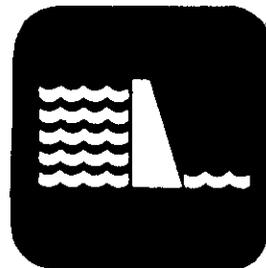
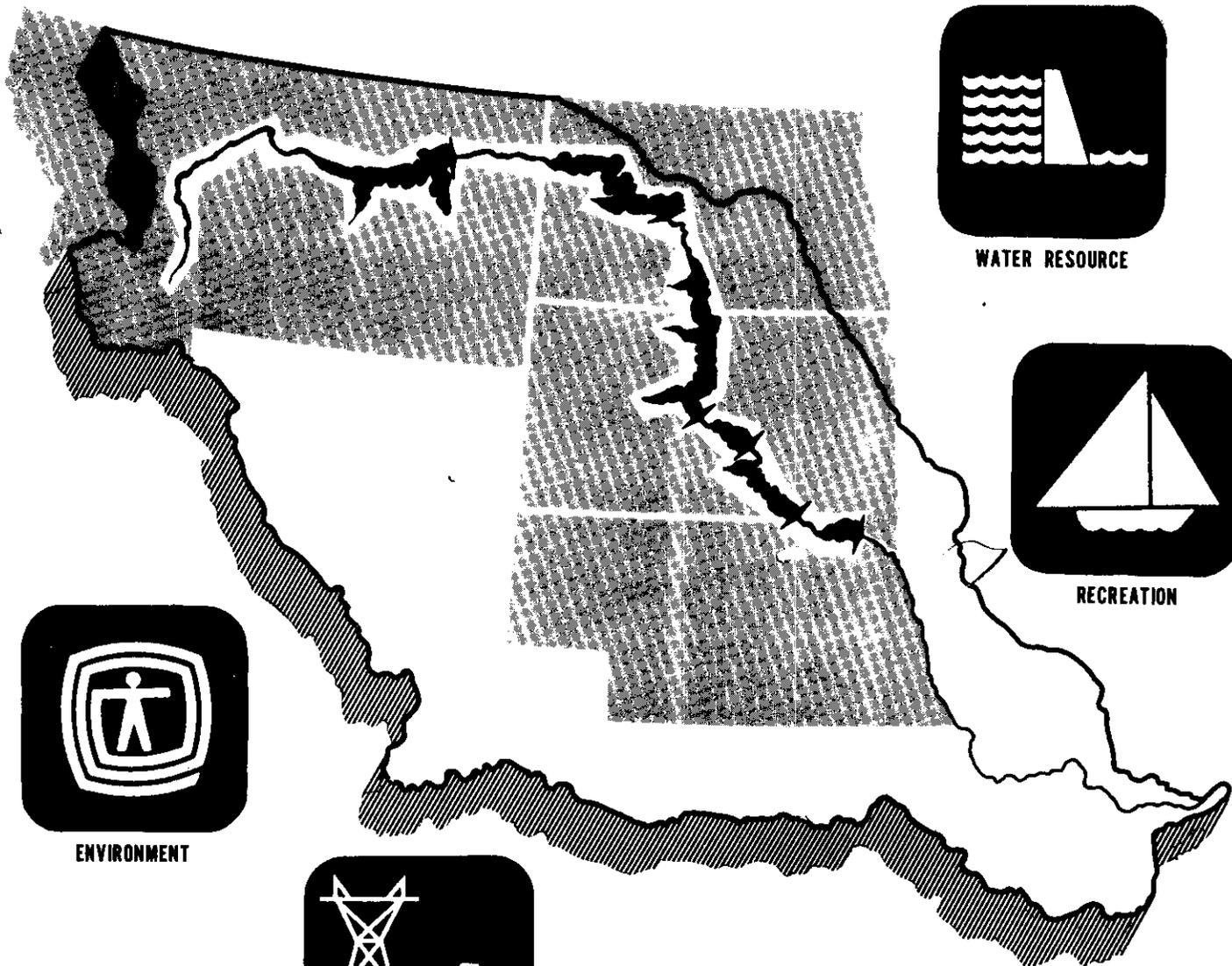


MISSOURI RIVER

SOUTH DAKOTA, NEBRASKA, NORTH DAKOTA, MONTANA
REVIEW REPORT FOR WATER RESOURCES DEVELOPMENT



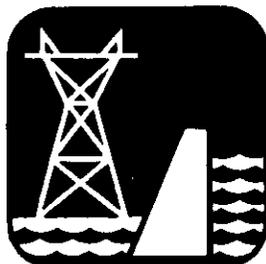
WATER RESOURCE



RECREATION



ENVIRONMENT



HYDRO-ELECTRIC POWER

VOLUME 1 OF 3

AUGUST 1977

MISSOURI RIVER, SOUTH DAKOTA,
NEBRASKA, NORTH DAKOTA,
MONTANA

Review Report for Water Resources Development

A STUDY TO REVIEW PERTINENT REPORTS ON THE MISSOURI RIVER AND TO DETERMINE THE ADVISABILITY OF PROVIDING ADDITIONAL MEASURES FOR FLOOD CONTROL, BANK STABILIZATION, NAVIGATION, HYDRO-POWER GENERATION, RECREATION, FISH AND WILDLIFE PROPAGATION AND OTHER PURPOSES BETWEEN THREE FORKS, MONTANA AND SIOUX CITY, IOWA.

U.S. ARMY CORPS OF ENGINEERS
MISSOURI RIVER DIVISION
AUGUST 1977

Syllabus

This study investigated a wide range of water resource problems and opportunities related to the Missouri River and the six main stem dams, along an area extending over 1,500 miles from Sioux City, Iowa to Three Forks, Montana. Subjects of the study were: the feasibility of installing additional hydro-power generating units both at the main stem dams and adjacent to the river; resolution of bank erosion, waterlogging, and residual flood problems; opportunities for recreation, fish and wildlife enhancement; operating plans of the main stem system considering future water use; and potential for extending navigation upstream from Sioux City, Iowa.

Several elements were dropped during the course of the study. Water allocation and marketing was an initial objective; however, basin states indicated such studies to be untimely. This report, therefore, does not make any recommendations dealing with priorities of water use. Surface inundation and waterlogging along a 10-mile reach upstream from the mouth of the Niobrara River during periods of high release from Fort Randall have been judicially determined to require Federal compensation of the landowners. A separate report will deal with this problem. In response to the waterlogging problem at Buford-Trenton, North Dakota, the Corps has developed a drainage plan to be accomplished under existing authority. Extension of navigation past the main stem dams or only as far as Yankton, South Dakota, is clearly infeasible even under the most favorable assumptions. Potential hydro-power additions at the Oahe and Fort Randall damsites and a pumped-storage facility at Garrison have been deferred for future evaluation.

The selected plan includes elements for bank stabilization and recreation access, additional hydro-power capacity, restoration of

trophy fishing at Lakes Oahe and Francis Case, and National Wild and Scenic River designation of the Gavins Point-Ponca State Park reach. Plan components were selected from an array of alternatives assessed in terms of national economic development, environmental quality, and social and regional effects. Bank stabilization consists of design and construction of soft protection works employing river management techniques designed to preserve the existing environment while at the same time preserving high bank lands. Missouri River sites authorized by river reach below Garrison, Fort Randall, and Gavins Point Dams in Section 32, PL 93-251, in addition to five locations below Fort Peck Dam and one location below Oahe Dam are included in the selected plan. The Federal construction cost will be \$15,307,000 and the non-Federal cost will total \$878,000. Construction of five river access sites in conjunction with bank protection will cost \$355,000. The selected hydro-power additions consist of a 185 mw expansion at Fort Peck with a reregulation dam at an investment cost of \$84,253,000; a 272 mw expansion at Garrison Dam with a reregulation dam at an investment cost of \$90,748,000; and a 1180 mw pumped-storage plant adjacent to Lake Francis Case at an investment cost of \$274,553,000. For the three hydro-power additions, annual benefits total \$68,893,000 and annual costs equal \$45,622,000 resulting in a 1.5 benefit-cost ratio. The plan selected for restoration of a northern pike fishery at Lakes Oahe and Francis Case consists of construction of rearing ponds and an enhanced lakeshore forage base at 12 sites at a cost of \$4,270,000. Improvements in fishing opportunity will yield \$1,080,000 in annual benefits; and with annual costs totaling \$363,000, the ratio of benefits to costs is 3.0. An additional element of the selected plan consists of designation of about 60 miles of the Missouri River from Gavins Point Dam to Ponca State Park under PL 90-542 as a component of the Wild and Scenic River System. A reconnaissance study has found that this river reach possesses the features that make it eligible for such designation. Acquisition of recreation easements, river feature stabilization, and a small amount of fee purchase for river access facilities results

in a first cost of \$7,412,000 and an annual cost of \$661,000.
Annual benefits of \$3,306,000 yield a benefit-cost ratio of 5.0.
Total investment cost for the selected plan is \$477,776,000.

This investigation has proceeded to the point of establishing the economic feasibility of improvement; however, further investigation is necessary to resolve certain remaining environmental issues. It is therefore recommended that the selected plan be authorized for Phase I design memorandum stage of advanced engineering and design, at an estimated cost of \$2,500,000.

MISSOURI RIVER

SOUTH DAKOTA, NEBRASKA, NORTH DAKOTA, MONTANA REVIEW REPORT FOR WATER RESOURCES DEVELOPMENT

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MISSOURI RIVER

SOUTH DAKOTA, NEBRASKA, NORTH DAKOTA, MONTANA, REVIEW REPORT FOR WATER RESOURCES DEVELOPMENT

The Study and Report

This section traces the numerous expressions of Congressional interest in the upper Missouri River and their consolidation into a single report. Administrative details concerning coordination with other entities, public participation and a bibliography of prior studies are also provided.

Purpose and Authority

The purpose of this study is to investigate a wide range of water resource problems and opportunities all having in common some link with the Missouri River. Original authority under which this study was made is contained in 20 separate Congressional actions extending from 1938 to 1970. Authority to consolidate these specific outstanding and interrelated actions was contained in a series of letters from the Office, Chief of Engineers (OCE) to the Missouri River Division during the period 1972 through 1977. In

addition to the specific study authorities, Congressional actions of a broader, general nature also impact on this investigation. These general authorities include Section 122 and Section 216 of the 1970 River and Harbor and Flood Control Act (PL 91-611).

Scope of Study

The studies have examined the feasibility of installing additional generating units at the existing main stem dams; the opportunities and feasibility for new power developments adjacent to the Missouri River; bank erosion problems and potential alternatives for problem resolution; waterlogging and sedimentation problems and potential alternatives for problem resolution; recreation, fish and wildlife enhancement opportunities including legal and institutional requirements for implementation; main stem system operating plans in light of possible future water uses; and an update of navigation potential upstream from Sioux City, Iowa. Studies were extensive enough to permit plan selection and to determine economic feasibility. The study area consists of the Missouri River reach and adjacent lands from Sioux City, Iowa, to Three Forks, Montana.

Study Participants and Coordination

The Corps of Engineers had the principle responsibility for conducting and coordinating the study, plan formulation, consolidation of other agency information and preparing the report, except for evaluation of the reach below Gavins Point for possible designation as a recreational river. Responsibility for this study was shared jointly with the Bureau of Outdoor Recreation.

Coordination with a number of interested agencies was a part of the study effort. Sources of input were:

Federal

Bureau of Reclamation	Environmental Protection Agency
Fish and Wildlife Service	National Park Service
Bureau of Outdoor Recreation	U. S. Geological Survey
Soil Conservation Service	Bureau of Indian Affairs
Federal Power Commission	Bureau of Land Management

Non-Federal

Missouri River Basin Commission
Nebraska Game and Parks Commission
South Dakota Department of Game, Fish and Parks
North Dakota State Game and Fish Department
Montana Department of Fish and Game
South Dakota Department of Natural Resource Development
Montana Department of Natural Resources and Conservation
North Dakota State Water Commission

Land use information was received from County Agents in Montana, North Dakota, Nebraska, and South Dakota; appropriate State Planning agencies served as information clearinghouses during the course of the study. Public meetings have been held at various times during the course of the separate survey investigations; the most recent meetings concerned the initiation of the additional hydro-power study in 1971. After consolidation of the surveys into a single Umbrella Study, public meetings were held at Bismarck, North Dakota, Great Falls, Montana, Pierre and Yankton, South Dakota, 28, 29, 30 June and 1 July 1976, respectively. In addition, two interim status reports were widely distributed to the public.

The Report

This report has been arranged into a main report with three appendices. The main report is a non-technical presentation of the

feasibility study. It contains a description of the study area, including existing improvements; current problems and opportunities; formulation of a suitable plan; a summary of economic benefits, costs, and justification; a designation of appropriate responsibilities between Federal and non-Federal interests; and recommendations for implementing the selected plan.

Appendix 1 is a technical report following the same general outline written in greater detail for the technical reviewer. Problems and their possible solutions are presented in the same order as found in the main report. Appendix 2 contains all pertinent comments on report review. Appendix 3 contains reports from other agencies.

Prior Studies and Reports

Prior reports by the Corps of Engineers covering the reach of the Missouri River under consideration in this investigation date back to 1881. The following table lists these reports and summarizes their conclusions.

PRIOR REPORTS BY CORPS OF ENGINEERS
ON THE MISSOURI RIVER

Report	Date	Type	Remarks
H. Ex. Doc. 92, 46th Cong., 3d Sess.	Febr. 1881	Preliminary report on navigation on the Missouri River.	No specific conclusions or recommendations on Missouri River above Sioux City, Iowa.
H. Doc. 91, 62d Cong., 1st Sess.	Dec. 1910	Report on 6-foot navigation channel, Missouri River, Sioux City to Williston, North Dakota.	Generally unfavorable to improvement, but snagging, rock removal, and limited stabilization works recommended.
H. Doc. 354, 69th Cong., 2d Sess.	Oct. 1926	Preliminary examination report, Missouri River, Kansas City, Kansas, to Pierre, South Dakota.	Channel improvements above Sioux City not justified.
H. Doc. 208, 73d Cong., 2d Sess.	Mar. 1933	The 308 report on examination and survey of Missouri River.	Recommended completion of navigation project below Sioux City and construction of Fort Peck Dam and Reservoir.
H. Doc. 214, 76th Cong., 1st Sess.	Dec. 1938	Re-examination report on navigation channel, Missouri River, Sioux City to mouth.	Recommended 7-foot channel in lieu of 6-foot channel. Subsequently authorized by River and Harbor Act of 1943.
H. Doc. 821, 76th Cong., 3d Sess.	Apr. 1940	Re-examination report with respect to flood control on Missouri River, Sioux City, Iowa to Kansas City, Missouri.	Recommended flood control project for protection of riparian lands against erosion between Kanslers Bend, Nebraska and Sioux City, Iowa.

PRIOR REPORTS BY CORPS OF ENGINEERS
ON THE MISSOURI RIVER
(CONT'D)

Report	Date	Type	Remarks
H. Dec. 475, 78th Cong., 1st Sess.	Dec. 1943	Review report on flood control on Missouri River from Sioux City to the mouth.	Recommended construction of 5 multiple-purpose dams on Missouri River above Sioux City, Iowa.
Investigation of Bank Erosion on Missouri River at Buford-Trenton Irrig. Project, North Dakota.	Dec. 1951	Reconnaissance report on bank erosion near pump intakes U/S from mouth of Yellowstone on Missouri River left bank.	Recommended emergency funds of \$30,000 be allocated under Sec. 14 of 1946 FCA to construct measures to protect Buford-Trenton pumping plant.
Protective Works in the Williston Area of the Garrison Reservoir	Dec. 1953	Responded to Senate Report on FY 1954 Appropriation Bill for protection to Williston, N.D., Lewis & Clark Irrig. Dist., & East Bottom of Buford-Trenton Irrigation District.	Presented a plan of protective works due to Lake Sakakawea impacts & due to sediment deposits in upper end of the Lake. PL 84-163 provided funds for purchase in lieu of protection, of Lewis & Clark Irrigation District and East Bottom. The Act was modified by PL 84-641 & PL 83-38 & East Bottom was purchased in 1958.
Review Report on Bank Stabilization Buford-Trenton Irrig. Dist., Missouri River, N.D.	Aug. 1961	Responded to 28 Jan. 55 resolution for determining methods of preventing land loss in Buford-Trenton Irr. Dist. from bank erosion.	Negative report since PL 85-58 in 1957 authorized purchase of East Bottom & for protection of intake structure of Buford-Trenton pumping plant & for bank protection works adjacent to Dist. Protective works completed in 1961.
Garrison Dam to Oahe Dam Bank Erosion Study	1961-1962	Response to 20 April 1959 Public works resolution for determining measures for reducing bank erosion problems.	In 1962, State of North Dakota requested deferral of study, subsequently isolated 5 high value areas in need of protection. Direct authorization of protective works by PL 88-253 on 30 Dec. 1963 and works constructed.
Missouri River, Ft. Peck Reservoir to Vicinity of Ft. Benton, Mont.	Jun. 1963	Joint Survey by Army & Interior on Missouri River power potential above Fort Peck, Montana.	Recommended High Cow Creek & Ft. Benton projects of 1020 mw to meet power demands. Plan not supported by Montana. No action taken on report.
Review Report, Missouri River, N.D., S.D., and NE.	Apr. 1965	Survey report on navigation & bank stabilization from Montana-North Dakota State line to Sioux City, IA.	Recommended extension of navigation U/S to Gavins Pt. Dam & bank protection works in same reach. Sec'y. of Army returned report in Apr. 1969.
Supplemental Report, Bank Erosion Problems, Gavins Point Dam - Sioux City, Iowa	Mar. 1972	Supplement to 1965 report prepared by joint task force of Nebraska, South Dakota, Universities, landowners, and BSWW and C of E on bank erosion measures.	Concluded best alternative would be selected land acquisition and bank protection measures in combination. Plan included in River & Harbors Bill in 1972 but vetoed by President Nixon.
Modification of Operation of Lake Francis Case, South Dakota	Oct. 1972	Response to Sec. 226 FCA 1970 to limit drawdown at Ft. Randall to reduce adverse environmental & aesthetic effects from normal 30-ft. drawdown.	The Coordinating Committee adopted a compromise operation limiting drawdown to 12.3 ft. except during droughts.

Resources and Economy of the Study Area

Although the Missouri drainage basin's 529,000 square miles account for 17 percent of the "lower 48," the area of this study is limited to the narrow belt bounding the reach from Sioux City to the Missouri River headwaters, as indicated on Plate 1. The counties immediately adjacent to the river along this reach have been designated as corridor counties; their area is 88,000 square miles, about one-third of the four-state total which lies within the basin.

Environmental Setting and Natural Resources

Elevations range from 4,000 feet msl at Three Forks, Montana, to 1,100 feet at Sioux City, Iowa. River slope varies from six feet per mile above Great Falls down to three feet per mile from there to Fort Peck Lake, with one foot per mile prevailing throughout the remainder of the study reach. Valley lands above Fort Peck are generally narrow and undeveloped; from Fort Peck to Garrison they average two miles wide. From the headwaters of Lake Sakakawea to Gavins Point Dam, a distance of 757 miles, the main stem reservoirs occupy more than 620 miles of the river valley. Open reaches of river exist between Garrison and Lake Oahe (87 miles), between Oahe and Lake Sharpe (five miles), and between Fort Randall and Lewis and Clark Lake (45 miles).

From Gavins Point Dam to Ponca, Nebraska, a distance of about 59 miles, the Missouri River is still in a semi-wild state. River discharges are regulated by the Gavins Point project and significant flooding has been eliminated. Except for isolated reaches, banks have not been stabilized and the river is free to meander over wide limits. Bank erosion is continually active. The river has a slope of about one foot per mile and the channel is from 1,200 feet to

5,000 feet wide, averaging 2,600 feet. The river has been stabilized 18 miles by the Sioux City to Kenslers Bend project. Upstream, the area between the normal high banks has multiple channels, low islands, sand bars, and bordering marsh with extensive willow growth. Some areas along the river bank are cultivated, while in others native timber growth extends a short distance inland from the bank.

Wide variances in seasonal flow characterize the Missouri River. The winter season is a period of low flows. From December to February, ice may cover the river as far south as Kansas City, Missouri. A typical spring rise begins in late March or early April with the melting of plains snow cover. A rise which is generally lower in peak flow but greater in volume is usually experienced in June when snowmelt from the higher plateaus and mountains may combine with runoff from prolonged spring rainfall. This is the usual period of maximum flow in the upper basin tributaries which are fed primarily by mountain snowmelt. Following the June rise, low flows usually prevail during the late summer and early autumn, interrupted by rises caused by occasional heavy rains.

The historic flood, by which all others in the upper basin are judged, occurred in 1881. A heavy snow blanketed the plains area that spring. Huge ice gorges in the Dakotas accompanied the spring thaw and the ice breakup. A crest of 18.5 feet above flood stage was reached at Yankton, South Dakota, highest known on the Missouri River. The flood produced a volume estimated to be over 40 million acre-feet at Sioux City, Iowa.

Runoff in 1975 from the drainage area controlled by the main stem reservoir system (i.e., upstream of Gavins Point Dam) exceeded any previous year in a record extending back to 1898, although downstream at Sioux City the annual volume in 1927 was one million

acre-feet greater. Regulation of this inflow resulted in new storage records at Fort Peck, Garrison and Oshe and record release rates ranging from 35,000 at Fort Peck in the upper end of the system to 61,000 at Gavins Point at the downstream end. Flooding associated with these releases was minor with the exception of a 10-mile reach upstream from the mouth of the Niobrara River -- about which more will be reported in subsequent pages. During the flood season 12 million acre-feet of flood flows were stored with reduction in peak flow of about 110,000 cfs in all the downstream river reaches except for an 80,000 cfs reduction below Fort Peck.

Annual runoff, like seasonal flow, fluctuates widely. At Sioux City the yield has ranged from 37 million acre-feet in 1927 to 10.6 million acre-feet in 1931. Since the first year of annual flow regulation, 1898, the upper basin has experienced two protracted droughts. The first, extending from 1930 through 1941, averaged 15.6 million acre-feet per year at Sioux City. The second, running from 1954 through 1961 averaged 18.3 million acre-feet annually. These values compare to the long-term average of 24.4 million acre-feet, based on 1949 depletion levels.

In its natural state, the Missouri River transported a sediment load increasing from an average of 25 million tons per year in the vicinity of Fort Peck to 150 million tons per year at Yankton, South Dakota. Since construction of the main stem dams, beginning with the closure of Fort Peck in 1936, sediment entering the reservoirs has been trapped, with a consequent change in the historic formation of accretion lands which formerly offset erosion effects.

Extremes in temperature across the basin are induced by alternating cold air masses from the northwest and warm air masses from the gulf region. Seasonal and even daily temperature ranges are large, frequently falling to 20 degrees or more below zero during the winter and exceeding 100 degrees during the summer months.

Most of the year, daily temperatures may vary from 30 to 40 degrees.

The highest average annual precipitation occurs in the mountains, where annual amounts may total over 40 inches. The Great Plains portion of the basin is noted for its relatively scanty and erratic precipitation. From the southwest to the northwest the average annual amounts range from about 25 inches to about 12 inches. Because most of the rainfall occurs in the plains between May and early July, productive agriculture is possible. Occasional high intensity thunderstorms, often with high winds and hail, cause severe crop damage. Winter snowfall in the plains is generally light.

Exploitation of mineral deposits in the Missouri River basin above Sioux City has historically played an important role in development. Early settlement of the mountainous areas of western Montana and the Black Hills of South Dakota was stimulated by the discovery of gold and silver; other base metals such as copper, lead, and zinc were exploited as well. More recently, ferroalloys and minor minerals, such as tungsten, vanadium, chromium, beryllium, lithium, uranium, and thorium have been produced. Expanded production of lignite and coal began in the mid-1960's. Additional thermal generating plants coupled with the promised development of gasification facilities will use appreciable quantities of water resources in the coming decades in addition to imposing tremendous socio-economic impact on rural communities. Taken together, sub-bituminous coal and lignite cover most of eastern Montana and the western one-half of North Dakota with a relatively small amount found in adjacent northwestern South Dakota. An estimated 160 billion tons of recoverable coal or about 37 percent of the Nation's total known recoverable reserves are located in this area.

Native soils in the basin vary with zones of climate and vegetation. Most have developed under grass cover. The exception is

the mountain complex soils of the Rockies, the Black Hills and adjacent areas where coniferous forests are the principal vegetation. Alluvial soils of bottomlands and terraces occur in all zonal groups.

Man and His Works

The Missouri River has played a key role in man's journeys and settlements across a heartland area making up a sixth of the 48 contiguous states. From prehistoric times until today, developing patterns of communications, population, and commerce have responded to the river's rich diversity in flora and fauna. Stone age hunters and gatherers were quick to exploit these riches which were much more important to their survival than to survival of men in a mechanized era. Throughout the 12,000 year chronology of known human occupation, the upper Missouri valley has provided the necessities of food, water, cover and fuel and with the convenience of a well landmarked trailway. Each of the Paleo-Indian, Archaic and Late Prehistoric hunting and gathering cultures knew and used these resources, although the degree varied among cultures.

Physical evidence left behind by these early peoples furnishes clues to their ways of life. An accumulation of such clues is termed a "site" by archaeologists. For the reasons mentioned above, the length of the Missouri trench abounds in such sites, representing the ways of life of many different peoples across 12,000 years of time and 1,600 miles of linear space.

POPULATION

By 1950, the Upper Missouri River Basin had attained a population of 1,615,000. During the next two decades, the population of the nation increased by 35 percent, the population of the entire Missouri Basin grew by 21 percent, but the Upper Basin changed very

little - increasing by six percent in the first decade and declining by three percent in the second.

All or parts of 24 Indian Reservations are located in the Missouri River Basin. Seventeen, plus part of the Sisseton-Wahpeton Reservation, are in the Upper Missouri River Basin area. Nearly 90 percent of the Missouri River Basin Indian population of 62,428 in 1973, lived on or near reservations in the Upper Basin area. Of these, almost 50 percent reside in nine of the above referenced reservations on or near the Missouri River above Sioux City.

LAND USE

Land use data provided by the Census of Agriculture are tabulated below. Changes in land areas from one enumeration year to another can result from changes in political boundaries, streams, lakes or construction of reservoirs.

LAND USE AND AGRICULTURAL PRACTICES

		<u>Montana</u>		<u>North Dakota</u>		<u>South Dakota</u>		<u>Nebraska</u>	
Land Area (1,000's of acres)	1949	77,224	(30,823)	25,864	(12,309)	47,834	(11,925)	13,605	(1,846)
	1959	77,164	(30,786)	25,485	(11,948)	47,733	(11,835)	13,593	(1,834)
	1969	77,074	(30,728)	25,406	(11,897)	47,466	(11,636)	13,569	(1,831)
Land in Farms (Percent)	1949	72.3	(66.3)	89.9	(39.1)	91.3	(95.9)	96.3	(96.4)
	1959	77.9	(75.8)	92.6	(92.3)	91.6	(92.9)	97.6	(95.9)
	1969	76.9	(73.4)	97.7	(98.6)	93.8	(96.7)	93.1	(91.9)
Number of Farms	1949	28,140	(11,378)	30,163	(13,380)	62,900	(14,471)	13,779	(6,414)
	1959	23,293	(9,482)	25,586	(11,125)	52,809	(12,345)	11,773	(5,557)
	1969	20,831	(8,338)	22,133	(9,942)	43,420	(10,155)	9,781	(4,382)
Average Size Farm (acres)	1949	1,984	(1,795)	771	(820)	695	(790)	951	(278)
	1959	2,586	(2,462)	923	(991)	829	(891)	1,127	(317)
	1969	2,844	(2,707)	1,121	(1,130)	1,026	(1,108)	1,291	(384)
Cropland (Percent of farmland)	1949	23.7	(18.0)	57.3	(51.8)	43.5	(43.3)	32.3	(65.8)
	1959	23.8	(25.7)	56.5	(50.4)	41.9	(43.1)	30.2	(62.7)
	1969	26.0	(28.5)	57.2	(50.8)	42.8	(44.0)	28.4	(67.1)
Pasture and Range (Percent of farmland)	1949	71.1	(68.1)	37.3	(42.6)	52.0	(53.2)	63.2	(26.4)
	1959	72.7	(70.2)	38.8	(44.3)	54.5	(54.1)	66.4	(30.8)
	1969	63.4	(59.4)	31.0	(34.4)	41.4	(38.3)	66.4	(26.1)

(xx) (Corridor Counties)

Source: U. S. Dept. of Commerce, Census of Agriculture

ECONOMICS

Generally, population levels and trends are related to levels and trends of employment. In the absence of employment opportunities, the resident population is pressured to become mobile, moving to where employment is available. Employment to population ratios, both in corridor and non-corridor counties of the upper basin area have historically been slightly lower than those for the Missouri River Region and the Nation as shown in the following table. This can be attributed to limited mobility of the labor force.

LABOR FORCE, EMPLOYMENT AND UNEMPLOYMENT, 1970

	<u>Labor Force</u> (1,000's)	<u>Employment</u> (1,000's)	<u>Employment/ Population</u> (Percent)	<u>Unemployment Rate</u> (Percent)
Montana	178.8 (82.1)	169.3 (77.4)	35.8 (35.2)	5.3 (5.7)
North Dakota	86.7 (46.8)	82.9 (44.5)	33.8 (34.4)	4.4 (4.9)
South Dakota	242.0 (46.5)	233.0 (44.9)	34.5 (36.6)	3.7 (3.4)
Nebraska*	33.4 (12.1)	32.7 (12.0)	35.7 (34.1)	2.1 (1.4)
Missouri River Region	NA	3,370.7	39.7	NA
United States	82,715	78,627	39.0	4.9

Note: * Above Sioux City

(xx) Corridor Counties

NA=Not Available

Sources: U. S. Dept. of Commerce Bureau of Census and U. S. Bureau of Labor Statistics.

The following tabulation is a comparison of major 1970 employment sectors in the corridor counties, the remainder of the four study states, and the United States.

EMPLOYMENT BY MAJOR
EMPLOYMENT GROUPS - 1970
(Percent)

Groups	Corridor Counties	Remainder Counties	U. S.
Agriculture, Forestry, Fisheries	20.6	21.5	3.7
Mining	0.8	2.3	0.8
Contract Construction	6.6	5.5	5.8
Manufacturing	6.2	6.9	25.0
Transport, Communications, Utilities	5.8	6.4	6.5
Trade	21.2	22.0	19.6
Finance, Insurance, Real Estate	3.8	3.4	4.9
Services	28.1	27.1	25.9
Public Administration	6.9	4.9	7.8

Source: U. S. Dept. of Commerce, Bureau of Census

Projections of population, employment, and earnings were from the 1972 OBERS Series E projections prepared for the Water Resources Council. Data were available only for Water Resources Subareas and state portions of subareas; however, it is considered that these relative rates of growth will apply to the corridor counties of concern in the current study.

PROJECTIONS OF POPULATION, EMPLOYMENT, AND EARNINGS
FOR STATE PORTIONS OF WATER RESOURCE SUBAREAS

	Year	Montana	North Dakota	South Dakota	Nebraska
Population (1,000's)	1980	455	229	637	81
	2000	446	217	621	66
	2020	449	207	618	59
Total Employment (1,000's)	1980	188	87	262	31
	2000	194	88	267	26
	2020	195	85	263	23
Earnings Per Employee (1,000's of 1975 dollars)	1980	12.2	11.3	11.1	10.6
	2000	20.0	18.8	18.5	17.8
	2020	33.1	31.7	31.1	30.2

During the period from 1980 to 2020, earnings are expected to increase about 2.2 times in Nebraska and 2.8 times in the remaining three states compared to 3.4 times in the MRB and 3.6 times in the U. S. Only the agricultural sector displays a significant decline while the service and government sectors increase somewhat. The projected levels of earnings per employee for the MRB in 2020 are \$34,700. Projected distribution of earnings by industrial group for the year 2020 by state is shown below. These data compare to the 1970 data shown on Page 13.

PERCENTAGE DISTRIBUTION
OF PROJECTED EARNINGS BY
INDUSTRIAL GROUP IN 2020

	SD	NE	NB	Mont
Agriculture, Forestry, Fisheries	12.4	28.5	14.3	8.4
Mining	0.7	0.1	1.1	0.8
Contract Construction	4.7	2.0	5.2	5.3
Manufacturing	8.9	5.1	5.4	6.3
Transport, Communications, Utilities	5.7	7.4	7.1	7.1
Trade (Wholesale - Retail)	16.0	17.1	18.4	16.0
Finance, Insurance, Real Estate	4.8	4.0	4.3	5.5
Services	20.6	17.4	21.9	22.0
Public Administration	26.2	18.4	22.3	28.6
Total	100.0	100.0	100.0	100.0

RECREATION RESOURCES

The main stem reservoir projects attract the vast majority of recreationists on the Missouri River within the study reach. During the 1967-1975 period, total average annual visitor days at the six main stem lakes was 8.2 million. As a comparison of passing interest, the total population of the four states containing or bordering these projects is less than 3.5 million. Accommodation of recreation demands at the lake projects is generally adequate at the present time, and with the exception of improved access, no

major facilities expansion is needed in the immediate future. Certain minor developments such as additional launching points are desirable but are contingent upon non-Federal sponsorship to provide at least one-half of the development cost and assume all of the operation, maintenance, and replacement responsibility. Reluctance by potential sponsors of recreation development to dedicate funds for expenditure on Federal lands, or to make long-term management commitments is presently deterring expansion of facilities and could some day result in overuse of existing developments; however, there is no evidence that this is a significant problem at the present level of demand.

THE MAIN STEM RESERVOIR SYSTEM

The six Missouri River main stem dams are located along a thousand-mile stretch of river extending from Yankton, South Dakota to Glasgow, Montana. An embankment volume of 125 million cubic yards makes Fort Peck the second largest earthen dam in the world. Oahe follows as number three. At the base of the flood control pools the lakes behind these six dams offer a million acres of flat water; at full pool, they total 755 miles in length.

Spillway discharge capabilities range from 275,000 to 827,000 cfs. Each project produces hydro-power, with plant capacities ranging from 100,000 kw to 595,000 kw for a total of 2,048,000 kw. Annual generation averages more than 9 billion kilowatt hours. Total flood damages prevented by the system through 1975 exceed \$1,400,000,000 in 1975 dollars. Over 8 million recreation days are accumulated by the projects each year. Immediately downstream of the study area a 730-mile navigation channel has moved an average of 2 - 2-1/2 million tons of traffic per year.

In the planning for, and the operation of, the main stem reservoirs, the general criteria and procedures have been:

- To maintain adequate reservoir storage space available for flood control on the Missouri River.
- To provide water for irrigation.
- To make releases from the lower end of the main stem system to supply the varying seasonal requirements of navigation and water quality control, thereby providing adequate water levels for municipal water intakes as well.
- To generate electrical energy as required to meet system loads, consistent with the other primary functions of flood control, irrigation, and navigation.
- To incorporate special operations responsive to requirements of fish and wildlife and recreation insofar as practical.

ENVIRONMENTAL SETTING

The entire area of the Missouri River drainage basin lies in a temperate grassland biome. Most of the basin falls in the mid-grass prairie region with dominant native vegetative species such as western wheatgrass, green needlegrass, side oats grama, needle-and-thread grass, and June grass. The remainder is located in the tall grass prairie dominated by big bluestem, Indian grass, switch grass, little bluestem, and sandreedgrass. The western portion of the study reach is in the short-grass prairie originally dominated by buffalo grass and blue grama. These regional variants are not homogeneous vegetation belts, but rather all three variants are mosaics of all three prairie types. Cottonwood, willow, elm and ash are among the important flood plain forests.

Many fish species are found along the entire main stem reach of the Missouri River. Among them are: shovelnose sturgeon, paddlefish, northern pike, goldeye, European carp, flathead chub, fathead minnow, blue sucker, bigmouth buffalo, smallmouth buffalo, river carpsucker, white sucker, black bullhead, channel catfish, stonecat, burbot, black crappie, walleye, sauger, freshwater drum,

emerald shiner, longnose dace, brassy minnow, silvery minnow, northern redhorse, largemouth bass, pumpkin-seed, bluegill, yellow perch and white crappie. Many of these species have been introduced thus giving them a distribution through the entire system.

A complete list of mammals that are found along the area of this study would include in excess of 75 species. Over one-third of this number can be found in good to excellent flood plain habitat along this entire reach of the river. Some of the more common members of this group are: the masked shrew, little brown bat, racoon, striped skunk, coyote, eastern cottontail, deer mouse, white-footed mouse, muskrat, and prairie vole. Species which are not commonly seen because of their behavior or habitat requirements, but occur throughout the main stem system would include the following: silver-haired bat, hoary bat, mink, river otter, red fox, badger, meadow jumping mouse, western harvest mouse and beaver. Three big game species can be found in the study area: the white-tail deer, the mule deer and the prong-horn antelope.

Three endangered mammal species range the upper basin. The northern rocky mountain wolf is found only in the extreme western portion of Montana. Its appearance in the study area is considered very unlikely. The black-footed ferret has been sighted in all four states of the study area. Little is known about this species, however, there does seem to be a relationship between black-footed ferrets and active prairie dog towns for food and shelter. Therefore, all prairie dog towns should be considered as possible ferret locations even if these towns occur in marginal habitat such as flood plains. Little is known about the third critical species, the swift fox. Indications are that it selects areas suitable for a year-round den site and abundant prey, usually in an open grass-land community.

Over 250 species of birds can be found in the main stem region

of the Missouri River if both migrants and nesting species are counted. Well over 60 percent of the number are found to nest in the region.

The American peregrine falcon, an endangered species, has been known to occur in the Fort Peck area. This species is primarily a migrant in this location; however, during the 1969 and 1970 nesting season one aerie was reported in Montana. Two other endangered species use the study area as a migratory route: the whooping crane and the Eskimo curlew. The last sighting of an Eskimo curlew occurred in the early 1960's. The whooping crane flies over a segment of the main stem region during its yearly migration. Since it is a migrant, it may occasionally use main stem areas as feeding and resting area.

Due to its alinement within the central fly way, the study reach of the Missouri is important to many species of migratory waterfowl. Several million ducks and geese use the main stem lakes, sand bars, islands, and open river as feeding and roosting grounds during their spring and fall migration. This is especially true in the river reach between Yankton, South Dakota and Sioux City, Iowa. In addition, dabbling ducks such as mallards, gadwall, pintail, blue-winged teal, and shoveler will use the area as a primary nesting ground.

Non-game birds make up the largest percentage of the bird fauna in the study area. This is a diverse group with each species having its own habitat requirement. Two species are noteworthy due to their propensity to nest on sand bars or sandy areas along the river proper. These are the piping plover and the least tern.

Pheasant and quail are the principle upland game birds using the mosaic of forest and agricultural lands on the flood plain. Prairie chickens, sharp-tailed grouse and turkey can be found on the upland prairie and breaks along the Missouri River.

Problems and Opportunities

The outstanding opportunity available to basin residents stems from the sizeable and regulated flow of the Missouri River, an asset susceptible of highly flexible adaptation to meet future needs. Most of the residual problems arise from attempts to satisfy those needs; while a majority receive benefits, the possibility of detrimental effects upon others must be identified and assessed on balance.

Water Use

The scope of this study originally included efforts to identify those water uses which would best promote the orderly, efficient, and timely utilization of the basin's resources. Such an analysis would recognize the competition for available water supplies, the economic and environmental effects, costing and marketing policies, and water rights. However, the basin states, using the forum of the Missouri River Basin Commission, have indicated unwillingness to participate in such studies at this time. The upper basin states in particular feel strongly that to quantify specific uses is premature and should not be undertaken until after state water plans have been updated and state water needs have been assessed.

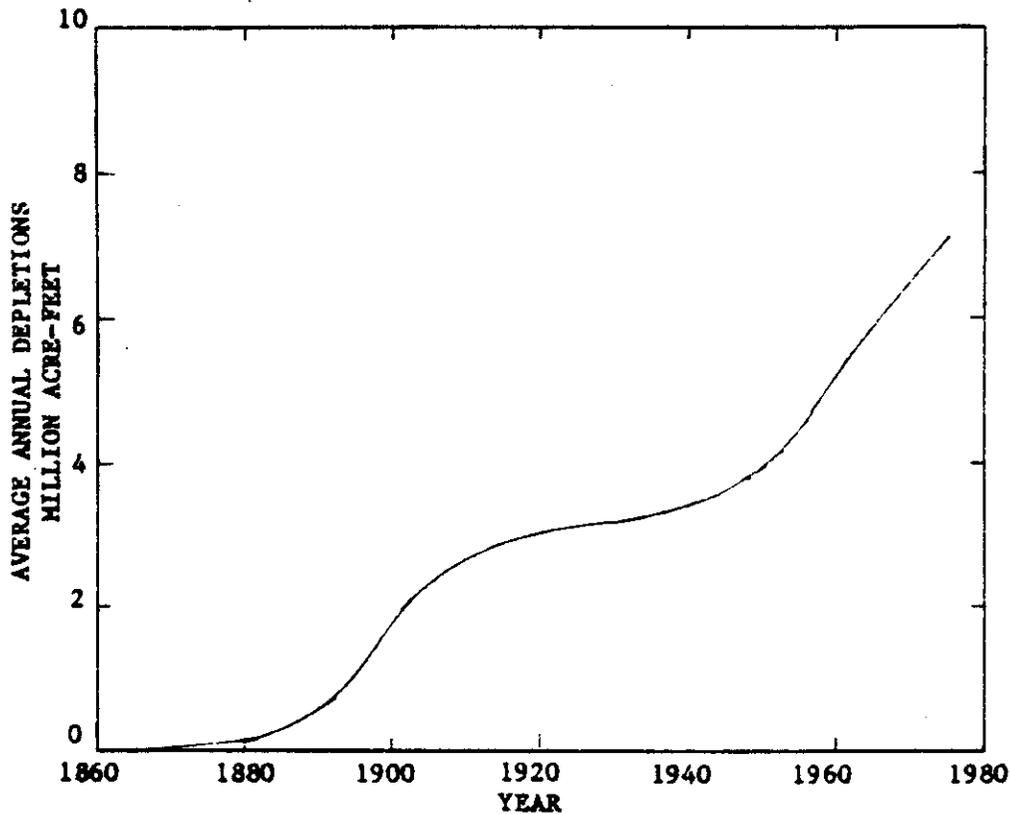
This position has caused a change in the report's scope. Studies are complete on the capability of the reservoir system to supply water for today's uses and for other potential future demands. These studies provide a baseline from which states, the River Basin Commission, and other affected interests can assess general impacts of future actions. There are not, however, any recommendations dealing with priorities of water use, only an outline of the analyses which will be required to address the physical, economic,

environmental, social, and legal and institutional issues at some future time.

WATER SUPPLY - PAST, PRESENT AND FUTURE

By 1898, Missouri River flows at Sioux City had been depleted an estimated average of about 1.5 million acre-feet per year. Beginning with that year a "reconstituted" flow record has been compiled on a monthly basis, utilizing gaging records where available, high water marks and readings taken at old military posts. Streamflow records, of course, reflect the constantly changing levels of water resources development and streamflow depletion. Growth of average annual depletions, including reservoir evaporation, is shown below. These reductions in flow reflect not only withdrawals from the Missouri itself, but depletions of upstream tributaries as well.

GROWTH OF STREAMFLOW
DEPLETIONS AT SIOUX CITY



To be useful as an accurate measure of surface water-supply availability, historic streamflow data must be adjusted to a common level of water resources development and water use and a corresponding common level of streamflow depletion. The year 1949 has become one common base level for studies utilizing Missouri River flows.

A second common base is the 1970 level of depletions. This level of consumptive use underlies analyses developed for the Missouri River Basin Comprehensive Framework Study and numerous subsequent operation studies conducted by the Corps of Engineers, many in collaboration with the Bureau of Reclamation. Among these are studies run in 1970, 1974 and 1976 to estimate projected impacts of industrial development of western coal fields, in addition to other uses. Measured against the predevelopment level of 28.5 million acre-feet, the average annual flow under 1970 conditions is depleted by 6.5 million acre-feet, of which one-fourth is evaporation from the six main stem reservoirs.

Concurrently with the mushrooming interest of energy companies in developing coal resources of the upper basin there began to be heard pronouncements that there is just not enough water to go around. In response to these frequently heard views, the Assistant Secretaries of Interior and Army appointed a regional Ad Hoc Committee to examine the issues involved in industrial water marketing from the six main stem reservoirs. This Ad Hoc Committee on Water Marketing was formed in December 1973, under the Chairmanship of John W. Neuberger, Chairman of the MRBC, with representation from Army, Interior and the basin States.

Through its efforts were developed the projections of future depletions presented on July 18, 1975 by the Department of Interior to the Subcommittee on Energy Research and Water Resources of the Senate Committee on Interior and Insular Affairs, and illustrated

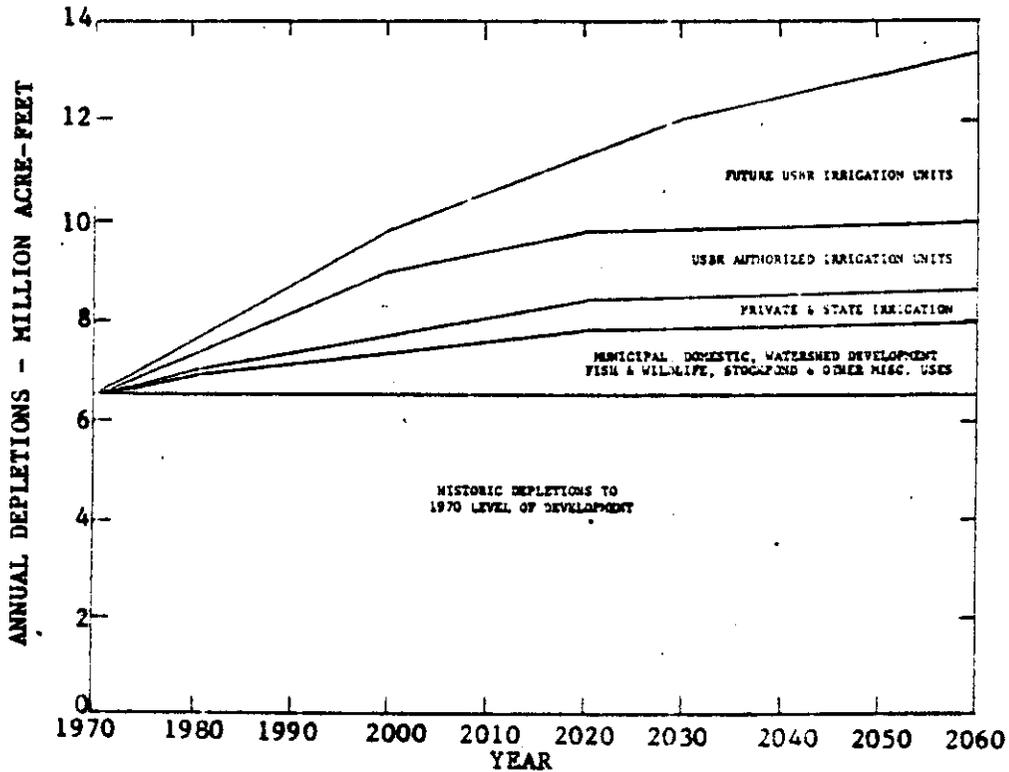
in the following figure. These depletions are essentially unchanged from the 1969 estimates made for use in the Missouri River Basin Comprehensive Framework Study with three exceptions -

- The Framework Study projected the existence in 1970 of several projects which have not been constructed. Depletions for the larger units were restored to streamflow, but the result was still an overstatement of depletions which amounted to several thousands of acre-feet annually.

- "Ultimate" depletions are an estimate of full water use. Above Sioux City, they were reduced from 15.3 million acre-feet (maf) per year in the Framework to 13.3 maf per year to eliminate irrigation projections unsupported by a water supply.

- Attainment of the ultimate level was shifted from the year 2020 to 2060.

AD HOC COMMITTEE PROJECTIONS OF
AVERAGE ANNUAL DEPLETIONS*
MISSOURI RIVER AT SIOUX CITY



* Excluding estimates of industrial use

A key conclusion formed by the Committee concerned minimum releases from the main stem system. Releases approximating 6,000 cfs from Gavins Point were found necessary to meet the Kansas City requirements, which also average 6,000 cfs, since downstream inflow during drouth periods scarcely offsets losses.

Once this lower bound had been set, maximum depletions compatible with it could be determined. During a repetition of the hydrologic cycle from 1898 to date, and based upon pre-development levels, the main stem reservoirs could support a year round release of 6,000 cfs throughout the most severe drought period, which extended from 1930 through 1941, and at the same time tolerate a depletion to natural flows of 16.3 million acre-feet per year. In years of better yield, higher releases would ensue. The value of 16.3 million acre-feet then becomes a limit to the extent of permissible depletion growth in light of present-day thinking as reflected by the Ad Hoc Committee on Water Marketing.

Based upon Committee projections, the Secretaries of Interior and Army entered into a Memorandum of Understanding (MOU) on 24 February 1975 with a duration of two years. Its expressed purpose was "to expedite the use of water for energy development in the Missouri River Basin. The terms hereof apply only to the six main stem reservoirs ..." The concept was to utilize "surplus" water, designated in the preceding figure as the component for USBR authorized irrigation units, until that time when the units themselves were ready to use the water. Responding in 1976 to the statutory requirement for update of the Missouri River Basin Comprehensive Framework Study/National Assessment, the Missouri River Basin Commission elicited data from the basin states on their estimates of present and projected future water use. Input came from the same State agencies which had served on the Framework Study Groups and the Ad Hoc Committee on Water Marketing, but future growth of depletions was projected only to the year 2000.

These projections are of interest in comparison to conclusions drawn by the Ad Hoc Committee regarding the near term availability of water for marketing to industry. Although the State Regional Future (SRF) quantified average annual depletions above Sioux City in 1975 at a level about 40 percent above the Ad Hoc values and 30 percent above the Framework, this is only a part of the problem. As stated earlier, the Ad Hoc evaluation slowed the estimated rate of future growth so that full attainment of consumptive uses other than for energy would not occur until 2060, forty years later than the Framework estimate. The SRF approaches this level for the year 2000. If depletions were to grow at such a rate, marketing assumptions quite different from those upon which the MOU was predicated would have to be developed. An additional set of estimates, the Modified Central Case (MCC) has been prepared for the assessment by Federal agencies. It is scheduled for extensive revision and, therefore, not evaluated in detail here.

CONSEQUENCES OF FUTURE DEPLETIONS

The effect of future depletions on main stem hydro-power generation may be summarized as follows: peaking capability in kilowatts will be reduced by less than ten percent; energy generation will decline about 500 kwh for every acre foot withdrawn, amounting to a decline of nearly 50 percent at the ultimate depletion level. Based on 1976 costs of generation, this energy could be replaced for one to three dollars an acre foot, depending on the fuel used. The ability of the main stem projects to deliver peaking power will be affected to a lesser extent than its ability to provide base load energy.

The combination of drouth and depletions can be expected to impact at times on water quality in the main stem reservoirs, although no effort at quantification has been made. Stress would be evidenced by establishment of thermoclines and reductions in dissolved oxygen in the lowermost waters of the lakes and by increased production of algal growth in the top levels. Between the reservoirs, total dissolved solids (TDS) are expected to increase from the

present 400-500 ppm range by one-fourth at Williston and three-fourths at Sioux City under ultimate conditions. Downstream conditions at Omaha would resemble Sioux City while Kansas City and Hermann would experience TDS increases of about fifty percent.

Environmental effects of depletions will be mixed. A lowering of average lake levels will strand certain gravel beds used for wall-eye spawning. On the other hand, reduced throughput of lake water will, as noted earlier, increase productivity and permit a longer time for extraction of these nutrients. Spawning migration during drouth periods may be interferred with by low water depths at the mouths of tributaries.

Dependability of the Missouri River navigation project will deteriorate rapidly once depletions exceed 13 million acre-feet per year. Even then, system inflows will be sufficient in about one year out of five to provide a full season. In more than half the years, however, this level will not provide enough water for any navigation service at all. Even after curtailed seasons rendered navigation infeasible, then, today's pattern of releases from Gavins Point of 25,000 cfs or more for at least some part of the ice-free season (most probably in early summer) would occur in about one year out of two. In other years, differences between summer and winter flows, as well as their absolute magnitude, would be markedly smaller than they are today. During protracted drouth periods, both summer and winter discharges from Gavins Point can be expected to average close to 6,000 cfs under ultimate depletion levels. These effects will be observable at Sioux City and well downstream.

Aside from the necessity to relocate some boat ramps and swimming beaches, recreation throughout the main stem system would receive little serious detriment from increased depletions. Recreation opportunities in the Gavins Point-Sioux City reach would be little affected when Gavins Point releases approximated 25,000 cfs during the summer months. However, during the years when summer releases

were significantly lower (as little as 6,000 cfs) a material reduction in public use could be expected. The recreational activities associated with areas of sand bar and shallow water during the 25,000 cfs flow condition could not be accommodated in the 6,000 cfs, low flow channel. Swimming, sunbathing and fishing are the dominant uses that would be affected by a reduction approaching 50 percent during the lowest flow year. Therefore, an estimated 25 percent loss of public use could be attributed to the reduced average annual flow of the Missouri River in the reach between Yankton and Ponca State Park.

The effects of depleted inflows summarized above are insensitive to the cause of the depletions. The State-Regional projections, for example, anticipate nearly 15 million acre-feet of depletions by the year 2000, of which more than 90 percent are attributed to irrigation. Although there is much present controversy regarding future allocation of water between energy and agriculture, both the relative magnitude of the two uses and the far higher economic return from industrial use indicate that some middle of the road approach to sharing the supply is warranted.

Status of Existing Plans and Improvements

The Corps of Engineers is pursuing several plans or commitments under authorities other than this study; still others are being conducted by other agencies.

CORPS OF ENGINEERS ACTIVITIES

- Construction of nine demonstration sites under the Stream-bank Erosion Control and Demonstration Act of 1974, three in NE, three in SD, and three in ND, with completion scheduled for FY 1978.
- Garrison and Oahe boundary revisions.
- Oahe and Big Bend wildlife mitigation.
- Participation in the joint Interior-Army MOU.

ACTIVITIES OF OTHER AGENCIES

- BOR proposal to include the Lewis and Clark Trail in the National Trails System Act (PL 90-543).
- Proposed wilderness designation for the Charles M. Russell National Wildlife Range and the UL Bend National Wildlife Refuge, adjacent to Fort Peck Lake, and managed by FWS.
- Designation of Missouri River, Fort Benton to Ryan Island, Montana under PL 90-542, the Wild and Scenic Rivers Act, enacted by PL 94-486.
- FWS study of fish population dynamics in Lake Sakakawea and Fort Peck Lake.
- Proposed designation of the lower five main stem lakes as a National Recreation Area.
- FWS operation of Lake Audubon National Wildlife Refuge on Lake Sakakawea.
- Little Missouri National Grasslands, abutting Lake Sakakawea.
- Knife River Indian Villages National Historic Site operation by National Park Service.
- Garrison Dam National Fish Hatchery operation by FWS.
- Garrison Diversion Unit construction by USBR.
- Lake Pocasse National Wildlife Refuge adjacent to Lake Oahe.
- Oahe Unit under construction by USBR.
- Karl E. Mundt National Wildlife Refuge, below Fort Randall Dam, administered by FWS.
- Gavins Point National Fish Hatchery administered by FWS.
- Eight hydro-power dams owned by Montana Power Company and located above Fort Peck.
- Canyon Ferry Dam, a multiple-purpose project of USBR, above Fort Peck.
- Nebraska Public Power District continues planning for a pumped storage project downstream of Fort Randall Dam.

Flood Problems

Since completion of the main stem dams, residual problems and opportunities associated with flood control have not been extensive in the reach from the headwaters to Sioux City, covered under this study. Power plant discharges during periods of downstream ice formation have created overbank flow on occasion in the Oahe headwaters below Bismarck. Below Fort Randall where channel capacity has been diminished by delta formation, flooding and also waterlogging have occurred in five of the last eight years. Resolutions by the Public Works Committee in 1960 and 1962 suggested the opportunity to provide flood control, as well as other multiple-purpose uses, by constructing reservoirs above Fort Peck and between Fort Peck and Garrison.

Runoff volumes during 1975 have already been described as the largest of record in the basin above Gavins Point. Regulation of these flood flows led to record high storages and moderately high releases. Some consequences previously described were flooding near Bismarck as well as below Fort Randall, and flooding of some private lands within flood control and surcharge zones. The result was a number of suggested changes in reservoir operating policy made by individuals who saw an opportunity to reduce undesirable effects upon their own property.

Navigation

Navigation traffic on the Missouri River utilizing diesel-powered towboats between Kansas City and the mouth dates back to 1915; in 1935 operations were extended to Sioux City. Since that time there have been numerous expressions of interest in extending the navigation project to Yankton and beyond, possibly terminating as far upstream as Fort Peck Lake. The desire for low cost transportation of agricultural products stimulated project support during

the early years; more recently, a search for the most economical exploitation of the vast coal reserves in Wyoming, Montana and North Dakota has sparked a companion interest. Opportunities range in scope from extending the head of navigation to Yankton, an additional 73 miles, to adding more than a thousand river miles necessary to reach Fort Peck Dam and beyond as far as Fort Benton.

Water Logging

Three locations within the study area have been identified where a rise in the groundwater table has impaired usefulness of the land - sometimes only intermittently - for agriculture or for human occupancy. Two of these were mentioned in the discussion of flooding problems: the Fort Randall-Niobrara reach and the area downstream of Bismarck. The third area, which has a history of waterlogging problems even though overbank Missouri River flows have not been reported, is in the Buford-Trenton Irrigation District, located just downstream of the mouth of the Yellowstone River.

Bank Erosion

In the natural river prior to the construction of the reservoirs, there was balance over the years between the destruction of valley lands by erosion of the high banks and the building of new valley lands by sediment deposited during the floods. This process resulted in a continual migration of the river channel within the Missouri River valley. Due to the balance between the erosion and the deposition processes, however, there was no long term net loss of high valley lands.

Since the dam closures, the operation of the reservoir system has eliminated both the floods and the sediment that were essential for the building process. On the other hand, the erosion of high banks continues. Consequently, bank erosion results in a permanent

net loss of high valley lands that are never replaced elsewhere in the valley as in the era before the reservoirs. High valley lands are being converted to river channel and sand bar areas, while the width between high banks continues to grow. This process, unless halted, would eventually transform the present river into a wide area of sand bars and channels, occupying an increasing proportion of the valley width between bluffs.

Aerial photographic surveys taken over the years have been analyzed to obtain estimates of valley lands lost in each reach. The estimates include only areas that were judged to be suitable for cultivation, for building sites, or for municipal or recreation facilities. They do not include the erosion of sand bar areas or low vegetated areas adjacent to the channel and riverward of the high river banks. The results of the post-dam period are summarized in the following table, which shows the total loss of valley land in each reach since the dam closure.

EROSION OF VALLEY BOTTOM LANDS SINCE DAM CLOSURE

	Miles of Open River	Miles of Erodible Bankline	Erosion Losses Since Closure		Estimated Future Losses		
			Period	Total Acres Lost	Acres Per River Mile Per Year	Acres Per River Mile Per Year	
Gavine Point Dam to Ponca State Park, NE (Miles 132.6-206.3)	53.7	103	1955-1975	3730	3.50	200	3.72
Fort Randall to Minbrara (Miles 140.7-260)	36.3	56	1952-1975	1030	1.29	30	0.83
Big Bend Dam to Fort Randall	0	None	1963-1975	None	None	None	None
Gahe to Big Bend (Miles 1072.3-1067.3)	5	2	1958-1975	See table 1/	See table 1/	1/	0.41/
Garrison Dam to Bismarck (Miles 1310-1389)	79	109	1953-1975	1772	.01	75	0.95
Fort Peck Dam to the Mouth of the Yellowstone River (Miles 1732.1-1771.6)	190	368	1937-1975	7406	1.03	130	0.69

1/ Erosion in this reach is concentrated in one area, where a potential loss of 100 acres exists over the next 50 years.

Bank erosion does not occur uniformly along the erodible bank lines at the average rates indicated above. Within each of the open river reaches the destruction of land in any one year is usually concentrated over a few thousand feet of bankline in one or a few locations. These locations of active erosion shift from place to place from year to year. Although the long-term annual acreage loss in each reach can be estimated, it is not possible to pinpoint specific locations and make future erosion predictions. What can be predicted is that over the years every stretch of erodible bankline is potentially subject to active erosion.

Hydro-Power

Projected power needs in the region are prepared annually and submitted jointly by the member systems to the Federal Power Commission. The most recent projection was submitted in April 1976 and covers the time period 1976-1995. Peak loads are projected to increase during this time period from approximately 16,000 megawatts in 1976 to nearly 48,500 megawatts by 1995. Assuming that required generating capability includes a 15 percent reserve margin, approximately 37,500 megawatts of new capacity will have to be added within the MARCA Region during the next 20 years. This is the equivalent of 18 main stem systems.

The study reach between Sioux City, Iowa and Three Forks, Montana has a fall of 2,925 feet in a distance of 1,583 miles. Forty percent of this drop occurs in the first 200 miles, between Three Forks and Great Falls, Montana. A third of this is developed by Federal, State, and private power, recreation, and water supply dams. From Great Falls, Montana downstream to Sioux City, Iowa, is a river reach 1,375 miles long with a total fall of 1,720 feet. Based on maximum operating pool elevations of the six main stem dams in the reach about half of this head is still undeveloped -- a potential source of additional hydro-power. In addition, four of the six

main stem dams have a total of 15 flood control tunnels which could be modified to accommodate turbines. Although little additional energy would be obtained by this move, substantial increases in capacity could be developed.

Uplands adjacent to the existing main stem reservoirs provide nearly unlimited opportunities to develop head for pumped storage hydro-power. Representative head differentials available in the various reaches range from almost 1,000 feet in the Fort Peck area to 250 feet at Gavins Point.

Recreation Fish and Wildlife

Proposed actions in response to opportunities in this field have been:

- Improvement of access to project lands at Fort Peck.
- Reestablishment of northern pike fishery at Lakes Oahe and Francis Case.
- Improved river access.
- Remedy of sediment blockage at lakeside boat ramps.
- Construction of subimpoundments for recreation and fishing.
- Designation of river segment under the Wild and Scenic Rivers Act.

Improvements Desired

During the week of 28 June 1976 the study's tentative findings and potential alternatives were presented to the public at four meetings held throughout the study area. Approximately 400 persons attended the meetings; the following views received significant support:

- Bank erosion is a serious problem which should be remedied at Federal expense.
- There is a critical need for additional electrical energy

in the area, which the Corps should help to meet.

- Hydro-power additions at Fort Randall caused serious environmental concern; the U. S. Fish and Wildlife Service felt additions to Garrison hydro-power would necessitate relocating the fish hatchery. Addition of a reregulation structure at Fort Peck was urged.

- Waterlogging in North Dakota and below Fort Randall were seen as problems.

- Recreation access and reach designation under the Wild and Scenic Rivers Act got wide approval.

Formulating a Plan

Application of the concepts enunciated in the Water Resources Council's Principles and Standards, to be fully appropriate, requires the ability to seek without undue constraint the path of economic efficiency, the path of environmental quality, and the best melding of the two. This complex procedure would be simplified if plans could be formulated by drafting every element on a clean page - with no past-due obligations cluttering the ledger sheets. Not every element of this study can be so treated. The main stem system predates by several decades the Principles and Standards; concepts which prevailed during its formulation have faced the test of operation. Some residual opportunities have been identified; some residual problems have surfaced. In some instances, Congress has already directed the initiation of actions attuned more to as-built conditions than to blank ledger sheets.

Factors Affecting Formulation and Evaluation

Technical, economic, environmental, and other factors, which played a decisive role from the initial screening of alternatives through the final iteration of selecting a plan, are identified in the following paragraphs.

TECHNICAL FACTORS

Significant technical criteria were specific to the several functions investigated, and are listed by category in this subsection.

- Missouri River channel capacity above the mouth of the Niobrara River has declined from a pre-project level of 120,000 cfs to a present day 40,000 cfs.

- For screening purposes, three principle assumptions were made concerning navigation: a tow configuration four barges long by three barges wide, transporting 18,000 tons could operate in all reaches studied; locking time for such a tow is 40 minutes, lock utilization is 100 percent; ice-free navigation is available for a nominal eight months per year.

- After an initial "one time" slump, high banks incur no increase in erosion as a result of fluctuations in river stage.

- Operation of the main stem system has essentially eliminated sediment-laden overbank flows. With the counterbalancing accretion process thus halted, high bank erosion results in a permanent and irreversible loss of high valley lands and high bank islands.

- The critical element in designing Missouri River bank stabilization works is not protection against high flow velocities, but against undercutting as a result of bed scour.

- Critical head (gross) for existing hydro-power units was used to match turbine and generator sizes on new units.

- Critical head (gross) for pumped storage was taken as the difference between minimum usable forebay elevation and afterbay base of exclusive flood control.

- Sizing of pumped storage projects was determined by available off-peak pumping energy.

- Maximum turbine size was set by a maximum penstock velocity of 35 fps, above which adequate design data were lacking.

ECONOMIC FACTORS

● Measures to ameliorate bank erosion problems have been portrayed to Congress by affected interests within this study area as a "cost of doing business" on the main stem system which should be assumed by the Federal Government. Since legislative action over the past 13 years has supported this viewpoint, remedial measures are formulated here to be responsive and at the same time as cost effective and economical as possible.

● All other structural measures were evaluated to insure that dollar benefits exceed project economic costs.

● All benefits and costs are expressed in comparable terms to the fullest extent possible. The annual charges include interest; amortization; and operation, maintenance, and replacement costs. Annual costs are based on a 100-year amortization period (50 years for navigation and pumped storage), 6-3/8 percent interest rate and July 1976 price levels, at least for selection of final plan elements.

● Although formulated with a 100-year life, hydro-power elements must be able to repay allocated costs in 50 years.

ENVIRONMENTAL AND OTHER FACTORS

● Fish and Wildlife Service "habitat unit" evaluation criteria were used to identify habitat type and value for baseline conditions upon which to predict project-induced changes in the study area's biological community.

● Significant detrimental environmental effects were avoided where possible; feasible mitigative measures were formulated to minimize such effects when they were unavoidable.

● Recreational activity demand generally was predicted from current Statewide Comprehensive Outdoor Recreation Plans; monetary worth of visitations was based on Principle and Standards criteria.

● Criteria found in Public Law 90-542 as amended, and the Evaluation Guidelines approved by the Secretaries of Interior and Agriculture in February 1970 were used in analyzing recreation river

potential.

● Predicted effects of fluctuating river stages and velocities on fish and fish habitat were based, in part, on procedures, information and criteria presented in "The Determination, Assessment and Design of 'In-Stream Value' Studies for the Northern Great Plains Region," 1975, prepared by Ken D. Bovee, University of Montana.

● The size and number of subimpoundments for propagation of northern pike were based on fingerling stocking rates of 30,000 per surface acre of littoral zone and fry stocking rates of 100,000 per surface acre of subimpoundment.

Possible Solutions

A study with objectives as numerous and broad as this one can be expected to generate a sizable number of possible solutions. The process of reducing this number to a final selected plan has observed one primary rule — not to plow the same ground twice. If one criterion demonstrated the complete infeasibility of some study element, no search was made for more reasons to reject it. Additionally, an effort was made to evaluate first those criteria which could be obtained most easily and cheaply. Usually these turned out to be project costs and project benefits.

Quite a different approach was followed once a particular structural solution proved to be economically feasible. When it became necessary to evaluate project acceptability as measured by environmental impacts, substantial amounts of time and effort were invested. Every attempt was made to go deeper than a selection of adjectives intended to convey subjective conclusions. Engineering analyses and field observations were directed toward quantifying specific impacts in terms of acres, feet, feet per second, and the significance of these parameters to the existing environmental setting.

FLOOD CONTROL

Flood control measures considered during the preparation of this report were:

- Flood control storage in new reservoirs upstream of Fort Peck or between Fort Peck and Garrison.
- Modification of operating criteria at existing projects.
- Modification of project boundaries.

The first of these possibilities soon proved to be lacking in economic justification, while the second entailed giving up other system benefits in unwarranted amounts. The third alternative was retained for more consideration.

NAVIGATION

In response to numerous Congressional directives to study an extension of the Missouri River navigation project from its present head at Sioux City, examinations were made of two possible routes and four possible terminals.

- Missouri River route; extend to Yankton.
- Missouri River route; extend to Chamberlain.
- Missouri River route; extend to Yellowstone River.
- Missouri River route; extend to Fort Benton.
- James River route; extend to Yellowstone River.
- James River route; extend to Fort Benton.

Each of these possible alternatives required further study.

WATERLOGGING

Possible solutions at the three locations within the study area identified as having waterlogging problems varied somewhat depending upon the proximate source of the water. Some solutions were applicable at every location; some at one place only. First determination of alternatives did not consider the question of Federal obligation to provide a solution; this was deferred to the second phase of

analysis.

- Flood plain management.
- Decrease in Missouri River stages by means of dredging.
- Construction of levees.
- Modification of interior drainage.
- Transfer of interest in lands by fee acquisition or easement.
- Modification of operating criteria at existing projects.

Modification of interior drainage by such measures as increasing gradient toward the river, installation of stoplog structures and pumping interior runoff over such structures during periods of high Missouri stage, showed promise at Buford-Trenton and were retained for further study.

Acquisition of an interest in the waterlogged lands appeared to be a workable solution at all three locations: Buford-Trenton, the reach downstream of Bismarck, and below Fort Randall.

Flood plain management and land use planning to preclude inappropriate development of lands with a high water table showed promise in the Bismarck area and were retained for further study.

BANK STABILIZATION

Three alternatives were identified which would be responsive to the public demand for amelioration of economic losses stemming from bank erosion. A fourth procedure is mentioned because of its considerable public support and not its efficacy.

- Extension of the so-called "hard" protection which is now installed from Sioux City to the mouth, and is aimed at controlling, and usually constricting, the river.

- Construction of "soft" protection which allows the river to retain the area between the present high banks, but attempts to halt further loss of high valley land.

- Federal purchase of a buffer strip on both sides of the river.

- Elimination of power peaking operations.

Excepting along those river reaches where it serves the additional function of training a navigation channel, hard protection has little basis for selection. Although it minimizes loss of arable land, it has been widely criticized as being destructive of habitat and is far more costly than soft protection. It was not considered further.

The concept of soft protection received widespread indorsement during the course of this study and was retained for further consideration.

Consideration was given to Federal purchase of a buffer strip on each side of the river, but because of uncertainties as to where erosion might attack, many thousands of acres would have to be acquired. For purposes of evaluation a buffer strip one-quarter mile deep was assumed, although this would undoubtedly prove insufficient in some places. This option was dropped because it does not solve the basic problem of continuing loss of irreplaceable land resources and lacks appreciable public acceptability.

On several past occasions State officials have proposed to reduce the economic impacts of bank erosion by eliminating hydro-power peaking operations and the associated fluctuations in stream-flow. This alternative would undoubtedly fail the test of time, since it would not significantly reduce erosion losses and would provide no accretion gains; nonetheless, affected citizens may attempt its enforcement as a last resort if no workable solution is proposed. This approach would seriously diminish the power peaking capability of the main stem reservoirs. It would rule out consideration of additional generators and would cut output of the existing

power plants during critical periods of peak demand. At Garrison, for example, the reduction in capacity could run as high as 50 percent; the replacement cost of these kilowatts would exceed six million dollars per year. This is not a logical selection.

HYDRO-POWER

The authorities under which additional capacity for generating electricity was examined in this study were all linked to the Missouri River. Hydro-power is not, of course, the only means by which more electrical energy can be provided in the area; indeed the very provision of more electrical energy is viewed by some as a detriment to quality of life. A number of possible alternatives thus required screening some of which lay outside the authorities of the Corps.

- New dam construction upstream from Fort Peck.
- New dam construction between Fort Peck and Garrison.
- Tailwater lowering at existing dams.
- Additional units at existing projects.
- Pumped storage projects.
- Load management.
- Economic incentives.
- Thermal generation.

Except for Big Bend and Gavins Point which showed early evidence of infeasibility, additional units at existing projects and new pumped storage projects survived preliminary screening for Corps implementation. Thermal generation was retained for comparison as the non-Federal alternative.

RECREATION, FISH AND WILDLIFE

A number of possible solutions were developed in response to five problems or opportunities in the area of recreation, fish and wildlife.

- Remedy sediment problems at boat facilities by periodic

dredging.

- Relocate facilities with problems.
- Abandon facilities with problems.
- Re-establish trophy fish population in Lake Oahe and Lake Francis Case by increasing hatchery capacity.
- Re-establish trophy fish population in Lake Oahe and Lake Francis Case by construction of subimpoundments for rearing.
- Re-establish trophy fish population in Lake Oahe and Lake Francis Case by construction of on-site rearing ponds.
- Improve lake shore and littoral habitat to increase forage base and spawning and nursing habitat at Lake Oahe and Lake Francis Case.
- Introduce substitute species in the lakes.
- Designate and develop Gavins Point to Ponca State Park reach of the Missouri River under the Wild and Scenic Rivers Act.
- Develop cooperative access and recreation sites throughout the bank stabilization works under PL 89-72.
- Improve access to Fort Peck public use areas by Corps effort.
- Improve access to Fort Peck public use areas under authority of PL 93-643.

Preliminary screening indicated that sedimentation at boat ramps can be handled within existing authorities; the remaining opportunities were retained for further study.

Alternatives Considered Further

Following the initial screening, alternatives which remained were further evaluated, with objective of leaving a manageable group for final analysis.

FLOOD CONTROL

- High inflow to a nearly full pool at Lake Oahe in 1975 resulted in flooding and swamping of lowlands south of Bismarck and

disclosed a need to revise project boundaries. Since this can be done under existing authority it has not been considered further here.

● Starting in 1969, flood control releases from the upstream reservoirs, via Fort Randall Dam, have caused surface inundation along a ten-mile reach upstream from the mouth of the Niobrara River. A number of landowners on the Nebraska side of the river joined to sue the United States, alleging a taking of certain real estate interests. The Court has found that the Government did acquire a flowage easement for which appropriate compensation is due. The Corps is presently investigating possible contributions which these lands might make to mitigation proposals for Oahe and Big Bend. That investigation will be reported upon separately from this report.

NAVIGATION

A major impediment to extension of the navigation project is the expensive locking facilities needed to get past the main stem dams. The most favorable circumstance would be movement of enough traffic to keep these locks busy 100 percent of the time, which would result in movement of eighty million tons during an eight-month navigation season.

Large coal reserves identified in the Northern Great Plains Resources Program report were used as the source of traffic in this analysis. Benefits were taken to be the savings made possible by barge shipment compared to rail. The table on pages 44 and 45 document a clear lack of feasibility. Extension of navigation only as far as Yankton entailed somewhat different assumptions about the source of traffic but resulted in similar infeasibility.

WATERLOGGING

Previous analysis has identified three locations within the study area with waterlogging problems attributable, at least in

part, to the presence of the main stem reservoir system: the Buford-Trenton area; the area from Bismarck, North Dakota to the boundary of Oahe, and the area bordering the 10-mile reach upstream of the Niobrara River. An examination of the geography and geology of the areas resulted in retention of three alternatives: improvement of interior drainage; acquisition of an interest in the land; and land use planning.

At Buford-Trenton, four factors have played a significant role in plan formulation.

- The upward trend in river stage seems to be levelling off since 1971. The sediment load now seems to be passing through the headwater area downstream, where it deposits to extend the delta into the reservoir.

- The most acute consequence of the rise in river stages has been to impede drainage through the open ditch drainage system in the District.

- During the 1975 crop season, in spite of abnormally high flows in the Missouri River, modest efforts by local farmers to block the ditch in Middle Bottom near the river and pump down the ditch water level resulted in above-average crop yields.

- Most members of the District do not want to sell out. Rather than part with their lands, they would prefer an interim solution that might prolong the period of economical agricultural operation.

In recognition of these factors, the Corps has developed a plan intended to function reliably over a range of Missouri River stages and concurrent interior drainage requirements. In the West Bottoms an earth-fill block is proposed for the riverward end of the main drain, with a gated conduit to permit gravity drainage during low Missouri River stages. When stages are higher, the gates will be closed and the water level in the main drain will be regulated by two pumps discharging over the earth block into the

ECONOMIC ANALYSIS FOR

CAPITAL COSTS

1	DIRECT COSTS	
2	NAVIGATION CHANNEL, SIOUX CITY TO GAVINS POINT - 79 MILES (\$ MILLION)	
3	LOCKS AT MAIN STEM DAMS (\$ MILLION)	
4	INTERVENING LOCKS AND DAMS (\$ MILLION)	
5	CANAL CONSTRUCTION (\$ MILLION)	
6	CONTINGENCIES - 20% (\$ MILLION)	
7		TOTAL DIRECT COSTS (\$ MILLION)
8	INDIRECT COSTS	
9	ENGINEERING AND DESIGN (\$ MILLION)	
10	SUPERVISION AND ADMINISTRATION (\$ MILLION)	
11		TOTAL INDIRECT COSTS (\$ MILLION)
12		TOTAL FIRST COSTS (\$ MILLION)
13	INTEREST DURING CONSTRUCTION - 15 YEARS - 6-3/8% (\$MILLION)	
14		GROSS CAPITAL INVESTMENT (\$ MILLION)

ANNUAL COSTS

15	ANNUAL CHARGES	
16	INTEREST AND AMORTIZATION 6-3/8% (\$ MILLION)	
17	OPERATION AND MAINTENANCE 1% (\$ MILLION)	
18		TOTAL ANNUAL ECONOMIC CHARGES (\$ MILLION)

BENEFITS

19	RAIL MILES - COAL FIELD TO HEAD OF NAVIGATION	
20	RAIL FREIGHT COSTS PER TON - UNIT TRAIN	
21	NAVIGATION MILES - HEAD OF NAVIGATION TO SIOUX CITY	
22	BARGE FREIGHT COSTS PER TON	
23	TOTAL FREIGHT COST PER TON - COMBINED RAIL-BARGE	
24	ALTERNATE COST PER TON - UNIT TRAIN - COAL FIELD TO SIOUX CITY	
25	SAVINGS - COST PER TON BY RAIL-BARGE - COAL FIELD TO SIOUX CITY	
26	ANNUAL BENEFITS - 80,000,000 TONS PER YEAR, COAL FIELD TO SIOUX CITY (\$ MILLION)	
27	BENEFIT COST RATIO	

EXTENDING THE NAVIGATION PROJECT

MISSOURI RIVER ROUTE			JAMES RIVER ROUTE			
SIOUX CITY TO -			SIOUX CITY TO -			
CHAMBERLAIN	YELLOWSTONE RIVER	FT. BENTON	YELLOWSTONE RIVER	FT. BENTON		
	21.9	21.9	21.9	21.9	21.9	2
3ea 438.8	10ea 1489.8	13ea 1992.8	-	3ea 503.0	3	
2ea 281.0	6ea 727.0	24ea 2730.0	14ea 1764.0	32ea 3767.0	4	
-	-	-	100.0	100.0	5	
148.3	447.7	948.9	377.2	878.4	6	
890.0	2686.4	5693.6	2263.1	5270.3	7	
89.0	268.6	569.3	226.3	527.0	9	
89.0	268.6	569.3	226.3	527.0	10	
178.0	537.2	1138.6	452.6	1054.0	11	
1068.0	3223.6	6832.2	2715.7	6324.3	12	
510.6	1541.3	3266.7	1298.4	3023.8	13	
1578.6	4764.9	10098.9	4014.1	9348.1	14	
105.4	318.2	674.4	268.1	624.3	16	
15.8	47.6	100.9	40.1	93.4	17	
121.2	365.8	775.3	308.2	717.7	18	
407	246	150	246	150	19	
\$3.26	\$1.97	\$1.20	\$1.97	\$1.20	20	
235	850	1341	780	1271	21	
\$0.70	\$2.55	\$4.02	\$2.34	\$3.81	22	
\$3.96	\$4.52	\$5.22	\$4.31	\$5.01	23	
\$4.89	\$4.89	\$6.96	\$4.89	\$6.96	24	
\$0.93	\$0.37	\$1.74	\$0.58	\$1.95	25	
74.4	29.6	139.2	46.4	156.0	26	
0.61	0.08	0.18	0.15	0.22	27	

Missouri River. The gravity drain for the West Bottoms will consist of a 72-inch conduit with the necessary emergency flood gates. In the Middle Bottoms, it is planned that the twin 36-inch conduits that are already in place can be utilized by adding the required flood gates.

This plan has been presented by the Corps during formal meetings of the Buford-Trenton Irrigation District in April and July of 1976 and has been indorsed both times as much preferable to land acquisition and meriting a trial. These works will be accomplished within existing authorities at the Garrison project; total cost of the plan is estimated at \$500,000.

In addition to the problem of flooding, discussed on page 41, the Bismarck-Oahe area has experienced a rise in the ground water table during years past sufficient to cause complaints from some property owners. The area already contains subdivisions and dwellings which presage still further growth. Extension of the Oahe project boundaries would remove some but not all this land from private ownership and the hazard of unwise land use.

Because these lands are in the path of Bismarck's southward growth, their owners have shown a marked lack of enthusiasm toward zoning them for non-structural uses. During the late 1960's the Corps attempted to implement a Congressional authorization to acquire some holdings in this area for wildlife mitigation for Lake Oahe, but intense local opposition put a halt to the appropriation of funds.

The Corps has installed four observation wells to observe ground water levels in the areas, and is continuing their evaluation as a part of the Oahe boundary study. Pending completion of this investigation there can be no conclusive identification of

system-related effects in this area. Since this problem is being dealt with under existing authority, no additional recommendations are made in this report. Nonetheless, the area needs continuing attention from local authorities as a problem area calling for careful land use management to prevent unsound development in an area that lies in large measure within the 100-year flood plain.

The procedures being undertaken in response to flooding in the Niobrara reach - acquisition of a real estate interest in the affected lands - have been presented on page 42. They will dispose of the waterlogging issue at the same time.

BANK STABILIZATION

The alternative of soft bank protection, retained for further consideration in this section, responds to a need which was recognized a number of years prior to this study. PL 88-253, the 1963 Flood Control Act, modified the Flood Control Act of 1938, "to include such bank protection or rectification works at or below the Garrison Reservoir as in the discretion of the Chief of Engineers and the Secretary of the Army may be found necessary." In accordance with the Act's legislative history, seven sites were selected for construction in the reach from Stanton to Bismarck, North Dakota, and have been nearly completed.

Continuing awareness by Congress of bank erosion problems within the present study area was evident in Section 32 of PL 93-251, the Streambank Erosion Control Evaluation and Demonstration Act of 1974. The Act provided that: "At a minimum, demonstration projects shall be conducted at multiple sites on ..." a total of four designated river reaches within the continental United States. Half of these lie within the compass of this report, specifically: "that reach of the Missouri River between Fort Randall Dam, South Dakota, and Sioux City, Iowa;" and, "that reach of the Missouri River in North Dakota at or below the Garrison Dam." This work, too, is

underway.

The most recent Congressional expression that bank erosion on the Missouri River is a problem which can and will be solved is contained in Section 161 of PL 94-587, the Water Resources Development Act of 1976. This Section amends Section 32 of the 1974 Act by identifying the work now under contract or design in the Garrison reach through specific river mile and bank designation and by adding 18 new sites designated in similar fashion.

At this writing, Congressional perception of bank erosion within the study area falls into three categories:

- The reach below Garrison, where action has been directed at specific locations.
- The reach between Fort Randall Dam and Sioux City, where action has been directed "at multiple sites" to be determined by the Corps of Engineers.
- All remaining reaches, which must compete with the rest of the Missouri Basin and of the nation where mandatory action is absent.

Specific data are available with which to identify the critical areas within the second and third categories listed above. The alternatives which remain available within the scope of this report are to analyze that data and to make recommendations aimed toward systematic, efficient and economical completion of the job which Congress has instituted, or to provide no input. The latter option will result in a continuation of the authorization and construction process now going on, that of direct Congressional response to locally identified problems. It has produced results in the past; however, a drawback does exist. Results so produced tend to be piecemeal, with the likelihood of neglecting other problem areas of equal severity. The alternative of no additional Federal action and a complete suspension of stabilization work has little credibility in this instance if past events afford any perspective of

the future.

HYDRO-POWER

After preliminary screening, potential hydro-power additions at four of the main stem dams and four locations suitable for pumped-storage were retained for further consideration. The next step was an evaluation of how well each element could be accommodated within the numerous constraints imposed by main stem operations and the regional power load, followed by analyses of project sizing and finally by investigation of alternative impacts on the Missouri River downstream of the affected main stem projects.

The result of this analysis was retention of Fort Peck and Garrison as prospects for additional power installations and deferral of further consideration of Oahe and Fort Randall. Wide variations exist in the extent and timing of future depletions which could affect the water supply to the latter two projects; the more severe estimates would result in their operation under unrealistically low load factors.

Pumped-storage sites at Fort Peck are too remote from load centers in the Missouri Basin to make possible reliable power transmission, particularly to headwater locations, without losing financial feasibility. These sites were dropped from further consideration. At Garrison, strengthening of the existing transmission grid to accommodate pumped storage in the near term would impose the same financial problem reported at Fort Peck -- inability to repay costs within fifty years. There is a likelihood, however, that the growth of thermal installation near the North Dakota coal deposits will make pumped storage feasible during the next decade, and another evaluation is suggested during the mid-1980's. At Fort Randall a differential of 700 feet or more between the right bank plateau and the elevation of Lake Francis Case proved to be a feasible location for a pumped-storage hydro-plant, which has been

designated as "Gregory County". An additional opportunity was disclosed when residents of local communities and rural areas asked that consideration be given to supplying municipal and irrigation water from the Gregory County forebay.

Screening conducted in the study to this point left the following alternatives from which to choose hydro-power elements of the selected plan:

- Addition of 185 mw at Fort Peck with or without a reregulation dam.
- Addition of 272 mw at Garrison with or without a reregulation dam.
- Construction of 1,180 mw of pumped storage at Gregory County with or without multiple-purpose water supply as a project function.

RECREATION, FISH AND WILDLIFE

This phase of the study eliminated three preliminary considerations in the field of recreation, fish and wildlife.

- Subimpoundments at Lakes Oahe and Francis Case were abandoned in favor of more effective and less costly measures.

- Introduction of substitute species to reinstitute trophy fishing was concluded to be a supplement rather than an alternative to northern pike re-establishment.

- Update of the Fort Peck Master Plan, scheduled for FY 1978 was found to be the most appropriate means to identify feasible measures for improving access to project lands.

Selecting a Plan

Federal agencies within the Executive Branch are obligated to conform, as appropriate, to the Principles and Standards for Planning Water and Related Land Resources (P&S). The System of Accounts (SA) is a display presented at the conclusion of this section with the four accounts of National Economic Development (NED),

Environmental Quality (EQ), Social Well-Being (SWB) and Regional Development (RD). This requirement is an integral part of the planning process, and as displayed, contains a summary of significant adverse and beneficial effects within the framework of the four accounts for each alternative formulated by the Corps of Engineers in conformity with the P&S.

No such obligation rests upon the Legislative Branch to observe Principles and Standards methodology, and to the extent that Congress has bypassed that methodology in enacting water resource legislation it is omitted from full treatment in the System of Accounts. Environmental impacts, however, are assessed for each structural alternative discussed.

BANK STABILIZATION

The procedure selected by this report in response to the bank erosion problem consists of a recommendation for the following elements:

- Design and construction of works at Missouri River sites specifically identified and authorized by Section 161, PL 94-578.

- Design and construction of works at sites authorized by river reach below Garrison, Fort Randall, and Gavins Point Dams in Section 32, PL 93-251 and identified in this report.

- Design and construction of works at sites identified in this report in the reach below Fort Peck Dam (at five locations) and in the reach below Oahe Dam (at one location). The Streambank and Erosion Control Evaluation and Demonstration Act of 1974 called for local sponsorship of all works accomplished thereunder; if it is to serve as an adjunct to that Act this report must be consistent with it. The very magnitude of the undertaking does, however, call for a down-to-earth appraisal of the assumption of maintenance responsibility. No local agencies within the study area possess the resources to maintain a project while it is in the "evaluation" phase. Only when project works have reached a condition of evident

stability will it be realistic to transfer responsibility to local sponsors. Understandings toward this end have been reached in obtaining sponsorship for work on the seven sites in the Garrison reach under PL 88-253, where a three-year "seasoning period" after completion, or a significant test of the works, precedes local assumption of maintenance responsibility. In similar fashion, all Section 32 projects will be under Federal maintenance throughout a "demonstration period" up to five years long, after which the project will be rehabilitated as necessary before turning it over for local maintenance. A compatible approach is proposed in this report.

ADDITIONAL HYDRO-POWER

An environmental quality (EQ) plan element addressed to electrical generation appears obscure at best. Designated EQ plan elements must satisfy rigid requirements which conflict with the planning objective of fulfilling future energy demands. Moreover, the option of "No Federal Action" does not resolve the dilemma since our present national response would be to meet the demand by private means. The non-Federal alternative, if built within Federal and State water and air pollution standards, should not result in significant adverse national environmental quality effects. This does not suffice for qualification as an EQ element, however; net positive environmental effects must be identified. These are lacking in the least-costly, non-Federal alternative, which in this study has been determined to be oil-fired combustion turbines at load centers throughout the region. Consequently, combustion turbines are precluded from designation as an EQ element; however, they most nearly approach EQ requirements and will be regarded throughout plan evaluation as the EQ oriented NED alternative. Plant locations and some other detailed data are lacking at this juncture.

Addition at Fort Peck of two units with installed capacity of 185 megawatts and a reregulation structure approximately eight miles

SUMMARY COMPARISON OF ALTERNATIVE PLANS FT. PECK

	Plan A Combustion Turbine	Plan B Additional Hydro-Power	Plan C Additional Hydro-Power
PLAN DESCRIPTION	All fired combustion turbine power generating plants located at or near load centers and of capacity equivalent to hydro-power facility.	Two additional hydro-power units with a dependable capacity of 196 MW and a rerregulation dam constructed 5 miles downstream of present dam.	Two additional hydro-power units with a dependable capacity of 196 MW and no rerregulation structure.
SIGNIFICANT IMPACTS (Sec. 122 of PL 91-011)	Included in "Relationship to Four Accounts" as shown below.		
PLAN EVALUATION			
Contribution to Planned Objectives	Contributes additional peaking capacity to meet anticipated peak load demands.	Same as Plan A.	Same as Plan A.
Relationships to Four Accounts			
National Economic Development (NED)			
Benefits	\$7,799,000	\$7,909,000	\$7,889,000
Costs	<u>7,799,000</u>	<u>3,808,000</u>	<u>4,770,000</u>
Net Benefits	0	\$2,101,000	\$3,119,000
Environmental Quality (EQ)	Thermal power generation will result in increased air and noise pollution; however, these pollutants are expected to stay within current EPA limits.	This plan will cause the loss of 8 miles of river habitat, inundate 200 acres of terrestrial habitat for the rerregulation pool, and cause a reduction in the habitat value of the dredge cut area. There will be increases in temperature and in river stage stability downstream from the rerregulation structure causing some habitat enhancement.	The increased river stage fluctuations will result in a substantial reduction in dredge cut and river habitat value for a distance of 10 miles downstream of the dam. The increased river stage fluctuation will also result in large periodically exposed mud flats.
Social Well-Being (SWB)	While thermal power will contribute to the satisfaction of growing peak energy demands, its consumption of non-renewable, largely imported, fuel resources will compete with other energy users.	This plan will help to meet demands for peaking power without the consumption of non-renewable resources and will enhance environmental and aesthetic values below the rerregulation structure.	This plan will help to meet demands for peaking power without the consumption of non-renewable resources.
National Development (ND)			
Net Regional Benefits	0	\$2,101,000	\$3,119,000
Peak Construction Employment	50	750	300
Plan Response to Evaluation Criteria			
Benefit Cost Ratio	1.0	1.4	1.7
Acceptability	Public acceptance may become questionable as production costs rise and fuel reserves decline.	Plan B is more acceptable to state and national environmental interests than Plan C and more acceptable from the viewpoint of regional energy production and national energy policy than is Plan A.	Plan C, while more acceptable than Plan A from the viewpoint of regional energy production and national energy policy, is unacceptable in view of state and national environmental interests.
IMPLEMENTATION RESPONSIBILITY	Plan A will be funded by private and public entities and regulated by Federal and State regulatory agencies.	Plan B will be funded by the Federal Government with repayment of its investment accomplished through the sale of power.	Same as Plan B.

downstream (Plan B) was chosen on the basis of the following criteria of primary significance, as extracted from the SA tabulation:

- Although Plan B is less efficient in maximizing net benefits than is the plan without reregulation (Plan C), it still exceeds by half the efficiency of the non-Federal alternative (Plan A).

- Both Plan B and Plan C result in environmental impacts of greater geographic scope than does Plan A. Adverse effects of Plan C extend downstream perhaps twenty miles while those of Plan B are confined to the eight-mile reach of the reregulation reservoir, below which conditions will be improved over those existing prior to addition of the two units.

- Plan B is more acceptable in the eyes of State and national environmental interests than is Plan C. Plan B is more acceptable from the viewpoint of regional energy production and national energy policy than is Plan A.

Addition at Garrison of three units with installed capacity of 272 megawatts with reregulation (Plan B) was chosen on the basis of the following criteria of primary significance, as extracted from the SA tabulation:

- Plan C, the NED plan, is the most cost effective; however, compared to Plan A, both Plan B and Plan C provide substantial net benefits.

- Both Plan B and Plan C result in environmental effects of greater geographic extent than Plan A. Adverse effects of Plan C extend about 30 miles below Garrison Dam while those of Plan B are confined to the vicinity of the 10-mile reregulation pool. Plan B will result in improved environmental conditions throughout the remainder of the reach below the reregulation dam.

SUMMARY COMPARISON OF ALTERNATIVE PLANS GARRISON

	Plan A Combustion Turbine	Plan B Additional Hydro-Power	Plan C Additional Hydro-Power
PLAN DESCRIPTION	Oil fired combustion turbine power generating plants located at or near load centers and of capacity equivalent to hydro-power facility.	Three additional hydro-power units with a dependable capacity of 272 MW and the construction of a reregulation dam approximately 11 miles downstream of present dam.	Three additional hydro-power units with a dependable capacity of 372 MW and a rerregulation structure.
SIGNIFICANT IMPACTS (Sec. 122 of PL 91-611)		Included in "Relationship to Four Accounts" as shown below.	
PLAN EVALUATION			
Contribution to Planning Objectives	Contributes additional peaking capacity to meet anticipated peak load demands.	Same as Plan A.	Same as Plan A.
Relationship to Four Accounts			
National Economic Development (NED)			
Benefits	39,489,000	59,604,000	59,379,000
Costs	<u>3,269,000</u>	<u>6,070,000</u>	<u>7,788,000</u>
Net Benefits	0	\$3,534,000	\$4,791,000
Environmental Quality (EQ)	Thermal power generation will result in increased air and noise pollution; however, these pollutants are expected to stay within current EPA limits.	This plan will cause the loss of approximately 10 miles of river habitat, inundate approximately 180 acres of terrestrial habitat and its associated biota. It will result in changes in habitat type at some portions of the Riverdale Game Management Area. The temperature and river stage stability will increase downstream from the rerregulation structure causing some habitat enhancement.	The increased river stage fluctuations will result in substantial reduction in river habitat value for a distance of 30 miles. Increased river stage fluctuation will result in an emergence of periodically inundated and dewatered shorelines.
Social Well-Being (SWB)	While thermal power will contribute to the satisfaction of growing peak energy demands, its consumption of non-renewable, largely imported, fuel resources will compete with other energy users.	This plan will help to meet demands for peaking power without the consumption of non-renewable resources and will enhance environmental and aesthetic values below the rerregulation structure.	This plan will help to meet demands for peaking power without the consumption of non-renewable resources.
Regional Development (RD)			
Net Regional Benefits	0	\$3,534,000	\$4,791,000
Peak Construction Employment	50	300	290
Plan Response to Evaluation Criteria			
Benefit Cost Ratio	1.0	1.6	2.0
Acceptability	Public acceptance may become questionable as production costs rise and fuel reserves decline.	The agencies most directly responsible for selecting environmental options in North Dakota have rejected Plan B as unacceptable.	Its economic efficiency makes this plan most acceptable to all interests other than environmentalists, who consider both Plans B and C unacceptable.
IMPLEMENTATION RESPONSIBILITY	Plan A will be funded by private and public entities and regulated by Federal and State regulatory agencies.	Plan B will be funded by the Federal Government with repayment of its investment accomplished through the sale of power.	Same as Plan B.

● Plan C will reduce social well-being by largely eliminating substantial recreation opportunities below the dam. With Plan B, recreation opportunities will be essentially preserved by merely shifting to a new location downstream of the reregulation structure.

● Plan B and Plan C are more acceptable from a regional energy production and national energy policy viewpoint than Plan A.

● Based on the above considerations and the comments received during field level review of the alternative plans, Plan B was selected as a reasonable trade between a decrease in net economic benefits, environmental quality, and areal extent when compared to Plan C.

Construction at river mile 918 of the Gregory County pumped-storage hydroelectric peaking plant consisting of three units with total installed capacity of 1,180 megawatts (Plan B) was chosen on the basis of the following criteria of primary significance, as extracted from the SA tabulation on page 57.

● It offers a more cost effective response to the region's need for added peaking capacity than does Plan A.

● It has the most wide-spread acceptability of the three hydro-plants selected.

● Expressed environment concerns are few and even they are uncertain to occur.

RECREATION, FISH AND WILDLIFE

Alternatives retained for final consideration address three areas of opportunity: selection of ways to restore trophy fishing at Lakes Oahe and Francis Case, facilitating recreational access and use of all open river reaches, and consideration of National Wild and Scenic River designation of the Gavins Point-Ponca State Park reach.

Restoration of a northern pike fishery at Lakes Oahe and

SUMMARY COMPARISON OF ALTERNATIVE PLANS GREGORY COUNTY

PLAN DESCRIPTION	Plan A	Plan B
	Oil fired combustion turbine units located near demand centers and capable of delivering 1180 mw of peaking power.	Pumped-storage hydm-power plant in Gregory County adjacent to Lake Francis Case providing 1180 mw of peaking power from 3 pump-turbine motor generators.
SIGNIFICANT IMPACTS (SEC. 122 OF PL 91-611)	Included in "Relationship to Four Accounts" as shown below.	
PLAN EVALUATION		
Contribution to Planning Objectives	Contributes additional peaking capacity to satisfy a portion of future peak loads.	Same as Plan A.
Relationship to Four Accounts		
National Economic Development (NED)		
Benefits	\$51,029,000	\$51,379,000
Costs	<u>51,029,000</u>	<u>52,444,000</u>
Net Benefits	0	\$17,635,000
Environmental Quality (EQ)	Turbines will increase air and noise pollution; however, pollutant concentrations are expected to stay within current EPA limits.	Power plant discharges may degrade the aquatic environment by increasing turbidity if fine colloidal sediment deposited by the White River should be resuspended. Pumping may cause some fish mortality unless fish screens are installed, in which case there will be some risk of siltling. Approximately 1,500 acres of terrestrial habitat now in cross will be destroyed along with a natural embayment at Lake Francis Case.
Social Well-Being (SWB)	Contributes to satisfaction of life style expectations by helping to meet regional power needs. Construction will be distributed among a number of load centers in major metropolitan markets where the incurrence of additional construction and related economic activity will have minimal effects.	Conversion of approximately two and one-half sections of land from agricultural production to forebay storage, and relocation of resident families will be necessary. Peak employment will exceed 1,000 during construction, placing a significant additional demand for services and housing on the 9 rural communities within 30 miles of the project site. Addition of 50 permanent jobs will contribute to community cohesion and positive community growth. Help meet regional power needs.
Regional Development (RD)		
Net Regional Benefits	0	\$17,350,000
Peak Construction Employment	200	1,080
Plan Response to Evaluation Criteria		
Benefit Cost Ratio	1.0	1.3
Acceptability	Public acceptance may become questionable as production costs rise and fuel reserves decline.	Plan B has the most general local acceptability.
IMPLEMENTATION RESPONSIBILITY	Plan A will be funded by private and public entities and regulated by Federal and State regulatory agencies.	Plan B will be funded by the Federal Government with repayment of its investment accomplished through the sale of power.

**SUMMARY COMPARISON OF ALTERNATIVE PLANS
RESOTRATION OF TROPHY FISHING**

PLAN DESCRIPTION	Plan A	Plan B
SIGNIFICANT IMPACTS (SEC. 122 of PL 91-611)	Included in "Relationship to Four Accounts" as shown below.	
PLAN EVALUATION		
Contribution to Planning Objectives	Secure Northern Pike fishery by stocking 5 million Northern Pike annually to maintain a minimum adult pike population of 3 fish/acre.	Same as Plan A.
Relationship to Four Accounts		
National Economic Development (NED)		
Benefits	\$1,080,000	\$1,080,000
Costs	<u>361,300</u>	<u>732,700</u>
Net Benefits	\$ 718,700	\$ 347,300
Environmental Quality (EQ)	Has not positive contributions to the EQ account and has no major adverse effects on the environment. About 2,400 acres of wooded shorelines will be removed resulting in a much improved habitat. The 140 acres destroyed by the ponds support little vegetation. Construction activity will have minimal effect.	Same as Plan A, except the hatchery expansion will displace 150 acres of crop or recreation land rather than land of lesser habitat quality.
Social Well-being (SWB)	Positive effects include strengthening the economic base of adjacent communities, improving recreation opportunity, enhancing shoreline aesthetics, and aiding efforts to reduce community decline and exmigration. Possible adverse effects include increased noise during construction and decline in public safety as a result of increased visitation.	Essentially the same as Plan A except construction activity will be limited to a single site.
Regional Development (RD) (within 100 mi. radius of project)		
Net Regional Benefits	\$ 930,400	\$ 852,400
Seasonal Service Employment	300	300
Plan Response to Evaluation Criteria		
Benefit Cost Ratio	1.0	1.5
Efficiency	Plan A produces greater benefits than the other alternatives considered.	Considerably less efficient than Plan A.
Acceptability	Produces EQ benefits with no loss in efficiency.	Somewhat less acceptable than Plan A.
IMPLEMENTATION RESPONSIBILITY		
Initial Investment		
Federal	\$3,202,400	\$7,561,300
State	<u>1,520,200</u>	<u>1,320,400</u>
Total	\$4,722,600	\$8,881,700
Operation, Maintenance, Replacement (Annual Equivalent)		
Federal	0	0
State	\$ 78,100	\$ 59,300

Francis Case by construction of 12 nine-acre rearing ponds and enhancement of 2,400 acres of shoreline and littoral zone (Plan A) was selected on the basis of the following criteria of primary significance, as extracted from the SA tabulation on page 58.

- Plan A maximizes net benefits and is twice as efficient as Plan B.

- Plan A maximizes EQ benefits. Plan B will displace 150 acres of crop or residential land with the hatchery facility while Plan A will convert 140 acres of less valuable terrestrial habitat to rearing ponds and to seeded habitat when the ponds are not in use.

Since PL 89-72 requires that consideration be given to outdoor recreation during the planning for water resource projects and that non-Federal bodies be given the opportunity to cost share recreation development with the Federal Government on a 50-50 basis, this report treats recreational development as an equal partner with other developmental activity in the study area to the extent that interest in non-Federal sponsorship is evident. In general, then, river access is discussed as a specific adjunct to the bank stabilization program.

An amplification of plans for river-based recreation, applicable to only one reach of the river is designated under PL 90-542, the Wild and Scenic Rivers Act. The Bureau of Outdoor Recreation (BOR) completed a reconnaissance level report in 1971 on the reach of the river between Gavins Point Dam and Ponca State Park, finding the river reach to possess the features that make it eligible for designation under the Act (Plan A). The alternative to such designation is river access in conjunction with bank stabilization under the authority of PL 89-72 (Plan B). This is the procedure followed in the remaining river reaches as described in the preceding paragraph. It provides access and service roads, boat launching, sanitary, and related recreational facilities that would accommodate an anticipated average annual increase of eight percent in the visitors

estimated to be currently using the river reach.

Since Plan A, as documented in the SA tabulation on page 60a better preserves an environmental resource of national importance, is the more efficient investment as judged by economic criteria, and can accommodate larger numbers of visitors, it was chosen as the recommended plan.

The Selected Plan

This section describes the selected plan under the three major topics of bank protection, hydro-power, and recreation, fish and wildlife. Plan accomplishments and effects are identified, including the cost of bank protection. Economics of the other features are discussed in a subsequent section. Information on design, construction and operation and maintenance is included to the extent necessary to substantiate the expected plan accomplishments and effects.

Bank Stabilization

The selected plan provides for bank protection measures in the reaches downstream from Fort Peck, Garrison, Oahe, Fort Randall and Gavins Point Dams in furtherance of Congressional expressions in the 1974 and 1976 Water Resources Development Acts, Sections 32 and 161, respectively.

PLAN DESCRIPTION

It is proposed to reduce bank erosion by employing river management techniques using a variety of structural bank protection measures in combinations that are appropriate for local river conditions. Typical elements are flow control structures, vane dikes, windrow revetment, artificial hardpoints, composite bankline revetment, sand fill revetment, and tree retards. Still other techniques

SUMMARY COMPARISON OF ALTERNATIVE PLANS DESIGNATION UNDER PL 90-542

PLAN DESCRIPTION	Plan A	Plan B
PLAN DESCRIPTION	Designation of approximately 60 miles of the Missouri River between Gavins Point and Ponce State Park as a Wild and Scenic River under the authority of the Wild and Scenic Rivers Act (PL 90-542). Federal funds will be used to preserve specific river features of outstanding aesthetic value and to upgrade existing recreation facilities and river access points.	Provision under Federal Water Project Recreation Act (PL 89-72) of access and service roads, boat launching, sanitary and related recreational facilities that would accommodate an anticipated increase of nearly 6 percent in the 1 million annual visitors estimated to be currently using the river reach.
SIGNIFICANT IMPACTS (SEC. 122 OF PL 91-611)	Included in "Relationship to Four Accounts" as shown below.	
PLAN EVALUATION		
Contribution to Planning Objectives Provide Recreation Opportunities	Recreation potential will be enhanced through the construction of sanitary, river access, and camping facilities to accommodate an additional 500,000 visitors per year initially, 750,000 ultimately.	Recreational potential will be enhanced through the construction of sanitary, river access and camping facilities to accommodate an initial visitation of nearly 40,000 per year and an ultimate visitation of 60,000 per year.
Preservation of Aesthetic Values	Plan A permits the preservation of specific river features that are recognized as having outstandingly remarkable aesthetic values. These include the river setting at Goat Island, the entrance of the James River and Missouri chutes paralleling Goat Island, forested high bank shoreline, island clusters, wooded bluffs and bird nesting areas.	Plan B does not contribute to this objective.
Relationship to Four Accounts		
National Economic Development (NED)		
Benefits	\$3,306,000	\$107,600
Costs	<u>660,800</u>	<u>38,400</u>
Net Benefits	\$2,645,200	\$ 69,200
Environmental Quality (EQ)	Preservation of the major physiographic elements of this river reach will significantly affect the future potential of terrestrial wildlife populations especially the larger mammals, such as deer, and some songbirds.	High bank and farm land will be replaced by cottages and trailers significantly and adversely affecting the wildlife population and environmental quality.
Social Well-Being (SWB)	Quality of life and social structure will be enhanced by preservation of existing recreation resources and development of new industry based on seasonal recreation.	Increased accessibility and availability of recreation activities will primarily benefit the local populace.
Regional Development (RD)		
Net Regional Benefits	\$3,264,400	\$ 80,750
Peak Construction Employment	60	10
Plan Response to Evaluation Criteria		
Benefit Cost Ratio	3.0	2.8
Effectiveness	Plan A preserves nationally important environmental resources and enhances recreation.	Significant resources are irretrievably lost.
Efficiency	Plan A produces greater benefits than the other alternatives considered.	Considerably less efficient than Plan A.
IMPLEMENTATION RESPONSIBILITY		
Initial Investment		
Federal	\$7,412,000	\$171,000
Non-Federal	<u>0</u>	<u>173,000</u>
Total	\$7,412,000	\$346,000
Operation, Maintenance, Replacement (Annual Equivalent)		
Federal	104,200	0
Non-Federal	61,600	15,300

may be developed which will meet the overall objective of the plan, which is to prevent loss of valley lands by protecting the high river banks, while leaving the river environment between the high banks in its present condition with no loss in water area. Of necessity, site treatment detailed here is based on river conditions existing at present. Since the location of the river channel is extremely variable and points of attack on the banks shift from season to season, specific types of structures and their locations will be adjusted at the time of construction to insure compatibility with prevailing field conditions.

Reductions in the long-term average flow of the Missouri River, as a result of future growth in depletions, will not diminish the need or function of the bank protection works. Field observations indicate that even though an overall correlation exists between rates of bank erosion and streamflow rates, very high rates of erosion still occur at specific locations during low flow periods. This occurs as a result of the continuing tendency for the main channel to migrate in and between the sand bar and to be directed toward the high overbank lands either at high flows or at low flows. In addition, the possibility of high basin runoff in any given year will continue to exist regardless of the extent to which future depletions materialize.

Since the basis for this plan element rests in Congressional expressions already enacted, implementation procedures must conform to those expressions. They call for non-Federal sponsors of the works who will provide without cost to the Federal Government:

- Necessary lands, easements, and rights of way;
- Federal indemnity against damages due to the construction
- Operation and maintenance after project completion.

No problem is posed by the first two requirements just listed; responsibility for operation and maintenance, however, must be scheduled in an equitable and realistic manner. Failing this, local sponsors

may be burdened beyond their resources in the commitment to maintain a project still in the developmental stage.

Scope of the program is presented in the following table which shows by river reach the work under construction, already authorized on a site-specific basis, or identified by this report as necessary to retard erosion at presently active sites. Two sites, identified in the table as Eagles Roost and Nine-Mile Gulch, abut the Federally owned Karl E. Mundt National Wildlife Refuge. Personnel of the Fish and Wildlife Service, who manage the refuge, have measured high bank caving of as much as ten feet of tree-covered prime eagle roosting habitat in one season; however, concern over possible habitat degradation has caused their present opposition to stabilization work. The area is retained in the table to document a problem area, but is not proposed for construction or included in the cost estimate.

**EXISTING AND PROPOSED BANK PROTECTION SITES
BELOW MISSOURI RIVER DAMS**

Missouri River Reach	Site Location 1960 River Mile	Right or Left Bank	Name of Area	Existing Work	Authorized Under Section 32 as Modified By Section 161	Other
Fort Peck	1620.8	R & L	Culbertson Area			X
	1675.8	Right	Poplar River Area Part II			X
	1679.2	Right	Poplar River Area Part I			X
	1739.0	Right	Fraser Lake Area			X
	1759.0	Left	Milk River Hills Area			X
Garrison	1310.0	Right	Cusker Flats		X	
	1311.0	Right	Fort Lincoln		X	
	1313.0	R & L	Bismarck-Mandan	1/		
	1316.5	Right	I-94 Highway		X	
	1316.5	Left	Pioneer Park		X	
	1320.5	Left	Burnt Creek		X	
	1323.0	Left	Eagle Park	2/		
	1326.5	Left	Indian Mound		X	
	1327.5	R & L	Square Butte	1/		
	1332.0	R & L	Dry Point	1/		
	1334.5	Right	Horseshoe Butte		X	
	1335.7	Left	Woganport		X	
	1338.5	Left	Price Part II		X	
	1341.0	Right	Price Part I		X	
	1343.5	Right	Pratty Point		X	
	1345.2	Left	Wildwood (Upper)		X	
	1345.0	Right	Sanger		X	
	1350.0	R & L	Painted Woods	1/		
	1355.0	Right	Washburn			4/
	1357.5	Left	Lewis & Clark Camp		X	
	1360.0	Left	Coal Lake Coulee		X	
	1362.0	R & L	Lake Mandan	1/		
1366.5	Left	Sandstone Bluff II		X		
1368.0	Left	Sandstone Bluff I		X		

BANK PROTECTION SITES (CONT'D)

Missouri River Reach	Site Location 1960 River Mile	Right or Left Bank	Name of Area	Existing Work	Authorized Under Section 32 as Modified By Section 161	Other
Garrison	1371.3	Right	Fort Clark Power Plant	1/		
	1372.0	Right	Stanton Power Plant	1/		
	1374.0	Left	Knife Point Part I		X	
	1379.5	Right	Knife Point Part II		X	
	1385.0	Right	Hancock		X	
Oaha	1067.5	Right	Fort Pierre			X
Fort Randall	851.3	Right	Choceau Creek			6/
	862.0	Left	Willow Bar			6/
	864.0	Left	Greenwood			6/
	868.0	Right	Sunshine Bottom			6/
	874.5	Left	Yankton Sioux Tribal			6/
	875.0	Right	Minemile Gulch			6/
	878.0	Right	Eagles Roost			6/
Gavins Point	755.5	Left	Elk Point			6/
	759.0	Right	Ionla Bend			6/
	760.5	Right	Ionla Bend			6/
	764.3	Left	Bolton Bend			6/
	767.0	Right	Ryan Bend			6/
	771.0	Left	Vermillion River Cause	2/	X	
	772.5	Left	Fairview			6/
	775.0	Right	Mulberry Bend		X	
	777.0	Left	Mulberry Point		X	
	779.0	Right	North Alabama Point			6/
	781.0	Left	Clay County Park			6/
	783.5	Left	Vermillion Boat Club		X	
	784.0	Right	Brooky Bottom Road	2/		
	786.0	Left	Vermillion Boat Club Area 2			6/
	790.0	Left	Audubon Bend			6/
	794.0	Left	St. Helena Bend			6/
	796.5	Left	Goat Island			6/
	798.5	Right	Cedar County Park			6/
	800.0	Right	Campbells Point			6/
	801.0	Left	Janna River			6/
803.0	Right	Yankton Reach			6/	
804.0	Left	Bush Island			6/	
805.7	Right	Beaver Creek			6/	
806.0	Left	Yankton Riverfront			6/	
806.6	Left	Sacred Heart Hospital	3/		6/	

1/ Authorized under PL 88-253, 1963

2/ Authorized under Section 32, PL 93-251, 1974, under construction as of 1 January 1977

3/ Authorized under Section 39, PL 93-251, 1974

4/ These sites are in specifically-named river reaches where "multiple sites" were authorized by Section 32, PL 93-251, but are not included in the present Section 32 program due to funding limitations.

The incorporation of recreation development -- specifically river access sites -- into the bank protection program is dependent on the identification of local sponsors willing to operate and maintain the site and to share 50 percent of the original cost. This requirement determined the number of sites recommended here -- three in North Dakota and two in Nebraska. Their extent does not represent

a full response to the recreational demand; rather, it represents the financial ability of identified local sponsors. It is possible additional sponsorship will be proposed during advanced design.

In light of the efforts which will be exerted during design and construction of the bank protection works to insure compatibility with current riverine habitat and bank alignment, no mitigative measures are recommended as being needed.

EVALUATED ACCOMPLISHMENTS

The primary accomplishments that will result from the bank protection plan are:

- Prevention of the permanent loss of 272 acres per year of valley lands below Fort Peck, Garrison, Oahe, Fort Randall, and Gavins Point Dams, based on estimates that the proposed measures would control about 80 percent of the estimated future land losses in all reaches, except for Fort Peck. In this reach the proposed measures are estimated to control about 20 percent of the land losses. Components of this averted loss are roads, bridges, residences, recreation lands with improvements, woodlands, pasturelands, and croplands.

- Stabilization of the location of the high river banks along the valley lands.

- Contribution of an essential element to proposal for designating the Gavins Point reach as a National Recreation River under the National Wild and Scenic Rivers Act.

- Provision of river access to pleasure boaters, fishermen and hunters to the extent of 15,000 visitor days per site per year for a total of 75,000 visitations annually.

ENVIRONMENTAL EFFECTS

The significant reduction in the rate at which Missouri River valley lands erode into the river is considered the most significant impact of the bank protection plan. Other less significant impacts

include procurement of the rock for use as riprap and the act of physically constructing the protective structures.

At the present rate of erosion, about 437 acres of high bank valley lands are being lost annually. The valley lands (viewed as flood plain lands extending about one mile back from the river shore) are made up of cropland, 64 percent; woodland, 11 percent and grassland, 22 percent. The remaining three percent includes municipalities, roads, marsh and water. At the river's fringe (a 500-foot border landward of the river bank) the make up of the terrestrial plant cover is about 25 percent cropland, 32 percent woodland, and 29 percent grassland; the remaining 14 percent is made up of roads, sand dunes, and marsh.

The fact that almost 20 percent of the valley woodland is found in the river fringe, coupled with the fact that woodland does not exist outside the Missouri River valley in the study area except for small amounts of farm woodlots and other drainages' fringe woodland makes the effect of keeping the high bank valley lands from eroding very beneficial. The importance of this effect is intensified because the Missouri River woodland is not being replenished to the same extent as it was before completion of the main stem dams virtually stopped overbank flooding - a condition that initiated the cottonwood-dominated woodland successional development. Concern has frequently been expressed that an adverse effect of bank protection may be further replacement of woodland by more profitable cropland. However, because much of the remaining woodland (particularly that located on the river fringe) is growing on very sandy soil which is not usually regarded as good quality cropland, the land use change attributable to bank protection may not be highly significant. There is, in addition, evidence that the more favorable tracts are undergoing conversion even without stabilization, making quantification of this effect no more than guesswork.

Direct effects of building the bank protection structures will depend upon the type of structure being constructed. Windrow revetments, either piled in prepared trenches or on the ground will have no immediate effect on the aquatic environment. As the rock sloughs into the river, due to undercutting, to form a barrier between the river and the bank land, the river will become turbid, at least in the immediate area of the sloughing. This effect will be temporary and would have occurred with or without the presence of the rock. Subsequent effects of the rock in the river may be to add aquatic habitat diversity which would be beneficial, since the Missouri River bed is composed almost totally of shifting and moving sand. Windrowed rock, if placed on the surface of the land, could also provide escape cover and possibly nesting cover for small land animals. In turn, windrowed rock could become feeding sites for predators and hunting sites for man. Windrowed rock placed in trenches and covered with dirt and seeded may be more aesthetically pleasing to man but of little use to small land animals. All other bank protection structures will be constructed in or interfacing with the river causing the immediate disruption of the river bed at the structure site. The effects would, however, be similar to the windrow revetments after sloughing into the river. Construction equipment noise and fumes would be an insignificant, temporary adverse effect. The proposed structures are not designed to diminish the water area of the Missouri River, nor to alter materially the configuration of the river within its high banks.

The cumulative effect, once all the proposed stabilization works are installed is not of great magnitude as indicated by the following data, which reflect the percentage of river shoreline that would be occupied by structures identified in the table on page 62: below Fort Peck, 1/2 percent; below Garrison, 8 percent; below Oahe 13 percent; below Fort Randall, 5 percent; below Gavins Point, 23 percent.

DESIGN

In accordance with the plan objective, a major design consideration will be to hold disturbance of bank and bar areas to a minimum to preserve a natural appearance. Suitability as fish habitat will be a primary criterion in the location and configuration of structures and selection of their construction materials. Critical technical factors affecting structure design and stability are bed-scour at the toe of the bank, weathering in the zone of stage variation, ice action, and filtering of fine river sand through the structure. Velocity, per se, is not an important consideration in designing Missouri River structures; neither is the threat that design stages will be exceeded and the works damaged by frequent overtopping. The river stages actually experienced will almost always remain below the top of existing high banks and will vary between fairly well definable limits because of the high degree of flow regulation attainable by the main stem dams. Further details concerning the structural measures listed on page 60 may be found in Appendix 1 of this report.

Exclusive of the river reach below Gavins Point Dam which is discussed elsewhere in this report, river access points will consist of a single lane boat ramp and boat dock, gravel parking area, sanitary facilities and all weather, gravel access road from the nearest public, all weather road. Each site will require five acres to accommodate facilities development and public use and 66 foot width right-of-way for the access road. Average length of access is estimated to be one-quarter mile, making the total land requirement for each access an average of 7.5 acres.

CONSTRUCTION

It is estimated that the initial construction phase of the bank protection plan could be completed in all reaches in five years following receipt of construction funds. Priority and exact location

of the works will be determined just before installation in order to insure maximum effectiveness. Construction techniques will vary at the various sites between placement by land or by floating plant depending on construction practicability, environmental impact or local site conditions and land use.

OPERATION AND MAINTENANCE

Description of the bank erosion process, the program recommended to reduce its effects, and the sponsorship requirements all point up the dichotomy to be found in responsibility for maintenance. On one hand, there exists a statutory responsibility for local assumption of the maintenance effort once construction is complete; on the other hand, an efficient approach to the problem calls for on-going activity in response to changing river conditions over the years which is closely allied to new construction. In the past, local entities have expressed reluctance to sponsor stabilization works they might be unable to afford. It is important that a clear demarkation be fixed between those continuing measures the Federal Government will undertake and those which must be undertaken locally.

Two aspects of this project extend the period of Federal responsibility beyond the end of initial construction:

● The nature of the program, "demonstration and evaluation," calls for innovative and unproven techniques. It is not reasonable to suppose their remedy lies within the limit of local resources.

● Since the accomplishment of an effective yet efficient plan depends on initial protection of presently evident "hot spots" with subsequent monitoring, identification, and annual treatment of new problem areas until bank erosion in the reach has been reduced to a tolerable minimum, both the initial construction and the annual treatment are considered here as properly accomplished by Federal effort.

Existing policy applicable to Section 32 projects, calls for

rehabilitation after five years of demonstration and evaluation. Continuation of this policy seems appropriate in the case of individual structures and reach segments after construction is fully complete. The best estimate, based upon past experience with bank protection works along the Missouri River main stem, is that twenty years of Federal treatment in the newly occurring areas of erosion will result in a well-stabilized section ready for local assumption of operation and maintenance responsibility. Federal costs for annual maintenance necessary for rehabilitation of existing structures, and the installation of additional works as required over a 20-year period after construction in a given reach, are estimated at five percent of the initial construction cost. After local takeover, annual maintenance costs are estimated to run one percent of construction cost.

CONSTRUCTION COSTS

Federal and non-Federal construction costs associated with the works tabulated on page 62 are given below. Not all of these costs, however, are newly created as a result of recommendations contained in this report. Some are costs authorized under Section 161 of the 1976 Water Resources Development Act for construction of specific works in the reach between Garrison Dam and Lake Oahe. Of the total \$8,101,000 shown in the table, \$400,000 is a recommendation for new authorization; the remaining \$7,701,000 is for work in compliance with Section 161. For orderly implementation of the recommendations in this report, it is necessary that all components of Federal cost be incorporated into the normal budgeting process. The non-Federal component arises from the provision of lands, easements and rights-of-way. Permanent easements have been costed for the lineal feet of bankline protected and for a distance of 100 feet back from the river. The acreage thus developed, together with construction access and overhead, makes up non-Federal construction costs.

**MISSOURI RIVER BANK PROTECTION
ESTIMATE OF CONSTRUCTION COSTS**

River Reach Downstream of	Cost in 1976 Dollars	
	Federal	Non-Federal
Fort Peck	\$1,592,000	\$ 26,000
Garrison	8,101,000	356,000
Oahe	333,000	11,000
Fort Randall	1,075,000	58,000
Gavins Point	11,907,000	752,000
Total	\$23,008,000	\$1,203,000

The unit cost of river access sites except the Recreational River is estimated to be \$49,200 not including land costs which are estimated to average \$4,300 per site. Including indirect costs of 35 percent, each of the five sites has a construction cost of \$71,000 distributed \$213,000 in North Dakota and \$142,000 in Nebraska.

Based on an economic life of 50 years and a discount rate of 6-3/8 percent, the average annual equivalent expenditure for maintenance of the bank protection works will be \$713,000 of Federal and \$146,000 of non-Federal cost. Operation and maintenance costs for the five river access points are estimated at \$2,400 per year, per site, to be borne entirely by the local sponsors.

Hydro-Power

The selected plan consists of the addition of five new generating units to the main stem dam system on the Missouri River to increase the installed capacity by 457 megawatts and the development of a pumped-storage facility adjacent to Lake Francis Case to provide 1,180 megawatts of peaking capacity.

PLAN DESCRIPTION

The primary components of the hydro-power addition consist of:

- A new two-unit powerhouse adjacent to the existing two powerhouses at the Fort Peck Project, Montana, together with appurtenant features and including a reregulation dam and reservoir eight miles downstream from the new powerhouse. Each of the two existing flood control tunnels would be modified to accommodate a turbine-generator unit with a nameplate capacity of 92.5 megawatts for a total additional installed capacity of 185 megawatts. The aggregate capacity at the Fort Peck Project with the addition would be 350 megawatts. The new powerplant would also include miscellaneous accessory equipment, switchyard expansion, and tailrace. The hydraulic capacity of the Fort Peck Project powerplant would be increased to 32,600 cubic feet per second. The reregulation dam would be located about 8 miles downstream from the Fort Peck Dam, storing water essentially within the existing channel banks along the 8-mile reach to provide 20,000 acre-feet of storage for regulation of downstream flows. The regulation project would require 1,290 acres of private land, the purchase of 480 acres of additional land to mitigate wildlife land inundated by the reservoir, and the relocation of existing tailrace recreation facilities downstream from the regulation structures. Furthermore, a gated structure would be required to prevent stage fluctuations in existing dredge cuts and two islands in the regulation pool would require riprap to protect banks from erosion.

- A westward extension of the existing Garrison Project, North Dakota, powerhouse to include two modified flood control tunnels which would accommodate one 80-megawatt turbine-generating unit each and one modified flood control tunnel which would accommodate one 112-megawatt turbine-generating unit. Included in the plan is a reregulation dam and reservoir about 10 miles downstream from Garrison Dam. The Garrison Project aggregate power capacity would be increased to 672 megawatts with the 272-megawatt plant addition.

The powerplant addition would also include miscellaneous accessory equipment, and a southward extension of the existing switchyard. The hydraulic capacity of the Garrison Project powerplant would be increased to 70,300 cubic feet per second. The Garrison reregulation reservoir would store about 30,000 acre-feet of water, all within channel, for downstream flow regulation requiring the purchase of 2,305 acres of private land. About 270 acres of additional land would be required to mitigate wildlife lands used for reregulation. Existing tailrace recreation facilities would be relocated downstream from the reregulation dam. Appropriate drainage facilities would be provided to allow proper drainage of the Garrison Dam National Fish Hatchery during reregulation operation cycles.

● A 1,180-megawatt pumped-storage powerplant adjacent to Lake Francis Case, located about three miles south of the Platte-Winner bridge in Gregory County, South Dakota. The pumped-storage facility would consist of a leveed-forebay with an active storage capacity of 46,800 acre-feet; a 1.6-mile long, 30-foot diameter, underground power conduit; a powerhouse with three 394-megawatt reversible pump-turbine units; and a 3,000-foot long trapezoidal-shaped tailrace section. The project would develop an average gross head of 711 feet for peaking capacity. Utilization of the reversible turbines to lift water for municipal and agricultural use to the forebay for ultimate distribution to towns and farms in and near Gregory County could be included as an ancillary function of the project. Perhaps one-half percent of the active forebay storage would be required to meet potential daily irrigation and municipal needs. The forebay operating range would be 61 feet per second and the afterbay (Lake Francis Case) operating range would seldom exceed 50 feet per year. Maximum discharge during generation periods would be 24,740 cubic feet per second and pumpback discharge would be 16,490 cubic feet per second. The forebay levee would be about 49 feet in average height and 30,100 feet in length. The water surface area of the forebay would be 1,155 acres. About 1,630 acres of private land would be required for the project including seven sets of farm

buildings.

EVALUATED ACCOMPLISHMENTS

Major contributions by the plan include:

- Contribution to the national economy in the amount of \$68,000,000 a year as measured by the alternative cost of generation.

- Addition of 1,637 megawatts to the installed capacity in the region served by MARCA, thereby satisfying four percent of the increase estimated to be necessary by 1994.

- Increase in efficiency in use of thermal resources by replacing oil-fired turbines, permitting substitution of base-load plants using less scarce and costly coal and lignite.

- Affords the potential to lift water 700 feet for consumptive use in the plateau area adjacent to Lake Francis Case.

ENVIRONMENTAL EFFECTS

The environmental effects at Fort Peck, Garrison and Gregory County result directly from design and operation of these projects.

At Fort Peck, the environmental impacts are as follows:

- Loss of eight miles of river habitat.

- Loss of the fishery in the reregulation pool area.

- Reduction in habitat value of the dredge cut area.

- Potential increase in the relative abundance of fishes below the reregulation dam as a result of moderation of temperature regimes.

- Loss of approximately 200 acres of terrestrial habitat through inundation, erosion or bank slope adjustment.

- Potential alteration of vegetated growth patterns induced by changes in groundwater regimes or as a result of decreased stage fluctuations.

- Potential for increased waterfowl diseases due to the creation of an ice-free reregulation pool.

At Garrison, the environmental impacts are as follows:

- Loss of ten miles of river habitat.
- Loss of the fishery in the reregulation pool area.
- Potential increase in the relative abundance of fishes below the reregulation dam as a result of moderation of temperature extremes.
- Loss of approximately 200 acres of terrestrial habitat through inundation, erosion or bank slope adjustment.
- Potential alteration of vegetal growth patterns induced by changes in groundwater regimes or as a result of decreased stage fluctuation.
- Potential damage to Garrison National Fish Hatchery as a result of frost-heave due to increased groundwater levels.

At the Gregory County pumped-storage power plant, it is expected that fall migrating waterfowl will use the forebay as a resting stop and the operating cycle will cause some circulation of nutrients. However, the project is expected to have little effect on lake temperature and dissolved oxygen content. Construction activities may add temporary increases in turbidity into the lake. The pumped-storage power plant would create three adverse effects. One is associated with construction of the plant and the two others are associated with the operation activities. The impacts from operation may be able to be ameliorated after further study but the construction impact is considered unavoidable. The effects are:

- A productive natural embayment will be pre-empted and its flora and fauna in large measure destroyed, to provide a site for the power plant and tailrace channel.
- Operation of the power plant in the pumping mode may draw fish into the pump turbines or otherwise inflict death or injury.
- Operation of the power plant in the generating mode may disturb sediment deposited by the White River, increasing turbidity and degrading water quality to the detriment of the aquatic community.

Transmission lines required for marketing of the additional

Tunnels three and four extended to permit proper alinement and spacing of two Francis turbines, the new powerhouse will contain miscellaneous accessory equipment, a 230 KV switchyard expansion and a tailrace. The new power plant will be operated from the control room in Powerplant Number One. Dependable capacity for both Garrison and Fort Peck additions was based on head available during the fourth year of the 1930's drought or August 1933.

A reregulation dam would be located downstream from Fort Peck Dam about eight miles. The storage is limited to essentially within the river channel to prevent undue flooding and reduction in power head. The reregulation structure and its upstream pond were designed to minimize discharge variation in the river downstream during operation of Fort Peck as a peaking plant. Automated gate operation with continuous sensing of the pool and tailwater levels will be employed to maintain uniform discharges throughout the range of changing water levels. The gate sills will be placed at the riverbed elevation to afford maximum utilization of available storage.

Three additional Francis turbines will be housed in a westward extension of the existing Garrison powerhouse. Steel liners will be installed on existing flood control tunnels numbers six, seven and eight and three Francis turbines will be added. As at Fort Peck, surge tanks are not proposed for the additional units; instead governor design will confine rapid load changes to the existing units. A reregulation dam would be located about ten miles downstream, its reservoir along the 10-mile reach essentially within channel banks. As at Fort Peck, automated gate operation and sensing of pool and tailwater levels would be employed.

Principal elements of the Gregory County Pumped-Storage Project consist of a forebay, power tunnel, powerhouse and discharge channel. Forebay storage of 47,100 acre-feet lies within a levee 30,100 feet

power would:

- Disturb the landscape during construction.
- Take land from agricultural production for tower structures.
- Increase the visual impact of lines at highways and recreation areas.
- Reduce vegetation by clearing within rights-of-way.
- Reduce some bird and animal populations as a result of collision with lines and clearing.

OTHER EFFECTS

Effects on cultural resources downstream from each of the re-regulation dams are considered uniformly beneficial. A survey will be conducted during post authorization design to determine cultural resources affected within the pool areas and the Gregory County pumped-storage project area. Those affected will be protected or the cultural data recovered and preserved.

Considerable concern has been expressed over groundwater effects to the Riverdale Game Management Area. About eight percent of the area would have a water table three feet or less below the soil surface thus increasing the acreage of wetlands and savannah should the water table sustain itself at the reregulation pool elevation.

An estimated 1,810 persons will be directly employed during the construction period and about 60 permanent workers in semi-skilled jobs would be added in areas which have experienced chronically high unemployment.

DESIGN

At the Fort Peck project the new power house will be located about 200 feet northwest of Powerhouse No. two, which is unable to accommodate the new units due to lack of space and soil stability problems which make excavation risky. In addition to accommodating

long and an average of 49 feet high. An impervious liner about three feet thick will prevent seepage out of the forebay bottom; alternatively, a slurry trench cutoff to impervious strata may be used depending upon further geologic exploration. The forebay levee has a 15-foot crown width, and side slopes of 1 on 3 for the top 30 feet of height flattening to 1 on 5 and 1 on 7 on the landward side as dictated by topography and 1 on 5 and 1 on 10 on the reservoir side. The reservoir side of the levee is lined with eight-inch bedding material and 20-inch riprap along the 1 on 3 side slope area while the 1 on 5 slopes are lined with eight-inch bedding and 17-inch riprap. An inclined vertical pervious drain and a horizontal pervious drain permit collection and disposal of seepage flows through the structure. Material for the levee embankment will come from tailrace excavation and forebay collector channel excavation. Dependable capacity was established with the forebay at minimum elevation and Lake Francis Case at the base of exclusive flood control.

CONSTRUCTION

Construction would require about three years each at Fort Peck and Garrison. The Gregory County Project would require about five years time for construction.

Borrow material for the reregulation dam embankments would be selected from the reregulation reservoirs. Material for the Gregory County forebay embankment would come from the tailrace and forebay excavation areas.

Prior to construction foundation conditions at Fort Peck and Gregory County will be evaluated for compatibility with designs, and model studies of the Gregory County Project will be made to define effects on lake bottom sediment deposits. An evaluation of soil transmissivity downstream from Garrison will be evaluated to determine if a possible groundwater problem would result. With

these exceptions, few construction problems are expected.

OPERATION AND MAINTENANCE

Operation and maintenance of the additional units will be incorporated into the on-going operation of the existing system. Daily and longer operating targets are set cooperatively by the Corps and the USBR, taking account of the water supply and the demand for electric power. Major operation and maintenance items include turbines and generators, electrical equipment, trash racks, reregulation structure, and service equipment. The reregulation dams downstream from Fort Peck and Garrison would be operated with automatic sensing equipment so as to minimize fluctuations downstream.

With an average water supply the Fort Peck enlarged plant could be expected to operate for about seven hours each day for six days per week and for about 17 hours each day no releases would be made. Under low flow conditions the plant would operate for five days per week with no generation on week-ends. Uniform operation on all seven days would occur during high flow conditions. The Garrison Project would operate for about 7.5 hours each day seven days a week, with no releases being made for the remaining 16.5 hours under normal daily releases. Some reduced generation may occur during low flow conditions.

The Gregory County Pumped-Storage project is designed to operate on a cycle, with on-peak generation for nine hours a day, five days a week and off-peak pumpback for about 8.3 hours a day on weekdays and 13 hours each on Saturday and Sunday. It is estimated by the Federal Power Commission that a plant of this type will be utilized about 1,000 hours annually. If needed during a critical period, the project could generate continuously for 23 hours before pumpback operations had to be resumed.

On-Site Rearing Ponds

The selected plan consists of Federal construction of nine-acre on-site fish rearing ponds at seven locations near Lake Oahe and five near Lake Francis Case for northern pike propagation with neighboring forage base development.

PLAN DESCRIPTION

The plan consists of two separate actions. The first is the establishment of semi-aquatic vegetation on a number of reaches of denuded lakeshore areas at Lake Oahe and Lake Francis Case. At each of 12 sites, about 200 acres will be seeded by conventional farming methods during the late fall and winter months. Sprigging of root stock from rooted semi-aquatic plants will also be performed on 100 acres during the same period.

The second part of the plan consists of constructing rearing ponds at the 12 sites adjacent to the reservoirs. Each would be located near the improved habitat area and the site would include space for temporary parking of a hatchery trailer, an access road, electric power source, and underground vault for waste disposal. The following table shows the approximate geographical location of the site.

ON-SITE FISH REARING PONDS AND FORAGE BASE DEVELOPMENT	
<u>Lake</u>	<u>Geographical Location</u>
Oahe	Cheyenne River Arm Cow Creek Area Whitlock Bay Area Swan Creek Area Blue Blanket Area Indian Creek Area Pollock Area
Francis Case	North Bay Area St. Phillips Bay North Wheeler Area Snake Creek Area Elm Creek Area

EVALUATED ACCOMPLISHMENTS

The implementation and operation of the plan would:

- Improve existing forage base consisting of increased numbers of prey fish species, insects, and other invertebrates
- Reduce shoreline erosion and stabilize banks along an estimated 200 miles of denuded shoreline
- Improve the lakes' northern pike populations by one-half million each year
- Increase fishing opportunities and visitation to the lakes by about 180,000 fishermen days annually.

ENVIRONMENTAL EFFECTS

The rearing ponds will have no major adverse effects on the environment and will result in an improvement over existing environmental conditions. Approximately 1,400 acres of denuded shoreline area at Oahe and 1,000 acres at Francis Case will be vegetated, marked by improving existing habitat both when inundated and when exposed. One hundred forty acres of terrestrial habitat will be destroyed by the construction and operation of 12 on-site rearing ponds. Much of this area presently supports little vegetation. Seeding and re-establishment of vegetation in the rearing pond bed each year may result in improved terrestrial wildlife habitat during non-operational periods.

OTHER EFFECTS

About 60 persons would be employed during the construction period. Increased regional sales and additional seasonal and part-time jobs are expected to occur along with an increase in out of state tourism.

DESIGN

Each pond would be 706 feet in diameter, surrounded by a levee

with a height ranging from four feet to 10 feet. Each ring levee will have side slopes of 1 on 3 and a 10-foot top width. A 2-3/4 foot corrugated metal pipe will extend from the sluice gate structure to the existing lake for draining the pool. The pool will be drained over a two-day period and filling time will approximate one day with portable 65-horsepower pumps. The bottom of the pond will be graded to a 1 on 100 slope and seeded annually. The top of the levee will be surfaced with gravel as will the extension of existing roads to provide access to the site. The site will be located at or above the elevation of the top of exclusive flood control zone of the reservoirs.

CONSTRUCTION

Construction would require about six months time. Techniques employed will be similar to those used in building sewage treatment ponds. Initial vegetative cover establishment along the lake shoreline will be followed by a five-year program of aerial reseed-
ing. This effort is part of the Federal construction cost.

OPERATION AND MAINTENANCE

Annual operation and maintenance will consist of pond farming, including annual seeding of the rearing ponds, collection of eggs during March and April and rearing to the fingerling stage, release of fingerlings into adjacent lakes, and maintenance of ponds, equipment, and access facilities. Pond maintenance and filling will begin approximately two to four weeks prior to fry release time. Maintenance to access roads, levees, and sluice gates will be accomplished as needed throughout the year. Pond filling operations will be accomplished using portable pumps to fill each rearing pond from the nearby lake. Make-up water for evaporation and seepage losses would also be provided periodically by the pumps.

Designation Under National Wild and Scenic Rivers Act

The selected plan consists of designating about 60 miles of

the Missouri River from Gavins Point Dam to Ponca State Park, Nebraska, as a component of the National Wild and Scenic Rivers system, to be classified and managed as a Recreation River.

THE SELECTED PLAN

Approximately 12,800 acres of bluff land, river bed, and islands will be acquired in recreation easement to provide for public use. A little over 1,700 acres of shore land averaging about 100 feet in depth will be acquired in scenic easement along essentially the entire river reach to be designated. Approximately 424 acres of land will be acquired in fee to provide for river access and development of public use facilities. Erosion control structures will be constructed to protect the two high bank islands and highly significant accretion lands from predictable loss due to river action.

All land forms between the high banks in five selected river reaches will be available under recreation easement for public use. These selected reaches cumulatively will amount to about 37 miles, which is nearly 65% of the total reach to be designated. A small amount of each of the two high bank islands will be acquired in fee with the remainder of the islands acquired in recreation easement. A small amount of Nebraska bluff land will be acquired in fee surrounded by a larger acreage of recreation easement at three separate locations. One area south of Elk Point, South Dakota, will also be acquired in fee for development as a major access area.

EVALUATED ACCOMPLISHMENTS

Designation of this reach as a component of the National Wild and Scenic Rivers System will provide permanent protection and enhancement of the recreational, geologic, fish and wildlife, historic, archaeological, and other values on this approximately 60-mile segment of the Missouri River. These values will be retained for both recreation and scientific benefits for generations to come through selective land acquisition, easements, intensive management, and environmentally

sensitive placement of compatible erosion control and bank stabilization structures.

The ultimate demand will be an estimated 750,000 additional recreation days within the designated segment of the Missouri River. Increased opportunity will be provided through improved access, recreational development, and resource preservation. Regional tourism is expected to increase markedly, with 90 percent of the additional visitation anticipated from beyond bordering counties. Assuming that each visitor from outside the bordering counties will spend \$7.50 per day, \$5 million annually will be added to the regional economy. Other identifiable social effects include additions to traffic volume amounting to about 200,000 "vehicle days" per year and 677,500 average annual visitors. Of the \$5 million expenditure, approximately \$170,000 would be for gasoline tax and \$170,000 for sales taxes. Seasonal and part-time employment would be supported for about 400 persons.

ENVIRONMENTAL EFFECTS - RECREATION RIVER

The establishment of a National Recreation River will preserve the habitat in this reach essentially as it is today subject to natural ecological changes. High bank areas will be preserved, benefiting the flora and fauna utilizing this area. Changing lowlands will provide habitat diversity as they do today. Warm water fishery habitat will be maintained, as will many islands, sand bar and other habitat critical to wildlife. Future development along this reach will be limited under the terms of the Wild and Scenic Rivers Act. Encroachment of agricultural land to the river shoreline will be limited by scenic easement. Structural protection of islands and high bank areas require a trade-off between reduced aesthetic value of a natural river and the loss of these features through erosion.

DESIGN

The selected plan consists of Federal acquisition of land,

construction of recreational facilities, and river access and construction of selected structures compatible with National Wild and Scenic River designation. Lands to be acquired are to accommodate recreation facility development, public use, and the preservation of the river and high bank features which make the river eligible for designation. Estimated land requirements include 424 acres in fee simple; 1,705 acres in scenic easement; and 12,812 acres in recreation easement which includes up to 6,648 acres of submerged riverbed. River access facilities will be improved at the existing public access points on the river, except at the Downstream Recreation Area of the Gavins Point project where access facilities are adequate. Recreation facilities will be developed at six additional areas to be acquired - two of which are on islands.

Acquisition of lands in fee simple is proposed for six specific areas from river mile 753 to 800 that will support recreation facilities and public overnight use that require safeguards against fires, and landscaping to accommodate tents and other camping units. Recreation easements in this reach from river mile 753.6 to 801.0 would allow public day-use on sand bars and low bank lands. The recreation easements will restrict the owner from making significant land use changes of a nature that would adversely affect public use, wildlife use, and the land's aesthetic values, and will provide for public use.

Scenic easements will be acquired generally along both banks the full length of the designated reach from Gavins Point Dam to Ponca State Park. Most reaches will be narrow, with some wider areas, particularly at reaches where gradual slopes or steep bluff lands make up an important visual feature of the designated river. The fundamental purpose of the scenic easement is to retain the river shoreline appearance in a condition that is compatible with Recreational River classification. Scenic easements will generally contain the same covenants as recreation easements, but will

not provide for public use.

CONSTRUCTION

Implementation of the selected plan can be completed by 1983. Real estate acquisitions and construction are to be Federal responsibilities.

OPERATION AND MAINTENANCE

Acquisition of necessary lands and real estate interests, and construction of initial recreation improvements will be accomplished by the Federal Government. Overall administration of the National River will also be the responsibility of the Federal Government through the Corps of Engineers. Operation, maintenance and replacement of new river access facilities to be constructed on existing public use lands will be the responsibility of the public agencies currently administering the sites. The Federal Government will retain responsibility for real estate easement administration, and operation, maintenance and replacement of facilities on the two islands, and will continue to operate, maintain and replace the recreation facilities in the Gavins Point downstream public use areas. Gavins Point will serve as the upstream terminal staging area for the national river. The operation, maintenance and replacement of the new public use area in South Dakota opposite Ponca State Park will be by South Dakota under a recreation lease issued by the Federal Government. The operation, maintenance and replacement of facilities at the three Nebraska bluff sites will be by Nebraska under recreation leases issued by the Federal Government.

Economics of Selected Plan

This section summarizes the economic data for the selected plan with the exception of bank stabilization, for which costs are presented on page 70.

Methodology

Tangible economic justification of the selected plan can be determined by comparing equivalent annual costs with an estimate of the equivalent average annual benefits for the plan over a period of analysis equivalent to 50 years except for the additions at Fort Peck and Garrison which are 100 years.

Costs

The following section contains a summary of first cost and annual charges for the recommended plan components.

HYDRO-POWER

Project investment cost is equal to first cost plus interest during construction. Based on the cost of similar projects, a contingency allowance of approximately 15 percent (20 percent for lands), an engineering and design cost, and a supervision and administration cost of approximately eight and seven percent, respectively, have been included in project first cost. Annual costs include interest and amortization, operation and maintenance, major replacement, pumping energy and recreation loss. The following tabulations summarized first costs and annual costs for hydro-power additions. Annual operation and maintenance costs were based on costs for similar projects.

HYDRO-POWER
First Cost Summary
(\$1,000)

	<u>Total Costs</u>	<u>(Mitigation & Relocation Incl. in Total)</u>
FORT PECK		
Lands and Damages	\$ 1,156	(292)
Dams	33,700	
Power Plant	31,800	
Roads	55	(55)
Recreation Areas	200	(200)
Bank Stabilization	350	(350)
Bldg., Grounds, Utilities	200	
Perm. Oper. Equipment	100	
Engineering & Design	5,100	(47)
Supervision & Inspection	<u>4,339</u>	<u>(40)</u>
TOTAL	\$ 77,000	(984)
GARRISON		
Lands and Damages	1,977	(210)
Dams	25,040	
Power Plant	45,200	
Levee	20	(20)
Recreation Area	25	(25)
Bldg., Grounds, Utilities	200	
Perm. Oper. Equipment	100	
Engineering & Design	5,572	(4)
Supervision & Inspection	<u>4,866</u>	<u>(3)</u>
TOTAL	\$ 83,000	(262)
GREGORY COUNTY		
Lands and Damages	1,372	
Dams	113,600	
Power Plant	88,210	
Roads	4,700	
Bldg., Grounds, Utilities	350	
Perm. Oper. Equipment	200	
Engineering & Design	15,300	
Supervision & Inspection	<u>13,268</u>	
TOTAL	\$237,000	

HYDRO-POWER INVESTMENT AND ANNUAL
COST SUMMARY
(\$1,000)

	<u>Ft. Peck</u>	<u>Garrison</u>	<u>Gregory County</u>	<u>Total System</u>
First Cost	\$77,000	\$83,000	\$237,000	\$397,000
Interest During Construction	<u>7,253</u>	<u>7,748</u>	<u>37,553</u>	<u>52,554</u>
Investment Cost	\$84,253	\$90,748	\$274,553	\$449,554
Interest & Amortization	\$ 5,382	\$ 5,797	\$ 18,337	\$ 29,516
Operation & Maintenance	160	180	950	1,290
Major Replacement	43	61	77	181
Pumping Energy	-	-	14,580 ^{1/}	14,580
Recreation Loss ^{2/}	<u>23</u>	<u>32</u>	<u>-</u>	<u>55</u>
Annual Cost	\$ 5,608	\$ 6,070	\$ 33,944	\$ 45,622

^{1/} 1,080 mw x 1,500 hr x \$9/mwh

^{2/} Value of \$2.25 per recreation day

REARING PONDS

This project has no interest during construction, even though establishment of the forage beds will be spread over a five-year period, because benefits to the project will accrue during this period. Consequently, investment cost is the same as first cost. Based on costs of similar projects, a contingency allowance of 20 percent, an engineering and design costs of eight percent, and supervision and inspection costs of seven percent have been included in the project first cost. Annual costs include interest and amortization, operation, maintenance, and replacement. PL 89-72 provides that a non-Federal sponsor assume all of the last three mentioned annual costs. Following is a summary of investment and annual cost components.

REARING PONDS
FIRST COST SUMMARY

<u>Description</u>		
FISH AND WILDLIFE		\$4,053,900 ^{1/}
Ponds	\$ 999,360	
Misc. Mechanical Equip.	45,600	
Control Structures	266,100	
Aux. Fish Support Items	2,552,400	
Fish Hatchery	153,000	
Structures	14,400	
Roads	23,040	
ENGINEERING AND DESIGN		115,200
SUPERVISION AND INSPECTION		100,900
FIRST COST		4,270,100

ANNUAL COST SUMMARY

Federal		
Interest		204,200
Amortization		<u>9,700</u>
Total Federal Annual Cost		213,900
Non-Federal		
Interest		68,100
Amortization		3,200
Operation and Maintenance		63,400
Major Replacements		14,700
Total Non-Federal Annual Cost		149,400
TOTAL PROJECT ANNUAL COST		363,300

^{1/} Computation of Engineering and Design and Supervision and Inspection only on Ponds, Fish Hatchery, Control Structures, and Access Roads. See Detailed Cost Estimate Tables.

DESIGNATION UNDER NATIONAL WILD AND SCENIC RIVERS ACT

Project first costs for the acquisition of lands and interests in lands and for development of associated recreation facilities are Federal costs which will result from classification and designation of the project area under provisions of the Wild and Scenic Rivers Act. Interest during construction is not computed since benefits will accrue as construction is completed on individual segments of the project. Therefore, the investment cost equals the first cost. Annual costs include interest and amortization, operation, maintenance, and replacement.

Based on costs of similar projects, a contingency allowance of 20 percent on recreation facilities and 25 percent on lands and damages and river feature stabilization has been included in the project first cost. Costs for engineering and design of eight percent and for supervision and inspection of seven percent were included in the first cost of the recreation facilities and river feature stabilization.

Operation, maintenance, and replacement costs were estimated on the basis of cost data experienced at similar types of recreation developments with similar intensities of utilization. The annual operation and maintenance costs for recreation lands and facilities approximate 12 cents per recreation day. Additional annual operation and maintenance costs include \$67,500 for maintenance of the river stabilization features, for a total annual operation and maintenance cost of \$148,350. The average annual value of future replacements is estimated at \$17,450. Following is a summary of capital and annual cost components.

REACH DESIGNATION PL 90-542

FIRST COST SUMMARY

Lands and Damages		\$2,835,000
Lands	\$ 300,000	
Recreation easement	1,000,000	
Scenic easement	200,000	
Contingencies 25%	375,000	
Administrative activities	960,000	
Recreation Facilities		2,630,000
Access roads	80,000	
Activity guides & controls	2,013,650	
Utilities	98,000	
Contingencies 20%	438,350	
River Feature Stabilization		1,050,000
Riprap slope treatment	420,000	
Stone training dikes	420,000	
Contingencies 25%	210,000	
Engineering and Design		294,400
Supervision and Inspection		<u>257,600</u>
TOTAL FIRST COST		\$7,067,000

ANNUAL COST SUMMARY

FEDERAL

Interest	\$ 450,000
Amortization	21,500
Operation and Maintenance	<u>48,700</u>
Total Federal Annual Costs	\$ 520,700

NON-FEDERAL

Operation and Maintenance	\$ 44,150
Major replacements	<u>17,450</u>
Total Non-Federal Annual Costs	\$ 61,600
TOTAL PROJECT ANNUAL COST	\$ 582,300

Benefits

Annual benefits for each recommended project component are discussed in the following sections.

HYDRO-POWER

Benefits consist of two components: power benefits and area redevelopment benefits. Power benefits are based on the cost of providing equivalent power via the most likely alternative means at composite financing. Composite financing, at 9.22 percent interest rate, has been determined by the Federal Power Commission to approximate the mixture of private, REA, and publicly-owned power generation in the marketing area. At each hydro-power site, at both composite and Federal financing, the least costly and most probable alternative source of power is oil-fired combustion turbine units.

The benefits shown are based on simultaneous installation of all hydro-power plan components. The power portion of hydro-power benefits are obtained by applying the power values to the specific characteristics of a hydro-plant under evaluation. Capacity benefits are computed as the sum of:

Dependable Capacity x Power Capacity Value

Interruptible Capacity (Installed minus Dependable) x 1/2
Power Capacity Value

The additional peaking capacity at the mainstem sites will result in a minor energy loss, since the higher average tailwater is not quite offset by the decline in "spills." The Gregory County pumped storage plant has an energy component which is evaluated as one portion of the project benefits; pump-back energy has already been identified as one portion of the project costs.

In addition to power benefits, the NED benefits include earnings to unemployed members of the labor force engaged in project construction. The "Area Trends in Employment and Unemployment"

published by the U. S. Department of Labor indicates that counties and Indian Reservations adjacent to the proposed power projects have sufficiently high chronic unemployment rates to qualify as redevelopment areas.

BENEFIT SUMMARY
(\$1,000)

	<u>Ft. Peck</u>	<u>Garrison</u>	<u>Pumped Storage</u>	<u>Total</u>
Capacity:				
Dependable	\$8,036,000	\$9,020,000	\$22,140,000	\$39,196,000
Interruptible	0	1,066,000	1,025,000	2,091,000
Energy:	<u>- 236,700</u>	<u>- 596,700</u>	<u>27,864,000</u>	<u>27,030,600</u>
Total Power	\$7,799,300	\$9,489,300	\$51,029,000	\$68,317,600
Area Redevelop.	<u>110,000</u>	<u>115,000</u>	<u>350,000</u>	<u>575,000</u>
TOTAL	\$7,909,300	\$9,604,300	\$51,379,000	\$68,892,600

REARING PONDS

Benefits are based on the re-establishment of a trophy northern pike fishery in Oahe and Francis Case lakes. At least 172,000 fishermen (activity days) would travel more than 100 miles for pike fishing, if pike were available. In addition, 8,000 pike fishermen from within 100 miles would be attracted to these lakes annually. The estimated 172,000 fishermen plus 8,000 amounts to approximately 180,000 new fishing days expected with the proposed project.

A \$6.00 value per recreation day for this specialized activity was selected on the basis that northern pike and muskellunge are the most desired sport fishes in many midwest and northern states, and annual benefits are estimated to be about \$1,080,000.

REACH DESIGNATION UNDER NATIONAL WILD & SCENIC RIVERS ACT

The determination of recreation benefits was accomplished by the Bureau of Outdoor Recreation (BOR). The two basic items to be determined in computing project benefits are the number of project-oriented visitors (expressed in recreation days) and the value of

each recreation day.

The value of a recreation day was established as equal to \$4.88. BOR estimates of increases in river-oriented visits attributable to the project start with an initial 500,000 recreation days in 1980, increasing to 750,000 recreation days in 1990. This level of visitation is estimated to be project capacity, and is anticipated to continue throughout the remaining 40 years of project life.

The average annual equivalent benefits derived from designation of the Yankton-Ponca reach under provisions of PL 90-542 are \$3,306,000.

Justification

Plan elements in the following tabulations show economic justification.

HYDRO-POWER

The selected hydro-power plan passes all three economic tests resulting in net NED benefits, net comparability benefits, and financial feasibility as stated by the marketing agency. The annual NED costs and benefits for components of the recommended hydro-power plan installed simultaneously are summarized below.

JUSTIFICATION (\$1,000)

	<u>Ft. Peck</u>	<u>Garrison</u>	<u>Pumped Storage</u>	<u>Total System</u>
Average Annual Benefits	\$7,909	\$9,604	\$51,379	\$68,893
Average Annual Costs	5,608	6,070	33,944	45,622
Net Benefits	2,301	3,534	17,435	23,271
Benefit-Cost Ratio	1.4	1.6	1.5	1.5

REARING PONDS

The estimated annual costs, the estimated annual benefits, and the ratio of benefits to costs are summarized below.

JUSTIFICATION

Average Annual Benefits	\$1,080,000
Average Annual Costs	363,300
Benefit/Cost Ratio	3.0 to 1.0

REACH DESIGNATION UNDER NATIONAL WILD AND SCENIC RIVERS ACT

The estimated annual costs are \$660,800 compared to annual benefits of \$3,306,000. This component of the selected plan is abundantly justified with a benefit-cost ratio of 5.0.

Summary

The economic performance of all plan elements is summarized below.

	ECONOMIC SUMMARY (Annual Benefits & Costs)			
	<u>Hydro-Power</u>	<u>On-Site Rearing Ponds</u>	<u>PL 90-542 Designation</u>	<u>Total</u>
Benefits	\$68,892,600	\$ 1,080,000	\$3,306,000	\$73,278,600
Costs	45,622,000	363,300	660,800	46,567,600
Net Benefits	23,270,600	716,700	2,645,200	26,711,000
Benefit-Cost Ratio	1.5	3.0	5.0	1.6

Division of Plan Responsibilities

In arriving at appropriate Federal and non-Federal responsibilities for implementing the various elements of the plan of improvement proposed herein, reliance has been placed on policies derived from various legislative acts adopted over a number of years. Application of these laws and policies to the various plan elements yields the requirements for establishing cost-sharing and other responsibilities which are outlined in subsequent paragraphs.

Federal Responsibilities

Federal responsibility for bank stabilization measures includes the obtaining of assurances from a non-Federal sponsor, followed by Federal funding and conduct of project design, construction, and subsequent periodic inspection.

Additional hydro-power facilities recommended in this report constitute a wholly Federal responsibility, including funding, design, construction, operation, maintenance, and replacement to be undertaken by the Corps of Engineers. Marketing and transmission of the power are also Federal responsibilities, accomplished in this region by the Bureau of Reclamation.

Every plan element proposing recreational and environmental enhancement calls for Federal conduct of project design, construction, and periodic inspection, with non-Federal cost sharing as listed below:

Additional Federal responsibility for recreation access as an adjunct to bank stabilization includes obtainment of a non-Federal sponsor, and agreement to pay not more than one-half of the total first cost of the recreation development. In the development of

fish rearing ponds, the Federal Government agrees to provide 75 percent of the total first cost and to undertake a five-year seeding program to revegetate the shoreline adjacent to the ponds. With the single exception of appropriate land use zoning, all initial effort associated with designation of the Gavins Point - Ponca reach under the Wild and Scenic Rivers Act will be a Federal responsibility. Federal funding will include costs for recreation and scenic easements, fee lands required for access and development, the development itself, and within-bank protective structures. Federal responsibility for operation and maintenance will be confined to selected lands and features.

Inasmuch as non-Federal interests would be unable to obtain Indian lands, should any be needed for project purposes, acquisition of such lands will be a Federal responsibility common to all elements of the recommended plan.

Non-Federal Responsibilities

A non-Federal sponsor will be required by administrative policy to accomplish certain items of local cooperation, commonly referred to as the a b c's.

a. Provide without cost to the United States all lands, easements, a right-of-way, and relocations necessary for the construction, and subsequent operation and maintenance of the project including suitable areas determined by the Chief of Engineers to be required in the general public interest for initial and subsequent disposal of spoil and necessary retaining dikes, bulkheads, and embankments therefor, or the costs of such retaining works. Accomplish without cost to the United States all alterations and relocations of highway bridges, buildings, streets, storm drains, utilities, and other structures and improvements.

b. Hold and save the United States free from damages due to the construction works. As provided in Section 9 of the Water

Resources Development Act of 1974, this shall not include damages due to the fault or negligence of the United States or its contractors.

c. Assume operation and maintenance of those elements previously identified for transfer from Federal responsibility upon completion of construction.

Non-Federal responsibilities by plan element are summarized as follows:

NON-FEDERAL REQUIREMENTS			
<u>Plan Element</u>	<u>Percentage of Cost Sharing</u>	<u>Applicable a-b-c's</u>	<u>Limitations on a-b-c Application</u>
Bank Stabilization	None except a-b-c's	a-b-c	O&M assumed 5 yrs after completion of individual structures; complete reach O&M assumed after 20 yrs of "seasoning".
Hydro-Power	No non-Federal responsibility		
River Access in conjunction with Bank Stabilization	50	a-b-c	O&M assumed immediately after completion of individual structures.
Fish Rearing Ponds	25	a-b-c	O&M assumed immediately except vegetation by aerial seed, a Federal responsibility for 5 yrs.
Reach Designation under PL 90-542	0	b-c	No transfer of Federal responsibility for terminal below Gavins Point, protection of riverine features or maintenance of recreation easements.
Water Supply per 1958 Water Supply Act	100% of allocated	(N.A.)	Share O,M&R per cost allocation

Cost Allocation

Expenditures to the functions recommended for service in this report are all treated as specific costs. To the extent required by law or regulation, these specific costs are proposed for repayment, cost sharing, or both but this procedure required no cost allocation.

Cost Apportionment

Distribution of estimated first cost and of annual operation, maintenance and replacement to Federal and non-Federal sources for the five recommended plan elements are displayed.

COST APPORTIONMENT (In Million Dollars)

Function	Capital Cost		Annual Costs					
	Fed	Non-Fed	Federal			Non-Federal		
			I&A	OM&R	Total	I&A ^{1/}	OM&R ^{2/}	Total
Bank Stab.	23.0 ^{3/}	1.2	1.54	0.71	2.25	0.08	0.15	0.23
Rec Access	0.2	0.2	0.01	0	0.01	0.01	0.01	0.02
Hydro-Power	449.6	0	29.52	16.10 ^{4/}	45.62	0	0	0
Fish Ponds	3.2	1.1	0.21	0	0.21	0.07	0.08	0.15
PL 90-542	7.4	0	0.50	0.10	0.60	0	0.06	0.06
Total	483.4	2.5	31.78	16.91	48.69	0.16	0.30	0.46
Less	449.6	Costs reimbursable to the Treasury of the United States with interest (current rate is 6-3/8%)						
Total	33.8	Non-reimbursable Federal capital costs						

^{1/} Interest & Amortization

^{2/} Operation, Maintenance, & Replacement

^{3/} Includes \$8.0 of stabilization work already authorized

^{4/} Includes \$14.58 Annual Cost of Pumping Energy and \$.055 Recreation Loss

Review of The Report

The primary objectives of this investigation encompassed a wide range of water resource problems and opportunities, all associated with the existing main stem Missouri River reservoir system. A systematic planning process was employed wherein all practicable alternatives were identified early in the study, screening techniques used to reduce the numerous alternatives, and combinations of these, to a manageable level, and detailed evaluation then made to arrive at a plan which demonstrated economic, social, and environmental viability. Throughout this process, extensive public involvement and coordination activities were carried out in order to test public acceptability of the various plan alternatives. Following completion of the analytical studies, including initial coordination and public involvement activities, drafts of a report and Environmental Impact Statement were circulated widely for review and comment. All comments received on the draft report are included in Appendix 2; responses to comments on the Draft Environmental Impact Statement are included with that document, which accompanies this report. The following paragraphs summarize the comments and views of others and Corps response.

Views of Federal Interests

Field offices of the Departments of Housing and Urban Development and Health, Education, and Welfare offered no comments of substantial effect upon the findings and recommendations in this report. Similar expressions were received from the Department of Transportation and the Soil Conservation Service of the Department of Agriculture. The Chicago Regional Office of the Federal Power Commission confirmed the need for additional generation capacity and agreed with the adequacy of the economics and final analysis contained in

this report with respect to hydro-power recommendations. In addition, no significant effects on developments by others are expected. The Energy Research and Development Administration commented that hydro-power plans should be related to plans by others and further discussion of alternatives may be in order. The thrust of these comments is not clear since their implication was that a choice must be made between hydro and thermal power, where in fact, the two were not mutually exclusive. Studies by the Corps, in coordination with the Federal Power Commission and the Bureau of Reclamation, have explored reasonable near term as well as long-term-alternatives for meeting regional power loads. These are presented in detail in the Technical Appendix to this report.

The Bureau of Reclamation, the hydro-power marketing agency for this region, has recommended acceleration of design and construction of all hydro-power proposals contained herein. It also certified that the investment in the hydro-facilities could be repaid from revenues in a 50-year period. The Bureau furnished an overview of environmental impacts for additional transmission lines and indicated more definitive studies would be made during the advanced engineering planning and design steps. This is a reasonable and economical approach in consonance with a systematic planning process. The Bureau of Mines pointed out that this investigation did not discuss any mineral evaluation of lands required from any of the proposals. Since lands that may be required are minimal and near the river itself, it was considered that such evaluations were not needed during this stage of planning. However, during the advanced planning stages this will be addressed.

Bureau of Land Management made the general observation that net impacts on each environmental component were not clearly presented and there was not an adequate discussion of cumulative effects in the Draft EIS. The pertinent section has been rewritten in an effort to reduce this deficiency. A specific observation was

that control structures between Gavins Point and Ponca State Park would be inconsistent with National Recreation River designation. The Corps has worked jointly with the Bureau of Outdoor Recreation to resolve this issue and retains the position that no inconsistency exists.

Comments by the National Park Service and the Advisory Council on Historic Preservation dealt primarily with the need for more investigation of cultural resources. This is recognized as a matter to be dealt with more fully during the advanced planning stages and will be addressed in detail after authorization. This is especially pertinent to Indian reservations as pointed out by the Bureau of Indian Affairs.

The Bureau of Outdoor Recreation which studied jointly with the Corps the eligibility of the Missouri River between Gavins Point and Ponca Bend as a National Recreation River presented a number of comments. With respect to the National Recreation River the Bureau believes its administration should be in consultation with the Secretary of Interior. This is considered appropriate and implementation of this proposal should include such a provision. The Bureau agreed also with the other recreational proposals contained in this report, while urging that implementation of bank stabilization techniques be staged to insure compatibility with a recreation river. The Bureau concluded that additional hydro units at Garrison are not acceptable, because of their impact on downstream recreation. This study has identified some detrimental impacts on recreation facilities downstream of Garrison. However, opportunities exist to relocate existing facilities, provide additional facilities, and generally offset many of these impacts. Accordingly, to abandon additional hydro-power units at Garrison at this stage of planning because of recreational impacts that can be mitigated in large measure is neither a reasonable nor a prudent course.

The United States Fish and Wildlife Service concluded that Gregory County pumped-storage facilities appear to be acceptable from a fish and wildlife standpoint provided fish screens and energy dissipaters are used in the afterbay area. The remaining projects are viewed as a source of environmental degradation, especially to fisheries. During this investigation the Corps has attempted to identify, insofar as is possible during this planning phase, all effects. Some can be mitigated, some are considered minimal, and others cannot be avoided and constitute a direct trade-off for other benefits - power, bank stabilization, and recreation. A survey investigation is not a long-range research project; rather, it is an effort to provide a reasonable basis for plan formulation. More detailed evaluation is usually required prior to actual construction. This has been the case here, and additional environmental studies will be conducted during the advanced planning stages. Certain conclusions of the Fish and Wildlife Service are not supported by Corps studies to date. Others will need to be addressed further. On this basis, the proposals presented in this report are recommended for advancement to the next planning phase.

Views of Non-Federal Interests

A mixture of views was expressed by a number of State agencies in Montana, North Dakota, South Dakota, and Nebraska. The State of Nebraska generally concurred in the proposals, but expressed reservations on the local cooperation requirements required for the bank stabilization plan elements. This latter view was expressed also by the water agencies in North and South Dakota. Despite this widely held view that bank stabilization should be accomplished entirely at Federal expense, provisions of Section 32 and Section 161 of the 1974 and 1976 Water Resources Development Acts leave the Corps no alternative to the obtaining of local sponsors willing to provide a-b-c's. The Fish and Game Agencies of Montana, North Dakota, and South Dakota presented views generally along the same lines as

the U. S. Fish and Wildlife Service. The Montana agency, however, was not opposed to additional power units at Fort Peck, per se, provided certain mitigation measures were adopted. Most non-governmental organizations, Chambers of Commerce, electrical utilities, etc., support the plans presented herein. Reaction of environmental organizations has been mixed. Most favor the Gregory County project, the recreation river, and other related recreation improvements. Their greatest reservations deal with bank stabilization and additional power units at the Garrison project.

Summary

The data developed in this report and the responses obtained from its review have led to the following conclusions:

- More detailed planning of the improvements proposed herein should be undertaken prior to construction; the Phase I study called for in the Recommendations will satisfy this need.
- During Phase I planning, the Corps of Engineers and State and local interests should work closely to arrive at acceptable bank stabilization measures that minimize maintenance costs and to examine the possibility of Federal assumption of such responsibilities.
- In view of the widespread acceptability of the Gregory County pumped-storage project, it should be undertaken first, followed by the additional power units at Fort Peck, then at Garrison.
- The National Recreation River should be designated in accordance with the provisions of PL 90-542, as amended.
- After evaluation of the bank stabilization structures in accordance with PL 93-251, additional bank stabilization structures should be authorized for construction in accordance with Phase I studies.
- The remaining plan element, fishery enhancement, should be the subject of Phase I further planning with the State of South Dakota.
- Further survey scope studies should be undertaken on the feasibility of additional power units at Fort Randall, Oahe, and

other potential pumped-storage sites. These should be targeted for completion in the early 1980's.

Plan Implementation

The preceding section took notice that a survey report is less than all-encompassing. Although this report has identified the feasibility of several among the many elements studied, it has also identified the need to develop additional information in certain areas. Some of these data could be acquired during the period of advanced engineering and design; some questions, however, need to be resolved before construction is authorized. Most items in the latter category involve differences in viewpoint concerning environmental issues upon which a project's future might depend. A few of the major ones are:

- The extent and seriousness of waterlogging below Garrison which might be induced by increased hydro-peaking.
- The acceptability of a reregulation structure in the trade-off process at Garrison.
- The need for and the feasibility of fish screens at Gregory County.
- The interest of South Dakota in a fish hatchery or sub-impoundments rather than fish rearing ponds.

These unresolved issues bespeak the preparation of a Phase I Design Memorandum prior to construction authorization. After resolution of these and several other questions identified in the report, it will be processed to Congress for authorization of the several elements, which will then await funding to initiate construction. Project completion might reasonably be expected during the 1980's.

Statement of Findings

The information developed during the course of this investigation and the stated views of other interested agencies and the concerned public have been reviewed and evaluated. The possible consequences of the alternatives considered have been analyzed for environmental, social well-being, and economic effects; engineering considerations; and other aspects of the public interest. This analysis resulted in the following findings:

● Environmental Considerations

Reregulation reservoirs below Fort Peck and Garrison,

8 and 10 miles long, respectively, will provide little habitat throughout their length, but will improve conditions downstream over those now prevailing.

Soft protection applied to areas of active bank erosion will prevent the irreversible loss of high bank lands without detriment to riverine habitat.

Additional peaking at Garrison shows little prospect of waterlogging valuable wildlife habitat; however, this premise is subject to positive demonstration by drilling and observing test wells during the period of Phase I design.

Pumped-storage hydro-power can be constructed and operated at Gregory County with minimal environmental losses.

● Social Well-Being Consideration

Hydro-power plants contribute to national energy goals.

Additional skilled and semi-skilled jobs at hydroplants are created in an area characterized by underemployment and unemployment.

River access and National Recreation River designation contribute to the quality of life.

● Engineering Considerations

Within the time frame of this study, the alternative to hydro-power is nuclear or fossil-fuel generation. Construction of the main stem dams has put an end to "accretion lands," making erosion an irreversible process.

Critical areas of bank erosion shift over time; a number of years are needed to stabilize a river reach effectively.

Feasibility of additional power generation at Fort Randall and Oahe depends in large measure upon the future growth of upstream depletions, a question presently in dispute.

● Economic Considerations

No alternative extension of the navigation project showed economic justification.

Hydro-power alternatives selected were in every instance more economical than the most likely non-Federal alternative.

A ready market exists for the output from every hydro-power alternative selected.

River access and other types of recreational development have benefits well in excess of costs.

● Other Public Interest Considerations

Congress has demonstrated in Section 32, PL 93-251, Section 161, PL 94-587, et al, an interest to remedy active erosion sites along the Missouri River. A systematic accomplishment of this intent is laid out in this report.

The selected plan, as developed in the "Formulating a Plan" and "The Selected Plan" sections, is based on thorough analysis and evaluation of various practicable alternative courses of action for achieving the stated objectives. Some adverse effects associated

with the selected plan cannot be avoided, others can be minimized through certain mitigative actions, and when weighed against considerations of national policy, statutes, and administrative directives, it is considered that, on balance, the total public interest could best be served by implementation of the plan presented herein.

With one exception, studies conducted during the course of this investigation were extensive enough to respond fully to the study authorities. In order to more nearly match needs arising over time, certain hydro-power plan elements have been deferred. The selected plan, therefore, provides an interim response to the 1969 Senate Public Works Committee resolution in regard to additional hydro-power. Studies responsive to this authority will be resumed later to provide further consideration of hydro-power additions at Oahe and Fort Randall Dams and pumped storage adjacent to Lake Sakakawea with the thought that energy requirements and water use policies of the 1980's may clarify the need for these plan elements.

This investigation and this report justify recommendation of the selected plan for Congressional authorization for the Phase I design memorandum stage of advanced engineering and design. This procedure provides two phases of project authorization and the opportunity to accomplish or continue detailed studies, to further define local support and assure that requirements for local cooperation can be met, to resolve both remaining areas of conflict and any new ones which may arise, and to confirm the elements of the plan before authorization of a plan is recommended to Congress for construction.

Recommendations

I recommend the selected plan, as set forth below, be authorized for the Phase I design memorandum stage of advanced engineering and design. The estimated cost of these studies is \$2,500,000.

● The addition of 185 megawatts of hydro-power at Fort Peck with a reregulation dam eight miles downstream at a first cost of \$77,000,000.

● The addition of 272 megawatts of hydro-power at Garrison with a reregulation dam 10 miles downstream at a first cost of \$83,000,000.

● Construction of 1,180 mw of pumped storage at Gregory County, S.D. at a first cost of \$237,000,000.

● Construction of bank stabilization at 30 areas of active erosion between Fort Peck Dam and Ponca, Nebraska, including recreational access at three sites in North Dakota and two sites in Nebraska at a cost of \$16,540,000, of which \$15,485,000 is Federal.

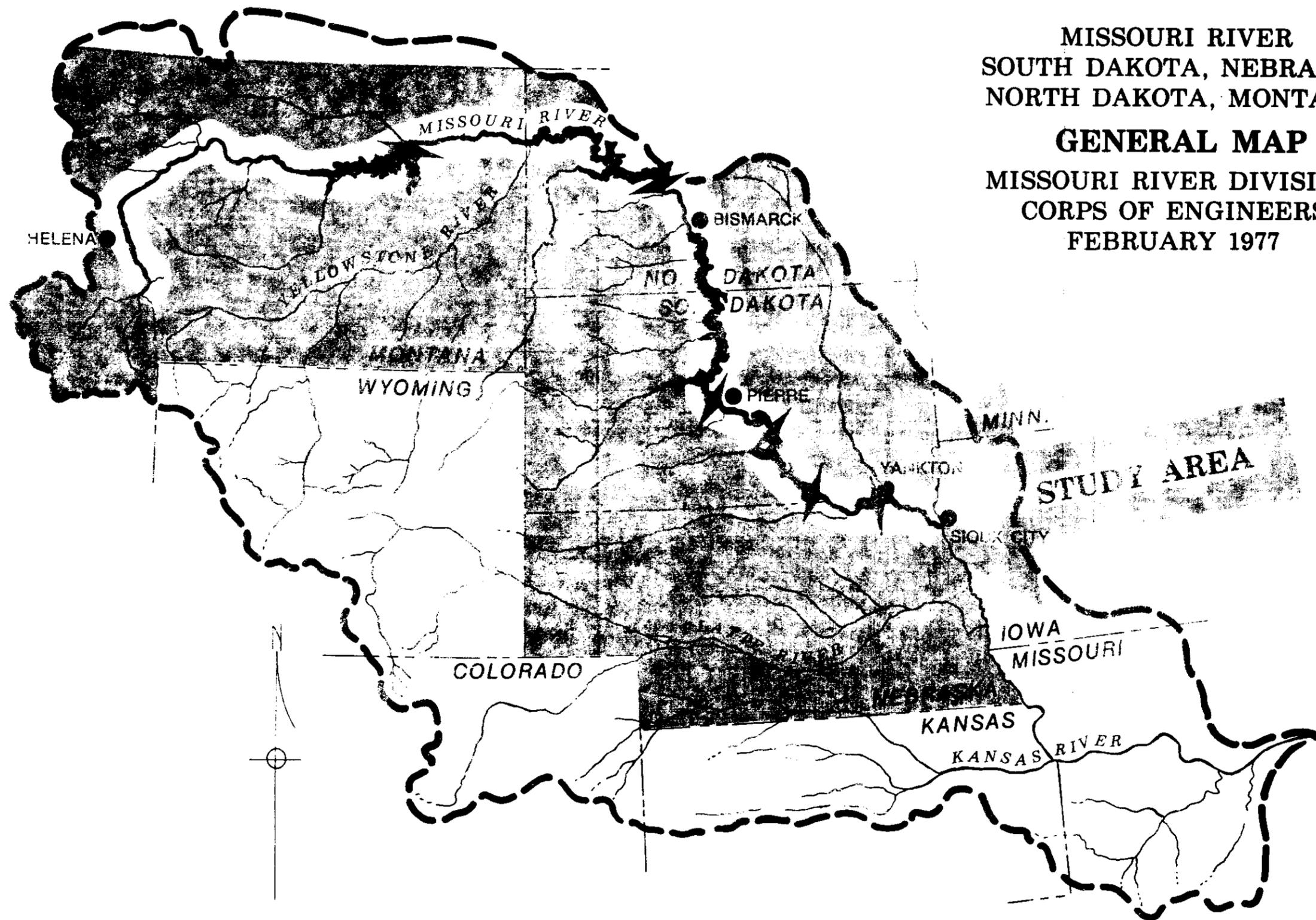
● Construction of fish rearing ponds and shoreline planting at seven sites on Lake Oahe and five sites on Lake Francis Case at a cost of \$4,270,000, of which \$3,203,000 is Federal.

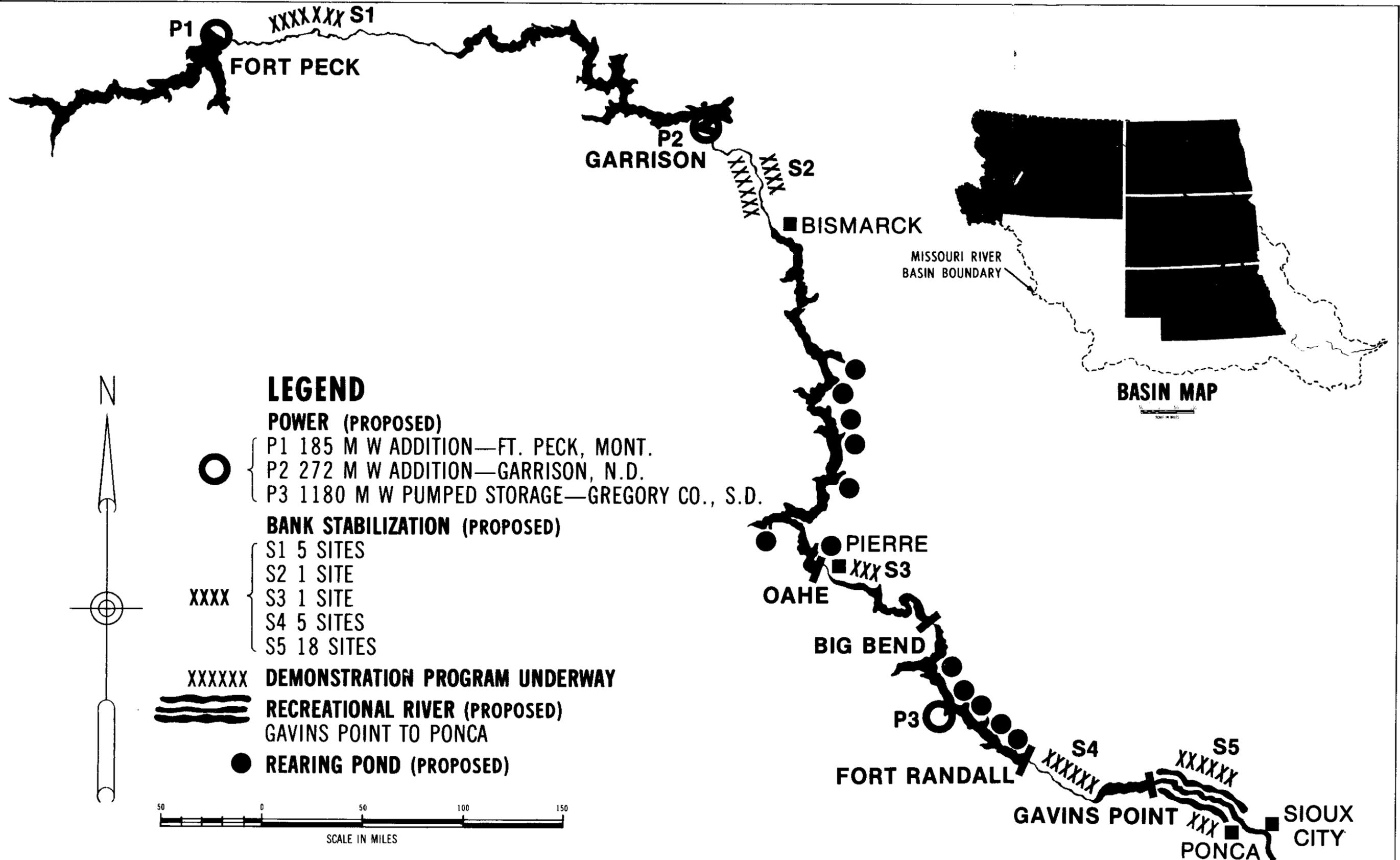
● Designation of the reach from Gavins Point Dam to Ponca State Park, NE as a National Recreational River under PL 90-542, as amended, through establishment of recreation and scenic easements and development of new recreation areas and improvement of existing recreation and access facilities at a cost of \$7,412,000.

(Date)

WILLIAM E. READ
Brigadier General, USA
Division Engineer

MISSOURI RIVER
SOUTH DAKOTA, NEBRASKA
NORTH DAKOTA, MONTANA
GENERAL MAP
MISSOURI RIVER DIVISION,
CORPS OF ENGINEERS
FEBRUARY 1977





LEGEND

POWER (PROPOSED)

- P1 185 M W ADDITION—FT. PECK, MONT.
- P2 272 M W ADDITION—GARRISON, N.D.
- P3 1180 M W PUMPED STORAGE—GREGORY CO., S.D.

BANK STABILIZATION (PROPOSED)

- XXXX S1 5 SITES
- XXXX S2 1 SITE
- XXXX S3 1 SITE
- XXXX S4 5 SITES
- XXXX S5 18 SITES

XXXXXX **DEMONSTRATION PROGRAM UNDERWAY**

≡ **RECREATIONAL RIVER (PROPOSED)**
GAVINS POINT TO PONCA

● **REARING POND (PROPOSED)**



MISSOURI RIVER
SOUTH DAKOTA • NEBRASKA • NORTH DAKOTA • MONTANA
GENERAL PLAN
MISSOURI RIVER DIVISION, CORPS OF ENGINEERS
FEBRUARY 1977