The streambed. Outlet tunnels through the north and south. Sediment deposition has reduced the capacity of the reservoir from 73,810 to 44,800 acre-feet. A penstock tunnel delivers water of Casper, Wyoming provides the principal project storage. Basin Project, include a pressure tunnel from Pathfinder Reservoir, part of the Glenbo Unit of the Missouri River District. and other lands south of the river.

**Pathfinder Dam and Reservoir**

**Operation Project**

The project irrigation systems—Lancaster, Fort Laramie, and other lands west of Casper, Wyoming. Construction of the Pathfinder National Wildlife Refuge provides guided tours and information about the area's wildlife and habitat. The annual rainfall is about 15.10 inches. The average winter snowfall is about 150 inches. Water diversions from the North Platte River are regulated by the Nebraska Department of Natural Resources. The river flows through the Nebraska Panhandle and drains into the Missouri River at Fort Calhoun.

**Guides for Genesee Dam, Reservoir, and Powerplant**

- Pathfinder Dam and Reservoir.
- Guernsey Dam and Reservoir.
- Platte River Valley.
- North Tunnel.
- South Tunnel.
- Penstock Tunnel.
- Diversion Dam.
- Power System.
- Transmission Lines.
- Regional Office, Region 7.

**Pathfinder Dam**

Pathfinder Dam is 1,030,000 acre-feet, and from the 5,500 square miles between Pathfinder Dam and Guernsey Dam, 90,000 acre-feet. Sixteen natural flows and runoff water determinate the project area from the December Project. The project area from December Project to have an annual average of 1.55 inches.

**Irrigated Crops**

- Wheat.
- Corn.
- Alfalfa.
- Sugar beets.
- Dry beans.
- Cotton.

**Benefits**

- The project lands lie along the North Platte River Valley, which has its origin in the mountains of Wyoming and drains into the Missouri River at Fort Calhoun.
- The average temperature in the area is 74 degrees Fahrenheit.
- The project is managed by the United States Reclamation Service, the predecessor of the present Bureau of Reclamation.

**NORTH PLATTE PROJECT**

**Pathfinder Irrigation District**

- Pathfinder Irrigation District.
- Northport Irrigation District.
- Poverty Basin Irrigation District.
- Seedstock Irrigation District.
- Fort Laramie Irrigation District.
- Central Nebraska Irrigation

**Water Supply and Utilization**

The water supply for the project is obtained from the North Platte Project in Wyoming, Nebraska, and North Dakota. The average annual rainfall during the period 1901-1957 was 14.20 inches, for Pathfinder Dam, 11.80 inches, and for Guernsey Dam, 10.00 inches. The average annual rainfall is 11.00 inches.

**Salts and Climates**

Most of the project lands consist of six inches and very fine sandy loams developed on loess plains. They are deep and well-adapted to the production of irrigated crops. The average annual rainfall for Pathfinder Dam, 4000 feet east at Gering, the average annual rainfall for Gering Dam, 9000 feet east at Yule, the average annual rainfall for the Gering Dam, 9000 feet east at Yule, Nebraska, and 9000 feet east at Yule, Nebraska, is 9000 feet east at Yule.

**Pathfinder Dam and Reservoir**

- Pathfinder Dam.
- Reservoir.
- Power Plant.
- Transmission Lines.
- Regional Office, Region 7.
Benefits

Bureau of Reclamation Projects in the North Platte River Basin Provide . . .

- Steady and abundant production of a variety of crops.
- Stored waters for approximately 390,000 irrigable acres.
- Gross crop values enriching the area's economy about $31 million annually, with full water supply and favorable weather.
- Throughout the Basin, increased production results in an estimated $8 million annual Federal income tax increase.
- Increased property values.
- More electric power to meet demands.
- New jobs . . . increased payrolls.
- New, expanded, and stabilized businesses and industries.
- Increased purchasing power for the area, States, and Nation.
- Needed schools, churches, hospitals, and other community and area facilities.
- Recreational opportunities.
- New economies resulting from recreation and related services.
- Flood control . . . elimination of erosion hazards.
- Improved living standards for all throughout the area.
The Basin History

In 1895, Nebraska enacted an Irrigation District Law permitting formation of districts with power to assess land for irrigation improvements. The Federal Reclamation Act, passed in 1902, permitted the Government to build irrigation works. With these two laws, the Reclamation Service (now Bureau of Reclamation) proceeded to develop the North Platte River to provide irrigation and power for the increasing demands of a growing area.

Boundaries of the 32,000-square-mile North Platte River Basin, a sub-basin of the Missouri River Basin, extend into Colorado, Wyoming, and Nebraska. The river originates in the Rocky Mountains and after winding 665 miles, joins the South Platte River near the town of North Platte, Nebr., to form the Platte River.

Pathfinder Dam was the Bureau of Reclamation's first construction in the North Platte and Missouri River Basins and stores water to irrigate lands of the North Platte Project area.

The Basin's first settlement occurred in 1834 at Ft. Laramie, Wyo. Later, the Oregon, Mormon, and California Trails followed the North Platte River. Squatters established a ranch in the 1860's. Longhorn cattle were herded in from Texas. Later, railroads replaced trails. Today, modern highways and airplanes ribbon the Basin.

Early homesteaders settled near the streams and rivers. Rainfall was scarce when most needed to mature the crops and irrigation was early recognized as essential. There were no facilities to conserve the surplus winter and spring flows for later use in the summer, and the water supply available from the natural flow of the rivers and streams was insufficient to permit significant agricultural development. The soil was fertile—requiring only water to produce various crops for an abundant livelihood.

In its assigned function as the Nation's principal natural resource agency, the Department of the Interior bears a special obligation to assure that our expendable resources are conserved, that renewable resources are managed to produce optimum yields, and that all resources contribute their full measure to the progress, prosperity, and security of America, now and in the future.

SEMINOE
(Kendrick Project)
Concrete arch dam
285 feet high, 530 feet long
Completed in 1939
Reservoir capacity — 1,010,825 A.F.
Powerplant capacity — 32,400 Kw.

PATHFINDER
(North Platte Project)
Masonry arch gravity-type dam
(Rocks quarried from mountains)
214 feet high, 432 feet long
Completed in 1908
Reservoir capacity — 1,015,888 A.F.

KORTES
(Kortes Unit)
Concrete gravity dam
244 feet high, 440 feet long
Completed in 1951
Reservoir capacity — 4,765 A.F.
Powerplant capacity — 36,000 Kw.

FREMONT CANYON POWERPLANT
(Glendo Unit)
Initial operation in 1961
Installed capacity — 48,000 Kw.
(3-mile; 18-foot pressure tunnel from Pathfinder Reservoir to Fremont Canyon Powerplant)

ALCOVA
(Kendrick Project)
Earthfill dam
265 feet high, 763 feet long
Completed in 1938
Reservoir capacity — 188,938 A.F.
Powerplant capacity — 36,000 Kw.

GUERNSEY
(North Platte Project)
Diaphragm type earthfill
135 feet high, 560 feet long
Completed in 1927
Reservoir capacity — 44,728 A.F.
Powerplant capacity — 4,800 Kw.

GLENDON
(Glenco Unit)
Earthfill dam
190 feet high, 2,096 feet long
Completed in 1958
Reservoir capacity — 798,196 A.F.
Powerplant capacity — 24,000 Kw.

LAKE MINATARE
(North Platte Project)
Earthfill dam, concrete paved upstream face
114 feet high, 3,760 feet long
Completed in 1915
Reservoir capacity — 62,190 A.F.
Offstream storage

LAKE ALICE DAMS
(North Platte Project)
Earthfill dams
37 and 24 feet high
Completed in 1912 and 1913
Reservoir capacity — 11,015 A.F.
Offstream storage
The North Platte River Basin

The North Platte River is the most important river in southeastern Wyoming and western Nebraska. The Bureau of Reclamation storage structures serve the North Platte and the Kendrick Projects, and the Kortes and Glendo Units of the Missouri River Basin Project. These projects and units are integrated multiple-purpose developments to provide water for irrigation, generation of hydroelectric power, enhancement of fish and wildlife, recreation, and to effect flood and sediment control. Power is transmitted by the interconnected Government-owned transmission system to localities and other power systems in the intermountain and Great Plains areas.

North Platte Project lands extend 311 miles along the river valley. The North Platte River water is controlled and utilized for power production at Seminole and Kortes Dams and Powerplants before entering Pathfinder Reservoir. Most of the water released from Pathfinder Dam passes through the Fremont Canyon Powerplant. Below this point, the water is further regulated and used for power generation at Alcova Dam and Powerplant and at Guernsey Dam and Powerplant. About 10 miles below Guernsey Dam, the Whalen Diversion Dam diverts river waters into Fort Laramie Canal, and into the Interstate Canal for irrigation use in the North Platte Project, and the Glendo Unit of the Missouri River Basin Project.

The Fort Laramie Canal runs southeast for about 130 miles along the south side of the river to serve irrigation water to eastern Wyoming and western Nebraska lands. The Interstate Canal runs along the north side of the river, following the contour of the land for 95 miles, with regulatory storage along the canal provided by Lake Alice and Lake Minatare Reservoirs.

Water supply for the Kendrick Project is provided by storage and release from Seminole and Alcova Dams and Reservoirs.

The Kortes Unit was the first unit initiated by the Bureau of Reclamation under the Missouri River Basin Project as a hydroelectric power development.
Transmission Lines

The Bureau's 2,400 miles of transmission lines in the North Platte River area distribute more than 850 million kilowatt-hours of electrical energy annually. The transmission lines system began in 1918, when the Lingle Powerplant was built to serve electric drag lines used to construct canals. Later, lines were built to Casper, Cheyenne, and Rawlins, Wyo., with connections to other systems in Colorado and Nebraska. Other lines constructed in the Missouri River Basin Project form an interconnected power system.

Construction, operation and maintenance is administered from the Bureau's North Platte River Projects Office in Casper.

Hydroelectric Power

Bureau construction costs allocated to power are repaid to the Federal Treasury with interest, except for that portion assigned to pumping project water for irrigation. The 6 powerplants in the North Platte River Basin have an installed capacity of 181,200 kilowatts and are an integral part of the Western Division System of the Missouri River Basin Project. Electrical power for the entire system is dispatched from a control center near Loveland, Colo.

The electrical energy produced in the powerplants is used for project purposes and sold to rural electric associations, municipalities, irrigation districts, cooperatives, and to wholesalers. Since the first powerplant went into operation on the North Platte River, gross revenues from power sales amount to over $55 million.

Irrigation

Water conserved and regulated in the series of Bureau of Reclamation reservoirs assures a dependable water supply for 390,000 acres of irrigable land in the Kendrick and North Platte Projects and in the Glendo Unit of the Missouri River Basin Project. Water users repay project construction costs allocated to the irrigation function to the Federal Treasury according to the irrigator's ability to repay. Costs in excess of those which the irrigator can repay are returned by surplus revenues from the commercial sale of power.

Stable water supplies permit production of a variety of crops such as sugar beets, potatoes, beans, corn, and other row crops, alfalfa and irrigated pastures. Most of the forage crops produced with irrigation are used for livestock feed.

In a normal year along the North Platte River, sugar beets supply sugar for 2,400,000 people, edible beans to feed 14,000,000 people, potatoes for 4,500,000 people, and meat to supply 4,500,000 people, from farms irrigated with water stored in Bureau of Reclamation reservoirs.

Sugar beets are processed in the area. There are meat packing facilities at Gering and slaughtering plants in other communities. A canning plant in Scottsbluff processes peas, beans, pumpkins, sweet corn, and cabbage. Transportation facilities available to project farms include highways, trucking companies and a railroad.

A comparison of irrigated lands with dry lands showed that irrigated lands in the North Platte River Basin produced 13 times more per-acre in terms of farm products sold off the farm, supports 27 times as many people, and provides 40 times the income, which pays 20 times more property tax, and 33 times more Federal tax.
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

THE GUERNSEY SURGE TANK

By
R. E. G., Assoc. Eng., Denver Office
Aug. 5, 1927
The Guernsey surge tank, North Platte Project, Nebr.-Wyo.


Pages 136-137.
The Guernsey surge tank is one of the vital elements of the Guernsey power plant, the first unit of which has recently been placed in operation. This plant develops power from water released from the Guernsey reservoir, and together with the Lingle plant supplies power for industrial, municipal and project uses in the territory along the North Platte River in eastern Wyoming and western Nebraska.

The location of the plant at the outlet of a reservoir whose primary purpose is for the storage of irrigation water, makes it necessary to operate under widely varying heads. The use of power by various flour mills and for domestic lighting makes it necessary to hold the frequency and voltage fluctuations within narrow limits. Power is supplied for industrial uses to motor units as large as eight hundred horse-power, whose intermittent use causes heavy load fluctuations.

Water power plants are inherently difficult to regulate, so that the exacting requirements in this case gave rise to a problem
in turbine regulation of unusual interest.

The Guernsey plant is supplied with water through approximately 170 feet of 25-foot horseshoe tunnel connecting with 700 feet of 12-foot circular tunnel. About 5,200 tons of water are enclosed within this conduit, and this great mass must be accelerated or checked each time the load on the turbines increases or falls off.

The turbine gates are controlled by a sensitive mechanism which opens the gates if the speed of the turbine drops, or closes the gates if the speed rises above a predetermined value. If the turbines were connected directly to the power tunnel and an increase of load caused the speed of the units to drop, the governor would react by opening the gates. Under this condition the head required to accelerate the water in the tunnel to its new velocity would be taken from the effective head on the turbine and the first result of a demand for extra power is an actual falling off of the output of the turbine. On a decrease of load the converse is true in that the closing of the turbine gates causes the pressure to rise and the first result is an increase in the power output of the turbine. To gain an idea of the magnitude of the transient power deficiency for this plant, a computation was made on the basis of an instantaneous load addition of 1,360 horse-power, or 20% of the full load capacity of the completed plant.
The calculation showed that the power supply would be deficient for nearly eight seconds with an accumulated deficiency of 27,000,000 foot-pounds of energy. This is somewhat greater than is expected, but the computation shows that a flywheel some 60 times as large as could be obtained would be necessary to provide satisfactory service. The need for shortening the distance from the turbines to a free water surface, as well as the necessity for limiting the pressure rise following a release of load to what could be safely borne by the power tunnel, made the installation of a surge tank imperative.

As finally designed, the surge chamber is a steel tank 85 feet high with a uniform inside diameter of 22 feet and rests directly on the concrete anchor at the junction of the power tunnel and the penstocks. This arrangement is mutually beneficial since the anchor not only supports the surge tank, but the surge tank and the water it contains provides a large proportion of the weight necessary to insure the security of the anchor. The uniform diameter from top to bottom is necessary both to provide the required area throughout the total range of head and to shorten the effective penstock length as much as possible. The resulting appearance is somewhat unusual and is said to have caused one engineer to remark that "the Guernsey plant is the only water power plant in the world with a smokestack."
The proportioning of such a tank so that it will properly perform all its functions and at the same time be as economical of material as possible is no small undertaking in itself, since the mathematics is very much involved. The fundamental physical relations governing the action of surge tanks are expressible in two parametric differential equations of the first order, involving the three variables; tunnel velocity, departure of water surface from the normal level in the surge tank, and time. These equations are of peculiar interest to the mathematician since they apparently belong to that class of equations for which no general solution is known. For any particular case, a close approximation to the correct solution may be found by applying the original equations successively over small increments of time. This method is laborious in the extreme and is made doubly so because the desired dimensions cannot be solved for directly but must be found by cut and try.

The mathematical difficulty is due to the fact that the frictional resistance to the flow of water is proportional to the square of its velocity, since if the assumption be made (at the expense of accuracy) that the resistance is proportional to the first power of the velocity, the equations become manageable and if the frictional resistance be neglected entirely they are easily solvable. The simplicity of the formulas derived on the above bases
and the known fact that they give, or can be made to give, results on the safe side, has gained them a wide acceptance among engineers. This is especially true in the case of the formulas derived by neglecting the friction entirely, because by their use the size of tank required can be solved for directly. It is also usually possible to design the penstock and connection so that the condition of negligible friction assumed is substantially justified in fact, it being highly desirable to reduce friction in the flow line in any case to save power.

It has come about, therefore, that the peculiar mathematical difficulties have caused an important point to be obscured, which is, that friction properly employed may here be turned from a liability into an asset, and may be used not only to decidedly decrease the size of tank required, but to improve its operation. These two desirable features are secured in this case, not by increasing the friction to flow in the power tunnel or penstocks, but by throttling the connection between penstock and surge tank sufficiently to introduce a calculated amount of resistance to flow. This resistance does not interfere in the least with the normal operation of the turbines, but does materially reduce the amplitude and duration of the surges caused by changes of load. An experienced turbine manufacturer recommended a tank of 35 feet diameter for this installation, based presumably on the accepted
formulas and practice. A comparison of the 35-foot open tank with the 22-foot throttled tank shows the profound effect of providing resistance to flow in the surge tank connection. In this case it is provided by bolting an annular ring to the top of the connection to the surge tank, thereby restricting the area through which the water must pass on entering or leaving the tank.

It is always interesting to check up a calculated result with the actual performance, and for this purpose there is reproduced a section of the automatic frequency recorder strip from the recording instrument at the Lingle plant. The single unit now installed at the Guernsey plant is placed on the line about 3 P. M. each day. The record shown is for the day of July 21, 1927. As recorded by the instrument the Guernsey unit came on the line at about eight minutes past three, after which time the decrease in frequency fluctuation is quite marked. (The time is shown as A. M. on the chart, but notations by the operator identify the time as P. M. The operator evidently interchanged A. M. and P. M. when changing the strip.) Increase of head available after the construction of the Guernsey dam is completed and further adjustments to the governor are expected to improve the performance somewhat.