COLUMBIA BASIN PROJECT, BANKS LAKE,
FEEDER CANAL AND HEADGATES
Grand Coulee
Grant County
Washington

HAER No. WA-139-E

HAER
WASH
13-GRACO,
1E-

BLACK & WHITE PHOTOGRAPHY

HISTORIC AMERICAN ENGINEERING RECORD
National Park Service
U.S. Department of the Interior
National Park Service
Cultural Resources
1849 C Street, N.W., Room NC 300
Washington, D.C. 20240

ADDENDUM TO:
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Grand Coulee
Grant County
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HAER WA-139-E
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PHOTOGRAPHS

WRITTEN HISTORICAL AND DESCRIPTIVE DATA

HISTORIC AMERICAN ENGINEERING RECORD
PACIFIC WEST REGIONAL OFFICE
National Park Service
U.S. Department of the Interior
333 Bush Street
San Francisco, CA 94104

HISTORIC AMERICAN ENGINEERING RECORD

COLUMBIA BASIN PROJECT, BANKS LAKE FEEDER CANAL AND HEADGATES

HAER No. WA-139-E

Location: Grand Coulee
Grant County
Washington

The east end of the Banks Lake Feeder Canal and Headgates is located at latitude: 47.9533, longitude: -118.9923. ~~The west end is located at latitude: 47.7901, longitude: -123.2231.~~ The latitude and longitude coordinates were converted from the UTMs via Montana State University and Yellowstone National Park RCN Utilities and Tools web site on November 19, 2013.

The west end is located at longitude: 47.942508, latitude: -119.022459 (Google Earth, August 2016).

Dates of Construction: 1946-51

Engineers: Bureau of Reclamation

Original Owner: Bureau of Reclamation

Original Use: Feeder canal and headgates

Present Owner: Bureau of Reclamation

Present Use: Feeder canal and headgates

Significance: The Feeder Canal and Headgates are a critical part of the irrigation component that was integral to the planning for the Grand Coulee Project. The John W. Keys III Pump Generating Plant takes water from Lake Roosevelt, created by the Grand Coulee Dam in the Columbia River, and pumps it up the steep gorge to the Siphon-Breaker Building, where it empties into the Feeder Canal. The Headgates are near the canal's terminus in an equalizing reservoir, known as Banks Lake. Water flows from the reservoir into the massive irrigation system of the Columbia Basin Project.

Project Information: This documentation study was initiated by the Bureau of Reclamation's Pacific Northwest Regional Office in Boise, Idaho. Joseph Pratt was the contracting officer; Derek Beery, Mike Flowers, Sean Hess, Pei-Lin Yu,

and Lynne MacDonald served as contracting officer representatives. Hess, Roise and Company, a historical consulting firm based in Minneapolis, Minnesota, was the prime contractor for the project, with photography and delineation completed by subcontractor Clayton Fraser of FraserDesign, Loveland, Colorado. Charlene Roise, principal of Hess Roise, was the project manager and historian, with research assistance from staff historian Elizabeth Gales and staff researcher Penny Petersen. CH2M HILL's Boise office provided editorial and other assistance, under the supervision of Mark Bransom, as a subcontractor to Hess Roise.

The Pump-Generating Plant (now known as the John W. Keys III Pump-Generating Plant, see HAER No. WA-139-C) takes water from Lake Roosevelt and pumps it up the steep Columbia River gorge to the Siphon-Breaker Building (HAER No. WA-139-D), where it empties into the Feeder Canal. The concrete-lined canal was originally planned to be open for most of its two-mile length, which runs in a generally westerly direction. Slides forced the installation of a cut-and-cover section, which was later replaced by a flume. Near the canal's terminus—in an equalizing reservoir known as Banks Lake (HAER No. WA-139-F)—its flow is controlled by a check structure with five radial headgates measuring 24′ x 25′. A 410′-long concrete chute with a V-type weir delivers the water into the reservoir.[1]

The Feeder Canal and Headgates were part of the irrigation component of the Grand Coulee project. To create a reservoir for irrigation, Reclamation first had to dam the Columbia River and build a pumping plant to push the water to the elevation of the prospective farmland. While advancing Reclamation's primary mission of "reclaiming" the arid but fertile lands of the western United States, the irrigation component took second place to the development of hydropower at Grand Coulee. This dominated construction work in the 1930s and early 1940s. Completing the irrigation works did not become a high priority until the demand for farms increased with the surge of World War II veterans needing housing and employment. Reclamation suddenly faced a goal of having 216,000 acres irrigated and settled by 1952.[2]

While planning for the irrigation system had been underway for many years, interest was revived in 1945 when the Denver office asked a local Reclamation crew to update ecological investigations of the anticipated route of the Feeder Canal. Issued in December, the "Revised Geological Report on Feeder Canal to the Grand Coulee Equalizing Reservoir" included a geologic map and cross sections of the canal.[3] (See ILLUSTRATION 1: Feeder Canal.)[4]

Like most other components of the Grand Coulee project, the Feeder Canal was a noteworthy example of its type. Its capacity of 16,000 cubic feet per second was greater than that of the All-American Canal, another substantial canal of its day, which had been developed in conjunction with Boulder (Hoover) Dam to bring irrigation water to California's Imperial Valley. Sloping at a gentle drop of 1-1/6′ per mile with water velocity of about 8.6′ per second, the Grand Coulee canal would extend almost two miles from the Siphon-Breaker Building to the reservoir. The concrete-lined canal was to be 25.5′ deep, varying in width from 50′ at its base to 126.5′ at its

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[1] Bureau of Reclamation, "North Dam and Feeder Canal," 1, Inspection Report, October 7, 1970, appended to Bureau of Reclamation, Annual Project History, Grand Coulee Dam Operations Office-Columbia Basin Project, Vol. 1, 1970.
[2] Bureau of Reclamation, Annual Project History, Columbia Basin Project, Vol. 15, 1947, 143. Additional information about the politics behind the development of the irrigation system is in "Columbia Basin Project, Grand Coulee Dam," HAER No. WA-193-A.
[3] Bureau of Reclamation, Annual Project History, Columbia Basin Project, Vol. 13, 1945, 99.
[4] Bureau of Reclamation, "Feeder Canal Location Map," 222-D-17426, September 18, 1953.

top, and with the sides at a 1.5:1 slope. At its terminus, it became a rectangular chute discharging into the reservoir.[5]

In January 1946, Reclamation crews began excavation for the Feeder Canal. The work was not easy. The canal traversed "a rugged terrain, involving much basaltic and granite rock excavation," according to the project history. Regardless, progress went well until the onset of a familiar and unwelcome challenge from the unstable soil that had tormented contractors for the Grand Coulee Dam and powerplants. On November 27, 1946, "several large cracks developed in the right bank . . . between stations 56 and 60, indicating a movement of a large mass of material towards the centerline of the canal." By the end of the year, crews had started to unload the slide area.[6]

Slides continued to bedevil the project. In May 1947, a third slide hit the area between stations 55 and 60, near the channel's terminus. Finally, Reclamation assembled a consulting board to study the problem. The board visited the site in October and concluded that the slides could best be combated by enclosing the channel. The solution appeared to be a 2,100′ cut-and-cover segment. Two rectangular, reinforced-concrete sections would serve as a transition into two cylindrical, reinforced-concrete tubes, each 25′ in diameter. To force the water into the tubes from the open canal, the elevation of the tubes was 3′ lower, which increased the water's velocity from 7.5′ to 16′ a second. Beyond the slide section, the canal returned to an open trapezoidal form until its terminus, where it became a rectangular chute that discharged into the equalizing reservoir.[7]

In the meantime, politics were also disrupting construction. Work on the Feeder Canal, along with the Pump-Generating Plant and other initiatives at Grand Coulee, ground to a virtual halt in July 1947 because a Congressional budget cut reduced Reclamation's work forces; the only ongoing activity was test drilling. Funding levels soon rose, but uncertainty about future support caused worries about reaching deadlines. The 1947 project history warned that all of the irrigation features—including the Feeder Canal—would need to be in place to meet the goal of having 216,000 acres under irrigation by 1952, and the "curtailment of the appropriations schedule . . . would result in a failure to deliver water to <u>any</u> of the lands, and would postpone the entire program one or more years."[8]

While the number of acres to be irrigated was subsequently reduced, the goal of starting the irrigation works by 1952 was not. As the excavation reached rockier areas, contractors were brought in to take over from the Reclamation crews. In January 1949, Morrison-Knudsen Company and Peter Kiewit Sons' Company began a contract to excavate 27,580 cubic yards of

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[5] Bureau of Reclamation, Annual Project History, Columbia Basin Project, Vol. 14, 1946, 239; Bureau of Reclamation, Annual Project History, Columbia Basin Project, Vol. 18, 1950, 125-127, 133.
[6] Bureau of Reclamation, Annual Project History, Columbia Basin Project, Vol. 14, 1946, 54-55, 239.
[7] Bureau of Reclamation, Annual Project History, Columbia Basin Project, Vol. 15, 1947, 58, 60; Bureau of Reclamation, Annual Project History, Columbia Basin Project, Vol. 18, 1950, 125-127, 133.
[8] Bureau of Reclamation, Annual Project History, Columbia Basin Project, Vol. 15, 1947, 59, 143.

rock for the Feeder Canal. The companies were also responsible for erecting a 350-ton automatic batch concrete mixing plant. By August, the contractors had finished excavating and trimming the canal from Station 3+12.12 to Station 35+00.[9]

This allowed contractor J. A. Terteling and Sons, who was also working on the North Dam, to proceed with concrete placement in the Feeder Canal. The company finished its first pour in the cut-and-cover section in August 1949. In the following month, Reclamation modified its contract with Morrison-Knudsen and Kiewit to expedite their work. The goal was to have the interrelated components—Pump-Generating Plant, Feeder Canal, and North Dam—completed early in 1951 so that testing could be done prior to initiating full operation the next year. The pipes to carry the water from the Pump-Generating Plant to the Feeder Canal were finished by May 1950. One of the first items listed in the "Chronology of Important Events" in the 1951 project history was the completion of the Feeder Canal on January 9. On May 7, the first pump in the Pump-Generating Plant was started and there was a "Celebration of First Irrigation Water." On May 10, Reclamation started to fill the equalizing reservoir.[10]

The inaugural 1952 irrigation season went smoothly—a pattern that continued after the 1953 irrigation season began May 18. Then on July 25, the system was abruptly shut down after problems were discovered with the lining of the Feeder Canal. The problem was apparently caused by unstable foundation materials between stations 81+04.5 and 91+04, including the area of the invert between stations 89+00 and 91+04. In October, Reclamation let a contract to the L. D. Shilling Company of Moses Lake, Washington, for about $195,000 to repair the damage. By the following month, the contractor had begun removing the canal's concrete lining between stations 51+04.5 and 91+04—as well as the inadequate materials beneath it—to a depth of about 2′. This area was filled with a cushion of crushed rock with 10″ drains. Two mats of steel were used to reinforce the concrete poured on top of this base.[11]

Although occasionally delayed by inclement weather, the work proceeded steadily throughout most of the winter, then accelerated as the opening of the irrigation season drew near. The progress report for March 1954 noted that "the contractor had a work force of from 25 to 65 men working a six-day week. Swing shift started on March 19 and graveyard shift on March 25." By early May, three shifts of up to 120 men each worked seven days a week to finish the canal and V-type weir. A Reclamation report called the repair work "one of the largest items of maintenance occurring since the completion of construction of Grand Coulee Dam." Pumping resumed May 21 when everything but the left and right catwalks, which were above the level of

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[9] Bureau of Reclamation, Annual Project History, Columbia Basin Project, Vol. 17, 1949, 31, 40.

[10] Bureau of Reclamation, Annual Project History, Columbia Basin Project, Vol. 17, 1949, 40, 42, 56-57, 203; Bureau of Reclamation, Annual Project History, Columbia Basin Project, Vol. 18, 1950, 152; Bureau of Reclamation, Annual Project History, Columbia Basin Project, Vol. 19, 1951, 2, 13; Bureau of Reclamation, Annual Project History, Columbia Basin Project, Vol. 18, 1950, 142, 152; caption for photograph CB-11863, May 10, 1951, H. W. Fuller, photographer, at Box 185, Album 29, National Archives and Records Administration-Rocky Mountain Region-Denver.

[11] Bureau of Reclamation, Annual Project History, Columbia Basin Project, Vol. 21, 1953, 50, 58, 62.

the water, was completed. The quick response got pumping started to refill the reservoir "before exhausting the stored water supply and without interference to water deliveries to the farms."[12] The repair apparently fixed the problem, and the operation of the Feeder Canal was relatively uneventful for almost two decades. In 1972, the cut-and-cover headwall of the Feeder Canal was extended. The project involved placing reinforcing bars and concrete, extending the air vent to the canal's left bank, and replacing the existing handrail. According to the annual project history, the headwall's extension "eliminated the need for annual installation of sandbags to contain the inflow during periods of high lake elevations."[13]

Also in 1972, Reclamation engineers developed a design for personnel escape devices. "The need for these devices became evident during the previous year," the project history explained, "when a pickup driver narrowly escaped with his life after leaving the road and driving into the canal."[14]

The installation of pump-generator units in the Pump-Generating Plant in the early 1970s had ramifications for the Feeder Canal, which had been developed to transport water in just one direction. An Environmental Impact Statement released in July 1975 explained: "The existing feeder canal, having been designed only for delivery of water into Banks Lake, requires modification to pass the 14,440 cfs in the opposite direction for full power production." The canal's capacity would be increased by widening it from 50′ to 80′, with the sides again at a 1.5:1 slope. The cut-and-cover section, which created a bottleneck for the water's flow, would be replaced by a new flume. Also, the channel's overall slope had to be adjusted to facilitate flow in either direction. The project was scheduled to start in spring 1977 and be finished two years later.[15]

Drilling in several locations to examine soil conditions exposed only one problem: the layer of soft clay and silt that had challenged so many parts of the Grand Coulee project. A report summarizing geologic conditions on the proposed alignment was completed in June 1976, and the results were so unfavorable that the alignment was dropped and a new area investigated.

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[12] Bureau of Reclamation, Annual Project History, Columbia Basin Project, Vol. 22, 1954, monthly reports for January-May, Annual Project History Section, 7; "North Dam and Feeder Canal," 1, Inspection Report, October 7, 1970, appended to Bureau of Reclamation, Annual Project History, Grand Coulee Dam Operations Office-Columbia Basin Project, 1970, Vol. 1.
[13] Bureau of Reclamation, Annual Project History, Grand Coulee Dam Operations Office-Columbia Basin Project, Vol. 3, 1972, 8.
[14] Bureau of Reclamation, Annual Project History, Grand Coulee Dam Operations Office-Columbia Basin Project, Vol. 3, 1972, 8.
[15] Bureau of Reclamation-Pacific Northwest Region, "Environmental Impact Study Report: Modification of Banks Lake Feeder Canal, Installation of Pump-generators 9-12 and Associated Operations of Banks Lake, Columbia Basin Project, Washington," July 1975, 1-3.

Potential borrow areas at Pleasant Valley, Crown Point, and Delano were also examined, with the Delano site looking the most promising.[16]

To obtain better information about soil conditions, Reclamation developed a Land Movement Monitor System (LMMS) for the Feeder Canal in 1977. The installation began in September with the drilling of fourteen holes outfitted with inclinometers. The first sections of the system began operation in November.[17]

In the same month, the Martin K. Eby Construction Company of Wichita, Kansas, was selected to do the modifications with a bid of $22.2 million, the lowest of the seven proposals that Reclamation received. The scope included altering the outlets to the discharge lines for Units P/G-9 through P/G-12; raising the headwall; removing approximately 6,100′ of the concrete canal lining, widening the trough, and pouring a new concrete lining; raising the lining in the remaining canal; and installing a 2,700′-long concrete flume with a 90′ base to replace the cut-and-cover section. The project also involved drilling more than 300 holes in the cut-and-cover conduits so that anchors could be installed to stabilize the two tubes. This would allow them to remain in service during the 1978 pumping season while the flume was under construction. In addition, the contractor had to erect a cofferdam 600′ long and 50′ high to prevent water from Banks Lake from flowing into the canal during construction.[18]

Eby's subcontractor, Continental Drilling of Seattle, began drilling holes for the earth-anchor tendons for the conduit tubes in January 1978. The anchors had to be placed at a minimum depth of 50′. Continental initially used air-track drills, which were better suited for making shot holes in rock than forming openings in the saturated sand and muck soils at the canal. When the holes collapsed before the anchors could be installed, more appropriate drill rigs were called into service. Time was of the essence for this task because of the impending irrigation season. By May 1, the subcontractor had completed 405 anchor tendons, which were tensioned from inside the conduit tubes.[19]

With the anchors in place, the contractor could begin excavating for the flume's retaining wall. To provide additional stability, four cast-in-place concrete piles were installed beneath every 25′

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[16] Bureau of Reclamation, Annual Project History, Grand Coulee Project Office-Columbia Basin Project, Vol. 1, 1975, 20-21; Bureau of Reclamation, Annual Project History, Grand Coulee Project Office-Columbia Basin Project, Vol. 2, 1976, 62, 65.
[17] Bureau of Reclamation, Annual Project History, Grand Coulee Project Office-Columbia Basin Project, Vol. 3, 1977, 28, 51.
[18] Bureau of Reclamation, Annual Project History, Grand Coulee Project Office-Columbia Basin Project, Vol. 3, 1977, 56; Bureau of Reclamation, Annual Project History, Grand Coulee Third Powerplant-Columbia Basin Project, Vol. 3, 1977, 63; Bureau of Reclamation, Annual Project History, Grand Coulee Project Office-Columbia Basin Project, 1978, Vol. 4, 66; Bureau of Reclamation, Annual Project History, Grand Coulee Third Powerplant-Columbia Basin Project, Vol. 4, 1978, 28.
[19] Bureau of Reclamation, Annual Project History, Grand Coulee Project Office-Columbia Basin Project, Vol. 4, 1978, 65-66; Bureau of Reclamation, Annual Project History, Grand Coulee Third Powerplant-Columbia Basin Project, Vol. 4, 1978, 28-30.

section of the flume. Areas excavated for the right side of the flume were partly backfilled with pervious materials to promote drainage. While waiting to start on the flume, the contractor worked on the vertical extension of the Feeder Canal headwall, a task finished by May 11. Part of the upward extension of the canal lining's right side was done by June 30.[20]

When the pumping season ended in November, the canal was dewatered with the aid of the temporary cofferdam. This hastily erected polyvinyl-chloride-faced dam was soon replaced by a stronger cofferdam sheathed with shotcrete. Three concrete cutoff walls were placed just downstream from this structure, extending from the slope of the embankment across the bottom of the canal. At the newly dry headworks area, the contractor began excavation to widen the left side of the canal and to modify the outlets for P/G-11 and P/G-12. By February 1979, excavation was finished and concrete was being placed for the new foundation.[21]

The original check structure had been removed by January 1979. The foundations for the cutoff walls and slabs and the first sections of wall for the new check structure were rising in February. By mid-April, the structure was "as far as it could be before the pumping season." Radial gates for the three central bays—2, 3, and 4, the only channels that would be used in the next two years—were in position and painted by the end of April. Smaller bays 1 and 5, situated completely on the slanted walls of the canal, were blocked with temporary transition walls and backfilled.[22]

The concrete canal lining was removed and the wider section excavated as far as the cut-and-cover section by mid-March, when concrete placement began. A month later, most of the new lining in this stretch was poured. Water was introduced to the canal on May 2, and pumping began the next day. This marked the beginning of the last season that the cut-and-cover section was in service.[23]

With the system once again able to convey irrigation water, the contractor returned to construction of the flume. Work to form the 1.5:1 slope of the flume walls was completed in mid-June, and by mid-July, more than 1,000 steel piles had been driven for the retaining wall foundation. Twenty-five-foot sections of the retaining wall were poured in three lifts. By early September, the contractor had placed all of the walls that could be completed before the end of the pumping season. After the season ended in mid-October, a temporary cofferdam was positioned just down from the check structure to facilitate the construction linking both ends of

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[20] Bureau of Reclamation, Annual Project History, Grand Coulee Project Office-Columbia Basin Project, Vol. 4, 1978, 65-66; Bureau of Reclamation, Annual Project History, Grand Coulee Third Powerplant-Columbia Basin Project, Vol. 4, 1978, 28-29.
[21] Bureau of Reclamation, Annual Project History, Grand Coulee Third Powerplant-Columbia Basin Project, Vol. 4, 1978, 29; Bureau of Reclamation, Annual Project History, Grand Coulee Third Powerplant-Columbia Basin Project, Vol. 5, 1979, 30.
[22] Bureau of Reclamation, Annual Project History, Grand Coulee Third Powerplant-Columbia Basin Project, Vol. 5, 1979, 30.
[23] Bureau of Reclamation, Annual Project History, Grand Coulee Third Powerplant-Columbia Basin Project, Vol. 5, 1979, 40.

the flume into the canal. At the same time, the contractor was widening the left side of the canal between the headworks and the flume.[24]

By April 1980, all concrete for the flume was in place and the temporary cofferdam below the check structure was removed. In the following month, pumps began filling the canal. Pumping into Banks Lake continued until the end of the season on August 8, 1980. After that time, a temporary cofferdam was installed between the lake and the end of the chute, the protected area was drained, and final work on widening the canal and outlet between the check structure and the weir was completed. By the end of the year, the Martin K. Eby Construction Company had finished its contract.[25]

After the 1979 season, the cut-and-cover section of the Feeder Canal was no longer needed to carry water, but it continued to serve an important function by buttressing the unstable hillside. While ideas to use the pipes for storing an emergency water supply were considered, Reclamation decided to leave them empty. Given the problems that the slope had generated in the past, this seemed the most prudent alternative.[26]

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[24] Bureau of Reclamation, Annual Project History, Grand Coulee Third Powerplant-Columbia Basin Project, Vol. 5, 1979, 30.
[25] Bureau of Reclamation, Annual Project History, Grand Coulee Third Powerplant-Columbia Basin Project, Vol. 6, 1980, 23-24.
[26] Bureau of Reclamation, Annual Project History, Grand Coulee Project Office-Columbia Basin Project, Vol. 5, 1979, 42; Bureau of Reclamation, Annual Project History, Grand Coulee Third Powerplant-Columbia Basin Project, Vol. 6, 1980, 22.

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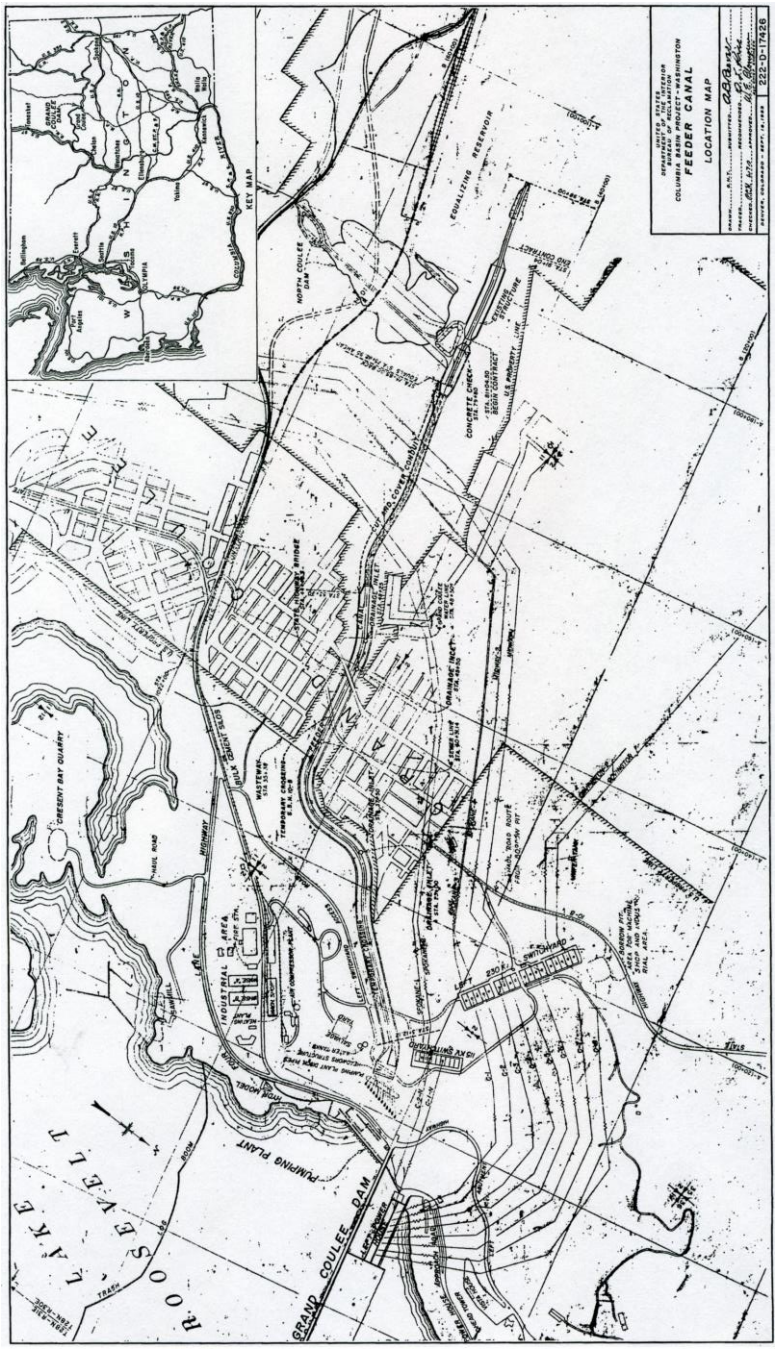

ILLUSTRATION 1: The Feeder Canal begins at the "headwaters structure" by the "pumping plant disch. pipes" to the west of Grand Coulee Dam's left abutment. The open canal winds to the west until reaching the "cut and cover conduit." The North Dam of the equalizing reservoir (Banks Lake) is adjacent to the canal's concrete check structure.
(Bureau of Reclamation, "Feeder Canal Location Map," 222-D-17426, September 18, 1953.)