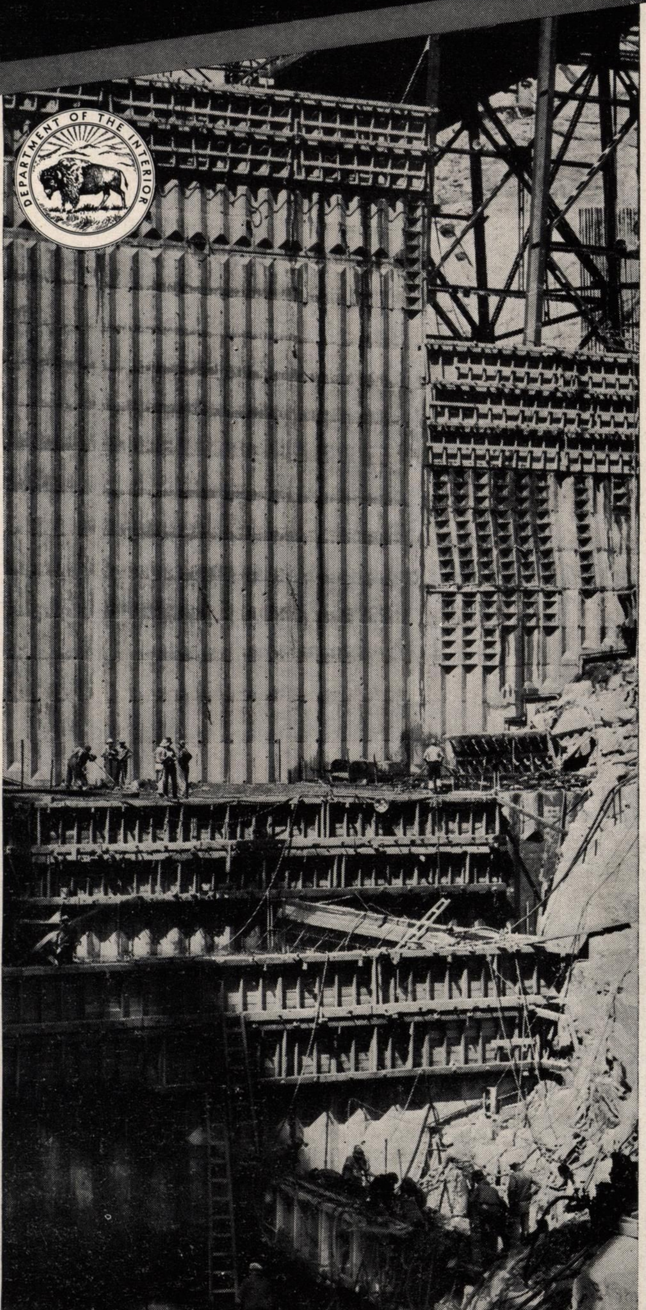
GRAND COULEE DAM

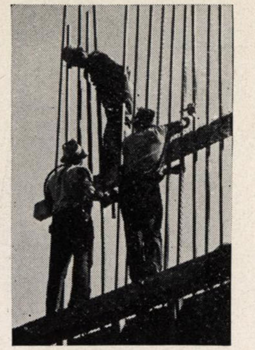
The Columbia Basin Reclamation Project

United States Department of the Interior

Bureau of Reclamation



CONSTRUCTION OF THE GRAND COULEE DAM



Reinforcing steel.

Putting the Columbia River to Work

The use of water from the Columbia River for the irrigating of enormous tracts of rich land in Central Washington has been dreamed of since the days of the earliest settlers. Modern equipment and methods, electrical power, and Federal loans make the Columbia Basin Reclamation Project feasible. The enforced abandonment of eroded, submarginal, and "dust bowl" lands, the natural increase in population, and the desire for improvement in standards of living make it necessary.

Preliminary Construction Work

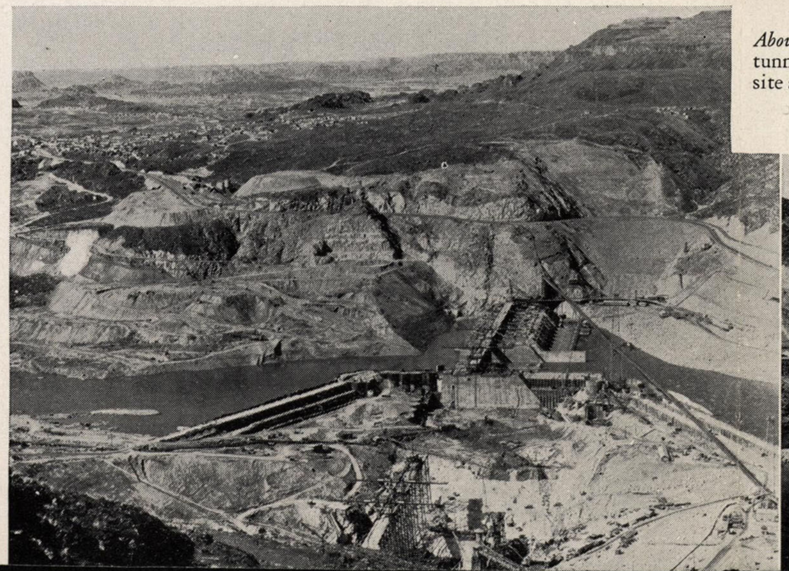
Work on the construction of the Grand Coulee Dam began in the winter of 1933–34. Facilities necessary for carrying on construction work included a 30-mile government railroad from the Northern Pacific line at Odair, a 30-mile high-tension transmission line from the Washington Water Power lines near Coulee City, the relocating and hard-surfacing of highways, a 950-foot steel highway bridge, telephone and telegraph lines, and two towns.

Mason City and Coulee Dam

On the east side of the river the contractor built Mason City, which includes a large mess hall, office buildings, hospital, hotel, laundry, recreation hall, store, churches and schools, over 280 residences, and 60 bunkhouses to accommodate over 1,200 men. Electricity is used for house heating in this town without chimneys. It is a temporary town, to be dismantled after the dam and power plant are completed.

The Government camp, known locally as Engineers' Town, but to the Post Office Department as Coulee Dam, is to be a permanent town for housing employees on the Columbia Basin Reclamation Project. Its houses, streets, and water, light, and sewer systems are of modern design and substantial construction.

Opposite the Administration Building, located at the foot of a cliff which bounds the town on the west, are 2 dormitories, and below them, toward the river, 77 permanent residences, post office, garages, and fire station, and, to the north, a school building. Beyond the schoolhouse, down the river, are 57 court-type three-room temporary houses and 4 temporary dormitories.

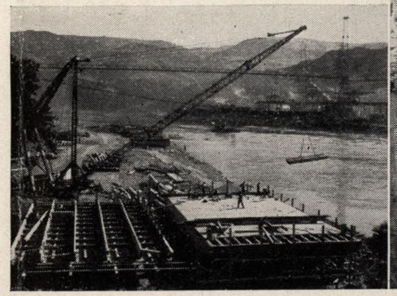


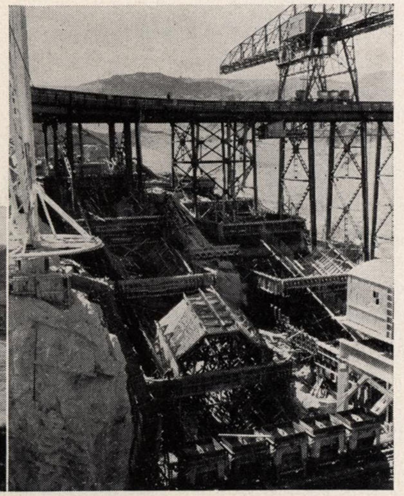
Plants of Unprecedented Size Required

Among the tasks of outstanding magnitude in the construction of the dam were the removing of nearly 18,000,000 yards of sand, gravel, clay, and boulders, and of over 1,000,000 yards of rock from the dam site, the diverting of the river from its channel, the opening and operating of a sand and gravel pit capable of turning out 25,000 yards of pit-run material in a day, and the designing, building, and operating of concrete-mixing and handling equipment sufficiently large to place over 15,000 yards of concrete in 24 hours.

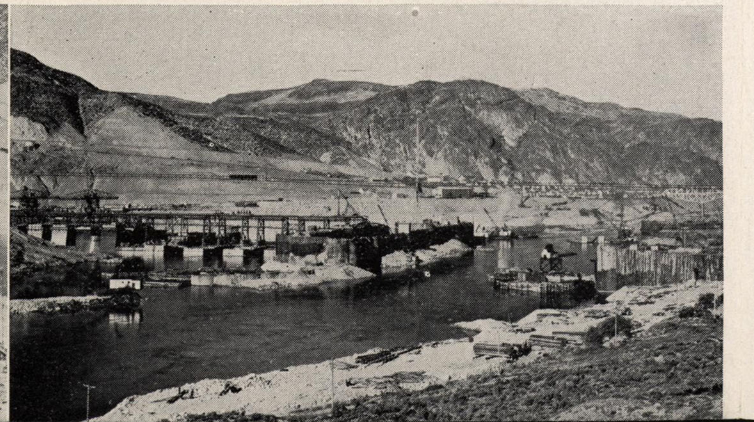
Millions of Yards of Material Moved

Over 13,000,000 yards of excavated material other than rock were loaded by large electric shovels on trucks or trailer wagons of 8- to 20-yard capacity, dumped through grizzlies which excluded large boulders, and carried away to spoil banks one-half mile to a mile distant by 60-inch belt conveyors, at the rate of 40,000 yards per day.





Above left: Building construction barges . . . *Above right:* Forms for penstock tunnels, placing trestles, cranes, and concrete buckets . . . *Below left:* The dam site and the entrance to the Grand Coulee . . . *Below:* River diversion in progress—cribs closing old channel.



Drills Explore Foundation Rock

Extensive examinations of the granite bedrock were made by various means, including the diamond drilling of 31,000 feet of holes, some to depths as great as 800 feet. Many holes, 36 inches in diameter, have been drilled to depths of 29 to 68 feet. Such holes permit the inspection of bedrock in place.

Crevices in Bedrock are Sealed

As is true of all massive igneous rocks, the granite bedrock developed numerous cracks and crevices when it cooled. Such openings in the rock, where they occur under the dam site, are sealed by grout of cement and water forced down into them under pressure through holes 2 inches in diameter and 30 to 200 feet deep.

West Side Cofferdam and Foundation

Bedrock under the entire dam site, including the river channel, was covered with a deep deposit of sand, clay, and boulders. In order to remove such material on the west side of the river, a 60-acre area was enclosed in a cofferdam formed of timber cribs faced with steel sheet piles and a 3,000-foot chain of cells of steel sheet piling along the river, averaging 110 feet in height, the cells being approximately cylindrical in shape and about 50 feet in diameter. Seventeen thousand tons—127 miles—of steel sheet piling were used in the west cofferdam.

From the enclosure area 10,000,000 yards of clay and boulders were removed to expose bedrock, create a diversion channel, and provide a tailrace for the powerhouse; and within the enclosure the west end of the foundation of the dam was built.

Cross-River Cofferdam

After the west end of the foundation, with its diversion channels, was completed, the flow of the river in its natural channel was stopped by a downstream cross-river cofferdam of timber cribs, built to fit the contour of the river bottom, floated into place, sunk by loading with gravel, and protected with a facing of steel sheet piles.

A second cross-river cofferdam, upstream, and the end of the west side concrete structure (blocks 39 and 40) complete the enclosure of a 55-acre area, which includes that part of the river channel to be occupied by the dam.

Aggregate for the Project

The world's largest plant of its kind furnishes sand and gravel on this project. In a pit a mile and a half downstream from the dam, and 900 feet above the river on the east side, power shovels transfer material from the bank directly to a belt conveyor system, which supplies it to the washing and screening plant. A belt conveyor 5,965 feet long moves the sand and the four sizes of gravel to storage piles at the dam site, and other conveyors supply the concrete-mixing plants, that on the west side being over 4,000 feet distant from the storage piles and served over a suspension bridge.

Mixing Plants of Record Size

Making concrete at the unprecedented rate of nearly 16,000 yards a day is the record of the two mixing plants located at the ends of the dam. One plant has turned out 9,290 yards in a day.

In the tops of the octagonal towers are bins for cement, sand, and four sizes of gravel. Below them are hopper scales which, under electrical control, weigh out the quantities of various concrete constituents required for any mix. These dump into one or another of four 4-yard mixers, which discharge their batches into 4-yard buckets carried, four on a flatcar, to the placing cranes.

Graphic records of all mixes are kept by automatic machines.

Traveling Cranes Place Concrete

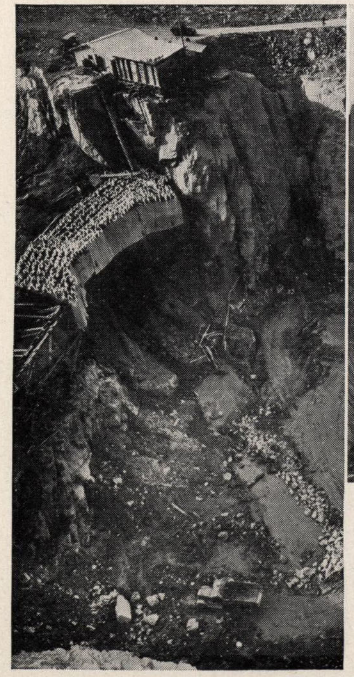
For the purpose of placing concrete, high steel trestles are built out over the dam site. Each carries three railroad tracks of standard gage, and these are spanned by traveling cranes with a reach of 115 feet. They lift the 4-yard, 11-ton loaded buckets from cars, lower them into the forms, and return the empty buckets to the cars. Crane operators and signalmen below communicate with each other by telephone.

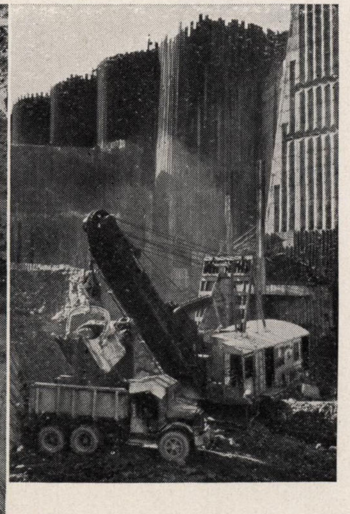
Blocks are Cooled and Joints Grouted

The dam is built up of columns of concrete, in most cases 50 feet square, each column consisting of 5-foot layers, or lifts, placed at intervals of not less than 72 hours. Ridges, or keys, vertical on transverse and horizontal on longitudinal faces, interlock adjacent columns.

The material going into concrete is usually of a temperature higher than that which the dam will finally reach. The reaction of cement with water causes heat to be liberated over a long period of time. So, for two reasons, it is found necessary to cool the concrete artificially, and so prevent the development of destructive shrinkage cracks later. It is done by circulating cold river water through miles of pipe embedded in the dam.

After cooling is completed and the concrete blocks have shrunk to their final dimensions, grout of cement and water is forced through a system of pipes into all contraction joints, cementing the blocks into a monolithic mass.



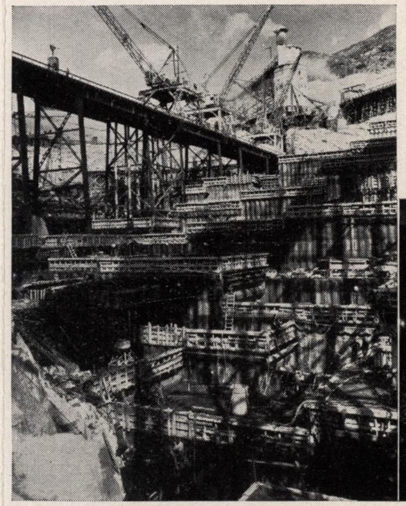


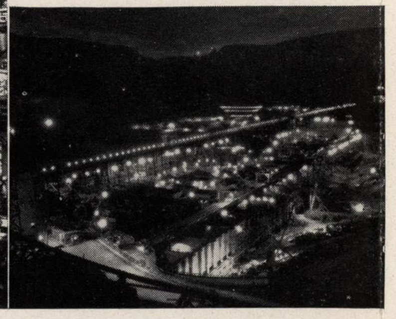
Left: Six miles of refrigerating pipes froze plastic clay into a solid dam to hold 200,000 yards of sliding ground . . . *Above:* Power shovel and truck. Such equipment moved nearly 20,000,000 yards of material

Expenditures are Widely Distributed

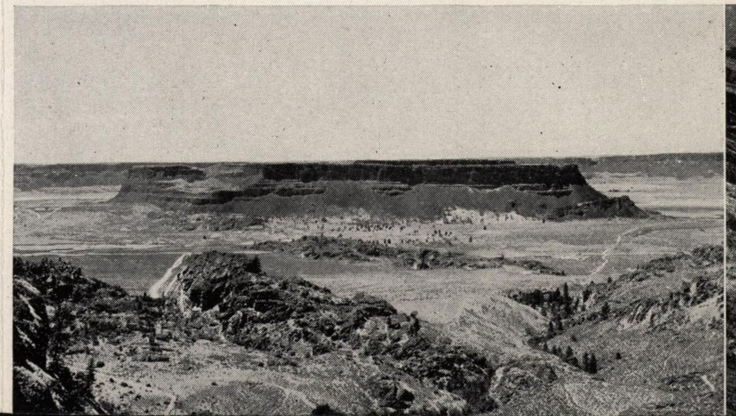
At the peak of each season's operations, 6,000 or more men have been employed, at wages averaging 83 to 90 cents per hour. A maximum of 8 hours per day and 40 hours per week is permissible. Much of the wages of workers goes east for the purchase of staple foods, clothes, household equipment, and automobiles.

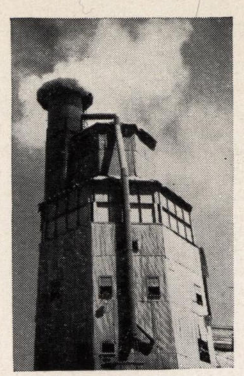
Of the millions of dollars spent by the contractor for equipment and supplies, and by the Government for construction materials, the greater part has gone directly to the East, South, and Middle West. A large percentage of the money spent with western firms was passed on to the eastern firms.





Above left: Concrete mixing plant, trestles, cranes, concrete buckets, stripped bedrock, and forms for 5-foot lifts 50 feet square . . . *Above right:* Work goes on 24 hours in the day . . . *Below:* Steamboat rock, once an island in the glacial stream, will become an island in the balancing reservoir in the Grand Coulee . . . *Below right:* Gravel-dressing plant can deliver over 15,000 yards of washed and graded material per day





East mix plant.

The Columbia River

That part of the Columbia River Basin above the Coulee Dam covers an area of 74,100 square miles, 39,000 square miles of it being in Canada.

At the dam site the river flows in a channel 700 to 850 feet wide, in a canyon a mile wide and about 1,400 feet deep. At this point the flow averages 109,000 cubic feet per second, ranging from about 20,000 second-feet to more than 400,000 second-feet. The average annual run-off above the dam is 79,000,000 acre-feet. Only a small fraction of that will ever be required for irrigation on the Columbia Basin Project. The irrigating season coincides with high-water periods.

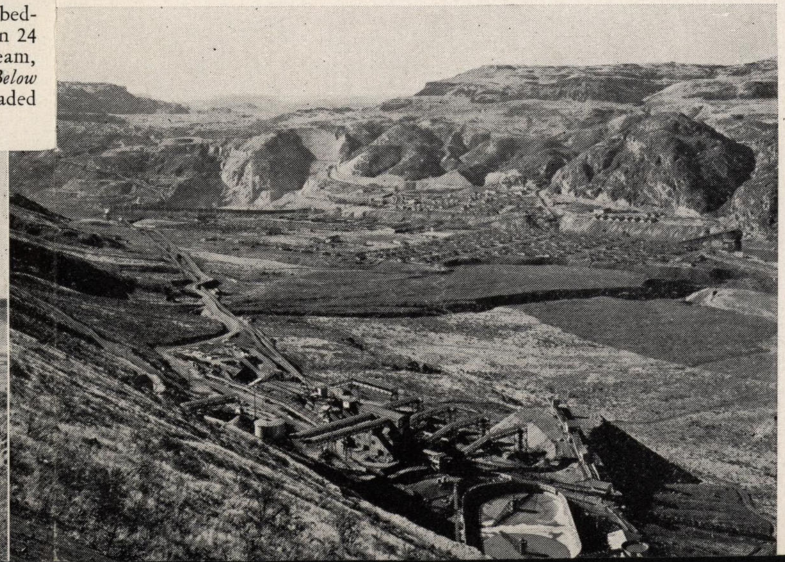
The Origin of the Grand Coulee

Many successive flows of highly fluid lava, issuing from fissures in the earth's crust, formed the extensive Columbia Lava Plateau of central Washington and forced the Columbia River into the Big Bend, where the lava flows terminated against the older rocks of the rising Cascades and Okanogan Highlands.

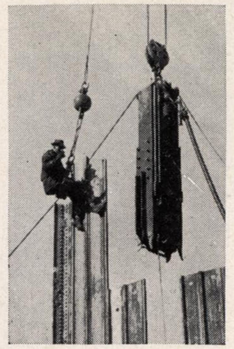
Ice sheets, moving down from the north, blocked the deep river canyon below the site of the Grand Coulee Dam at least twice, thousands of years ago, causing it to fill and form a reservoir extending far back toward the headwaters of the river. A tremendous flood of silt-laden glacial water overflowed the canyon wall, and, running away southward, formed rapids at declivities, and finally some notable waterfalls.

Rapids, originating north of the site of Coulee City, developed into a huge waterfall which cut the Upper Grand Coulee 25 miles back toward the river. A second fall, developed just north of the site of Soap Lake, cut out the Lower Coulee, terminating at the Dry Falls. At one time there was at Steamboat Rock a waterfall 800 feet high. South of Coulee City is the site of an ancient waterfall over 400 feet high and over 3 miles long.

About 40 cubic miles of rock were cut out of the Coulees in 5,000 or 6,000 years, and perhaps as much material was deposited in a huge lake to the southward by turbid waters and floating icebergs from the glaciers.



Grand Coulee Dam



Steam pile driver.

As the first step toward actually realizing the Columbia Basin Reclamation Project, the Grand Coulee Dam is under construction on the Columbia River in central Washington

It will be the largest man-made structure in the world, three times bigger than the largest Egyptian pyramid. It will contain enough concrete to lay a 6-inch pavement over 7½ square miles of land, or to make two 16-foot highways from coast to coast. The dam is second to the 727-foot Boulder Dam in height, but is two and one-half times greater in volume.

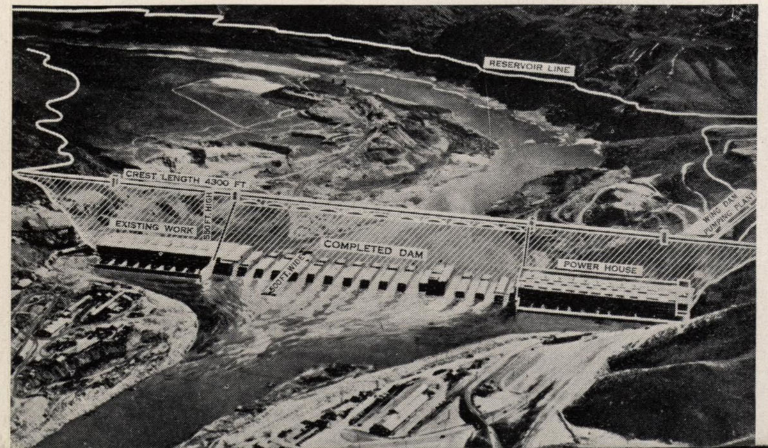
At each end of the dam there will be a powerhouse 765 feet long and 112 feet wide, and at the west end of the dam a pumping plant 790 feet long and 180 feet wide.

Behind the dam a storage reservoir, 151 miles long and extending to the Canadian border, will be formed. It will contain about 10,000,000 acre-feet of water, of which about 5,000,000 will be useful for river regulation and power generation. Two months' average flow of the river would be sufficient to fill the reservoir.

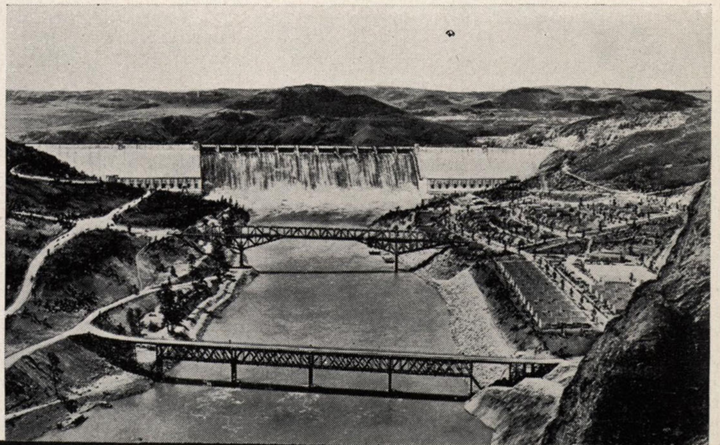
The Grand Coulee Dam is the key to the development of power on the Columbia River—the greatest potential source of useful energy among the rivers of America. Plans of the Army engineers provide for 10 dams on the Columbia between the Canadian border and the mouth of the river, to utilize 92 percent of the fall of the river within this country. The Grand Coulee Dam accounts for 27 percent of the total head.

By controlling the flow of the river, the Grand Coulee Dam will double the firm power of plants between it and the mouth of the Snake River, and will increase by 50 percent the firm power output of other plants below that point, including that at Bonneville. Release of stored water will maintain low-water levels in the lower river 2 feet higher than those of the uncontrolled river, providing a deeper navigable channel or reducing the dredging required.

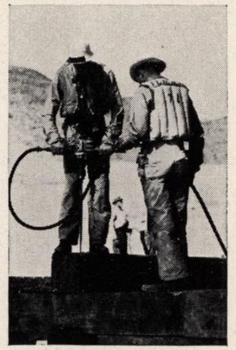
Above: Site of Grand Coulee Dam in 1933 . . . *Below:* The foundation of the dam, completed January 1938 with ultimate structure, covered in contract with Consolidated Builders, Inc., shown in outline



Grand Coulee Dam, as it will appear when completed—a composite of photograph and design drawings.



Irrigation Project



Cofferdam cribs.

The Columbia Basin Reclamation Project will reclaim 1,200,000 acres of land, regulate the flow of the Columbia River, and develop electrical energy to be used for pumping for irrigation and for other purposes.

The land to be irrigated lies south and east of the Big Bend in the Columbia River, in an area 60 miles wide, east and west, and about 85 miles long, extending from Soap Lake to Pasco.

The mean annual temperature on the project lands is 50.4°. During the irrigating season, April to October, it averages 62.2°, days being hot and nights cool. The mean annual precipitation averages 8.2 inches, less than half of it falling in the growing season. Soil and climate are suited to temperate zone crops.

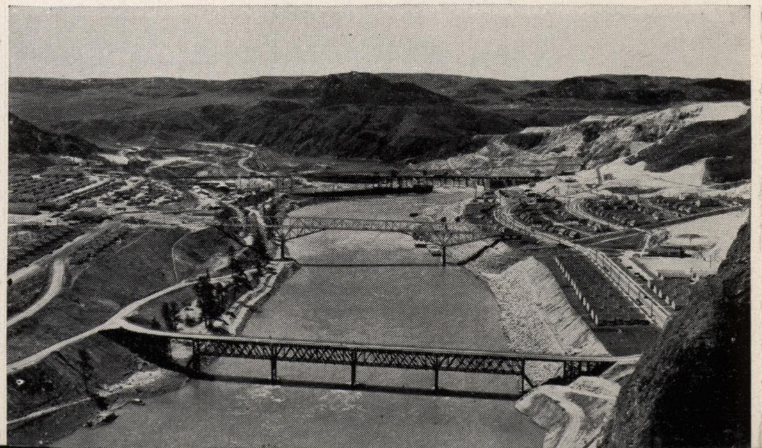
Most of the land is owned by individuals and corporations. It will be available to bona fide settlers at government-appraised dry-land values. One individual will be allowed to hold only a limited acreage.

Waters of the upper Columbia River will be impounded in a storage reservoir 151 miles long by a massive concrete dam near the mouth of the Grand Coulee; part of the power generated at the dam will be used during high-water season to pump water into a balancing reservoir in the Grand Coulee; a main canal will carry the water to the heads of the main east and west canals near Coulee City; and a system of laterals will distribute it to the land.

The project will be self-liquidating from income from settlers and purchasers of power.

Homes will be provided for 25,000 to 40,000 families on the land, and for about an equal number in towns in the irrigated areas, that is, for a total of 200,000 to 400,000 people. Trade with industrial centers, and with agricultural districts producing various crops not grown locally, will support 100,000 to 200,000 people elsewhere in the United States.

Site of the Grand Coulee Dam in 1937. Contractor's camp left; Government camp right.



Statistical Data

The Grand Coulee Dam is the most massive man-made structure in the world. It is a unit of the Columbia Basin Reclamation Project, under construction by the United States Bureau of Reclamation, which will ultimately irrigate 1,200,000 acres of land, regulate the flow of the Columbia River, and develop electrical power for use on the project and elsewhere.

Ultimate Dimensions and Ratings

Length	At base 3,000 feet, at crest 4,300 feet
Width	At crest 30 feet, at base 500 feet
Spillway	Width 1,650 feet, capacity 1,000,000 second-feet
Spillway gates	11, 28 feet high, 135 feet long
Outlet tunnels	60, diameter 8½ feet
Power-plant capacity	2,420,000 horsepower, or 1,890,000 kilowatts
Turbines	18, each rated at 150,000 horsepower
Generators	18, each rated at 120,000 kilovolt-amperes
Estimated annual output (firm)	8,320,000,000 kilowatt-hours
Estimated annual output (secondary)	4,200,000,000 kilowatt-hours
Maximum (secondary) for irrigation	2,260,000,000 kilowatt-hours
Storage basin	Area 82,000 acres, length 151 miles
Capacity	Total 10,000,000 acre-feet, useful 5,000,000 acre-feet
Pumps	12 (2 spares), capacity each, 1,600 cubic feet per second
Average pumping head	280 feet
Motor rating	65,000 horsepower
Columbia River Basin above Coulee Dam	Area 74,100 square miles, in Canada 39,000 square miles
Principal tributaries	Kootenai, Clark Fork, Spokane Rivers
Mean annual run-off above dam	79,000,000 acre-feet
Maximum required for irrigation	6,000,000 acre-feet
Mean annual flow	109,000 second-feet
Maximum recorded flow	492,000 second-feet
Excavation for the dam	Common, nearly 18,000,000 cubic yards
Excavation for the dam	Rock, over 1,000,000 cubic yards
Excavation for sand and gravel (ultimate)	About 25,000,000 cubic yards
Main excavation conveyor	60 inches wide, length about 7,000 feet
Maximum output per day (21 hours)	50,839 cubic yards
Concrete, final total in dam	11,250,000 cubic yards
Cement, final total in dam	12,000,000 barrels
Reinforcing steel, powerhouses, etc	77,000,000 pounds
Steel sheet piling	19,000 tons
Timber, all purposes	60,000,000 board feet

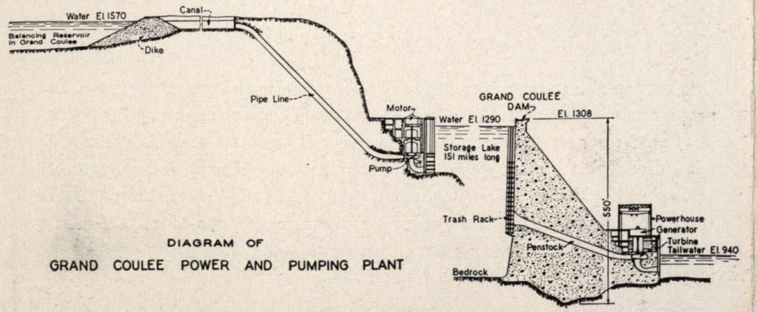


DIAGRAM OF
GRAND COULEE POWER AND PUMPING PLANT

GPO 6—9650

Reclamation

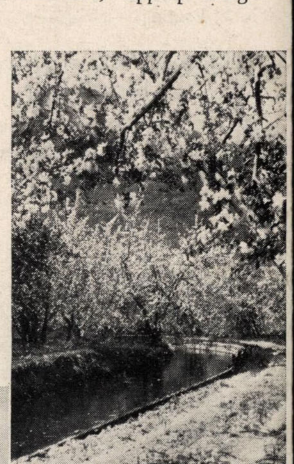
West of the 100th meridian are 11 States, about 39.5 percent of the land in the United States, about 9.5 percent of the population, and about 4.5 percent of the farmed and cropped area.

The annual precipitation is from 3 to 20 inches—only a tenth to a half of that required for agriculture. Irrigation is indispensable to the development of the Western States, and to support their mining, stock raising, and commercial activities.

The Western States can never be agriculturally self-supporting. They are now and always will be heavy purchasers of eastern agricultural products. Their own agricultural products supplement rather than compete with eastern crops in producing a balanced national diet.

The conservation of water, the fundamental resource of the West, has been assigned to the United States Bureau of Reclamation, established in 1902 to carry out the provisions of the Reclamation Act, "appropriating the receipts from the sale and disposal of public lands in certain States and Territories to the construction of irrigation works for the reclamation of arid lands."

In the 36 years of its existence the Bureau has built 138 dams and reservoirs to regulate streams and conserve water which now irrigates 2,800,000 acres of land, once dry and useless. More than a billion dollars' worth of taxable property has been created, and homes have been made out of deserts for about 900,000 people.



Above right: A Wenatchee irrigated apple orchard . . . *Right:* Washington range sheep . . . *Below:* Yakima irrigated lands . . . *Below right:* A desert crop of greasewood.