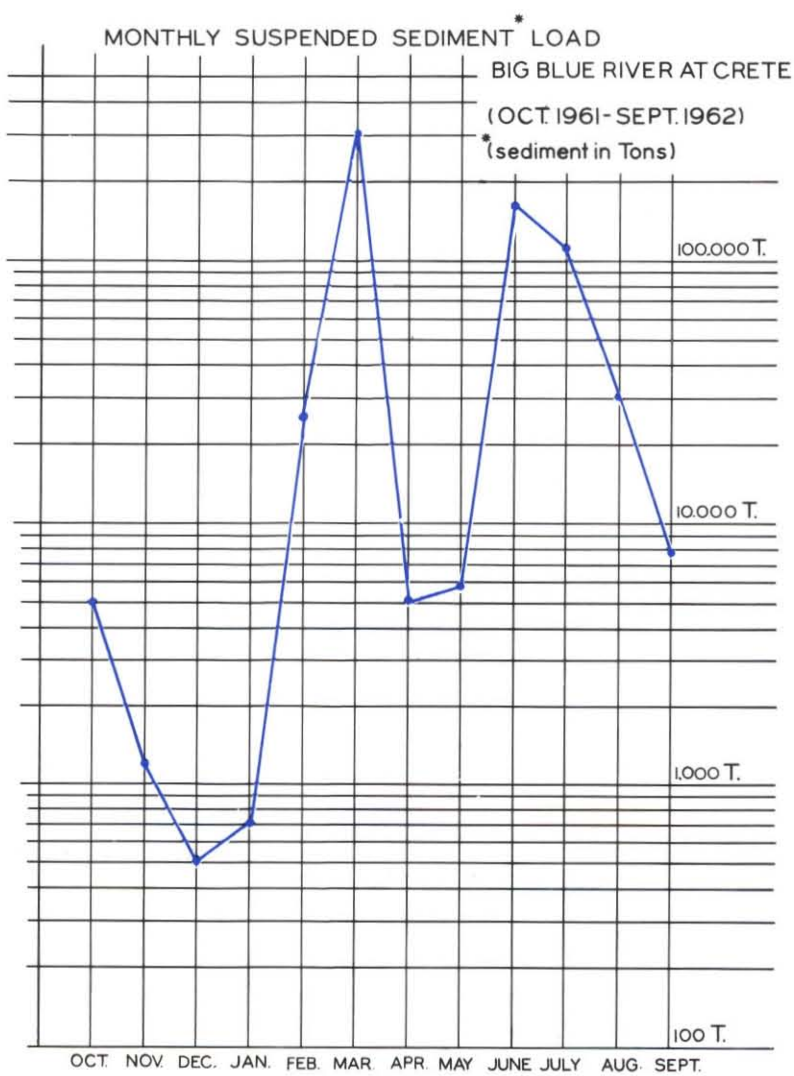


FIG. 9

SOURCE: Nebr. Dept. of Health

Historically, there were at least 20 low head dams on the Big Blue River. At present, only the following five are holding water: Crete, Wilber, DeWitt, Holmesville, and Barneston. All of these dams, except Crete, are used in the generation of electric power. These impoundments, in general, help to improve the water quality because they act like waste water retention ponds. The impoundments contain a high plankton population which utilize many of the pollutants as food. This is evidenced by the fact that there is a reduced phosphate content and an increased dissolved oxygen content below most of the dams. The river does not show a major increase in pollutants at the Kansas-Nebraska state line in spite of the fact that a large amount of waste water is discharged into the river between Crete and the state line.

Marysville, Kansas obtains its drinking water from the Big Blue River. The present quality meets the Kansas Health Department requirements for a raw drinking water supply. However, the increasing amounts of waste water from municipal, industrial, and agricultural users indicate there will need to be an upgrading of the waste water effluents. South of Marysville, the Big Blue River flows into Tuttle Creek Reservoir. Data collected by the Nebraska State Health Department indicate that both the phosphate and nitrogen concentrations are high enough to cause eutrophication at least in the upper reaches of the reservoir.

Table 7 shows the chemical water quality of the Big Blue River at Crete and Barneston based upon a large series of analyses by the Nebraska Department of Health. For each analysis, the maximum, minimum, and modal concentrations are given. The mode is the value which occurs most frequently and was used because it appeared to represent the most reliable value. The data in Table 7 show little change in the concentration of chemical ions between Crete and Barneston.[13]

TABLE 7
CHEMICAL SURFACE WATER QUALITY BIG BLUE RIVER
PPM

STATION	pH			HARDNESS			ALKALINITY			ORTHOPHOSPHATE			NITRATE		
	Minimum	Modal	Maximum	Minimum	Modal	Maximum	Minimum	Modal	Maximum	Minimum	Modal	Maximum	Minimum	Modal	Maximum
Crete	6.8	7.8	8.3	45	175	265	45	215	335	0.1	1.45	3.1	0.6	1.1	2.1
Barneston	6.7	8.0	8.7	15	175	285	35	200	275	0.3	1.2	2.9	0.01	0.01	1.8

Source: Nebraska State Department of Health (13)

The Biochemical Oxygen Demand (BOD) and the Chemical Oxygen Demand (COD) are commonly used as measurements of pollution. The BOD analysis measures the ability of the microorganisms to break down organic matter by biochemical oxidation and the COD analysis measures the ability of the available dissolved oxygen in the stream to break down the organic matter by chemical oxidation. Table 8 shows the BOD and COD concentrations in the Big Blue River at Crete and Barneston.[13] The dissolved oxygen content found in the river, plus the reaeration which occurs from water spilling over the power dams, appears to be adequate to carry out the necessary oxidation reactions.

TABLE 8
BOD AND COD CONCENTRATIONS
Big Blue River
(mg/1)

	BOD			COD		
	Min.	Mode	Max.	Min.	Mode	Max.
Crete	3.3	4.8	16.8	4	43	152
Barneston	3.0	4.3	14.7	8	35	156

Another indicator of water quality is the coliform bacteria count. The M.P.N. Coliform analysis is a measurement of a group of organisms which include all aerobic and facultative anaerobic nonsporeforming bacilli which ferment lactose with a gas formation. The interpretation of the M.P.N. Coliform count is difficult since many of the species of bacteria are common soil organisms.

The measurement of fecal coliform has recently been perfected so it can be done on a routine basis and provides a more realistic indication of pollution. A recent study by the Nebraska Department of Health indicates that, although many municipalities are contributing a heavy load of fecal coliform, the river has the ability to destroy the majority of these coliform by the time it reaches the state line.

WATER QUALITY GLOSSARY

PPM——Parts per million

Dissolved Solids——Total amount of organic and inorganic material, in solution in water or wastes. Public Health Service Drinking Water Standards recommend rejection of sources having more than 500 ppm total dissolved solids.

Turbidity——A measure of the fine suspended matter in liquids which prevents light passage.

MPN——Most probable number, reflects the bacterial density per 100·ml which would be likely to yield the observed results, or would yield the results with the greatest frequency.

Coliform Bacteria——Bacteria which are found in soil on vegetation, and in warm-blooded animals, and often used as an indicator of pollution.

pH——Represents the hydrogen ion concentration and is an indicator of alkalinity or acidity.

Alkalinity——Measure of water's ability to neutralize acid and is due primarily to the presence of hydroxide, bicarbonate, and carbonate.

Hardness——Represents the total concentration of calcium and magnesium ions expressed as calcium carbonate. Water with greater than 120 ppm concentration is considered hard.

Phosphate——May be measured as Orthophosphate (PO4) or as Total Phosphate. Found in wastes and synthetic detergents. Not considered harmful to humans. Traces of phosphate increase the tendency of algae to grow.

Nitrate (NO3)——Represents the most highly oxidized phase in the nitrogen cycle and, when excessive amounts occur, can contribute to the illness known as infant methemoglobinemia (blue babies).

Biochemical Oxygen Demand (BOD)——The quantity of oxygen utilized by bacteria in the oxidation of organic matter in a specified time at a specified temperature.

Chemical Oxygen Demand (COD)——Indicates the quantity of oxidizable compounds present in water, has sometimes been correlated with BOD.

Syndets——Synthetic detergents. Concentrations of 1 ppm can cause a light froth in water.

Chlorides——One of the major anions in water and waste water. Concentrations produce a salty taste and exert a deleterious effect on metallic pipes and agricultural plants.

Dissolved Oxygen (D.O.)——Amount of dissolved oxygen available for aquatic life. The lower limit for most fish is 5 ppm.

Eutrophication——The process of adding dissolved nutrients, especially nitrogen and phosphate, to a lake or river which in turn develops undesirable growths of algae making the water undesirable for fishing and recreation.

OTHER RESOURCES

People

Population of the Big Blue Basin was estimated by counties from the U. S. Census of Population and historic changes in population from 1870 to 1960 are shown in Table 2.

Population of the basin reached its peak of approximately 140,000 in 1890, compared to the 1960 total of nearly 107,700. This loss in population of approximately 32,000 has been an almost steady decline from 1890 interrupted only by the early 1900's and hastened by economic depression in the 1890's and 1930's. The loss of farm population and the lack of growth in the urban areas have been the major factors in the decline of population in the basin.

The historical base of the population in the basin has been in the rural areas which provided 65 percent of the 1960 population. This accounts for the relatively even distribution of population throughout the basin, as evidenced by the population density map, Figure 10.

For purposes of analysis, the population was broken down into three broad categories of urban, rural nonfarm, and rural farm. These categories are defined as follows:

Urban––Consists of the population of those cities of 2,500 or larger.

Rural Nonfarm––Consists of the population of those places of less than 2,500 and those living in rural areas, but not classified as farmers.

Rural Farm––Consists of the people living on farms.

Table 9 shows this population breakdown, both by number and by percentage, for the last three Census periods for the Big Blue Basin and the State of Nebraska.

Six urban areas lie within the basin and in 1960 made up 32 percent of the basin population. These six urban areas increased in population by 20 percent from 1940 to 1960, but by only five percent during the last ten years of that period. The proximity of the urban areas, Lincoln and Omaha, to the north and east of the basin, has hampered the historic growth potentials of these six urban areas. However, future growth is expected to occur in Beatrice, Crete, and Seward because of their location with relationship to Lincoln. The urban areas of the basin serve primarily as trade and service centers for the surrounding agricultural area.

An increasingly larger percentage of the basin population now resides in the rural nonfarm areas. The rural nonfarm category has increased from 29 percent of the total population in 1940 to nearly 36 percent in 1960.

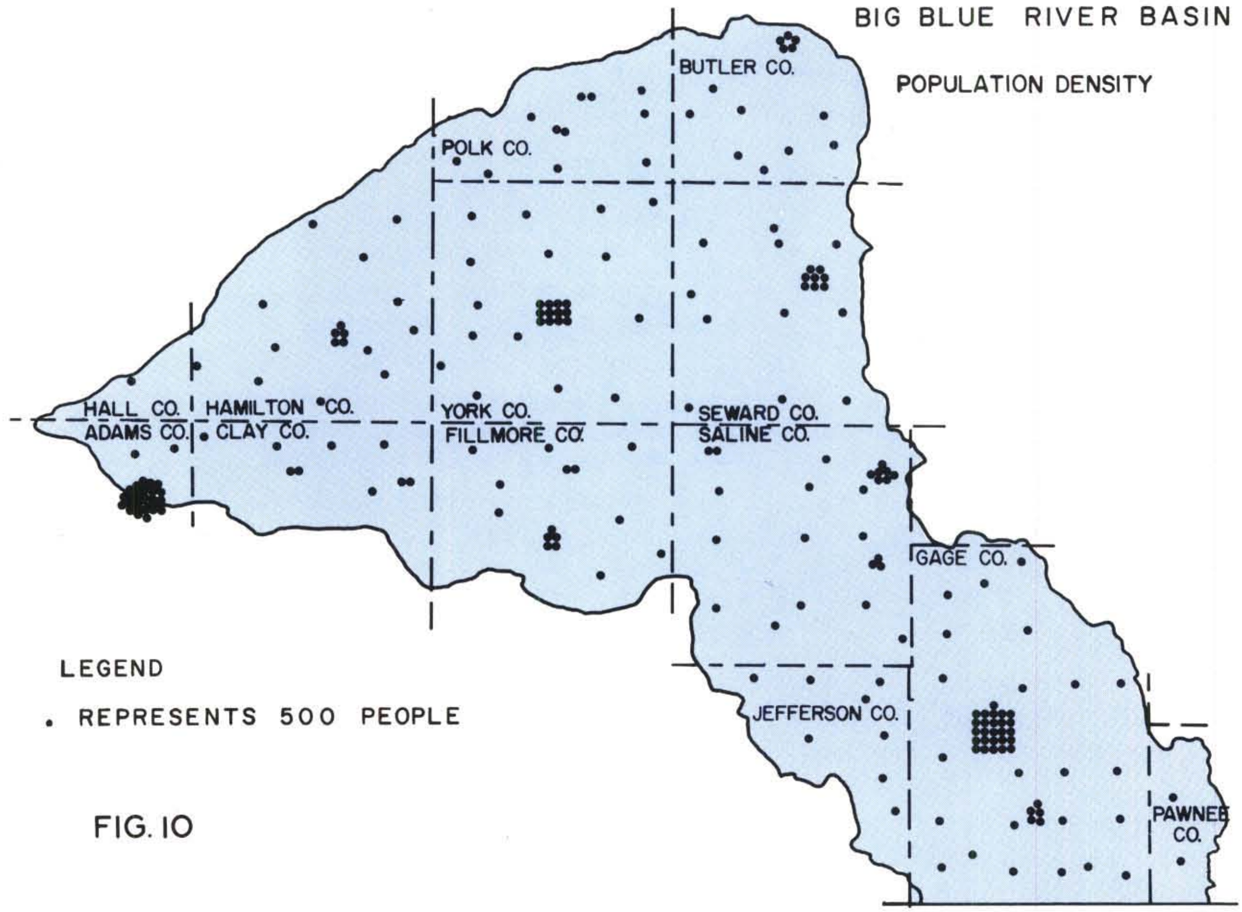


FIG. 10

TABLE 9
POPULATION DISTRIBUTION – BIG BLUE BASIN AND NEBRASKA

	BIG BLUE BASIN						NEBRASKA		
	Number			Percent			Percent		
	1940	1950	1960	1940	1950	1960	1940	1950	1960
Urban	28,335	32,345	33,988	23.5	28.9	31.6	39.1	46.9	54.3
Rural farm	56,903	45,000	33,831	47.2	40.3	31.4	37.6	29.5	21.9
Rural nonfarm	35,372	34,415	39,865	29.3	30.8	37.0	23.3	23.6	23.8
TOTAL	120,610	111,760	107,684	100.0	100.0	100.0	100.0	100.0	100.0

SOURCE: U. S. Department of Commerce, Bureau of Census, U. S. Census of Population

If the rural nonfarm category is broken down in more detail and the communities separated as in Table 10, a residual population is revealed. This residual segment is composed of people who live outside corporate limits of cities and villages, but are not classified as farmers. The growth in this residual segment has been greater than the growth in the total rural nonfarm category during the 1940-1960 period. This points out that the growth in the rural nonfarm category has been linked to the rural nonfarm segment, rather than growth in any of the smaller communities. Analysis of this segment by counties shows that two-thirds of this gain came in the six counties where urban areas are located and suggests that the growth in the rural nonfarm category is more closely related to urban growth.

Table 10 shows that the overall performance of the smaller communities was much better during the 1950 to 1960 decade than during the previous decade. This might indicate that some stabilizing effect is taking place in these areas.

The farm population of the Big Blue Basin has decreased from 47 percent of the total population in 1940 to 31 percent in 1960. (6) This trend in quite similar to the decreasing farm populations both in the state and the nation. Increases in farm size and concurrent decreases in farm numbers, caused by the substitution of agricultural technology for labor, has resulted in this decreased farm population.

TABLE 10
POPULATION CHANGES IN THE RURAL NONFARM CATEGORY
BIG BLUE BASIN

Category /1	NO.	1940 POP.	1950 POP.	1960 POP.	Change 1940-1960		Change 1950-1960	
					Total	Percent	Total	Percent
250	31	5,935	4,728	4,562	- 1,373	- 23.1	- 166	- 3.5
250-500	15	6,220	5,628	5,202	- 1,018	- 16.4	- 426	- 7.6
500-1,000	7	4,483	4,295	4,494	+ 11	+ .2	+ 199	+ 4.6
1,000-1,500	7	7,556	7,911	8,659	+1,103	+ 14.6	+ 748	+ 9.5
1,500-2,500	3	6,617	6,610	6,631	+ 14	+ .2	+ 21	+ .3
Other /2		4,356	4,920	10,191	+5,835	+134.0	+5,271	+107.1
TOTAL	63	35,167	34,092	39,739	+4,572	+ 13.0	+5,647	+ 16.6

1/ Cities and villages of less than 2,500 population grouped by 1960 size.

2/ Those people who reside outside of incorporated places, but not on farms.

SOURCE: U. S. Department of Commerce, Bureau of Census, U. S. Census of Population

The 1960 employment was comprised of 32.6 percent on farms; 13.6 percent in forestry, mining, construction, and manufacturing; and 53.8 percent in the trade and service sector. A comparison of employment data in Table 11 shows that the agricultural industry has been the only category suffering significant employment losses. However, the losses in agricultural employment have been quite similar to the losses in agricultural employment in the remainder of the state and nation. While there has been some growth in the other employment sections, their growth has been at a slower rate than the state and national trends. This illustrates that the lack of good growth in the nonagricultural sectors has caused the economy of the Big Blue Basin to lag behind the growth rates of the state and the nation.

A comparison of the population growth of the Big Blue Basin and that of the state for the past two decades indicates:

1. The loss of farm population in the basin has been nearly the same as the loss of farm population throughout the state.

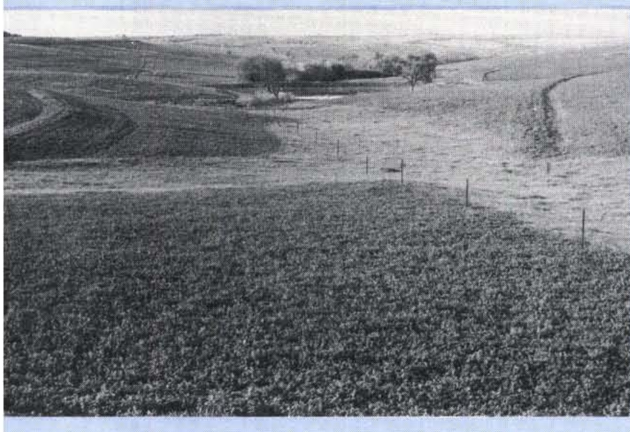
2. The small growth in the rural nonfarm category has been quite similar to the state trend.

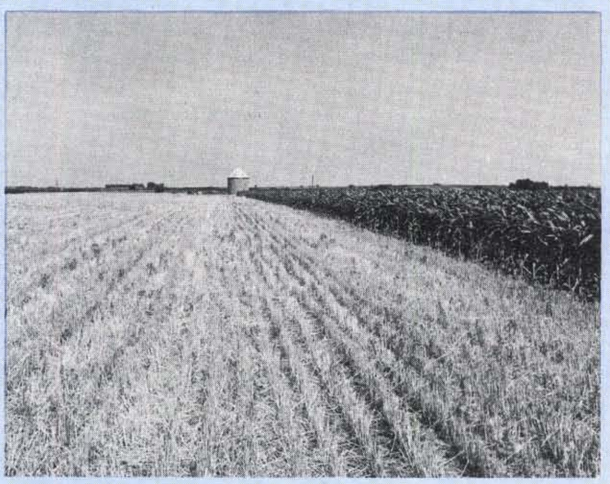
3. The 20 percent gain in urban population has been decidedly less than the nearly 47 percent gain for all urban areas in the state.

TABLE 11
EMPLOYMENT IN THE BIG BLUE BASIN

	1950	**1960**
Agriculture	17,372	12,600
Forestry and Mining	82	47
Contract Construction	2,152	1,923
Manufacturing	2,771	3,275
Transportation, Communication and Public Utilities	2,417	2,428
Wholesale Trade	1,350	1,284
Retail Trade	5,487	5,788
Finance, Insurance, and Real Estate	730	953
Service	7,584	9,588
Other	957	738
TOTAL	40,902	38,624

SOURCE: U. S. Department of Commerce, Bureau of Census, U. S. Census of Population





Agriculture

The Big Blue River Basin lies in a transitional zone between the Corn Belt on the east and the Central Great Plains on the west. Farms are mostly diversified family-size units. The lack of adequate rainfall in some years has encouraged extensive private irrigation development in the basin resulting in the establishment of corn as the most important crop, with milo and wheat being important dryland crops. Livestock production accounts for over half of the gross farm sales of farmers in the basin and is an increasingly important source of farm income as exhibited by the figures in Table 12.

The net income of farm families in the Big Blue Basin has historically been somewhat below nonfarm income in the basin and in other areas, but quite similar to farm income in other parts of the state and nation. This points out the characteristic low income problems associated with the agricultural industry.

As discussed previously, employment in agriculture has declined steadily in the past, caused by the substitution of technology for labor and the resulting increases in farm size. Agricultural employment composed one-half of the working force in 1940 compared to approximately one-third in 1960.

The decline in farm numbers and the resulting increase in farm size, not unlike agriculture in most areas, is also apparent in the Big Blue Basin. The average farm size and number of farms in the basin, as shown in Table 13, have made dynamic changes in the twenty years since 1944. The total number of farms has decreased from 13,402 in 1944 to 9,540 in 1964 and the average farm size has increased from 212 acres in 1944 to 301 acres in 1964.[6] Improved agricultural technology has played a major role in this change and is expected to continue to be a prime factor.

Agriculture has increasingly become a high investment industry. The 1964 Farm Census listed the average value of land and buildings on farms in this area as $64,500 per farm. Value of farm real estate per acre has nearly tripled between 1944 and 1964 due both to actual increases in general land values and large capital investments in private irrigation development.

In 1964 cash receipts from livestock and crop sales were 144 million dollars, an average of $15,100 per farm, and an increase of 163 percent over 1944.

TABLE 12
VALUE OF FARM PRODUCTS SOLD
BIG BLUE BASIN

FARM PRODUCTS SOLD	1944	1949	1954	1959	1964
Milk, Cream & Dairy Products	4,197,700	4,521,000	5,070,200	5,599,600	6,004,100
Poultry & Products	6,679,800	6,476,700	4,462,800	3,985,800	3,036,400
Other Livestock & Livestock Products	19,981,400	28,724,800	33,730,600	52,909,600	78,732,800
Forest Products Sold	5,000	5,600	7,200	13,200	9,400
Crop Sales	24,085,800	34,680,400	45,626,300	63,979,100	56,593,600
TOTAL SALES	54,949,700	74,408,500	88,897,100	126,487,300	144,376,300

SOURCE: U. S. Department of Agriculture (6)

TABLE 13
FARM SIZE AND FARM NUMBERS
BIG BLUE BASIN

	1944	1949	1954	1959	1964
TOTAL NO.	13,402	12,973	11,957	11,003	9,540
			PERCENT		
< 100 acres	16.5	16.9	13.6	13.9	14.0
100-179 acres	30.3	28.5	26.7	21.5	17.5
180-259 acres	26.2	26.1	26.2	23.2	17.9
260-499 acres	24.6	25.5	29.9	35.6	38.7
> 500 acres	2.4	3.0	3.6	5.7	11.9
Average Size (acres)	212.0	218.0	235.0	261.0	301.0

SOURCE: U. S. Department of Commerce, Bureau of Census, Agricultural Census, 1959

Industry

Industrial development has historically been limited in this area because of geographical location, unavailability of many natural resources, limited supplies of skilled labor, certain institutional factors such as state and local regulations, and competition for industry from the larger urban areas. Industrial development potential is in those industries which are not market or resource oriented but whose market or resource supply is based on agriculture. Normally industries which are not market or resource oriented are small in nature.

The basin employed 3,275 people in manufacturing, 1,923 in contract construction, and 2,428 in transportation, communications and public utilities in 1960. (6) This was a gain of only 286 employees since 1950 in the nonagricultural sector. The 1950-1960 rate of growth in these sectors was somewhat less than state trends and occurred at a time when the basin lost 4,772 employees in the agricultural sector.

The 1958 Census of Manufacturing listed approximately 110 manufacturing plants in the basin. Only ten of these employed 100 or more people and 44 of these plants appeared to be linked directly to agriculture. Manufacturing establishments in the basin are generally small and many are oriented toward agriculture. Plants in the garment, mobil home, pet food, boat-trailer, and heating and air-conditioning equipment industries, some of which have been in operation since 1958, are among those employing 100 or more people. Recent trends toward decentralization of industries, such as the meat packing industry, may hold some promise for increased industrial production in this area.

Fish, Wildlife and Recreation Resources

The major wildlife resources of the Big Blue Basin consist mainly of upland game birds, waterfowl and deer. Some of the better quail and pheasant hunting areas of the state are found in this region. Fertile soils, generally favorable climatic factors and an abundance of food support good game bird populations. Nesting cover is the principal limiting factor of pheasants. Severe winter weather limits quail populations in certain years. However, a series of mild winters will easily allow the buildup of quail populations.

Cottontail rabbits are generally abundant over most of the basin. Squirrel and deer are of lesser importance due to habitat restrictions. The stream courses, occupying a small part of the total land area of the basin, constitute the primary squirrel and deer habitat. Deer were rare as recently as ten years ago, but deer hunting is increasing in the basin with an estmated 300 head harvested in 1965. (3)

The basin is considered an important waterfowl resource area from a regional and national standpoint. Variable rainfall conditions make some depressional ponds in this area unfavorable for sustained use but they are considered important enough for waterfowl production, even during drought periods, that the U. S. Fish and Wildlife Service has acquired several marsh areas. Waterfowl use includes feeding and resting areas used during the spring and fall migration periods. The Bureau of Sport Fisheries and Wildlife, under the Wetland Acquisition Program, has delineated approximately 8,000 acres for purchase and have acquired about 2,600 acres to date. During the 1956-64 period, a period including drouth years and restrictive regulations, the estimated average annual duck harvest in the basin was 29,000. (3)

Fishing waters in the basin are less plentiful than in other parts of the state but do provide opportunities for many fishermen every year. The Big Blue River is well recognized as one of the better cat-fishing streams in the state. Small numbers of warm water sport fish such as bass, bluegill, and crappie are also present. Many of the smaller lakes are over-populated with non-game fish such as carp, bullhead and drum. (3) The streams in this area are warm water streams and nearly all require private access. Public fishing is provided at eight lakes totaling some 112 acres owned by the Nebraska Game and Parks Commission and at four points on the Blue River. Fishing in farm ponds and small watershed structures has increased in recent years.

There are a very limited number of public owned camp grounds or water-based recreational areas in the basin. While most of the larger towns have municipal swimming pools and parks, suitable areas for most forms of out-door recreation are extremely limited.

The historical aspects of the basin are not of great general significance. However, the site of the first homestead filed under the Homestead Act of 1862 has been preserved at Homestead National Monument located in Gage County just west of Beatrice. Another area worthy of mention is the site of the Otoe Indian Reservation near Wymore. This village existed during the period 1855-1882 prior to movement of the Otoes to Kansas.

Other Natural Resources

Natural resources other than those already discussed are quite limited. The only mineral resources of significance are sand, gravel and rock deposits. Some tests for gas and oil have been made but no commercial production has been developed.

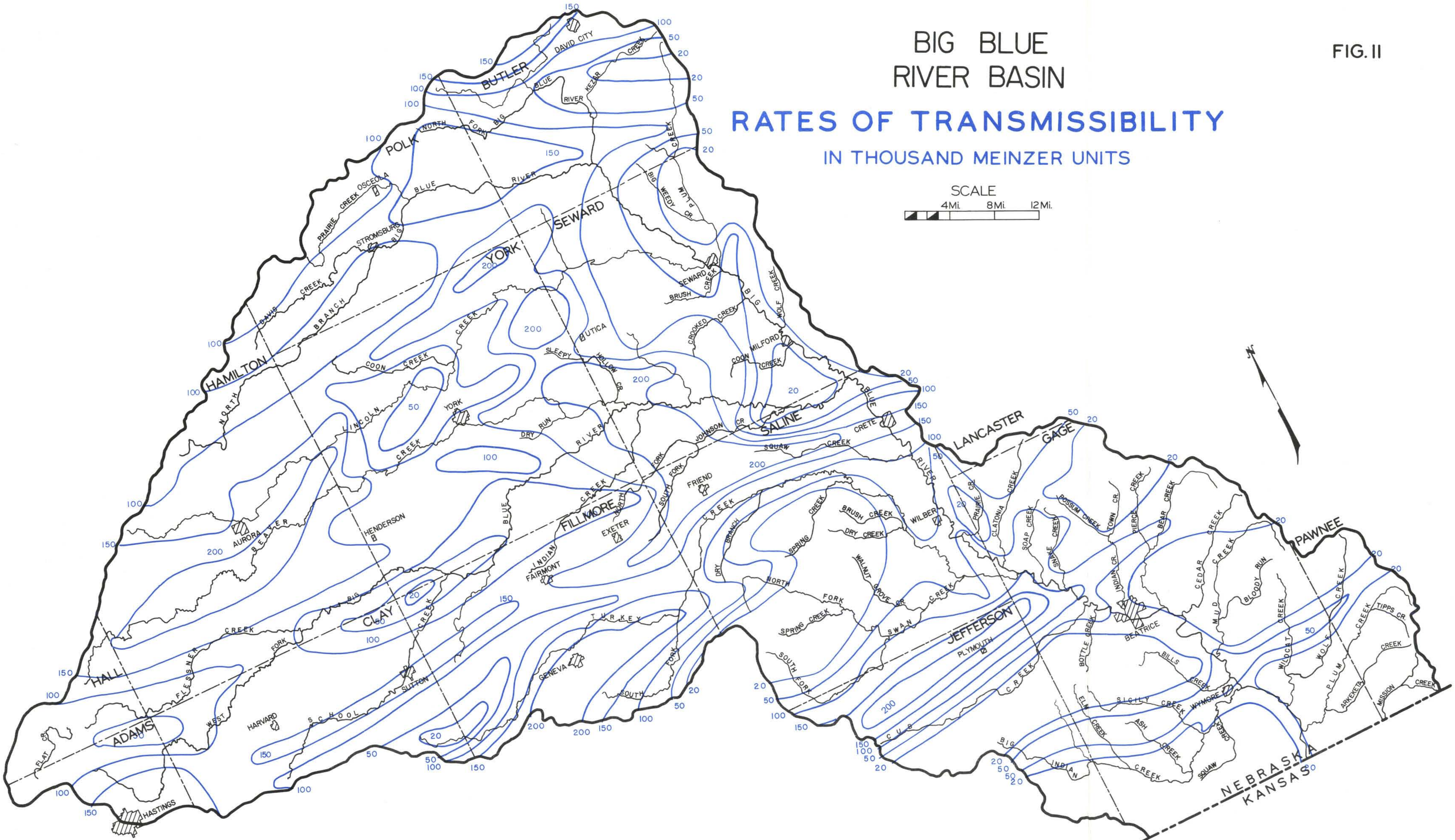
The forest resource of the Big Blue Basin consists mainly of bottomland hardwoods. Economic returns for quality hardwoods have improved in recent years. The management of high value species such as walnut, oak, and hackberry, and closer utilization of cottonwood and other species for pallets, chips and pulp, should continue to improve the economic return. Many of the stands of American Elm in the upper parts of the basin are infested with Dutch Elm disease. This creates a debris accumulation problem in areas where these stands are adjacent to the stream channels. Better utilization of wood products will remove from the stands much of the logs, limbs, and other debris that have contributed to channel plugging in the basin.

FIG. II

BIG BLUE RIVER BASIN

RATES OF TRANSMISSIBILITY

IN THOUSAND MEINZER UNITS



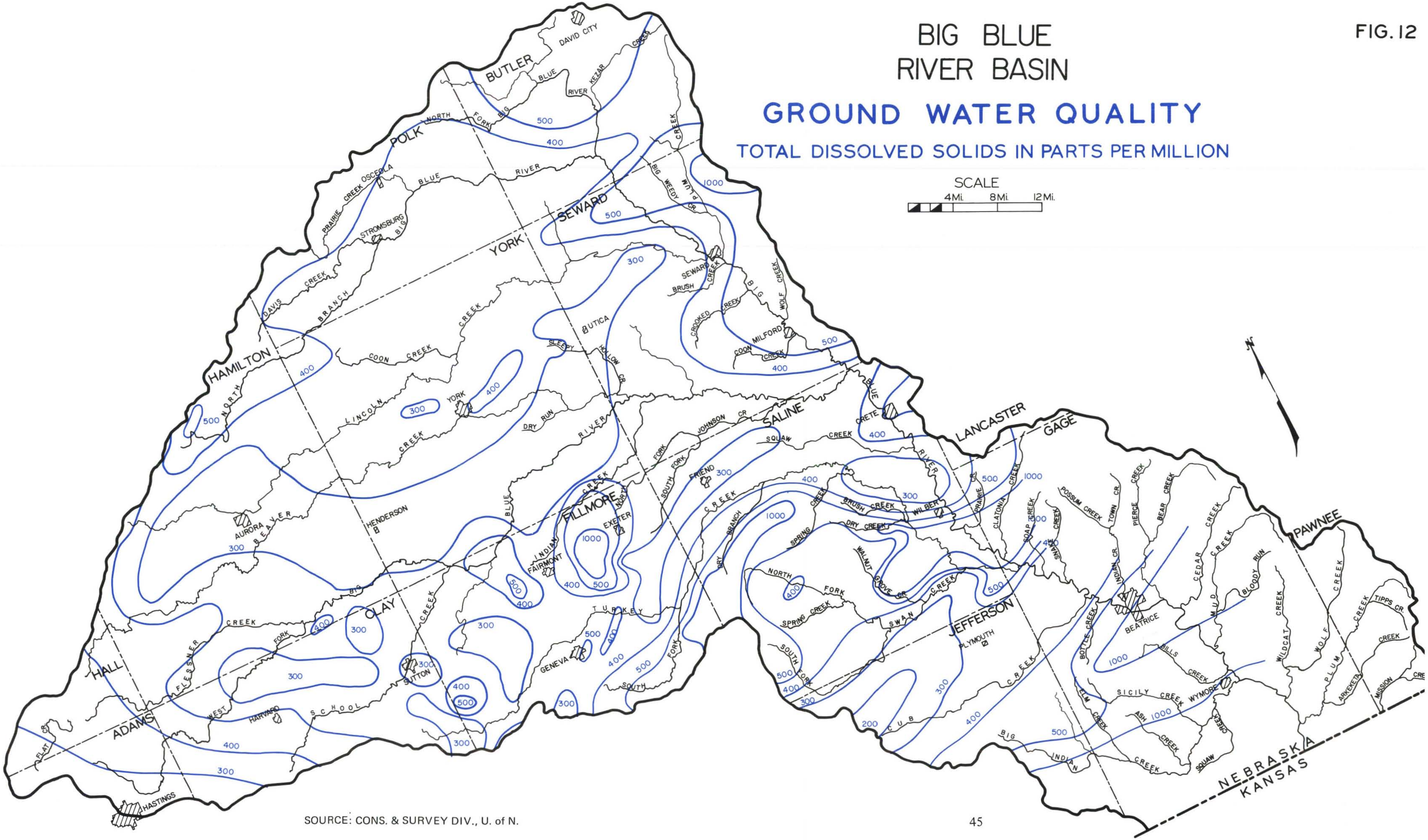
SOURCE: CONS. & SURVEY DIV., U. of N.

FIG. 12

BIG BLUE RIVER BASIN

GROUND WATER QUALITY

TOTAL DISSOLVED SOLIDS IN PARTS PER MILLION

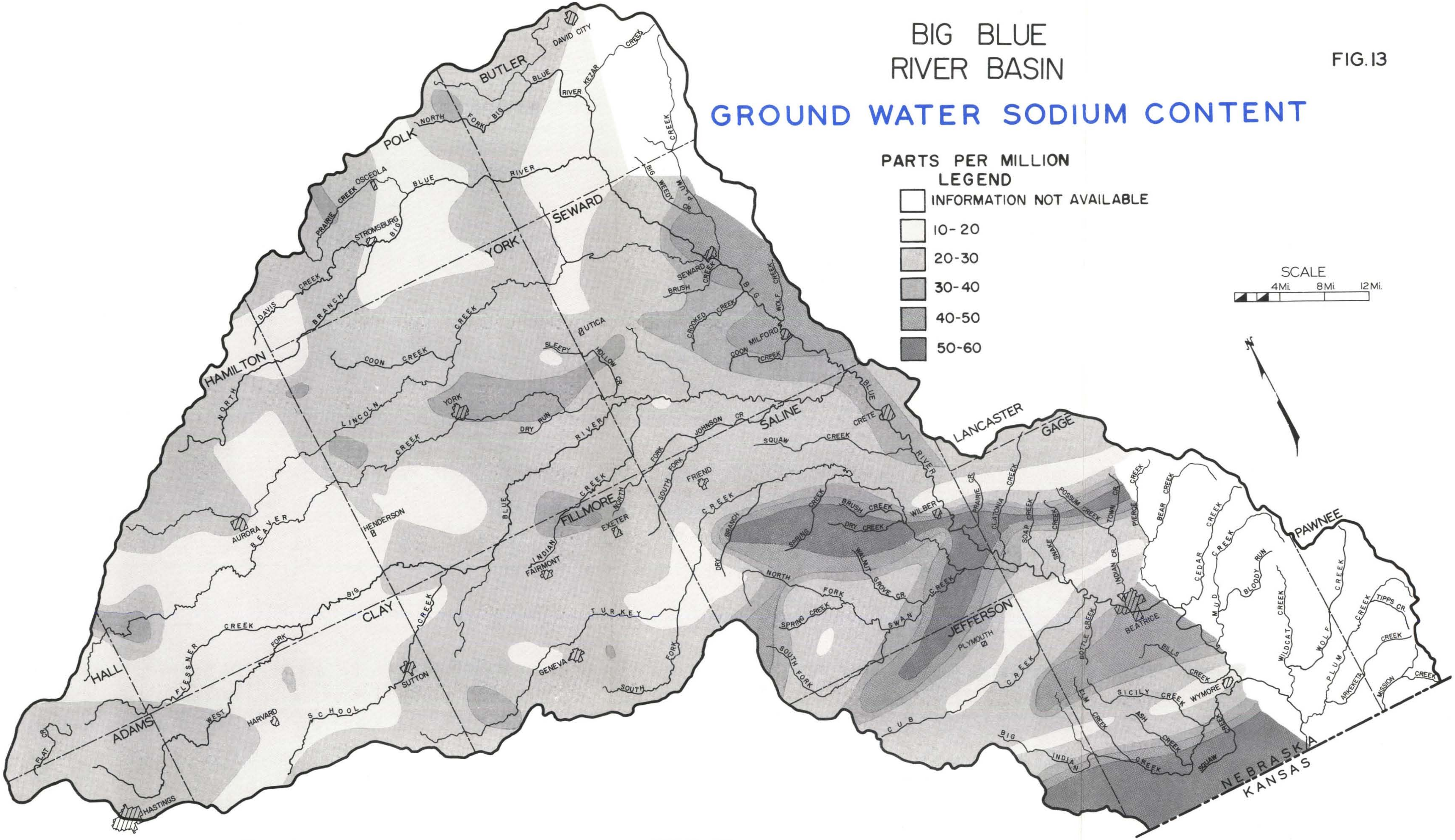


SOURCE: CONS. & SURVEY DIV., U. of N.

BIG BLUE RIVER BASIN

FIG. 13

GROUND WATER SODIUM CONTENT



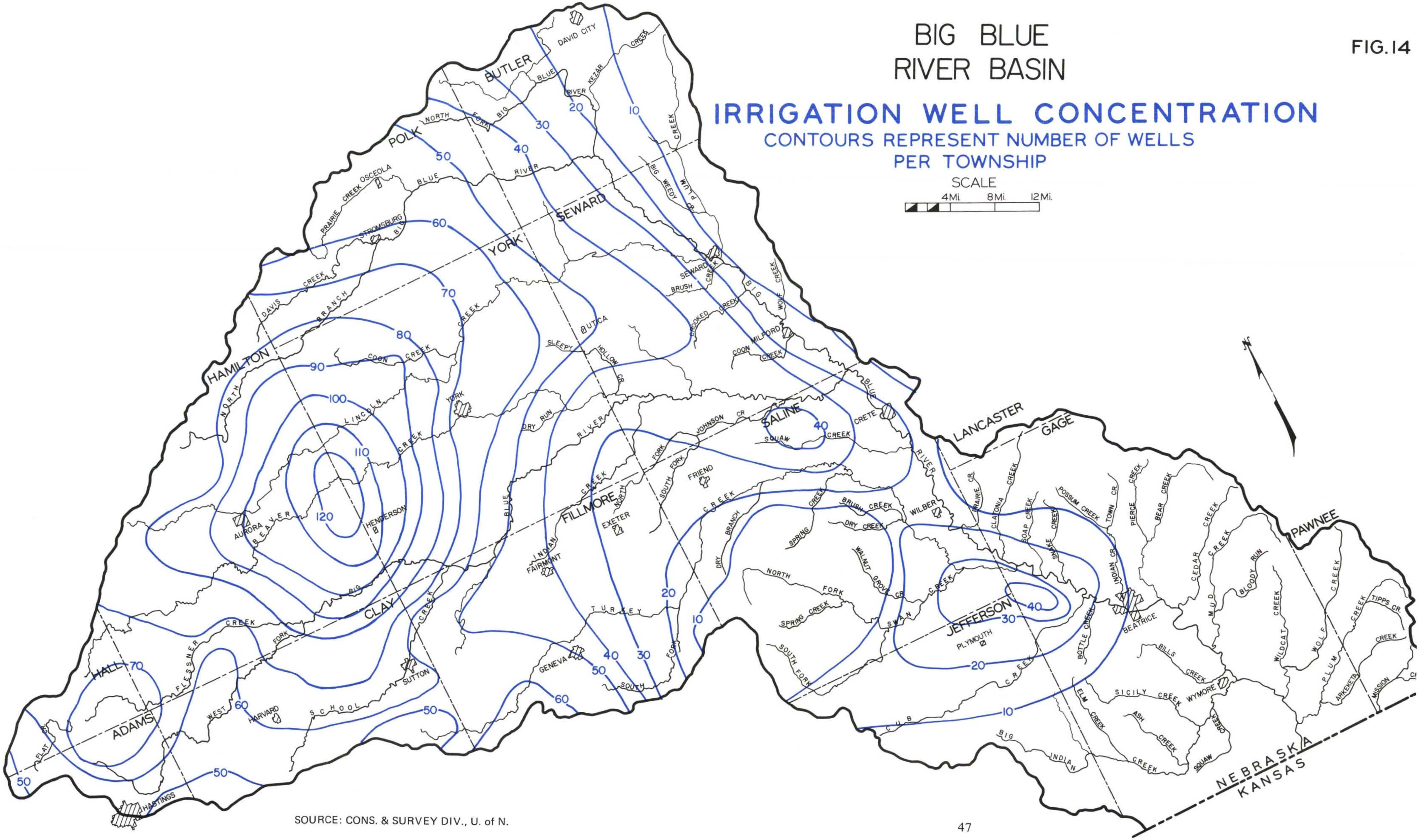
SOURCE: CONS. & SURVEY DIV., U. of N.

FIG. 14

BIG BLUE RIVER BASIN

IRRIGATION WELL CONCENTRATION

CONTOURS REPRESENT NUMBER OF WELLS PER TOWNSHIP



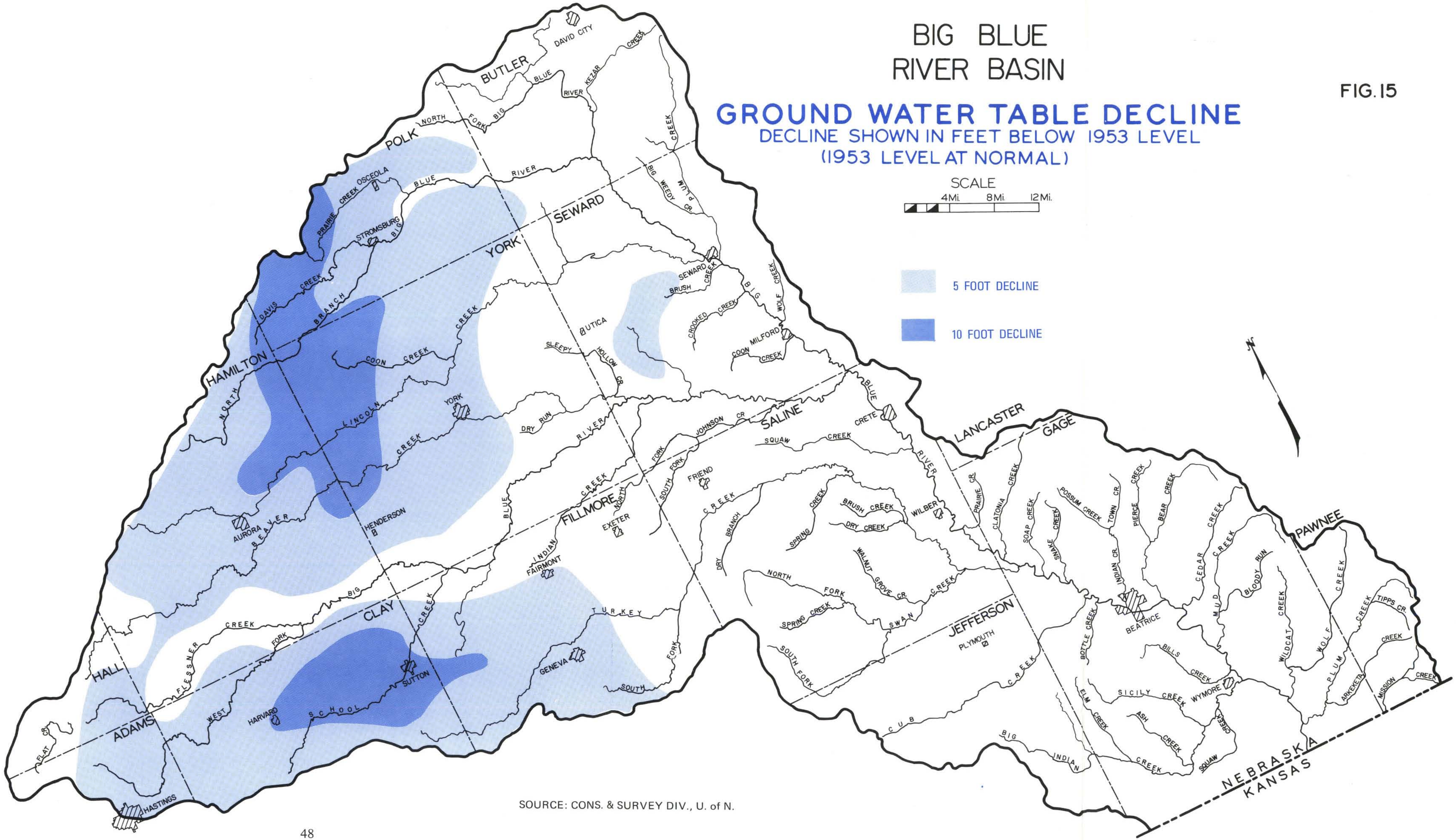
SOURCE: CONS. & SURVEY DIV., U. of N.

BIG BLUE RIVER BASIN

FIG. 15

GROUND WATER TABLE DECLINE

DECLINE SHOWN IN FEET BELOW 1953 LEVEL
(1953 LEVEL AT NORMAL)



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BASIN NEEDS

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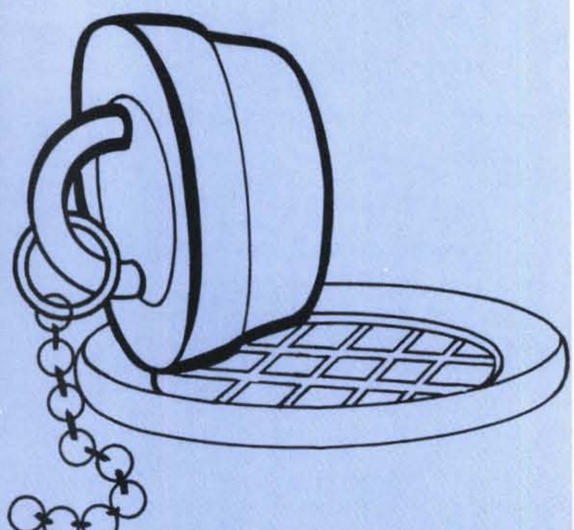


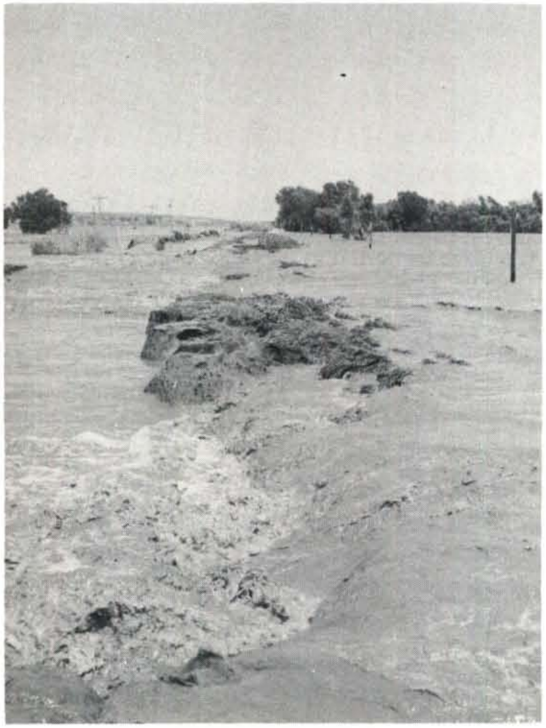
DRAINAGE

Drainage needs are quite evident in the upper regions of the Big Blue Basin where topography is flat and channels are poorly defined. Many of the tributaries have level upper valleys with low, broad ridges and table lands between the principal drainage ways producing poorly defined water courses. Water from heavy storms ponds in the upper areas and does not drain out. There are about 110,000 acres of agricultural land in the basin with this type of damage, of which approximately 87,000 acres are considered to need project action.

Several drainage districts have been organized in the past–some before the turn of the century. The number still in operation is unknown but it is believed about a half dozen maintain some degree of activity.

At the present time one local organization has requested assistance in planning a project for alleviation of drainage problems. The area requesting drainage includes about 3,700 acres near the village of Exeter in Fillmore County. The primary cause of this particular problem is a clay layer causing a perched water table in a depressional area having poorly defined surface drainage channels.

FLOOD CONTROL



Widespread and intense rainfall often causes severe but localized flooding in many areas throughout the basin. Flood water damages from over-bank flows are significant on about 242,000 acres of flood plain lands in the Big Blue Basin. About 50,000 acres of these flood prone lands are on the Big Blue mainstem and the lower reach of the West Fork, and the remaining 192,000 acres are located on the other tributaries. [6]

Associated with the flood damage problem on the tributaries is the erosion and sedimentation problem. Many of the stream channels on these tributaries have been partially filled with sediment and are often clogged with debris and excessive growths of weeds and trees. In addition, channel conditions on the tributaries in many cases, are so poor that over-bank flow occurs from storms of less than annual frequency. [6] The effect of these clogged channels on the stage-discharge relationship is apparent in Table 14.

Flooding causes heavy losses to the economy of the Big Blue Basin. Reduced yields and lower use of the land are the principal items of damage with roads, bridges and urban damages next in consideration of total damages. Portions of 20 communities are subject to damage by overflow from floods on the larger tributaries and the mainstem. Table 14 shows the number of acres that have been flooded by various floods in the basin.

TABLE 14
MAXIMUM FLOODS OF RECORD ON BIG BLUE RIVER IN NEBRASKA
RECORDED FLOOD

Station	Flood Stage (Ft.)	Date	Observed Stage (Ft.)	Discharge (CFS)	Acres Flooded In Basin
Barneston	22.0	June 1941	34.3	57,700	82,000
Crete	15.5	July 1950	28.7	27,600	72,000
Barneston	22.0	June 1951	28.8	26,000	138,380
Seward	18.0	June 1957	22.3	15,300	65,700
Ulysses	15.0	June 1963	24.9	———	25,400
Crete	15.5	June 1967	29.8	24,500	———
Seward	18.0	June 1967	22.8	14,500	———
Barneston	22.0	June 1967	26.4	27,000	———

SOURCE: Department of Water Resources and Geological Survey

The channels in the upper reaches of the principal tributaries have very flat gradients and are joined by other channels from the broken table lands passing through narrow V-shaped valleys with moderate to steep side slopes. The sloping valley walls are generally cropped with resulting runoff leading to sheet and rill erosion. Such sheet and rill erosion of cropland and over-grazed pasture land produces most of the sediment carried by streams in the Big Blue River Basin. The main sediment damage comes from deposition in stream channels which reduces channel capacities and causes more frequent over-bank flooding. The sediment also decreases the effectiveness of the reservoirs and dams constructed in the Big Blue Basin by reducing the pool volumes. Sheet and rill erosion is of concern in all parts of the basin but is most serious in the Loess-Drift Hills physiographic area. The gradual removal of the thin cap of highly productive loess is exposing undeveloped and much less productive underlying glacial and residual soil materials. Sheet erosion is also high on grasslands and woodlands because over 60 percent of these grazed areas in the basin have been severely overgrazed.

Gully erosion, like sheet erosion, is most prevalent in the southeastern portion of the basin. Unstable base grades in water courses result in deep gullies, often with active over-falls at their heads and subsequent loss of production from the voided and depreciated areas, reduced production from the adjacent area due to accelerated sheet erosion, increased cost of crop production, and the cost of installing conservation measures for grade stabilization.

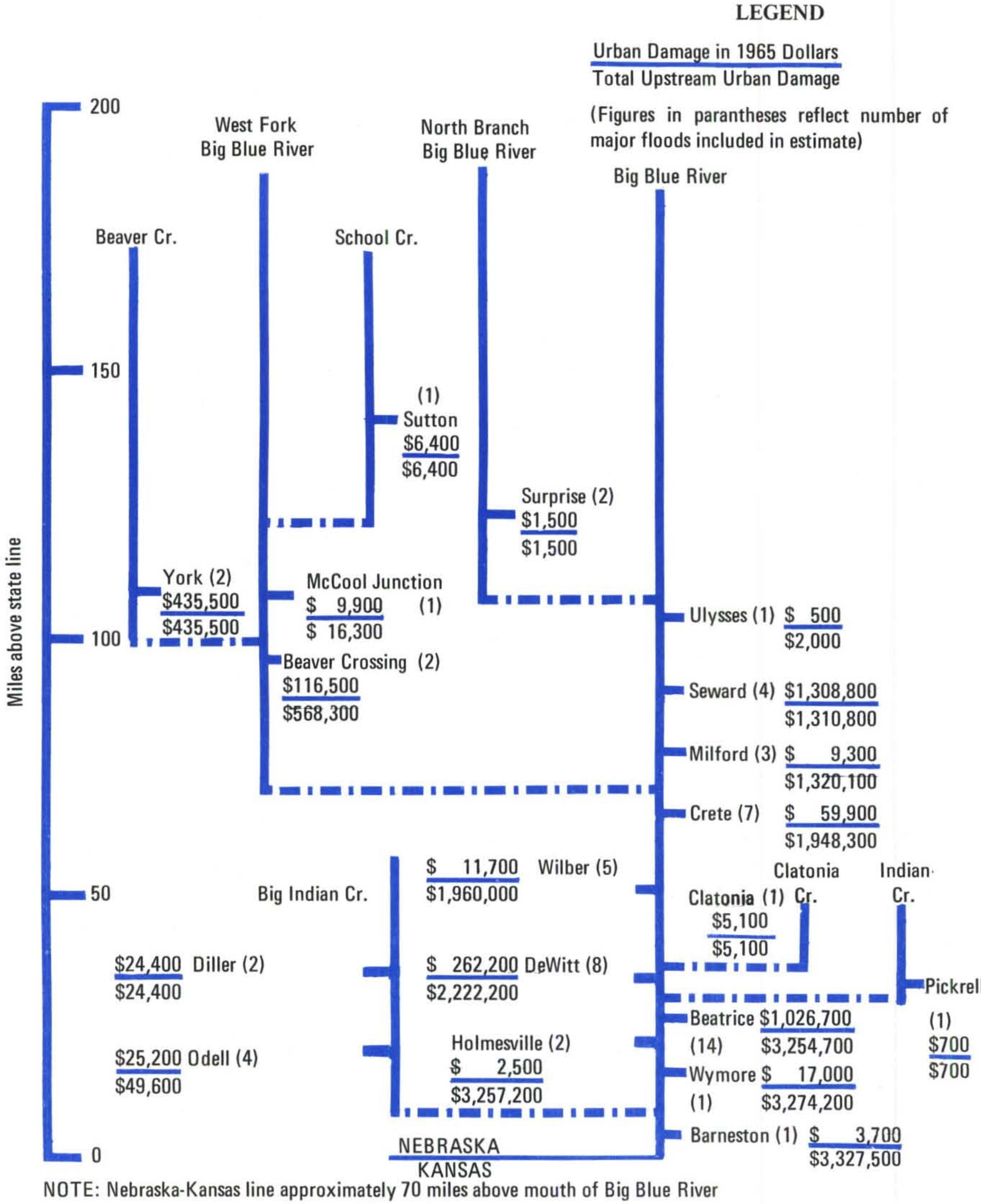
In most cases the application of sufficient land treatment measures on the cropland and the proper management of grass and woodlands will control gully formation. However, there are numerous areas which require installation of erosion control structures. The severe stabilization problem areas needing project action have a total drainage area of approximately 118,400 acres. (6)

In some localized reaches, particularly along the larger tributaries in the lower basin, stream bank erosion and flood plain scour have caused either a permanent loss of good agricultural land or have materially reduced the productive capacity of the bottomlands. Streamflow records indicate that flooding has occurred somewhere in the basin in 35 of the 64 years of the period 1902 through 1965. The recent flood in June, 1967, approached or surpassed record stages in the basin from Seward to Beatrice and once again pointed out the urgent need for a complete flood control program. Preliminary estimates indicate damages of over $2,000,000. Local protection works at Seward prevented severe damage to the city but considerable losses were sustained in the unprotected areas near Seward and elsewhere along the Big Blue River and lower reaches of certain tributaries. The record 1951 flood damaged 138,000 acres of rural area. Only a small portion of this flooded acreage would be protected by existing and currently authorized projects. The existing and authorized local protection projects offer little protection for the agricultural flood plains on the Big Blue River and its tributaries. Studies indicate that transposition of the 1951 storms over the Big Blue Basin could result in flood runoff which the Tuttle Creek Reservoir in Kansas could not completely control and which would cause discharges in excess of design capacity and damage approximating one billion dollars at the Kansas Cities alone. (9) Backup flood control storage for Tuttle Creek Reservoir is considered desirable in the Big Blue Basin with incremental benefits for this storage estimated at about three million dollars annually. Figure 16 is a schematic diagram showing the Big Blue River and estimated flood damages which have occurred since 1940 at various municipalities within the basin. It might be emphasized that this figure does not include all damages but does include major flood damages through 1965 as estimated by the Corps of Engineers and updated by the Soil and Water Conservation Commission. Figure 18 shows the locations which have received flood damages in the past.

An example of the problems created by the meandering water course of the Big Blue River is a large log and debris accumulation located near DeWitt, Nebraska upstream from Beatrice. This large log jam has been in place for several years and has increased flooding and the related damages. It also has the potential of becoming dislodged during a high flood flow and damaging many highways and railroad bridges as it moves downstream. This type of problem is not unusual in the Big Blue Basin.

Nearly 300 small water storage structures exist in the Big Blue Basin. These are mostly farm ponds but also comprise some small watershed structures constructed on the various watershed projects. Of these 118 were large enough to require storage right filling with the State Department of Water Resources and 87 of these have a total reported storage of 41,078 acre feet.

FIGURE 16
ESTIMATED URBAN FLOOD DAMAGE
FOR 1940-1965 PERIOD



NOTE: Nebraska-Kansas line approximately 70 miles above mouth of Big Blue River

Desirable floodwater retarding sites are not available in most upstream areas of the Central Loess Plains. This creates a problem since a complete flood control program involves more than large mainstem reservoirs. Runoff can be partially controlled by improved channels in the upper main valleys and tributary stream reaches and also on the flat lands between the major drainage ways. In the central or middle portion of the basin, the major streams have sufficient capacity to contain the more frequent flood peaks. However, channel clearing and removal of excess dense brush debris and dead trees needs to be carried out in this area to improve the carrying capacity of the streams. The installation of drop inlets, drop spillways, concrete trickle channels and vegetative waterways is needed to control gullies and head cuts throughout the basin. The drop inlets and drop spillways re-establish the channels on nonerosive grades while concrete trickle channels and vegetative waterways reduce the erosive action on the water courses.

The small watershed project is primarily designed to alleviate rural flood damages thereby providing more usable farmland and higher crop yields. Table 15 shows a complete list of the watersheds which have been organized in the Big Blue Basin giving total acreages, planning and construction status, and the percent of flood water damage to be eliminated upon completion.

IRRIGATION

While irrigation in this basin was first resorted to as a means of compensating for drought conditions, experience during the past two decades has demonstrated the deficiencies in growing season moisture in most years. The benefits of providing adequate moisture for crops, particularly in the July-September period, have been well demonstrated and this has resulted in a rapid increase in the acreage of irrigated land. Even so, the need is still apparent during the following periods of severe drought.

A sharp increase in irrigation well construction was noted during the dry period of 1955-1956. This was the driest two-year period on record even surpassing those of the 1930's. This area of the state normally receives a greater amount of precipitation than those regions west and north and thus has a lower irrigation requirement. On-farm requirements for irrigation water are estimated to range from 0.50 to 0.95 foot per acre.

Lands in the eastern half of the basin have been investigated to determine their suitability for surface water irrigation. This reconnaissance investigation covered some 200,000 acres believed capable of receiving service from selected storage sites and resulted in four acres in the basin being classified as to their irrigability. The land suitable for irrigation in these four areas totaled 125,000 acres. (5) These areas are located in Butler, Seward, Saline, Jefferson and Gage Counties along the west side of the Big Blue River as shown in Figure 17. This survey covered only those lands which were located below potential storage sites having runoff sufficient to irrigate large blocks of lands. Many additional acres located in the upper basin are suitable for irrigation but have not been surveyed to date.

A large percentage of the land classified as irrigable is presently being irrigated from ground water. The estimated amount of available surface water will be sufficient to supply about 43,000 acres not presently irrigated. The irrigation water requirement was estimated by a consumptive use method utilizing temperature records from Lincoln and precipitation records from Seward. The average seasonal requirement was estimated at 0.67 foot per acre at the point of plant use and about 1.50 feet per acre at the diversion point.

TABLE 15
SMALL WATERSHED SUMMARY

Watershed	Counties	Acres	Percent Planned	Percent Construction July, 1967	Number of Structures*		Percent Damage Reduction
					Proposed	Completed	
Big Indian	Gage, Jefferson	131,700	100	34	35	16	79
Cub Creek	Gage, Jefferson	92,300	100	5	29	1	73
Little Indian	Gage	47,900	100	100	63	63	not available
Dorchester	Saline	5,300	100	75	5	4	73
Plum	Gage, Pawnee	44,700	100	55	32	22	73
Mud	Gage	38,900	100	45	29	14	79
Soap	Gage	25,400	71				
Bear–Pierce–Cedar	Gage	76,800	100	20	33	10	68
Dry	Jefferson, Saline	8,300	10				
West Ulysses	Butler	2,400	0				
Mission Creek	Pawnee, Gage, Kansas	22,500	100	3	16	0	72
Clatonia	Gage, Lancaster	25,300	100		8	0	70
Swan	Saline, Jefferson	156,200	0				
Wolfe-Wildcat	Gage, Pawnee	57,000	0				
Dogtown	Fillmore	8,000	0				

* Includes both flood control and grade stabilization structures

SOURCE: U. S. Department of Agriculture (6)

MUNICIPAL AND INDUSTRIAL WATER

At present approximately 25 million gallons per day, or about 9 billion gallons per year, of municipal and industrial water is utilized in the Big Blue Basin. This compares to 40 million gallons per day pumped for agricultural uses excluding irrigation and over 100 billion gallons utilized annually for irrigation.

While industrial activity in the basin is low, some new plants have been constructed such as the Phillips Petroleum Company and the Cominco Products Inc. fertilizer plants near Beatrice. A large scale increase in the use of industrial water is not expected to occur in the basin within the next 20 to 30 years. Some hydropower plants exist at present but the use of water for power generation in the Nebraska portion of the Big Blue Basin is rapidly being discontinued. The plant at Hastings, Nebraska is presently using ground water for cooling purposes after which it is discharged into a branch of the West Fork of the Big Blue River adding 12 cubic feet per second of flow to this branch.

All of the towns in the basin obtain their present water supplies from wells and many towns bordering the streams discharge their sewage effluents into the streams. Table 15 shows typical chemical analyses of public water supplies in the basin. This table shows three towns, Dwight, Rising City and Marquette that are presently using water that exceeds recommended nitrate levels. The sulfate level of water supplies for Marquette and Odell is above the recommended limit.

POLLUTION ABATEMENT

It would appear that in the near future there may be inadequate flows for the abatement of waste effluent at Hastings and York. According to computer studies by the Federal Water Pollution Control Administrations, there is a present need for abatement of waste effluent at Hastings and York, Nebraska. (7) Due to inadequate streamflows at these towns sewage treatment effluents are not now adequately assimilated. Hastings, on the headwaters of one of the Big Blue River tributaries, does not present possibilities for upstream water storage for dilution of wastes. However, at York, Nebraska, the Corps of Engineers has investigated a dam site upstream from York to supply water primarily for dilution requirements. (9) At Hastings the need at present is 25 cubic feet per second in the summer, 17 cubic feet per second in the spring and fall and 11 cubic feet per second in the winter. The present need at York is 19 cubic feet per second in the summer, 7 cubic feet per second in the spring and fall, and 2 cubic feet per second during the winter months. (7) At the present time, no part of the flow in the Big Blue River has been reserved for dilution of waste waters. Tertiary treatment utilizing modern technology can achieve 97% BOD reduction plus nitrogen and phosphorous removal. Indications are that several communities and/or industrial waste treatment plants in this basin will be forced to build tertiary plants within the next ten years to meet Nebraska Water Quality Standards. (13)

TABLE 16

CHEMICAL ANALYSIS OF MUNICIPAL WATER SUPPLIES IN THE BIG BLUE BASIN, NEBRASKA (ppm)

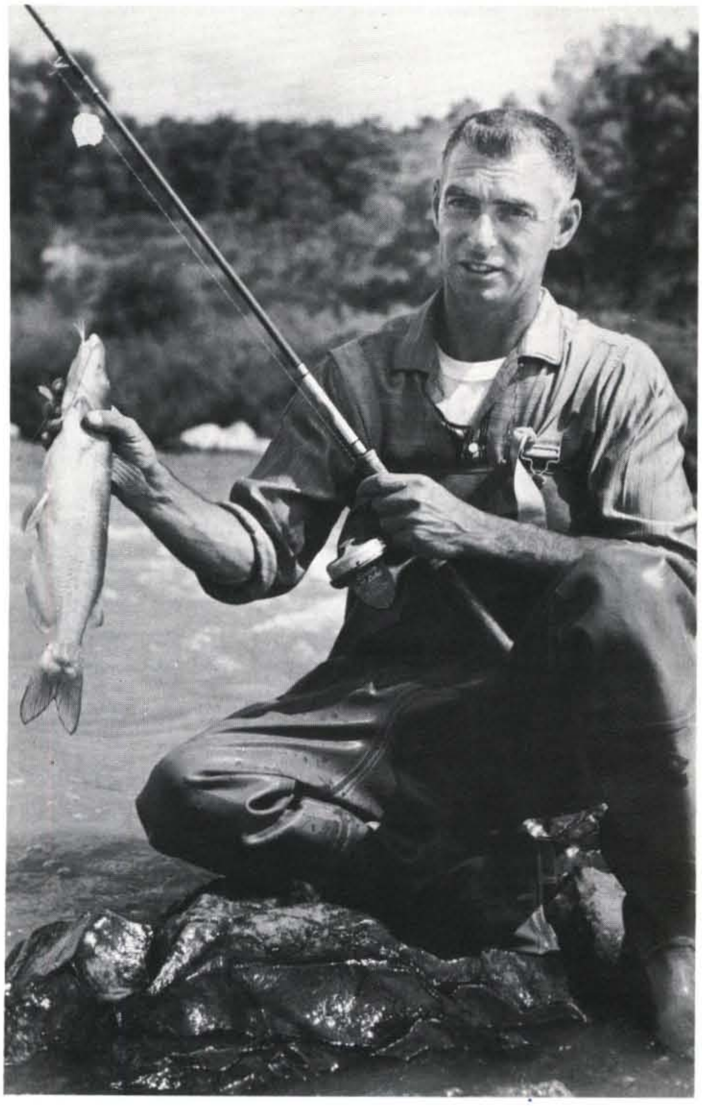
Location	Total Dissolved Solids	Iron (Fe)	Fluoride (F)	Hardness (CaCO3)	Nitrate (NO3)	Chloride (Cl)	Sulfate (SO4)
Aurora	218	0.0	0.7	168	0.8	12	36
Beatrice	305	0.0	0.3	200	0.5	16	31
Beaver Crossing	348	0.1	0.3	252	0.0	18	37
Benedict	354	0.0	0.3	228	1.6	14	31
Bradshaw	331	0.0	0.35	194	1.9	18	28
Cortland	330	0.0	0.3	220	2.3	10	15
Crete	308	0.1	0.3	189	1.3	10	27
David City	542	0.1	0.4	390	0.0	6	43
DeWitt	777	0.0	0.5	116	3.2	167	17
Diller	462	0.6	0.4	276	6.6	38	52
Dawson	428	0.2	0.6	238	2.5	9	151
Dorchester	333	0.1	0.3	236	0.0	16	14
Dwight	1,078	0.4	0.6	762	24.0	112	178
Exeter	412	0.0	1.0	280	0.0	10	67
Fairmont	466	0.4	0.4	305	5.0	19	91
Friend	409	0.7	0.6	282	0.0	9	29
Geneva	331	0.2	0.4	232	0.5	17	55
Giltner	418	0.1	0.4	260	1.7	14	42
Grafton	304	0.7	0.3	212	1.3	16	11
Gresham	367	0.1	0.3	250	1.8	7	6
Hampton	320	0.0	0.5	180	0.1	16	9
Harvard	447	0.0	0.4	288	0.0	23	143
Hastings	295	0.2	0.4	156	6.2	19	29
Henderson	299	0.1	0.5	198	1.2	15	13
Jansen	375	0.1	0.4	306	1.4	10	6
Marquette	836	0.0	0.6	504	13.0	26	300
Milford	373	0.1	0.4	244	1.3	7	19
Milligan	577	1.0	0.4	372	5.2	19	71
Odell	1,121	0.0	0.6	730	6.5	43	476
Osceola	552	0.0	0.3	357	3.9	13	30
Phillips	506	0.0	0.6	300	3.5	28	177
Plymouth	320	0.0	0.4	292	5.0	42	101
Polk	407	0.0	0.4	288	4.8	11	5
Rising City	851	0.0	0.6	549	13.0	17	109
Seward	408	0.0	0.2	218	1.2	13	60
Shelby	332	0.0	0.3	230	1.6	6	5
Staplehurst	454	0.3	0.5	284	5.1	16	18
Stromsburg	518	0.0	0.4	313	1.3	23	56
Sutton	319	0.1	0.3	212	1.1	21	13
Swanton	400	0.0	0.3	216	0.0	24	26
Tobias	778	0.0	0.5	480	4.0	42	74
Ulysses	316	0.0	0.4	248	1.9	12	19
Utica	422	0.3	0.3	214	4.6	12	22
Waco	432	0.0	0.3	292	5.4	18	26
Western	470	0.0	0.3	344	4.4	22	36
Wilber	292	0.0	0.3	140	1.4	32	31
Wymore	378	0.1	0.3	270	0.5	11	14
York	359	0.0	0.3	226	0.8	19	31

SOURCE: Nebr. Department of Health, Analysis of Public Water Supplies, January, 1967.

All of the incorporated communities in the Big Blue River Basin are presently providing some degree of wastewater treatment. Several of the larger industries in the basin also have their own treatment facilities. Many of these wastewater treating facilities will have to be enlarged and improved within five to ten years and those communities having only primary treatment at present will have to provide secondary treatment within three to four years. (13)

Contributors of pollution from agricultural sources are silt, feed-lots, chemicals and irrigation return flows. This type of pollution has a serious effect upon water quality in the basin but little is being done to control it. [13] More research and technology is necessary to determine economic methods of control and treatment.

RECREATION



Recreational areas in the Big Blue Basin are in short supply. The area available for public use includes only 0.14 percent of the total area in the basin. The areas available are being used at or near capacity and any increase in carrying capacity is unlikely.

The Nebraska Game and Parks Commission is taking an inventory of the outdoor recreation facilities provided by municipalities in the state. Data available for 32 communities in the basin indicate they are deficient in public recreation lands. Standards for estimating needs for outdoor recreation lands have been proposed in the Nebraska Comprehensive Outdoor Recreation Plan as follows. Metropolitan areas and cities of 5,000 to 10,000 population will need 15 acres per 1,000 population by 1980. Cities of 1,000 to 5,000 population will need 20 acres per 1,000 population, villages less than 1,000 population 25 acres, and non-urban areas 40 acres per 1,000 population by 1980.

The Outdoor Recreation Resources Review Commission (ORRRC) estimated the demand for recreation will triple by the year 2000. According to data published by that group, activities most in demand are the simple pleasures of driving and walking. Other activities of considerable demand are games, picnicking, swimming, sightseeing, and fishing.

Place of residence has a definite effect on the type and amount of recreational activity. Urban residents tend to participate more frequently in recreation activities than rural residents because of more leisure time. In the Big Blue Basin, most of the people live in places of less than 5,000 population. As a result, their per capita participation in recreation other than hunting and fishing is believed to be less than the national average. The lack of quality recreational resources, especially scenic and water based, severely limits the range of activities.

The demand of basin residents was considered as being mostly satisfied within the basin. However, nonresidents from outside areas such as the cities of Lincoln and Omaha also seek recreation satisfaction within the basin. This outside demand results in shortages of quality recreation opportunities and facilities, and tends to press lower quality areas into greater utilization.

The demand for recreation was expressed in activity occasions for comparison purposes. An activity occasion is defined as participation by an individual in a specific recreation activity during any part of a day. To find this activity occasion demand, participation rates developed by ORRRC were applied to the population. For projected demands, these rates were adjusted by the composite effect of socio-economic factors and applied to the projected population. The following table shows the activity occasions demands for 1960 and 1980. (3)

TABLE 17
TOTAL SEASONAL DEMAND IN ACTIVITY OCCASIONS

ACTIVITY	1960	1980
Driving and Sightseeing	743,812	1,063,786
Swimming	446,938	643,111
Outdoor Games and Sports	417,107	637,786
Walking for Pleasure	343,580	486,595
Bicycle Riding	205,777	246,133
Picnicking	204,241	284,662
Viewing Outdoor Games	159,400	228,443
Boating	137,035	231,447
Ice Skating	97,248	216,752
Nature Walks	75,419	106,883
Horseback Riding	57,453	53,894
Camping	40,235	73,489
Sledding	24,879	62,603
Attending Outdoor Concerts	22,693	35,748
Water Skiing	19,097	40,291

SOURCE: Nebraska Game and Parks Commission (3)

Demand for water-based recreation is on a sharp increase. The location of these recreation sites depends largely on the activities desired. People will, however, travel a much greater distance for quality hunting, fishing and boating than for picnicking or outdoor games. The estimated amounts of land and water needed for the major activities are shown in the following table.

TABLE 18
STATUS OF NON–URBAN LANDS AND WATER FOR RECREATION
(in acres)

ACTIVITY	SUPPLY	1960 DEMAND	1960 NEED	1980 DEMAND	1980 NEED
Boating	None	2,610	2,610	4,408	4,408
Water Skiing	None	909	909	1,918	1,918
Swimming	None	19	19	28	28
Camping	4	90	86	328	324
Picnicking*	13	146	133	203	190
TOTAL	Land	236	219	531	514
	Water	3,538	3,538	6,354	6,354

* About 50 percent of picnicking needs should be met by municipalities
SOURCE: Nebraska Game and Parks Commission (3)

This indicates some 6,300 surface areas of water will be needed by 1980. Any projects which are authorized and constructed prior to 1980 will decrease this amount by the number of quality acres they provide.

One of the major problems in providing sufficient recreation in the basin is the lack of adequate water storage sites further compounded by the basin's proximity to the population centers of the state with the resultant large demands.

FISH AND WILDLIFE

The ORRRC report previously mentioned shows that 46 percent of all persons over age 17 participate or wish to participate in hunting and fishing activities.

The demand for fishing is expected to increase tremendously. In 1960 a national survey of fishing and hunting by the Bureau of Sports, Fisheries and Wildlife of the U. S. Department of Interior stated that two out of every five persons over 12 years old went hunting, fishing or boating in 1960. This is roughly a total of 50 million people. In Nebraska, two out of every seven persons of age 12 or over purchased hunting and fishing permits in 1960. This was a conservative representation of hunting and fishing participation as persons less than 16 years old and landowners who hunt or fish on their own lands are not required to purchase these permits. In the Big Blue Basin two out of every eight persons purchased hunting or fishing permits. Fishing permit sales are slightly below the state average reflecting somewhat the lack of quality fishing in the basin. Low use of the fishery resource of the basin by non-residents is due to better opportunity elsewhere. Estimated demand in activity days for fishing derived from ORRRC statistics was 375,230 in 1960 and will be 465,000 in 1980.

The number of persons purchasing hunting permits in the Big Blue Basin is slightly above the state average indicating to a degree the quality of hunting. There are seven percent more hunters per 1,000 population in the basin than in the state as a whole. High non-resident hunting pressure is also anticipated. Seasonal demand for hunting in the Big Blue Basin is estimated at 251,000 activity days for 1960 and 266,000 activity days for 1980. (3)

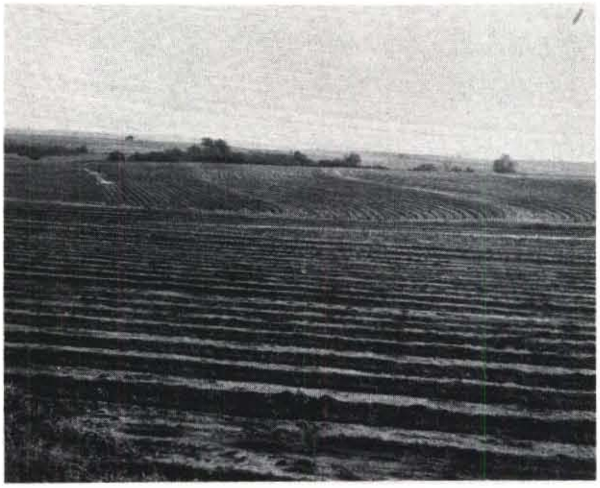
At the present time the prairie chicken is the only game species in danger of extinction in the Blue Basin. Some agitation has been evidenced for the return of the mourning dove to the list of game birds. Waterfowl breeding populations have decreased in the past several years because of the loss of breeding areas. Drainage of certain depressional areas could contribute to further declines in waterfowl populations.

SOIL AND WATER MANAGEMENT

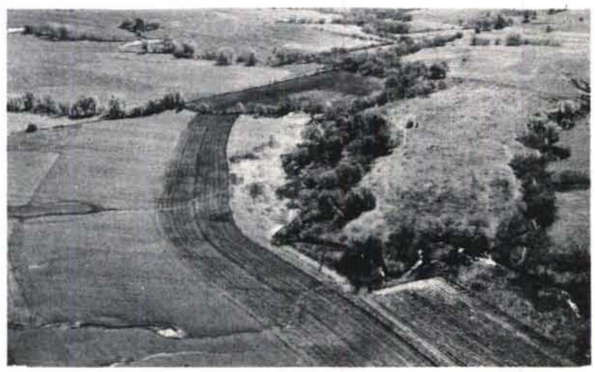
The application of conservation measures to the land by individual landowners and operators is the largest single activity needed in the development of water and land resources of the basin. The main needs of the basin are flood control on the mainstem and the lower stream reaches of the principal tributaries, drainage of the upland depressional areas and stabilization of the ground water table in the upper and central part of the basin. The greatest overall need of the basin is land treatment. Lands in the upper basin have moderate slopes which are subject to erosion and contribute large quantities of sediment during flood flows. Only about 25 percent of this land is now adequately treated. Land treatment in the lower basin has been accomplished to a large degree in conjunction with small watershed projects.

Thirty-nine percent of the agricultural land in the basin has been adequately treated, but 32 percent of the land has less than half the required treatment applied. The more important conservation measures which have been applied and the degrees of application are: contour farming, of which an application of 37 percent has been made with a remaining need of 625,000 acres; grade stabilization structures of which 30 percent have been installed and a total of some 4,700 remain to be constructed; irrigation water management of which 30 percent of the optimum has been reached leaving 341,700 acres needing further improvement; proper use of pasture and range of which around 30 percent has been accomplished with a total of about 360,000 acres remaining; construction of level and gradient terraces of which about 30 percent has been accomplished, leaving approximately 34,000 miles for further construction; forest management, of which 20 percent has been accomplished, leaving 29,500 acres needing treatment; forest protection which is about 60 percent complete, leaving 33,000 acres; tree planting, of which 27 percent has been accomplished, leaving 11,300 acres to be planted. [6]

Soils in the basin fall into one of seven categories with the distribution as shown in Figure 2. These categories are based upon the soils' capabilities and restrictions that must be observed in their use. Class I soils have no limitations restricting their use. Only about seven percent of the soils in the basin fall in this class. Some class II soils appear in this class when they are leveled and irrigated, removing the climate restrictions which had been responsible for their being in this class originally. Most Class I soils in the basin are irrigated.



Nearly half of the soils in the basin are in Class II. These soils have slight limitations in use and may require some other conservation practices to prevent soil deterioration or to improve the air-water relationship in the soil. Class II lands need a conservation cropping system and good crop residue management to maintain productivity. Farming on the contour and terracing are necessary to reduce erosion. The majority of the irrigation in the basin is on Class II soils.



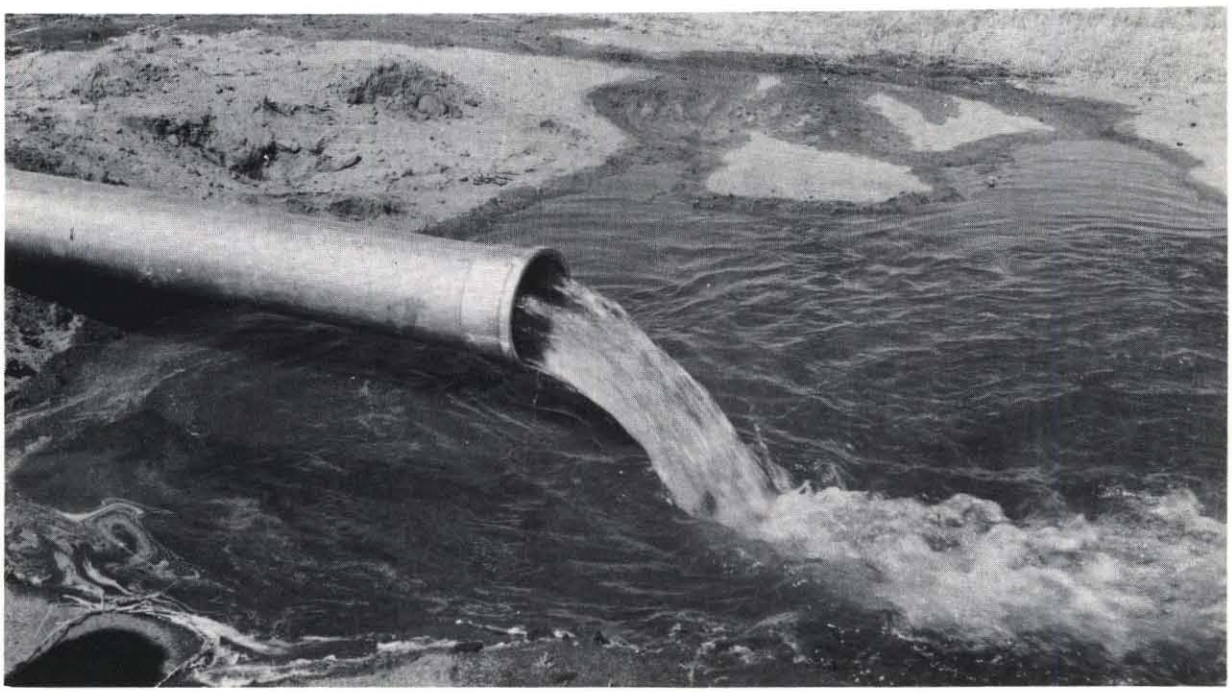
Class III lands comprise about 25 percent of the basin land area and require conservation cropping systems and proper management. These lands may be irrigated with the use of proper irrigation management practices.

Class IV lands, occupying approximately ten percent of the total area in the basin, have very severe limitations restricting the choice of plants and requiring very careful management to prevent erosion. Less than ten percent of these lands now have adequate conservation treatment. Cultivation of Class IV lands must be limited to systems and treatments which leave adequate residue on the surface to help stabilize and reduce the stream runoff. Grade stabilization structures may be needed in watercourses in these areas to control channel gradients and prevent further gully development.

Class V lands, composed of the marshy wet areas unsuitable for cultivation, are insignificant with regard to the total area of the basin, but are quite significant to fish and wildlife interests.

Class VI lands are generally unsuitable for cultivation and use is limited to range, woodland, wildlife or recreation. Nearly ten percent of the basin area is in this class. Some 75,000 acres being cropped should be converted to permanent cover. This soil in the cultivated stage produces much of the sediment present in the basin. Most of the timber lands in this basin are on the narrow flooded lands near the stream channel. These are Class VI lands which contribute to the debris collected in the numerous log jams which may damage bridges and fences.

Class VII lands occupy less than one percent of the area of the basin. These lands are unsuited for cultivation and their use is mainly grazing, woodland or wildlife habitat. Most of this land is presently native range. It requires proper use and careful management.



Much remains to be done in the area of agricultural water management. Not only is the rainfall runoff poorly controlled but the water which is applied on the more gentle slopes for irrigation is also poorly managed. Good water management also involves solving the problem of poor drainage in the upper basin. No data is available on specific farms in the basin in the way of runoff losses from surface irrigation. However, the Extension Service of the University of Nebraska has conducted tests on demonstration fields in the area which show runoff losses of over 22 percent in all cases and as high as 40 percent in one case. Nearly half the irrigators in the basin apply water as a small stream which they shut off when it reaches the end of the field. This results in a poor distribution of the irrigation water and causes excess percolation losses and leaching of nutrients in the upper end of the field. The practice of using a maximum nonerosive velocity stream with the recovery reuse system is used by only nine percent of the irrigators in the basin. This practice results in virtually no runoff loss. Over a third of the irrigators use a maximum nonerosive velocity stream with no cut back in stream flow during application. This practice has become popular because of the high labor cost involved in controlling the irrigation stream compared to the low cost of water. Reuse systems offer the possibility of substantial water savings and development of automatic systems is presently underway. There are presently about 500 sprinkler irrigation systems in the Big Blue Basin.

Evaporation losses occur through the spraying of water by the sprinkler system, from the open carrier ditches and from the soil surface itself. This evaporation may vary from five to 25 percent of the water applied depending on the method of irrigation, wind, air temperatures, crop cover and humidity. One means of cutting down this evaporation is use of a closed pipe system. Evaporation losses from the soil can be partly controlled by tillage practices which leave some crop residue on the soil surface.

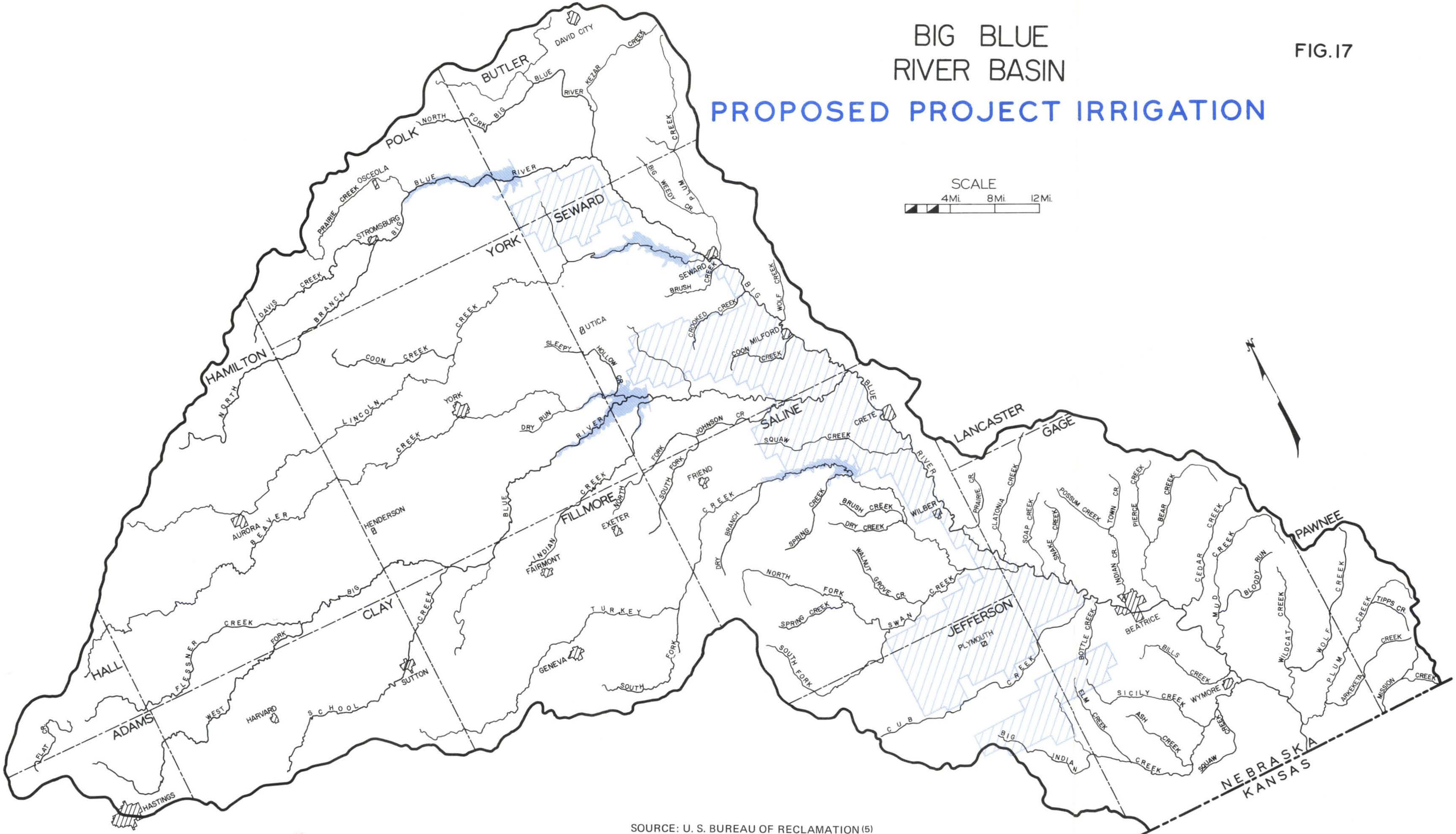
Deep percolation losses resulting from over-irrigation are not water losses to the basin but are an economic loss to the individual operator. This percolation of water leaches the crop nutrients and may also result in perched water tables where impermeable barriers prevent downward movement of water to the regional water table.

Water saving can be realized in several different ways. One important aspect is to continue the use of good land leveling and proper irrigation management practices. Adequate design of sumps and reservoirs to minimize the evaporation as well as tillage practices which minimize soil evaporation, reduce compaction and conserve water are needed. The Extension Service has estimated that these practices could save over 120,000 acre feet per year in the basin. (4)

FIG. 17

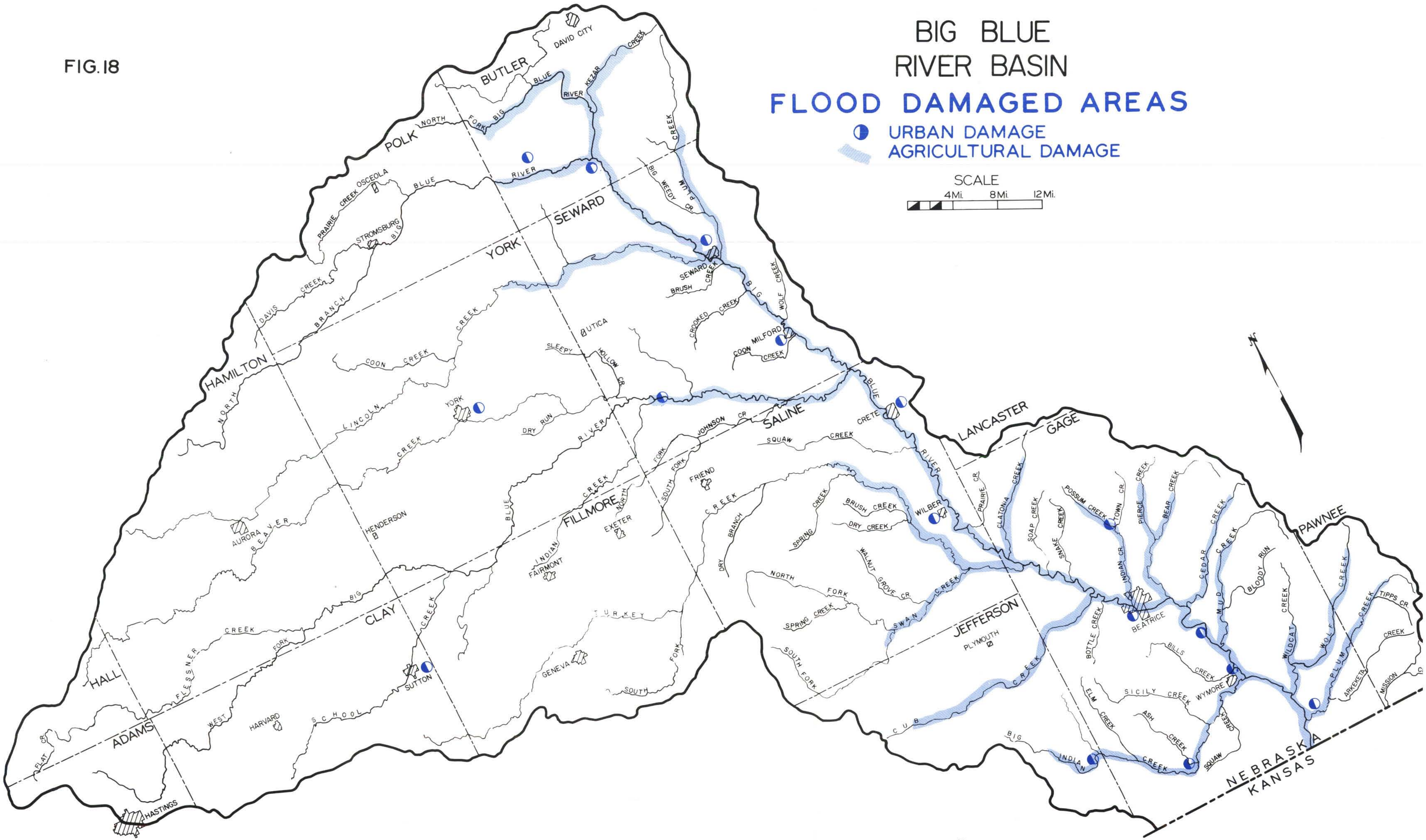
BIG BLUE RIVER BASIN

PROPOSED PROJECT IRRIGATION



SOURCE: U. S. BUREAU OF RECLAMATION (5)

FIG. 18


BIG BLUE RIVER BASIN
FLOOD DAMAGED AREAS
URBAN DAMAGE
AGRICULTURAL DAMAGE
SCALE
4 Mi.
8 Mi.
12 Mi.
BUTLER
POLK
SEWARD
YORK
HAMILTON
SALINE
LANCASTER
GAGE
PAWNEE
FILLMORE
CLAY
JEFFERSON
HALL
ADAMS
DAVID CITY
OSCEOLA
STROMSBURG
SEWARD
UTICA
MILFORD
YORK
CRETE
FRIEND
WILBER
AURORA
HENDERSON
EXETER
FAIRMONT
BEATRICE
PLYMOUTH
WYMORE
SUTTON
GENEVA
HARVARD
HASTINGS
NEBRASKA
KANSAS
BIG BLUE RIVER
NORTH FORK BIG BLUE RIVER
WEST FORK
BIG BLUE RIVER
LITTLE BLUE

PROPOSED DEVELOPMENTS

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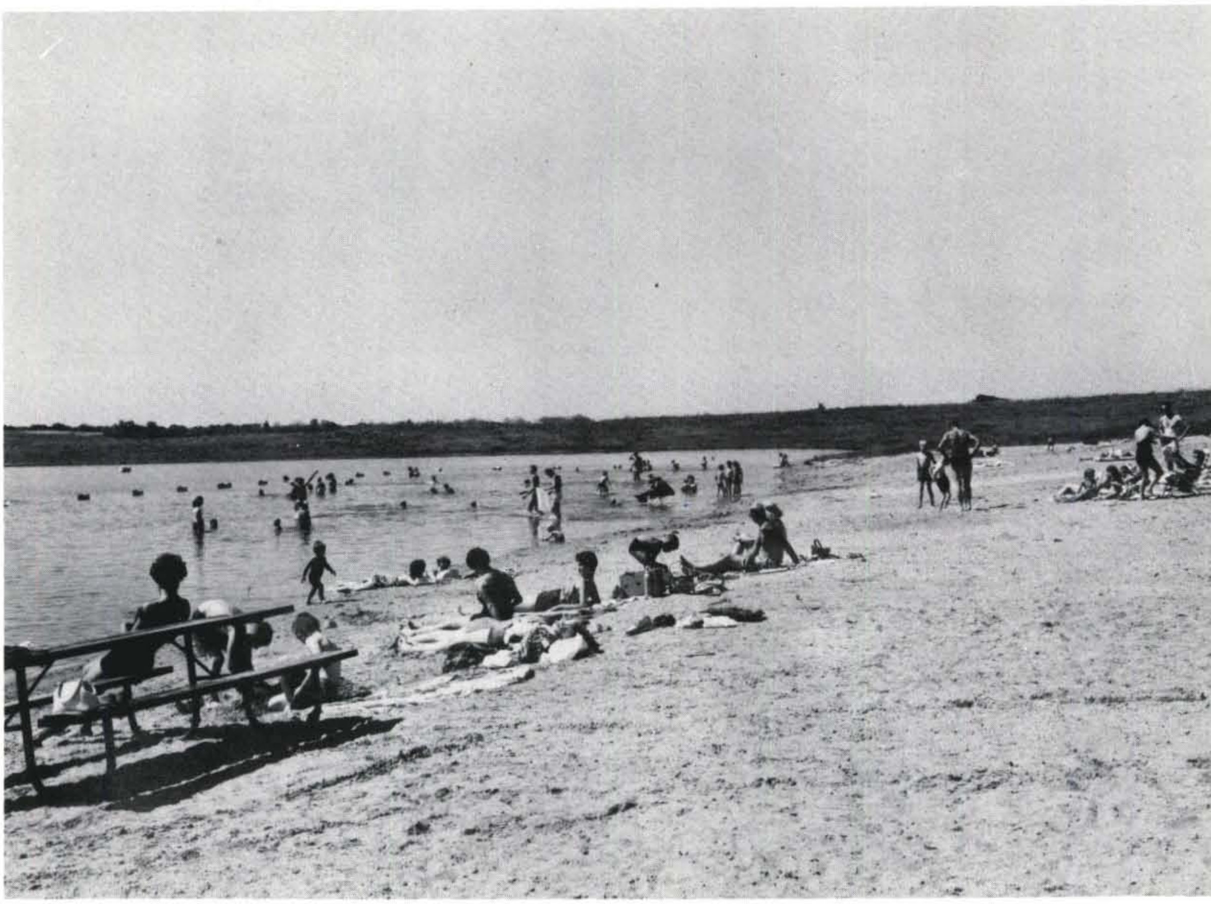
Specific water and land resource developments in the Big Blue Basin have been proposed by three federal agencies–Bureau of Reclamation, Corps of Engineers, and Soil Conservation Service. This section briefly explains and evaluates some of these multipurpose proposals developed with data and analyses supplied by other state and federal agnecies. The potential dam and reservoir sites in the basin and data pertaining to them are shown on Figure 19 and Table 19.



The Bureau of Reclamation has determined that four potential storage sites and three areas of land warrant further investigation for possible project irrigation. These sites are the Surprise Dam and Reservoir on the North Branch of the Big Blue, Beaver Crossing Dam and Reservoir on the West Fork of the Big Blue, Seward View Dam and Reservoir on Lincoln Creek and Shestak Dam and Reservoir on Turkey Creek. (5)

The three areas of land investigated are near Goehner, Dorchester and Plymouth and are shown on Figure 17. These areas contain a combined total of about 125,000 acres (5) with only sufficient water to supply 43,000 acres. These potential reservoirs would all be multiple in purpose and include storage for flood control, quality control, fish and wildlife, and recreation, along with irrigation. The use of surface water for irrigation at these sites would help stabilize the water table in the immediate area but would not alleviate the critical ground water problem in York and Hamilton Counties further west. All four developments would require pumping plants to lift the water from the reservoirs onto the lands.

Features of the Sunbeam Unit, which is the only unit the Bureau has investigated in detail thus far, would be the dam and reservoir on the West Fork of the Big Blue River, a pumping plant with a capacity of 330 second feet to serve 19,000 acres in the Goehner area, a diversion dam about 20 miles below the reservoir, and another pumping plant with a capacity of 198 second feet to serve 11,000 acres in the Dorchester area. The Beaver Crossing Dam and Reservoir site would have a total capacity of 538,300 acre feet. Of this total, 119,200 acre feet would be for conservation storage and 404,000 acre feet for flood control. The area inundated by the conservation and flood control pools would be 7,800 and 17,700 acres, respectively. The conservation storage would supply irrigation water for up to 30,000 acres but if minimum streamflows are required below the site, this acreage would be reduced. The Sunbeam Unit with the Beaver Crossing Dam site has a total direct benefit-cost ratio of 1.34:1.00. The total b/c ratio is 1.42. Some adjustment of recreation benefits could affect the b/c ratio favorably.

Studies made by the Bureau indicate the water supply at the Beaver Crossing site is sufficient to supply 30,000 acres. The study covering the 1930 to 1961 period of reference produced five hypothetical shortages, with only two being significant. Two alternative sites were also considered by the Bureau of Reclamation in this area. One of these was the Staplehurst Dam and Reservoir on the Big Blue about a mile above Staplehurst. This site involved considerable relocation and was also susceptible to high evaporation losses in relation to total storage. The foundation conditions were also found to be adverse at this site. The Sunbeam Dam and Reservoir site is located on the West Fork of the Big Blue above the town of Dorchester. This site also involved extensive relocations of railroads and the town of Beaver Crossing. (5)

The Corps of Engineers is primarily concerned with flood control of large drainage areas and has completed a local flood protection improvement project at Seward, Nebraska. Another has been investigated and authorized at Beatrice. Their basin plan of development is quite similar to that of the Bureau of Reclamation with greater emphasis on flood control. Large reservoirs providing a high degree of flood protection are necessary for control of the main stream and the larger tributaries. The Corps of Engineers has investigated 21 potential large-reservoir sites in the basin. Some of these are essentially the same sites as have been investigated by the Bureau of Reclamation.

TABLE 19
POTENTIAL RESERVOIRS

PRELIMINARY RESERVOIR SITE DESIGNATION	STREAM	DRAINAGE AREA SQ. MI.	TOTAL STORAGE AC. FT.	PURPOSES	SURFACE AREA (ACRES) CONS.	FLOOD
A	North Branch Big Blue	314	90,300	FC		
B	Lincoln Creek	162	63,200	FC		
C	Lincoln Creek	327	308,900	FC, R, UC		
D - Seward View	Lincoln Creek x	445	227,300	FC, Irr. R	4,500	8,676
E	Big Blue	648	227,000	FC		
F	Plum Creek	86	64,800	FC, UC		
G	West Fork Big Blue	354	87,900	FC		
H	West Fork Big Blue	587	221,000	FC, R, UC		
J	West Fork Big Blue	1,220	686,600	FC, UC		
K - Sunbeam	West Fork Big Blue	1,330	195,800	FC, Irr, R		
N	Turkey Creek	197	150,400	FC, R, UC		
O	Turkey Creek	315	282,500	FC, R, UC		
Q	Turkey Creek	457	193,700	FC, R, UC		
V - York	Beaver Creek x	172	64,700	FC, WQ, R		
X	Beaver Creek	261	147,900	FC, UC		
Staplehurst	Big Blue River	626	100,000	FC, Irr, R		
Shestak	Turkey Creek x	415	180,500	FC, Irr, R	4,300	7,496
Surprise	North Branch Big Blue x	337	176,700	FC, Irr, R	4,100	7,831
Beaver Crossing	West Fork Big Blue x	1,154	538,300	FC, Irr, R	7,800	17,686

x Under Detailed Study

Purposes: FC - Flood Control
Irr - Irrigation
WQ - Water Quality
R - Recreation & Fish and Wildlife
UC - Unallocated Conservation Storage

Source: Corps of Engineers (9)

A large share of the flood control requirements included in the Corps of Engineers' storage estimates are for protection of cities downstream in Kansas. The storage that would be provided in the Blue Basin would be considered as back-up storage for the existing Tuttle Creek Reservoir. Five sites have been suggested for further investigation and possible development in the basin. These suggested sites are the four proposed by the Bureau plus an additional site at York on Beaver Creek. The site at York would be for both pollution abatement and flood control purposes.

The Soil Conservation Service has also proposed developments for the Big Blue Basin. The Service operates under a joint memorandum of understanding with the Soil and Water Conservation Districts of the state. The objective of this memorandum is to bring about the use of each acre of agricultural land within the limits of its capabilities and the treatment of each acre in accordance with its needs for protection and improvement. In accomplishing these objectives they operate under several criteria. One of these is applying conservation treatment to the land under a Federal cost-share system. Another is the development of the Small Watershed Project similar to the Big Indian Creek Watershed Project near Wymore.

In the Big Blue Basin nine watershed work plans have been completed and approved. The projects now in operation or under construction are: Dorchester, Cub, Mission, Plum, Bear-Pierce-Cedar, Big Indian, Little Indian, and Mud Creek. Clatonia Creek is presently awaiting Congressional funding. These nine watersheds in the Lower Basin under some stage of development represent a total of 485,400 acres. Applications for planning assistance have been received from five additional watersheds totaling some 250,000 acres. Of the 19 remaining separately delineated watersheds in the basin, it is felt that at least Plum and Kezar Creeks are potentially feasible projects under existing criteria. The current status of the watershed program is shown on Figure 20.

Seven proposed small watershed projects in the basin would control about 61 percent of the runoff from the drainage areas involved. This would benefit some 43,000 acres of flood plain now damaged.

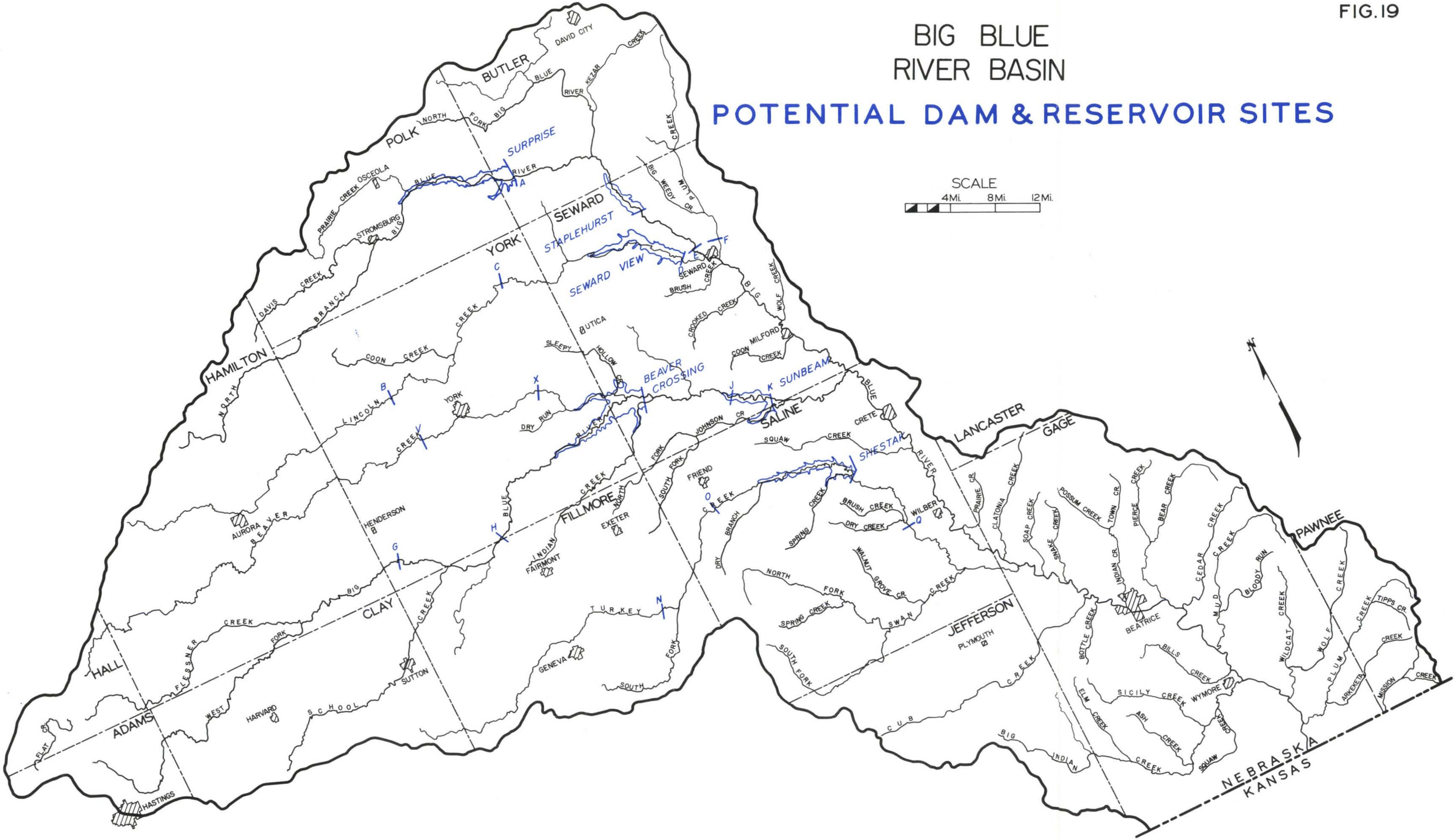
Development proposed by other federal agencies will complement that proposed by the three principal agencies. Any development anticipated by the recreation or fish and wildlife interests will be related to multipurpose reservoirs. The Bureau of Sport Fisheries and Wildlife, Department of Interior, has purchased and manages four depressional areas in the Big Blue Basin totaling some 2,650 acres of land and water which it intends to develop for waterfowl production. Another 5,350 acres of wetlands in the basin have been delineated for purchase.

Development of hydro power began early in the settlement of the basin. No new development is likely because of the low power heads and the small variable water supply.

FIG. 19

BIG BLUE RIVER BASIN

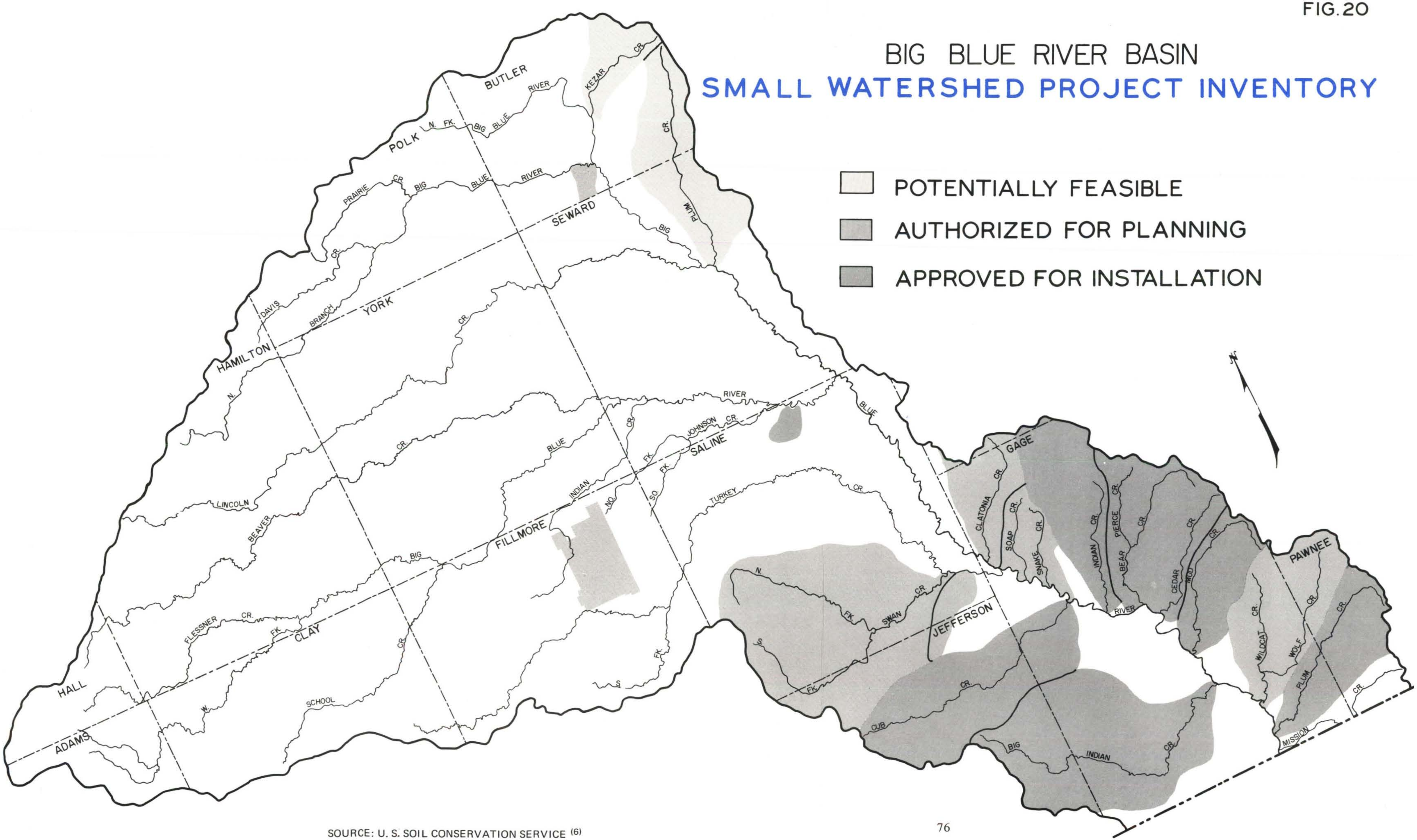
POTENTIAL DAM & RESERVOIR SITES



SOURCE: U. S. CORPS OF ENGINEERS

FIG. 20

BIG BLUE RIVER BASIN
SMALL WATERSHED PROJECT INVENTORY



SOURCE: U. S. SOIL CONSERVATION SERVICE [6]

RECOMMENDATIONS

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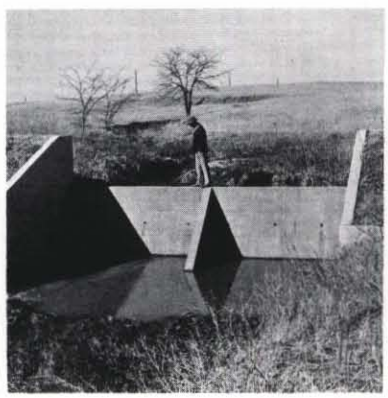
FLOOD CONTROL

Flooding has been prevalent throughout the Big Blue River Basin. Floods cause property damage and loss of life as well as problems associated with erosion, sedimentation and public health. The complete control of floods is seldom, if ever, feasible. However, man has learned to control floods to a tolerable extent.

The Federal Government allocated in excess of seven billion dollars nationally between 1936 and 1962 for flood control. Yet, the national flood damage toll has been higher each year than the year before. One might assume from this that at the present rate of construction of flood protection works, the effort would never be complete. This is true only if we fail now to provide for the future. Dams and impoundments are many times after-the-fact protection because of the financial justification in the form of flood damages that are required prior to construction. Of the increase in flood damages, 45 percent has been attributed to the increase in property values, 25 percent to an increase in the amount of flooding, and 30 percent to an increase in building and other uses of flood hazard lands. Flood control can best be achieved where a total flood control program is implemented. Such a program includes:

1. Soil and water conservation treatment on all lands
2. Detention structures on tributaries
3. Mainstem structures storing large amounts of flood water
4. Proper flood plain use achieved through flood plain zoning and management
5. Adequate flood warning, evacuation, and flood forecasting networks
6. Channel improvement, levees, and bank stabilization projects


The Soil and Water Conservation Commission is vitally interested in doing all practicable to prevent flood damages. One method popularly referred to as flood plain management has not been actively pursued by local units of government in the Blue Basin or in the State of Nebraska. However, the State Legislature recently passed legislation (2-1506.04 through 2-1506.14 R.S. Supp. 1967) which gives the Soil and Water Conservation Commission authority to regulate land use in the flood plain after sufficient information concerning flood frequency and inundation upon the flood plain to enact regulations has been in the hands of the local unit of government for one year and regulations have not been implemented to State minimum standards. Land use regulation is one part of a complete program of flood prevention that can be put into effect quickly and inexpensively to yield great benefits. Land use regulation by its nature is a forward looking program which will not rectify past errors but can help to prevent future mistakes. Land must be subjected to regulations before growth takes place and not after since the expense of the latter procedure involving building removal and/or extensive flood control measures probably would be too great. Inventories of past flood damage experience indicate that many towns, large and small, located in the basin have current flood problems and comprehensive planning action should be taken now to protect against increased future damages. Present size of the town, whether it is growing or stable, and regardless of the degree of flood hazard existing at the present should not detract from the recognition of the problem. Planning should acknowledge that the economy and population is an expanding one and that only by planning now can future crises be effectively provided for with minimum time and expense. All towns located in or adjacent to flood plains and specifically, Beatrice, York, Wilber, Crete, Osceola and Seward, should immediately consider the advantages of management of land use through zoning regulations.

Seward is protected by a levee constructed by the Corps of Engineers in 1953. However, since the construction of this project, changes in development have occurred in Seward and new building has taken place in the flood plains of both Plum Creek and the Big Blue River. This is pointed out specifically for consideration since a flood plain study for Seward, Nebraska was recently completed by the U. S. Geological Survey and is available for the use of local governmental bodies. Seward should give active consideration to Flood Plain Management as an integral component of planning for flood damage reduction.

Another significant area of consideration is the increasing potential of flood insurance as a deterrent to flood damage costs. The Congress is considering amending existing legislation and appropriating funds for this program to be administered by the Office of Housing and Urban Development. Local units of government should follow developments in this field closely.

The Corps of Engineers has considered several sites for flood control reservoirs in the basin and estimates that four of five reservoirs may be justified for flood control with a major share of the benefits occurring well downstream in Kansas. Although justification for these projects is mainly from flood control benefits available in Kansas, the projects would be multiple in purpose and consider all functions. The latest flood in June, 1967 caused damages estimated roughly at $2,000,000 in the Nebraska portion of the Big Blue Basin.

The construction of large reservoirs for the control of flood waters will be most valuable for the reduction of urban flood damages. Large dams are constructed to control storms of high magnitude and are designed to be relatively safe for use upstream of urban areas where failure could be catastrophic.

The small watershed program (P.L. 566) affords a high level of flood protection for those upstream tributaries on which feasible watershed work plans have been implemented. However, such projects have only minimal effect in reducing the flood crest in the major valleys of the basins such as the Big Blue. The Watershed Protection and Flood Prevention Act is administered by the Soil Conservation Service in cooperation with such local sponsors as watershed conservancy districts.

SPECIFIC RECOMMENDATIONS ON FLOOD CONTROL

Recommendations to Federal Agencies

1. As a result of the flooding which occurred in June of 1967 the Corps of Engineers should re-examine the flood control potential of the five reservoirs previously investigated. These sites are at Surprise, Beaver Crossing, Sunbeam, Shestak and Seward View.

2. The Soil Conservation Service should continue planning activities for small watershed projects. Their program should include development of water disposal systems for cropland and depressional areas of the basin.

3. The Soil Conservation Service needs to accelerate the construction phase of the small watershed program.

Recommendations to State Agencies

1. The Soil and Water Conservation Commission should increase assistance for small watershed and local flood protection projects with funds provided by the small watershed flood control statute 2-1503.01 through 2-1503.02, R.S. Supp., 1965.

2. The Soil and Water Conservation Commission should encourage and give leadership in developing feasible P.L. 566 applications.

3. The Soil and Water Conservation Commission should counsel with local leaders in Beatrice, DeWitt, Crete, and Wymore to discuss the possibility of structural and nonstructural measures for channel improvement to provide local flood protection. State and Federal agencies should be solicited for technical advice.

4. The Soil and Water Conservation Commission and the Department of Economic Development should coordinate their activities recognizing that comprehensive planning involves a dovetailing of the programs of the two state agencies. Close liaison should exist between the two state offices in order that the complementary nature of their work might progress most expeditiously.

5. The Soil and Water Conservation Commission and the Department of Economic Development should collaborate to hold public meetings with city, county, and village officials responsible for development of Beatrice, York, Wymore, Wilber, Barneston, Odell, Pickrell, DeWitt, Beaver Crossing, Sutton, Clatonia, Crete, Milford, Seward, Ulysses, Diller and McCool Junction to discuss the need for comprehensive planning including land use regulations, under both the Housing and Urban Development Act and local sponsorship.

6. The Soil and Water Conservation Commission should advise the Director of Banking of the availability of information such as that in the U. S. Geological Survey Atlas covering historical flooding around Seward and should encourage the use of this type of information by lending institutions involved in providing financing for development within such areas.

7. The Soil and Water Conservation Commission has authority under the flood prevention and damage reduction act, Statutes 2-1506.01 through 2-1506.14 R.S. Supp., 1967 to clear channels of debris. Funding should be provided to allow clearing of log jams such as the one which exists on the Big Blue River just east of DeWitt.

8. The Soil and Water Conservation Commission should coordinate Federal, State and local drainage programs to ensure compatibility with flood control and wildlife features.

9. The Governor's office, in cooperation with and from information supplied by the Soil and Water Conservation Commission, should ensure that all state agencies are aware of the flood hazard that exists throughout the Big Blue Basin and that no department encourages unwise development of flood prone lands by providing state funds, approval of Federal expenditures, or failing to exercise discretionary authorities.

10. The State Highway Department should evaluate its criteria of providing cross drainage facilities adequate only for moderate size floods. The high cost of flooding road structures and inundating land in high hazard areas may well justify the expenditure necessary to provide a higher degree of protection.

11. The State Highway Department should closely examine bridges in high hazard areas for which they are responsible to determine if areas adjacent to the pilings or abutments are eroding. Such areas should be protected by rip-rap or other suitable coverings if economically justifiable.

12. The Agricultural Engineering Department of the University of Nebraska should initiate research in the use of pits, injection wells, and vertical french drains in areas having a perched water table as a means of draining the depressional areas to the regional groundwater reservoir. A possible area for carrying out this research is in the vicinity of Exeter, Nebraska. State and Federal agencies should be solicited for technical advice.

Recommendations to Local Units of Government

1. Watershed Conservancy Districts need to accelerate their easement and right-of-way procurement actions for P.L. 566 watersheds.

2. Watershed Conservancy Districts need to accept greater responsibility in operation and maintenance activities to ensure structural safety and provision of desired operational facilities.

3. The cities and villages of Surprise, Ulysses, York, McCool Junction, Sutton, Seward, Beaver Crossing, Milford, Crete, Wilber, DeWitt, Beatrice, Pickrell, Wymore, Diller, Odell, Clatonia, and Barneston should work with the county officials in Butler, York Clay, Fillmore, Seward, Saline, and Gage Counties to prevent further development in the high flood hazard lands. Each of the towns mentioned has suffered flood damages in the past.

4. Request for assistance in obtaining studies on which to base land use regulations should be addressed to the Nebraska Soil and Water Conservation Commission. Until such time

as special flood plain information studies may be available, the limits of major floods such as the mainstem Big Blue flood of June, 1967 include areas in which further development should be regulated using the city and county zoning authorities.

5. Upon reaching favorable feasibility status, Watershed Conservancy Districts should begin to tax at a rate sufficient to ensure that adequate funds will be available to discharge local responsibility at the time they are needed. Failure to do so may result in unnecessary delay in construction of much needed flood prevention facilities.

6. The Big Blue River Watershed Planning Board should take the position of leadership in examining the flood warning system used in the basin. Assistance for such a study should be requested from the United States Weather Bureau, State Civil Defense Office and the Nebraska Soil and Water Conservation Commission.

7. Cities and villages responsible for the operation of services such as water supply and sewage disposal should examine the physical location of their systems to determine the vulnerability to floods. If necessary, such services should be flood proofed. Advice on flood proofing techniques can be obtained from either the Corps of Engineers or the Nebraska Soil and Water Conservation Commission.

8. Counties should search for opportunities to incorporate flood water detention dams in road construction programs as a desirable alternative to constructing bridges. Assistance in locating suitable sites is available to the county engineer and others responsible for local road construction from the Soil Conservation Service, Corps of Engineers, Soil and Water Conservation Commission, and local soil and water conservation districts.

9. Counties and cities should examine those bridges in high hazard areas for which they are responsible to determine if areas adjacent to the piling or abutments are eroding. Such areas should be protected by riprap or other suitable covering if economically justifiable.

IRRIGATION

A concerted effort toward greater efficiency in the use of irrigation water should be made by basin residents. Many of the ground water problems, both quantity and quality, can be partly remedied by better water management on the part of the ground water irrigators.

The development of reuse systems whereby the water is collected and pumped or diverted for use elsewhere improves efficiency. This system requires considerable capital outlay in some instances but results in more efficient use of the irrigation water and agricultural fertilizers.

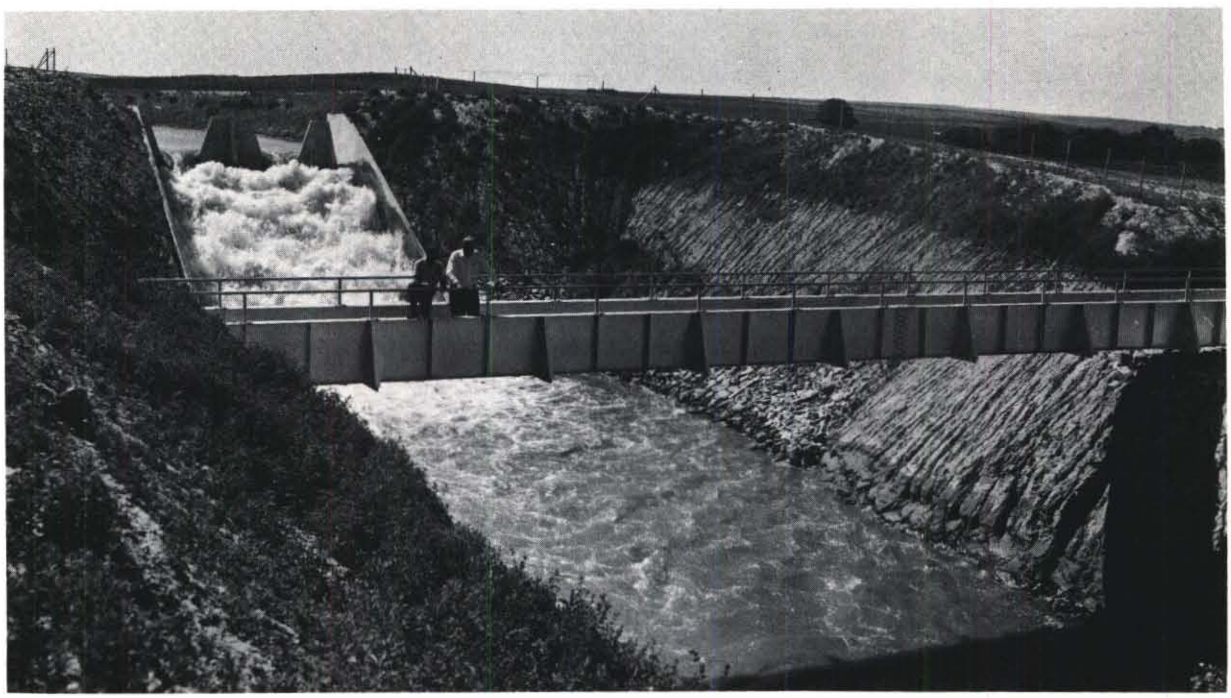
Overirrigation leading to deep percolation losses may have aggravated high nitrate conditions in the ground water in parts of the basin.[12] Better control of irrigation water by use of moisture sensing devices which give a reliable indication of the wetting front during irrigation is needed. Use of this high nitrate water for irrigation is beneficial to the crop. However, if it is applied in conjunction with a high nitrogen fertilizer and poor control of the percolation loss, it may result in an increased ground water nitrate level.

During many years the rainfall in the basin is nearly sufficient to meet moisture demands of most crops. However, the supplemental water supplied by irrigation provides moisture when rainfall distribution is poor. The economy in the upper and central parts of the basin is predominantly geared to irrigation. Farming patterns and plant populations reflect this fact.

Surface water irrigation has been used in other areas to stabilize the ground water reservoir. Not all soils in the Big Blue Basin are conducive to recharge in this fashion and caution will be needed in application of water for this purpose. The proposed development at the four major reservoir sites, Beaver Crossing, Surprise, Seward View, and Shestak, is deficient in meeting the recharge need because the reservoir sites and proposed land areas are below the area of critical ground water table decline. The cost of pumping the water upstream to these areas would likely be prohibitive.

Recharge from the many depressional areas which occupy the upper part of the basin should be investigated. The existence of these natural sumps should not be overlooked as a means of stabilizing the water table but research in recharge methods needs to be instigated. If a feasible means can be found for introducing water into the ground water aquifers for storage, reduction of evaporation over that experienced from comparable surface storage sites would be appreciable.

While present legal restrictions may prevent importation of water into the Big Blue Basin, such may not always be the case. The basin contains many acres of land suitable for irrigation for which water is not now available. Presently proposed projects should be examined with the prospect of importation in mind in order that maximum utilization may be made of the available reservoir sites.



SPECIFIC RECOMMENDATIONS ON IRRIGATION

Recommendations to Federal Agencies

1. The Bureau of Reclamation should review procedures used in computing water requirements and develop or utilize methods that would recognize the reduced requirements for irrigation in subhumid areas such as the Big Blue Basin. Consideration should be given to the design of project delivery systems to incorporate gated pipe, canal lining, and other water-saving devices.

2. The U.S. Congress should reconsider the present limitation of project water availability to individual ownerships of not more than 160 irrigated acres within a federal reclamation project.

3. The study which is being conducted by the Bureau of Reclamation to determine the economic and engineering feasibility of the Sunbeam Unit composed of the Beaver Crossing Dam and Reservoir, supply and distribution facilities, and the associated lands in the Goehner and Dorchester areas should be expedited.

4. The Soil Conservation Service should provide more technical assistance to irrigators to promote better use of irrigation water.

5. The Bureau of Reclamation in cooperation with the Conservation and Survey Division should conduct a study on methods of ground water stabilization as part of the Nebraska Basin Units Survey.

6. The Agricultural Stabilization and Conservation Service should provide additional funds to assist in irrigation development providing better efficiency in water use.

Recommendations to State Agencies

1. The Nebraska Soil and Water Conservation Commission in cooperation with the Conservation and Survey Division should outline those areas where abnormal depletion of the ground water resource is occurring.

2. The Agricultural Extension Service of the University of Nebraska should greatly increase educational efforts aimed toward reducing wasteful irrigation practices.

3. The Agricultural Engineering Department of the University of Nebraska should institute research in the use of natural depressional areas for recharge.

4. The Conservation and Survey Division of the University of Nebraska should institute a program of investigation to determine those areas in the upper portion of the Big Blue Basin where the topography, soils, and geology lend themselves to successful ground water recharge practices.

5. The University of Nebraska should further study the best water use-crop yield relationship to determine the optimum use of irrigation water.

Recommendations to Local Units of Government

1. The Big Blue River Watershed Planning Board should determine the present desire for extension of irrigation in the basin, including the amount of water considered necessary to supplement natural rainfall. Assistance should be requested as needed from both the Bureau of Reclamation and the Nebraska Soil and Water Conservation Commission.

2. The Big Blue River Watershed Planning Board, in cooperation with the Extension Service and the Soil and Water Conservation Commission, should determine whether potential and present irrigators would be interested in using imported water if it were available.

3. Local Soil and Water Conservation Districts should continue to promote better irrigation water management and the use of tailwater recovery systems where practical. The Districts should employ personnel in irrigation layout when adequate assistance is unavailable from state and federal agencies.

4. Ground Water Conservation Districts should be organized by local people for the purpose of managing and regulating the ground water resource of the basin. Such districts should conform to hydrologic boundaries and include all problem areas including urban areas.

MUNICIPAL AND INDUSTRIAL WATER SUPPLIES

Public water supplies for domestic and industrial uses in the basin are drawn exclusively from ground waters. The primary characteristics of a public water supply are potability, dependability and palatability. The latter, while desirable, is of the least importance.

Ground water supplies are adequate to provide sufficient quantities of water through the foreseeable future. In areas having declining water tables, some control in well locations may be necessary but there appears to be no danger of serious shortages.

Potability is dependent upon the chemical and bacteriological qualities of the water and is subject to change at any point between the aquifer of supply and the faucet. Some ground waters of the Blue Basin have nitrate levels in excess of recommended drinking water standards of the State Health Department. High nitrate levels are sometimes responsible for the condition in new born infants termed methemoglobinemia of "blue babies".

Perhaps the most serious danger to public water supply users is the almost total lack of disinfection by chlorination or other approved methods. While the practice has become commonly used throughout the world, no community within the Big Blue Basin provides such protection. Disinfection is an essential practice for treating the raw water supply and maintaining the safety of the water in the event of bacterial contamination entering the delivery system.

Fluoridation, while not considered an essential practice for public health, has proven effective in the prevention of dental caries. It is recommended by the U. S. Public Health Service, the Nebraska Department of Health and various medical and dental associations. Additional study and education concerning the practice of fluoridation should be encouraged.

Municipal water use in the basin will increase as a result of population growth. An increase in per capita consumption is also expected with more widespread use of high water using devices such as dishwashers, garbage disposals, and automatic washers. Some cities could decrease the per capita use of water by pricing it to discourage wasteful water use.

Per capita water use in the Nebraska portion of the basin now averages 121 gallons per day according to information compiled by the U. S. Public Health Service. The Public Health Service estimates basin wide usage to increase to 180 gallons per capita per day in 2020 and to 200 gallons per capita per day in 2070. (7) These estimates are probably conservative. It is expected that the municipal and industrial water requirements will total 43 million gallons per day in 2020 and 66 million gallons per day in 2070.

An estimate of the 1965 population of the Big Blue River Basin was derived from urban and county population estimates published by the Bureau of Business Research of the University of Nebraska. This estimate of 108,000 was not significantly different from the 1960 census figures and suggests that the population decline may be leveling off and the possibility exists for growth in some of the urban areas.

The Economic Research Service (USDA) estimates the total population of the basin to increase to 112,400 in 1980; 116,500 in 2000; and 122,000 in 2020. (6) This increase is expected to occur primarily in the urban areas as rural nonfarm population is expected to maintain its present share of 37 percent of the total population and farm population to decrease gradually from its present 31 percent of the total population to 13 percent in 2020.

Table 20 shows the projected population by category, in number and percentages, for 1980, 2000, and 2020. Figure 21 graphically illustrates the historic and projected population growth of the Big Blue Basin and the state. Population projections for the state were derived from U.S. Bureau of Census projections and extended to fit the projection dates. State population projections were made as a range of probabilities rather than a specific level.

TABLE 20

PROJECTED POPULATION – 1980, 2000, 2020

YEAR	Rural Farm Pop.	%	Rural Nonfarm Pop.	%	Urban Pop.	%	Total Pop.	%
1950	45,000	40.3	34,415	30.8	32,345	28.9	111,760	100.0
1960	33,831	31.4	39,865	37.0	33,988	31.6	107,684	100.0
1980	25,900	23.0	42,500	37.8	44,000	39.2	112,400	100.0
2000	20,700	17.8	43,800	37.6	52,000	44.6	116,500	100.0
2020	15,900	13.0	46,100	37.8	60,000	49.2	122,000	100.0

SOURCE: U. S. Department of Agriculture (6)

SPECIFIC RECOMMEDATIONS ON MUNICIPAL AND INDUSTRIAL WATER SUPPLIES

Recommendations to Federal Agencies

1. The Public Health Service should offer its assistance to the State Department of Health and the city officials of Rising City, Dwight, Marquette, and Odell in finding a solution to the problem posed by high nitrate and sulfate levels in the drinking water supply.

2. Farmers Home Administration should provide assistance where needed in development of needed rural water systems.

Recommendations to State Agencies

1. The State Department of Health should instigate a meeting between their personnel, the U.S. Public Health Service, and the city officials of Rising City, Dwight, Marquette, and Odell to consider solutions to the problems posed by high nitrate and sulfate levels in the public water supplies of these communities.

Recommendations to Local Units of Government

1. Officials responsible for public water supplies should act immediately to protect such supplies from contamination by providing disinfection through chlorination or some other proven method.

2. Officials responsible for public water supplies should continue educational programs showing effects of fluoridation of the water supply in the control of dental caries in children.

3. Cities should institute a policy of metering water users and using a realistic graduated pricing system as one means of eliminating waste.

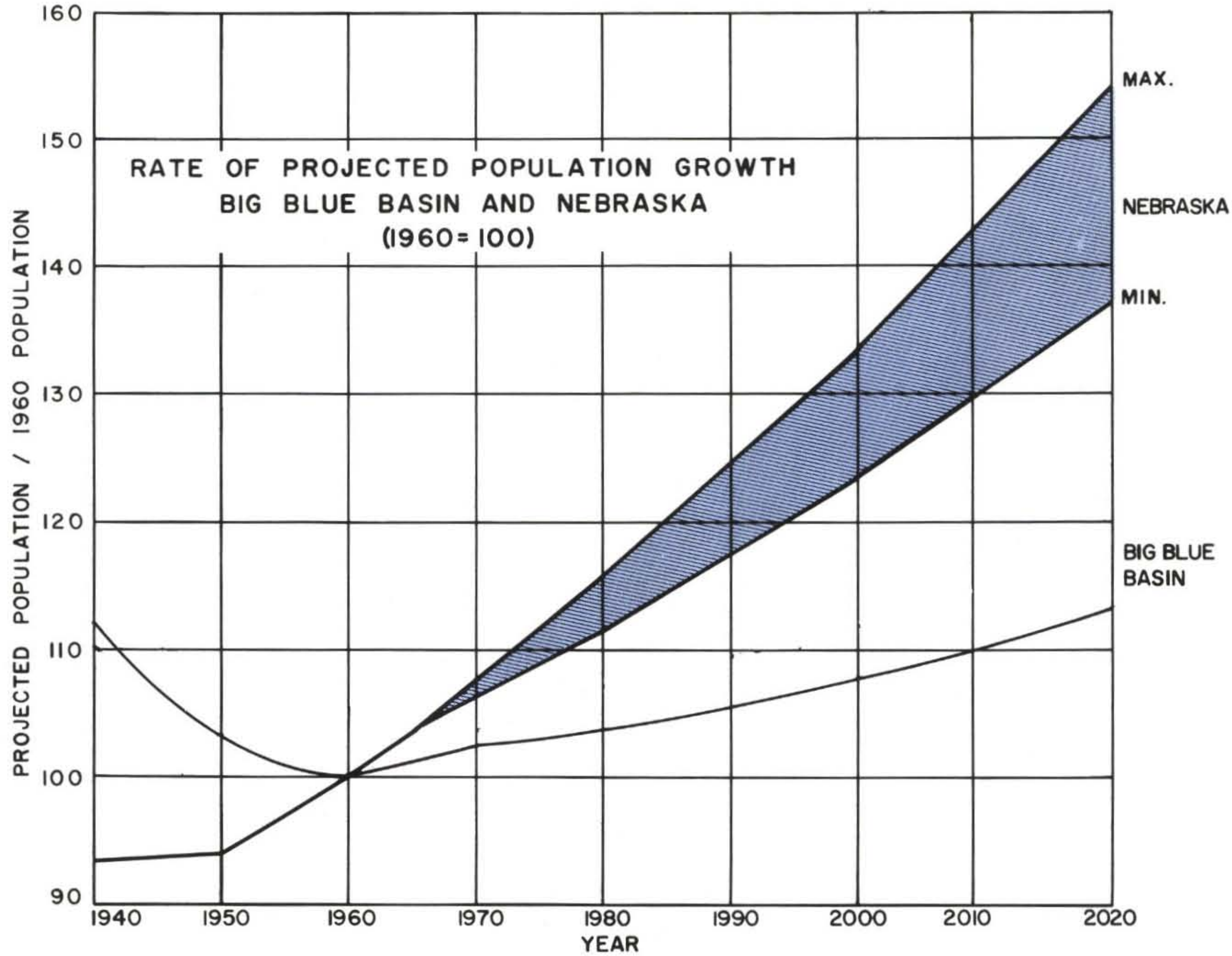


FIG. 21

WATER QUALITY

The chemical and bacteriological quality of all waters within the Big Blue River Basin should be of concern to the urban dweller who uses water for industrial and domestic purposes as well as the rural dweller who makes use of it for livestock, crops and household uses.

Water quality standards for streams within the state have been proposed by the Water Pollution Control Council of the State of Nebraska whereby waters will be classified for their highest use such as domestic, recreational, agricultural or industrial. If Nebraska water quality standards are not considered adequate, the federal government will establish these quality standards for all interstate waters and their major tributaries within the State of Nebraska. More testing and control activities are probably going to be required of the State of Nebraska. Water quality standards must be such that existing quality of any water is not lowered.

Disposal of wastes continues to be a growing problem. Future waste loads will continue to grow and cities should plan now for expansion of treatment facilities.

If sufficient streamflow and suitable reservoir sites exist, storage reservoirs can provide water for dilution and abatement of pollution conditions. This is not prevention but only a partial cure. Provision of adequate treatment facilities is the preferred method of pollution abatement.

The Public Health Service estimates Hastings and York will have an annual need for water for pollution abatement of 35,000 and 7,750 acre-feet, respectively, by the year 2020. Since adequate storage sites are unavailable at Hastings, alternatives will have to be considered. This could be an advanced treatment process of a type dependent upon the effluent presently being discharged. Water for waste dilution could be imported into the headwaters of the West Branch of the Big Blue above Hastings if legal restrictions did not prevent it. It might also be accomplished in conjunction with the importation of water for other purposes such as ground water stabilization and irrigation. Future ramifications in diversion laws may allow this facet to be considered in future planning.

Control of pollution caused by fertilizers, sediment, feedlots, and agricultural chemicals should be emphasized. Some of these chemicals have a long lasting effect and can prove detrimental to downstream users. Fertilizers can cause high nitrate values in ground water making it unsafe for human use. Sediment is probably the greatest pollutant in the basin especially in total amount.

SPECIFIC RECOMMENDATIONS ON WATER QUALITY

Recommendations to Federal Agencies

1. The Federal Water Pollution Control Administration should re-evaluate the need for low flow augmentation in the mainstem of the Big Blue River and evaluate the benefits that could be obtained by supplementing the characteristic low base flow of the stream.

2. The Soil Conservation Service should accelerate programs to reduce soil erosion and resultant sedimentation.

3. Cost-sharing and technical assistance in the field of waste disposal and treatment presently available to urban areas needs to be expanded to include rural areas.

Recommendations to State Agencies

1. The Nebraska Soil and Water Conservation Commission is currently coordinating water oriented data collection among state agencies. All agencies responsible for this type of data should advise the Commission of their programs so the collection and use of data by agencies such as the Department of Health can be made most effective.

2. The Nebraska Water Pollution Control Council should develop effluent standards as a basis for regulation necessary to achieve water quality goals which have been set by the Council.

Recommendations to Local Units of Government

1. Milford should act immediately to incorporate at least secondary treatment as a part of the operation of their sewage collector and disposal system.

2. Hastings should give consideration to the provision of either additional sewage treatment or use of sewage effluent for some other purpose. Its location within the basin precludes use of surface water for dilution unless water is diverted into the Blue Basin and the West Fork of the Big Blue River.

3. Local soil and water conservation districts should increase their activity in promoting land treatment on watersheds in the basin to reduce the sediment load in the streams.

LAND TREATMENT

Overutilization of much of the pasture and rangeland aggravates the sediment problem caused by erosion of many of the topsoils on the sloping lands of the basin. This is not only a loss in soil and productivity, but also decreases channel capacities and will decrease effective capacities of any proposed reservoirs.

Future land use, shown in Table 21, is not expected to change appreciably. The trends toward urban land use, that are so striking in some parts of the nation, are not expected to greatly affect land use within the basin. The present urban areas are expected to grow but the amount of land involved should not be significant in total and will be important only to those local areas involved. The U.S. Department of Agriculture expects total non-agricultural land to increase some fifty percent by 2020, but still occupy only 5.5 percent of the total land area of the basin. (6)

TABLE 21
PROJECTED LAND USE: 1980 and 2020
BIG BLUE BASIN

1980	Central Loess Plains Acres (Thousands)	Central Loess Plains % of Land Resource Area	Nebr-Kansas Drifthills Acres (Thousands)	Nebr-Kansas Drifthills % of Land Resource Area	Basin Total Acres (Thousands)	Basin Total % of Total Land
Cropland	1,951.7	80.9	341.8	67.4	2,293.5	78.5
(Nonirrigated)	(1,351.7)	(56.0)	(328.6)	(64.9)	(1,680.3)	(57.5)
(Irrigated)	(600.0)	(24.9)	(13.2)	(2.5)	(613.2)	(21.0)
Pasture	263.5	10.9	100.7	19.9	364.2	12.5
Woodland	23.5	.9	19.4	3.8	42.9	1.5
Other Ag. Land	69.8	2.9	18.1	3.6	87.9	3.0
Total Ag. Land	2,308.5	95.6	480.0	94.7	2,788.5	95.5
Non Ag. Land	105.0	4.4	26.6	5.3	131.6	4.5
Total Land	2,413.5	100.0	506.6	100.0	2,920.1	100.0
2020						
Cropland	1,911.0	79.2	335.9	66.3	2,246.9	77.0
(Nonirrigated)	(1,261.0)	(52.3)	(318.0)	(62.8)	(1,579.0)	(54.1)
(Irrigated)	(650.0)	(26.9)	(17.9)	(3.5)	(667.9)	(22.9)
Pasture	285.4	11.8	104.8	20.7	390.2	13.4
Woodland	24.6	1.0	19.8	3.9	44.4	1.5
Other Ag. Land	59.2	2.5	14.8	2.9	74.0	2.5
Total Ag. Land	2,280.2	94.5	475.3	93.8	2,755.5	94.4
Non Ag. Land	133.3	5.5	31.3	6.2	164.6	5.6
Total Land	2,413.5	100.0	506.6	100.0	2,920.1	100.0

SOURCE: U. S Department of Agriculture (6)

The remaining 94.5 percent of the land in the basin will remain in agricultural uses. Small increases are expected in the forest and woodlands category and pasture and rangeland is expected to increase by 16.5 percent by 2020. It might be expected that much of this shift in land use will take place on the less productive and more eroded soils as better management practices are instituted.

The total amount of cropland is expected to decrease by about four percent by 2020. Most of this change will come about by conversion of cropland to pasture land and non-agricultural uses.

The most notable land use change expected is the increase in irrigated lands which are projected to increase some 36 percent to 667,900 acres by 2020. This change will continue to be most pronounced in the western portion of the basin.

It should be pointed out that the anticipated increase in irrigation development considers only the past trends of private well irrigation development and does not include the possibility of project type irrigation development. Should one or more major irrigation projects of this type come into existence, considerable additions to the irrigated acreage of the basin could be expected.

In the event large scale irrigation development occurs, adequate treatment should be given to areas receiving water to prevent excess runoff and erosion. This treatment would consist of, but not be limited to, land leveling, drainage channels, diversion terraces, etc.

Increased conservation measures in the upper part of the basin will also improve the excess water problems now existing in the depressional areas.

SPECIFIC RECOMMENDATIONS ON LAND TREATMENT

Recommendations to Federal Agencies

1. The Department of Agriculture should accelerate research to determine new soil conservation techniques more applicable to current farming methods.

2. The Agricultural Stabilization and Conservation Service, with the responsibility of administering funds for installation of conservation practices, should continue to emphasize the use of such funds for permanent practices only to accelerate the land treatment phase of the conservation program.

3. The Soil Conservation Service should provide the necessary staff to provide leadership in accelerating land treatment. Contacts and followup calls should be made with all landowners and operators in the basin.

Recommendations to State Agencies

1. The Soil and Water Conservation Commission should increase their counseling and technical and financial assistance to soil and water conservation districts in an effort to accelerate the land treatment program.

2. The Departments of Agricultural Engineering and Agronomy of the University of Nebraska should accelerate research in the area of conservation farming to determine methods more suitable and acceptable to current farming practices.

3., The Extension Service of the University of Nebraska should provide educational leadership in developing and promoting land treatment measures.

Recommendations to Local Units of Government

1. Local soil and water conservation districts should employ personnel to carry out a more aggressive program of land treatment.

2. County and township governing bodies should consider the incorporation of drop inlet structures on road systems where feasible and practical.

3. County and township governing bodies should reshape and seed road ditches and drainageways where practical to control erosion and sediment.

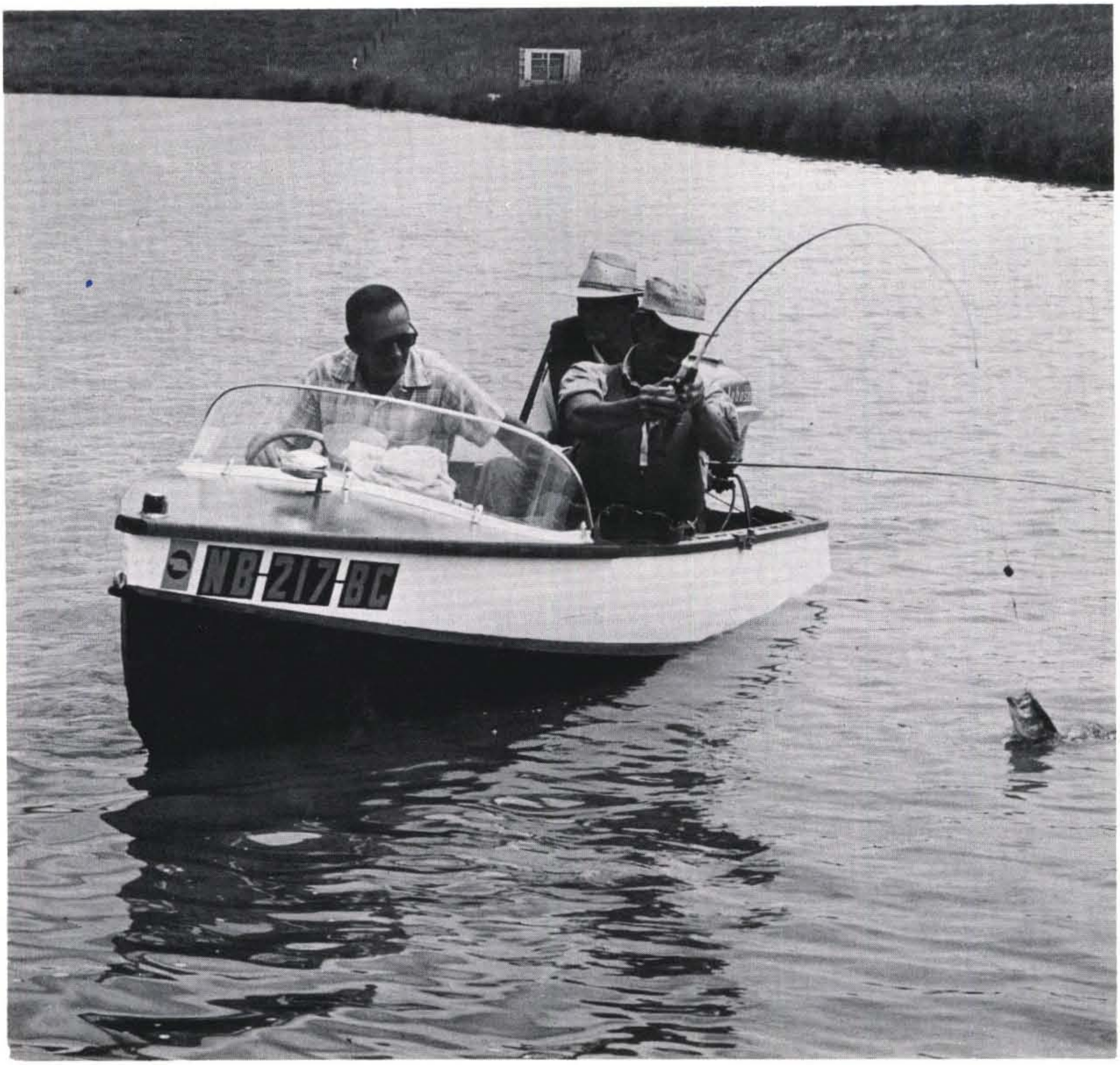
4. Soil and water conservation districts should consider the possibility of enacting land use regulations to require conservation practices.

RECREATION

Provision of sufficient future supply and access to the existing supply of recreational opportunities are major problems in the area of recreation and fish and wildlife. The extent of federally owned land in the basin is minor and state owned recreational areas total less than 0.05 percent of the total area.

Small watershed projects sometimes lend themselves quite well for use as recreation and fish and wildlife areas. Present policy requires that local interests assume part of the cost involved in providing recreation features in a watershed structure. The demand for recreational functions in some areas of the basin could be alleviated if local groups participated in these projects where suitable. These projects are limited in the water they can provide but are often well distributed within a basin.

Sites which are located near major state on interstate highways are attractive for out-basin recreation use, especially that stemming from the large urban areas. However, site selection must consider all phases of resource development and conditions.



There are several schools of thought on the economic feasibility of recreational developments. Some feel that recreation's chief values are social and esthetic in nature but regardless of how one considers it, there is little doubt that recreation does have a fiscal impact upon an area. Some of the factors which affect the value of recreation and fish and wildlife are quality of the recreation, expected success, alternative expenses in the area, attractiveness of the environment, and the rate of use in comparison to the optimum capacity. The estimated economic evaluation of recreation for the Big Blue Basin is shown in Table 22.

Factors which conserve soil and reduce sediment also contribute to quality recreation by decreasing silt bar accumulation and turbidity. Chemical quality must also be controlled especially in reservoirs where water contact activities are practiced.

The continuing shift of population from farm to city will have the effect of contributing to an increased demand for suitable recreation and fish and wildlife areas.

TABLE 22
ESTIMATED ANNUAL VALUE OF OUTDOOR RECREATION
BIG BLUE BASIN

Activity	(Thousands of Dollars) 1960	1980
Fishing	516.9	729.1
Hunting	251.2	265.7
Boating	159.2	241.3
Water Skiing	19.4	37.3
Picnicking	49.7	233.9
Camping	43.8	69.8
Swimming	284.3	423.8
TOTAL ANNUAL	1,324.5	2,000.9

SOURCE: Nebraska Game and Parks Commission (3)

SPECIFIC RECOMMENDATIONS ON RECREATION

Recommendations to Federal Agencies

1. The Bureau of Reclamation, and the Corps of Engineers, in future studies of the Big Blue Basin should give consideration to the development of the Beaver Crossing Dam and Reservoir as the primary recreation site in the Big Blue Basin. However, development of feasible recreation facilities should be encouraged for all other sites.

2. The Soil Conservation Service should investigate the possibility of incorporating recreation and fish and wildlife features in all watershed structures, with particular emphasis on the more desirable sites.

Recommendations to State Agencies

1. Recreation development in the Big Blue Basin should be primarily oriented toward development of facilities associated with the Beaver Crossing Dam and Reservoir site, but consideration should be given to all potential sites.

2. The Game and Parks Commission should assist the Soil Conservation Service in planning the developing measures for improvement of wildlife habitat throughout the basin.

3. The Game and Parks Commission should participate in resource programs of research and development to enhance the opportunities for fish, wildlife, and recreation interests.

Recommendations to Local Units of Government

1. All counties should develop a county park system or plan which considers the existing and proposed water use areas.

2. Local sponsors of watershed districts should consider acquisition of land for recreation in conjunction with suitably sized small watershed structures as a means of meeting local recreation demands.

PLAN FORMULATIONS

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In the formulation of a recommended plan of development in the basin an effort was made to consider all the beneficial uses which water could serve. The outstanding needs in the Big Blue Basin fall primarily in six areas.

1. Land Treatment
2. Flood Control
3. Irrigation
4. Ground Water Stabilization
5. Recreation
6. Low Flow Augmentation

Land treatment is vitally needed to decrease the soil erosion and resultant sedimentation of the stream channels. Adequate land treatment measures can also favorably benefit flood control and ground water recharge facilities.

Flood control can be obtained by a variety of structural and non-structural means including mainstem reservoirs, levees, flood plain zoning and small watershed projects. A combination of these is proposed for installation.

Project type irrigation in the Big Blue Basin is hampered by the small supply of available surface water in comparison to the large expanses of high quality irrigable lands located primarily in the upper and central portions of the basin.

Ground water stabilization is a technically difficult procedure when specifically done with recharge alone in mind. Stabilization by artificial recharge can many times be accomplished as the deep percolation losses from surface water irrigation project. However, reservoir sites in the upstream areas of the Big Blue Basin, as well as available water supplies, make such a project infeasible in the area which is now experiencing a decline in the level of the ground water table.

Water-based recreation is usually limited to those sites having a fairly stable water surface. Other types of recreation are often associated with water resource developments. The site offering the greatest recreation potential is Beaver Crossing on the West Fork, Big Blue River. Small watershed reservoirs offer excellent opportunities for development of water-oriented outdoor recreation and fish and wildlife uses by local units of governments, such as counties.

Low flow augmentation is a means of alleviating some of the pollution and water quality problems which exist. This is not a desirable way to improve these conditions and should only be used after all treatment and preventive measures have been installed. The limited supply of water, especially in the upper reaches of the Big Blue Basin, makes flow augmentation unlikely without an additional source of water. The plan for major reservoirs was developed with the following assumptions:

1. Importation of surface water to the basin is not possible under existing state law.

2. State regulation of ground water development is not possible under existing state law. Therefore, the possibility of developing surface water irrigation projects at the present time is doubtful since adequate water is still available at a comparable cost from ground water sources in most areas. Formulation of the plan, with irrigation as a primary purpose, would thus involve the guarantee by some non-Federal entity of those costs allocated to conservation storage.

3. To minimize the present non-Federal obligation for financial support, the major reservoir plan was formulated to provide primarily flood control with the expectation that at such time as surface water irrigation projects are implemented, the operation of the reservoir as a system could be changed. Additional flood control storage would be provided to replace any flood storage converted to conservation uses.

MAJOR RESERVOIRS

Surprise Dam and Reservoir

The Surprise Dam and Reservoir site is located one and one-half miles west of Surprise, Nebraska on the North Branch of the Big Blue River. The site, when fully developed, will have a total storage capacity of 176,700 acre feet. This site lies below a drainage area of 337 square miles. To achieve full control of floods in this area an allocation of flood control storage space of 118,000 acre-feet is necessary. Sediment and dead storage are estimated to require a total of 8,700 acre-feet. The remaining storage space allocated to conservation is 50,000 acre-feet. Since this reservoir is near the head waters of the main stem of the Big Blue River it is recommended that this conservation space be utilized to provide augmentation of the low base flows which occur in the Big Blue River.

Seward View Dam and Reservoir

The Seward View Dam and Reservoir site is located on Lincoln Creek approximately two miles west of Seward, Nebraska. This site, when fully developed, will provide a total storage of 227,300 acre feet. The dam and reservoir lie below a drainage area of 445 square miles. Flood control storage of 156,000 acre-feet should be allocated to fully control flood runoff from the drainage area. It is estimated that 11,300 acre-feet of storage are required for sediment and dead storage. The remaining unallocated conservation space will be approximately 60,000 acre-feet. It is recommended that full site development be made with deferred conservation storage available for later use in development of surface water irrigation.

Beaver Crossing Dam and Reservoir

Beaver Crossing Dam and Reservoir is located below the junction of Beaver Creek and the West Fork of the Big Blue River approximately one mile west of Beaver Crossing. This dam site and reservoir, when fully developed, would have a storage capacity of 538,300 acre-feet. The drainage area upstream of the reservoir is 1,154 square miles. The provision of 404,000 acre-feet of flood control storage is recommended to fully control this drainage area. Dead and sediment storage are estimated to require a total of 46,200 acre-feet. The remaining unallocated conservation space would be approximately 88,100 acre-feet.

The Bureau of Reclamation has investigated the Beaver Crossing site and the associated irrigable lands in a reconnaissance level report titled "Reconnaissance Report on the Blue Division, Nebraska and Kansas - July, 1965". They are now engaged in a study of the engineering and economic feasibility of constructing the unit. Full development of this site should be encouraged with deferred storage available for future irrigation development.

Shestak Dam and Reservoir

Shestak Dam and Reservoir is located on Turkey Creek six miles southeast of Dorchester. Full development of the site would provide a storage capacity of 180,500 acre-feet. The drainage area above the site is 415 square miles. The storage space required to fully control flood runoff from the drainage area would be 145,200 acre-feet. Dead and sediment storage are estimated to require 10,500 acre-feet. The unallocated conservation storage remaining would be 24,800 acre-feet. This site should be developed with deferred storage provided for future advent of irrigation interests.

SMALL WATERSHED PROJECTS

The major reservoir plan is limited to the availability of suitable sites. Significant tributaries which would remain uncontrolled by the major reservoirs include the North Fork of the Big Blue River, Kezar Creek, Plum Creek (Seward and Butler Counties), Clatonia Creek, Swan Creek, Johnson Creek, Cub Creek, Indian Creek, Bear Creek, Pierce Creek, Cedar Creek, Mud Creek, Wolf-Wildcat Creek, Plum Creek (Gage and Pawnee Counties), Mission Creek, and Big Indian Creek. Small watershed projects which are currently under construction or completed include Cub Creek, Big Indian Creek, Clatonia Creek, Dorchester, Indian Creek, Bear-Pierce Cedar Creeks, Mud Creek, Plum Creek (Gage and Pawnee Counties), and Mission Creek, Planning assistance for Swan Creek and Wolf-Wildcat Watersheds has been requested of the Soil Conservation Service. To achieve full flood control of the mainstem of the Big Blue River those watershed projects which appear feasible but have not yet been constructed should be expedited through the planning the construction process. These include Kezar Creek, Plum Creek (Seward and Butler Counties), Swan Creek, Soap Creek, Dry Creek, and Wolf-Wildcat Creek. Other watershed areas which have been investigated or are seeking planning assistance include West Ulysses Watershed and the Dogtown Watershed at Exeter.

LOCAL FLOOD PROTECTION PROJECTS

While construction of the recommended major reservoirs and additional watershed projects will provide excellent control of flooding on the mainstem of the Big Blue River, such projects often take years for completion. Therefore, it is recommended that towns having existing flood problems proceed with securing the necessary local protection in the form of levee construction, channel rectification and flood plain zoning. In particular, Wymore, DeWitt, and Crete should take steps to initiate planning for local protection. A local protection project has already been proposed for Beatrice and is currently under restudy. The City of Beatrice should indicate to the District Engineer of the Kansas City District of the Corps of Engineers a willingness to undertake the local responsibilities associated with obtaining such protection.

ALTERNATE PLANS OF DEVELOPMENT

The structural plan recommended for the basin would change significantly in the event that additional water was available for importation. While at the present time water supply is inadequate in the upper basin to provide for either surface water irrigation or ground water recharge on a project basin, such developments could be accomplished with additional water and would be of great value. The topography of the basin is such that water supplies brought into the basin through the western boundary could be well distributed throughout the basin. Capture of return flows from imported water being used for surface water irrigation or ground water recharge could facilitate multiple reuse of water introduced in the basin. In the event large amounts of water were imported to the basin it would be necessary to provide reservoirs in the upstream areas of the basin for the storage and regulation of flows. Irrigation of some 14,000 acres in the Surprise area and 18,000 acres in the Plymouth area, in addition to the lands in the Dorchester and Goehner areas to be irrigated from the Beaver Crossing Reservoir, would become feasible. These lands represent only that portion of the potentially irrigable lands in the basin which have been investigated to date and found suitable. Without doubt many additional acres would also be suitable for irrigation. Development of additional irrigation in the area of Surprise Dam and Reservoir and Shestak Dam and Reservoir will require the provision of additional conservation space in these reservoirs beyond that recommended at the present time. Provision of flood control space to replace that reallocated to conservation could be accomplished through construction of additional reservoirs. Several additional reservoir sites have been investigated by the Corps of Engineers and data on these sites are included elsewhere in the report. These sites are shown on Figure 19.

Construction of Reservoir "E" on the main stem of the Big Blue River south of Staplehurst could provide flood control storage equivalent to that converted to conservation uses in Surprise Reservoir as well as control the drainage area contained within the North Fork of the Big Blue River and Kezar Creek. Due to its location immediately upstream of Seward, Nebraska it would provide a high degree of flood protection for that city. Damsite "B" on Lincoln Creek north of Bradshaw and damsite "C" on Lincoln Creek south of Gresham would provide space for flood control equivalent to that reallocated to conservation use in the Seward View Reservoir. Damsite "V" on Beaver Creek south of Bradshaw or Damsite "X" on Beaver Creek east of York would provide adequate storage to replace flood control storage reallocated to conservation use in the Beaver Crossing Reservoir. Damsite "V" would also offer the advantage of providing water quality control in the York area as well as serve as a potential source of water for York in the event that uncontrolled irrigation pumping seriously depletes the available ground water supply. Damsite "G" on the West Fork south of Henderson and Damsite "H" on the west fork north of Fairmont offer alternative possibilities of flood control storage. Damsites "B", "V", "G", and "H" in particular could serve in addition as reservoirs for reregulation of imported water as well as central features of a ground water recharge project. Reservoir "N" on Turkey Creek northwest of Milligan and Reservoir "O" south of Friend are alternative sites which could provide replacement of the flood control space in Shestak Reservoir which might be reallocated to conservation uses.

IMPLEMENTATION

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Development of the features outlined in this report are dependent upon local interests, availability of funds, project sponsorship, the development of future needs, possible changes in law and policy, and in part on future available water sources.

Proper land treatment and use should have early and continued encouragement since it is basic to the economy of the region and may affect several functions. It will also provide some reduction in flooding as well as reducing erosion. This will result in less sediment deposition in reservoirs to be constructed and provide more desirable and higher quality waters for many uses–particularly recreation.

Flood damages can be reduced by a combination of flood plain zoning, small watershed project developments, and various recognized forms of mainstem structural measures. The sequence of construction will depend upon the interests and needs of the local people and the availability of funds. As the evolution of transbasin diversion takes place, consideration of importing water from outside sources may indicate that some new potential reservoir locations and some possible reallocation of flood control storage may be warranted.

Lands in the lower basin can utilize available surface waters conjunctively with ground waters for irrigation, but additional surface water will be required from outside the basin to achieve ground water stabilization and thus sustain present development and attain supplemental irrigation in the upper areas of the basin. Adequate reservoir sites are quite limited but lands suitable for project type irrigation are located over most of the basin.

Development of these lands for both surface water irrigation and for conjunctive use with ground water should proceed in relation to the availability of water as evidenced by trends in ground water depletions and the desires and needs of the local people.

Recreation, in addition to specific single purpose developments, can be achieved in conjunction with development of several of the other functions but should be emphasized at those reservoir sites having the more stable water surface elevations. Proximity to population centers and accessibility from major highways should also be considered in recreation development.

Low flow augmentation may be required on certain streams but should not be considered as a substitute for installation of suitable waste treatment and safe disposal methods. Some low-flow augmentation may be desirable below reservoir sites to meet water quality standards in interstate streams having municipal water supply uses and for recreation and fish and wildlife.

The Nebraska Soil and Water Conservation Commission looks to the Big Blue Watershed Planning Board (as presently constituted) to give the necessary leadership in implementing the various facets of this report. In turn, this Planning Board must secure and stimulate the cooperation and assistance of such local organizations as: soil and water conservation districts; watershed conservancy districts; ground water conservation districts; county and township governing boards; and municipalities. The Commission will actively seek the necessary appropriations and authorizations for state, federal, and local agencies to carry out their responsibilities in line with recommendations included in this report. The Commission will assist in the coordination, counseling and granting of other assistance to local units of government from such funds and assistance as are available to the Commission. As part of the State Water Plan, the Commission shall make appropriate recommendations to the Office of the Governor and the Nebraska Legislature as are necessary to implement the Big Blue River Report.

It should be noted that the Commission is presently in the process of preparing a special work item on reorganization of local natural resource districts in Nebraska as part of the State Water Plan. This special work item (if enacted into law) could have a tremendous impact on the recommendations of this report by affording local people the necessary legislative and other tools to adequately sponsor the various projects and programs recommended herein.

In implementing the features of the Big Blue River Basin Plan, consideration must continually be given to technological advances, changing economic conditions, and changing needs and desires. A review by the Commission will be made periodically to appraise changes in development and outlook, and to permit adjustments in the basin plan as desirable.

The Nebraska Soil and Water Conservation Commission pledges its resources to the citizens of the Big Blue River Basin in assisting them in adopting the provisions of this and subsequent reports for their area that are developed as part of or are compatible with the Nebraska Water Plan, as authorized by the 1967 session of the Nebraska Legislature.

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