GARRISON DAM AND RESERVOIR
RIVERDALE, NORTH DAKOTA

THE MISSOURI RIVER BASIN DEVELOPMENT PROGRAM

DEPARTMENT OF THE ARMY
GARRISON DISTRICT
CORPS OF ENGINEERS
RIVERDALE, NORTH DAKOTA
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FORWARD

In the vast basin of the Nation's longest river there is today in progress a water and land resources development program which is the largest undertaking of its kind in history. The 10 basin states (Mont., Wyo., Col., N.Dak., S.Dak., Neb., Kansas, Minn., Ia., Mo.) and six federal agencies (Departments of Agriculture, Interior, Commerce, Corps of Engineers and Federal Power Commission) have joined to harness the Big Muddy and its tributaries and improve its watershed lands to gain multiple benefits for the people of this country's agricultural heartland.

The Missouri Basin Inter-Agency Committee, with representation from the states and 16 federal agencies involved, has been created to coordinate the development.

Here, in a 529,000-square-mile region comprising one-sixth the continental United States, a multibillion dollar plan for the construction of reservoirs and other engineering features, together with the application of soil and water conservation measures, will yield benefits of flood control, irrigation, electric power, soil conservation, and navigation. There will also be related gains in the development of fish and wildlife, recreation, water supply and pollution abatement, forest and mineral resources, and business and industrial growth.

The ultimate objective to which the program will be continually adapted in response to changing conditions and needs is the full productive use of all resources of the Basin in a manner that will best meet Basin needs and make the greatest long-time contribution to the strength and progress of the Nation.

PROGRAM FEATURES

The program as now planned proposes:

1. More than 100 multipurpose reservoirs on the Missouri River and its tributaries with a capacity of 110,000,000 acre-feet of water for various uses.
2. Irrigation of more than 5,000,000 additional acres of land, and supplemental water for approximately 2,000,000 acres now receiving an inadequate supply.
3. Application of soil and moisture conservation measures on nearly 340,000,000 acres of farms, ranches, range lands, and forests to gain extensive benefits in erosion and sediment prevention, flood control, and improved agricultural production.
4. Hydroelectric plants having an ultimate installed generating capacity of 3,200,000 kilowatts and an annual output of more than 13,000,000,000 kilowatt-hours.
5. Control of floods by storage capacity exclusively for flood control in most of the reservoirs in the development program, providing for elimination or considerable reduction of flood damage on 5,000,000 acres of valley lands. Local flood-protection works at many cities, both large and small, shielding high-value areas subject to flooding. Agricultural levees along the Missouri River from Sioux City, Iowa, to the mouth, protecting 1,400,000 acres of fertile farmland.

6. Stabilization works along the Missouri River to prevent erosion of valuable agricultural land, bridges and approaches, and industrial centers, and to establish a navigation channel up to Sioux City.
7. Controlled streamflow, through reservoir retentions and releases, to improve municipal, industrial, and domestic water supplies and alleviate stream pollution.
8. Improvement of fish and wildlife habitat and construction of new features to encourage such development.
9. Construction of recreational facilities at reservoir sites, in forests, and in other suitable areas to utilize recreational potentials.
10. Provision of statistical, informational and other aids to agriculture, industry and business, to promote the far-reaching gains and growth to be expected from full development of the Basin's resources.

Several reservoirs and other features already have been completed, and much of the remaining program is well under way. The plan is a flexible one, subject to modification in the light of developing experience.

Because of the magnitude of this endeavor and the widespread nature of its benefits, reaching across state lines and even outside Basin boundaries, the major undertakings are being financed primarily by Federal funds. State and local agencies, however, play a key part by planning and correlating their own resources-development programs with the whole. The attainment of the program's goals involves individual participation by many thousands of Basin residents.

The broad concept of the plan was not developed at a single stroke but rather is a vast acceleration and coordination of the existing programs of many agencies, whose experience with the problems involved extends back for decades.

MISSOURI RIVER MAIN STEM RESERVOIR SYSTEM
(Refer to Map following page 2)

The system of six main stem dams on the Missouri River in Montana and the Dakotas constitutes the backbone of the multiple-purpose Missouri Basin river control feature of the over-all development plan.

These reservoirs, five of which are built or under construction by the Corps of Engineers, will create a mighty reservoir chain stretching from Yankton, South Dakota, to central Montana. They will have a combined storage capacity of 73 million acre-feet. This is equivalent to almost three times the average annual flow of the Missouri at Sioux City, Iowa.

These projects when completed will exercise complete control of the main river flows originating above them, placing this great natural resource at the service of the people of the valley and the nation. They will provide major flood control, store water for irrigation of over 2 million acres of land, have power plants with a combined generating capacity of 1,500,000 kilowatts of hydropower, insure adequate flows for commercial navigation on the river below Sioux City; insure adequate stream flows for municipal water supply, improvement of stream sanitation and conservation of fish and wildlife.

GARRISON DAM, a giant among rolled-fill earth dams, is a key in the main river reservoir chain. Located 75 miles northwest of Bismarck, the capitol of North Dakota, Garrison Dam has been under construction since 1946, is now about 75 percent completed, and already is in partial operation. Scheduled for completion in 1956, it is part of the Pick-Sloan Plan for Missouri River control and development authorized by Congress in the 1944 Flood Control Act. The dam is 12,000 feet long, will be 210 feet high, has a base width of a half mile and crest width of 60 feet. It will create a reservoir 200 miles long, have a 1,500-mile shoreline and a storage capacity of 23 million acre-feet. The first of five 80,000-kilowatt hydro generators will go in operation next spring.

FORT PECK DAM, uppermost of the Corp's main stem system, was built in the 1930's. The dam is 4 miles long and 250 feet high above stream bed. It creates a reservoir 189 miles long at full pool, covering an area of 245,000 acres. Storage capacity is 19,000,000 acre feet. It is located near Glasgow, Montana. It is credited with preventing flood damages estimated at over $100,000,000 in the last sixteen years. Its power plant, now having an installed capacity of 85,000 kilowatts, is producing power at the rate of about $1,500,000 annually.

OAHE DAM, near Pierre, South Dakota, which rivals Garrison Dam in size, is just entering the major construction phase. About 10 percent of the construction has been completed. It will be of earth fill construction as are all the main stem dams. The dam will be 240 feet high, create a reservoir 250 miles long and have a storage capacity of 23,600,000 acre feet. Its power plant will have an ultimate installed capacity of 425,000 kilowatts.

FORT RANDALL DAM, near Lake Andes, South Dakota, is the nearest to completion of the four main river projects under construction. Now about 85 percent finished, it is in partial operation for flood control, stream flow regulation and power production. The dam is 10,000 feet long and 160 feet high above stream bed. The reservoir, now holding about 1,500,000 acre-feet of water, will have a maximum capacity of 6,300,000 acre feet when completed. Its power plant will have eight units of 40,000 kilowatts each, two of which are now in operation and a third nearly ready to go on the line.

GAVINS POINT DAM, lowermost of the main stem projects, is located near Yankton, South Dakota, and is about 25 percent completed. Primarily a re-regulating structure to smooth out peak power flows from Fort Randall, it will also perform flood control service and have a 100,000-kilowatt power plant.

BIG BEND DAM, authorized for construction above Chamberlain, South Dakota, is not expected to be placed in construction for several years. It is designed to function as part of the main stem regulatory system, with provision for a power plant of 120,000 kilowatts.

OBJECTIVES OF GARRISON RESERVOIR

FLOOD CONTROL: To provide 4,250,000 acre-feet of storage space reserved for flood control. Each year before the spring thaw, the reservoir will be drawn down to the bottom of the upper flood control pool. During the seasonal March and June rises, the excess water will be stored. After July, the water level will be slowly reduced so as to be back to the bottom of the flood control pool by spring. As far as possible, the level will be lowered by meeting irrigation, electric power, navigation, and downstream dry weather needs.

IRRIGATION: To provide, under current Bureau of Reclamation plans, for irrigation of almost 1,000,000 acres of land in North Dakota by diversion from Garrison Reservoir via the Snake Creek Arm of the lake. There is a possibility of future irrigation of up to 2,000,000 acres of land. The reservoir will also support other irrigation projects by guarantee of reliable water supply and control of floods.

ELECTRIC POWER: To provide 400,000 kilowatts of installed capacity, 250,000 kilowatts of dependable capacity, and 1,700,000,000 kilowatt hours of annual energy to the Missouri Basin power pool. It appears that the bulk of this power will be allocated to REA, Federal, and other public-owned users.

NAVIGATION: To contribute to the development and maintenance of reliable navigation from Sioux City, Iowa to the mouth of the Missouri.

WATER SUPPLY: To provide for dry weather water regulation to meet downstream needs for industrial and municipal use. In addition, features of the Garrison Diversion Irrigation Project include provision of dependable water supply for about 30 towns, and along the valleys of the James and Cheyenne Rivers.

PUBLIC HEALTH: To help guarantee the minimum flows necessary for stream sanitation downstream and in the area of the Garrison Diversion Irrigation Project.

RECREATION: To create a great lake in an area where recreational opportunities incident to lakes are meager. Under a carefully controlled and coordinated plan, recreational developments will become a major contribution to the welfare of the local people.

FISH AND WILDLIFE: To create a great commercial and sports fishery and vast habitat areas for water fowl. New fisheries and breeding grounds for ducks and geese should far exceed in value to the public the river bottoms habitat inundated.

RESERVE WATER: To store 13,850,000 acre-feet of multi-purpose use reserve water. In conjunction with the other reservoirs in the over-all plan, the part of the Basin drawing water from the main stem of Missouri can be carried through a major extended drought period such as that of the 1930's.

GARRISON DAM & RESERVOIR

Garrison Dam and Reservoir is one of the key projects in the authorized "Pick-Sloan" plan for comprehensive control and development of the water resources of the Missouri River Basin. The dam will be a multiple-purpose project and will be operated for flood-control, power, irrigation, navigation, and stream sanitation benefits. A brief table of data pertinent to the project follows:

DAM	
Type	Rolled earth-fill
Length	12,000 feet
Maximum height	210 feet
Top level	el. 1875
Volume	70,000,000 cu. yds.
SPILLWAY	
Location	East abutment
Type	Gated concrete-chute
Crest gates-type	Tainter
Crest gates-number and size	28-29'x40'
Crest level	el. 1825
Crest length	1336 feet
OUTLET WORKS	
Location	West abutment
Intake Structure	
Type	Reinforced Concrete
Height	259 feet
Gates (Service)	
Power	10-12'x26' Vertical lift caterpillar
Reservoir Regulation	3-18'x24.5' Tainter
Tunnels	
Type	Circular, concrete lined
Use	Power and reservoir regulation
Number and size	
Power	5-29' inside dia.
Reservoir ragulation	1-26' inside dia. 2-22' inside dia.
POWER	
Initial - 3-80,000 KW units	240,000 KW
Ultimate- 5-80,000 KW units	400,000 KW
RESERVOIR	
Maximum normal operation pool	el. 1850
Capacity (1)	23,000,000 ac. ft.
Area (1)	390,000 acres
Length of pool (1)	200 miles
Length of shoreline	1500 miles

EMBANKMENT:

Work on the Garrison Dam and Reservoir project has been underway since 1947 and by the end of the 1953 construction season both the east and west portions of the embankment had been brought up to full highth and work started on filling the center section of the dam. By 1 July 1954 the center section was up to 90 feet and it appears that the contractor may practically finish out the embankment, except for cleanup and some final grading by the end of this construction season. The contractor, Peter Kiewit-Morrison-Knudsen Company, is working a seven-day week with two eight-hour shifts a day. The workers haul between 80,000 and 100,000 cubic yards of dirt a day, depending on weather and other factors.

The embankment foundation consists of alluvial sand, extending as deep as 110 feet, on the east side of the river, and outwash clays with sand and gravel lenses on the west side. Underlying these materials and extending up to or near the surface on both sides of the river is the "bedrock" foundation, geologically designated as "Fort Union." This "bedrock" is highly consolidated and consists largely of clayey materials. Cut-off against excessive seepage through the alluvial overburden and the upper sand and gravel strata in the outwash materials is effected by a combination of steel sheet piling cut-off walls and impervious-filled cut-off trenches. Control of sub-drainage is effected by means of sub-drains extending along the downstream toe and by a system of drainage relief wells extending deep into the pervious foundation strata immediately downstream from the dam.

OUTLET WORKS:

A system of outlet works was provided in the west abutment of the dam for diversion of the river during the closure stage of the dam construction in the spring of 1953 and for permanent control of water releases as required for flood control, power production, and downstream water uses. The outlet works consists of eight tunnels, an intake structure at the upstream ends and a stilling basin and power plant at their downstream ends, with excavated channels connecting the river both upstream and down-stream. (See general plan attached).

The Intake Structure provides gate-controlled inlets to all eight tunnels. Each of the three regulating tunnels is served by a single tainter-type gate, 24.5 ft. high by 18 ft. wide. Each of the five power tunnels is served by two vertical-lift, "caterpillar" type gates, each 26 ft. high by 12 ft. wide, with a dividing pier between. Provision is made for emergency gates ahead of the service gates in all inlets. Individual hoists for service gates and cranes for emergency gates are located on a housed-in operating deck, well above the maximum reservoir level.

The intake structure is a massive, concrete building, having overall dimensions of 540 ft. in length, 170 ft. base width, and 259 ft. height (including a 56-foot high superstructure over the operating deck). Due to anticipated rebound and settlement movements of the foundation (which is the Fort Union clay formation), the structure actually is divided into four separate towers, each serving two tunnels and connected by short concrete conduits provided with articulated joints at the points of connection with tunnel portals and the intake structure.

POWER PLANT:

The power installation will consist of five 80,000 kw units, three of which are being installed in the initial construction and the remaining two at a later date as growth of demand requires. Garrison Dam is scheduled for power "on line" in April 1955 for the first unit. It is anticipated that the second unit will go on the line the last of 1955 or first of 1956 and the third unit to follow in about eight months.

The turbines are Francis type, vertical shaft, having runner diameters of 210½ inches. They are rated 88,000 h.p. each at or near best efficiency at 150 ft. head of water. The plant firm power will be 99,000 kw, and the ultimate installation (five units) will have a dependable capacity of 297,500 kw, and an average annual gross energy output of 1,712,000,000 kwh (of which 867,000,000 kwh is primary energy). Power will be delivered from the switchyard near the east end of the powerhouse at 230 kv and 115 kv by an ultimate total of seven transmission lines, interconnected with a transmission network that will eventually tie in all the Missouri River hydropower plants.

Now under construction at Hollinwood, Lancishire, England, are the main power transformers for Garrison Dam. This contract calls for the construction and delivery of nine transformers made up in banks of three, with the first bank now at Garrison Dam. One transformer, complete with oil, weighs 181,000 pounds. They have a combined weight (all nine) of 1,637,000 pounds. Each transformer uses 7,380 gallons of oil for cooling and electrical conductivity. Each transformer measures 24 feet high, 12.5 feet wide and 14 feet long.

SPILLWAY:

The spillway is located high in the east abutment of the dam. Its primary purpose is to allow surplus water than cannot be handled by the regulatory tunnels to pass safely around the dam. It will enable passage of the greatest flood conceived to be possible of occurrence without raising the reservoir to a level which would threaten to overtop the earth dam.

The design capacity is 827,000 c.f.s at a reservoir level 16 ft. below the crest of the dam. By comparison, the maximum natural river discharge of record is 281,000 c.f.s. The spillway is a "chute" type, concrete construction, with gate-control provided at an ogee-type weir at the upstream end of the chute. The gates will be tainter type, 28 in number, each 40 ft. long by 29 ft. high, individually operated by electrically driven hoists mounted on the separating piers. A highway extending across the crest of the dam will continue across the spillway by means of a bridge across the tops of the gate piers. The over-all length of the gated spillway crest is 1444 ft. and the length of the chute, including a stilling basin at the downstream end, is 3200 ft. The width of the chute (and stilling basin) portions of the structure is 800 ft. A total of about 700,000 cubic yards of concrete is being used in the spillway structure. Of the nearly 60 million cubic yards of excavation required for the spillway, all that is of suitable quality material (80 to 85 %) is being used in the dam embankment.

RELOCATION FEATURES:

Impoundment of the reservoir waters has required the relocation of about 24 miles of railway, 108 miles of highways and roads, a highway bridge being built over the Missouri River, two towns, a Government Indian Agency Community being relocated, numerous telephone, telegraph and power lines, and a few small cemeteries all being relocated. The construction of over 100 miles of roads on the Fort Berthhold Indian Reservation was finished this year.

SNAKE CREEK:

Snake Creek Dam, North Dakota's largest completed dam (except for paving), is often called the "little brother" to Garrison Dam. According to the original design of the Garrison project, Snake Creek embankment was designed only as a relocation of Highway 83, Soo Line tracks and telephone and telegraph lines about five miles north of Coleharbor. With the advent of the Bureau of Reclamation's proposed irrigation project of diverting Garrison Dam water, the Snake Creek embankment took on even more significant importance as a sub-impoundment feature for irrigation. At full operating level the Snake Creek reservoir will be about four miles wide and 12 miles long. At the present time there is a free-flow conduit under the dam connecting the Garrison and Snake Creek reservoirs. It is anticipated that a pumping plant will be installed in that conduit to facilitate holding the Snake Creek reservoir at any given level as an aid to irrigation. It is also expected that this reservoir will become the largest goose hatching plant in the country as proposed by the U. S. Fish and Wildlife Service.

Construction on this three-mile long and 85 ft. high dam started June 12, 1951 and was completed November 9, 1953. The first Soo Line train crossed the new tracks on July 20, 1954. The embankment will be paved and traffic diverted by September 1954.

LAND ACQUISITION:

The total area of land to be acquired for the dam, reservoir and appurtenant works is 460,000 acres. Of this total we have now acquired about 427,000 acres.

RECREATION:

In order to assure an orderly and progressive development of the recreational potential of the reservoir area the Corps of Engineers in cooperation with numerous State, Federal and local Government agencies, worked out a complete Garrison Reservoir Development Plan which is now in the hands of higher authority for approval. Provisions have been made for a number of camping, fishing, picnic, and private cottage sites, as well as sites for organized group camp sites. However, most of the areas will not be developed unless and until the public indicates that the areas will be used.