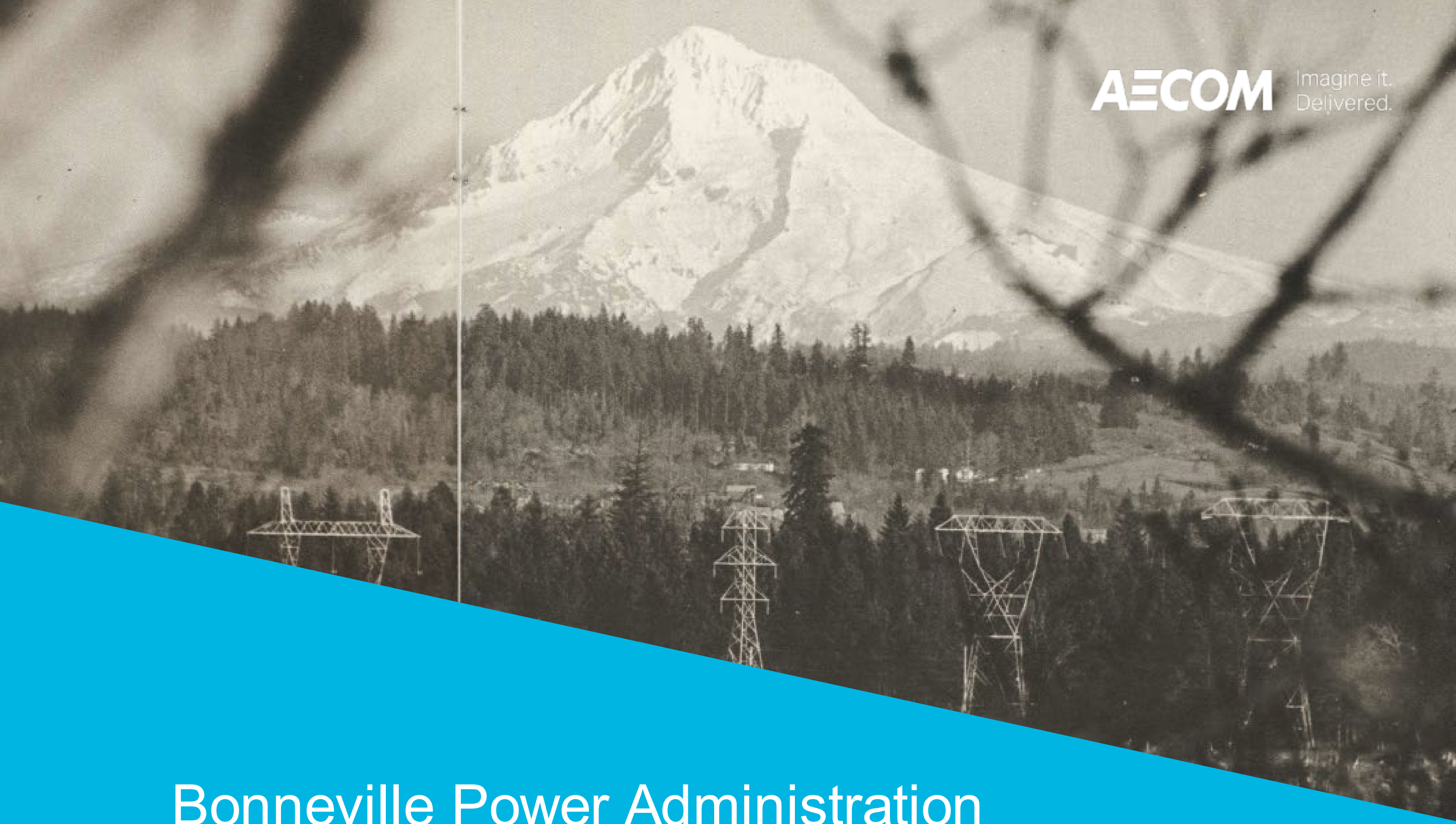


Bonneville Power Administration Transmission Lines Historic Context Report

Washington, Oregon, Idaho, Montana, Wyoming, California, Nevada

Prepared for:
Bonneville Power Administration
905 NE 11th Avenue
Portland, OR 97232

Prepared by:
AECOM
111 SW Columbia
Portland, OR 97201
aecom.com

Contract 87253

March 2022

Cover Photo: BPA's transmission line corridor facing east toward Mt. Hood, 1971 (BPA, *Federal Columbia River Power System Annual Report*. U.S. Department of the Interior, 1971).

Table of Contents

Appendices

Figures

Tables

Acronyms and Abbreviations

AC	alternating current
BPA	Bonneville Power Administration
CGITS	compressed gas insulated transmission system
DC	direct current
HVDC	high voltage direct current
ID	Idaho
kV	kilovolt
LIS	land information system
LVPL	Lower Valley Power and Light, Inc.
MPDF	Multiple Property Documentation Form
MT	Montana
NARA	National Archives and Records Administration
NEPA	National Environmental Policy Act of 1969
NHPA	National Historic Preservation Act of 1966
NAR	North American Rockwell Corporation
NRHP	National Register of Historic Places
OR	Oregon
PA	Programmatic Agreement
PP&L	Pacific Power & Light
PSCP	Power System Control Program
PUD	Public Utility District/People's Utility District
PWA	Public Works Administration
REA	Rural Electrification Administration
ROW	Right of Way
SHPO	State Historic Preservation Office
TLD	Transmission Line Database
TLM	Transmission Line Maintenance
TRED	Transmission Reference Entity Database
WA	Washington
WPA	Works Progress Administration
WPPSS	Washington Public Power Supply System
WWII	World War II
WY	Wyoming

1. Introduction

The history of the Bonneville Power Administration (BPA) includes the development of over 700 transmission lines spanning 14,865.8 operating miles through the seven states (Ore., Wash., Idaho, Mont., Wyo., Calif., and Nev.) in the BPA service area. Transmission lines are the primary element in BPA's system. BPA has completed previous National Register of Historic Places (NRHP) eligibility evaluation efforts for its historic substations and other facilities with historic buildings, as well as for individual transmission lines, but has identified a need for a historic context to use in a more widespread identification and evaluation effort for its historic transmission lines. A Multiple Property Documentation Form (MPDF) prepared by George Kramer in 2012 has provided a basis for evaluating historic resources within the BPA transmission system. This BPA Transmission Line Historic Context incorporates and builds on that MPDF with a more detailed focus on transmission lines. This report documents the historical events and patterns—both national and local—that have influenced development of the BPA grid; specifically, the transmission lines, which are the backbone of BPA's entire system.

The historic context provides an overall summary of the following:

- Development and construction of the BPA transmission lines and development of lattice steel, steel monopole, and wood pole structures unique to BPA;
- How the lines operate within their specific local areas and as part of the overall grid;
- Wheeling arrangements between BPA and other power entities;
- BPA's engineering achievements and innovations in power and how the historic lines embody those achievements; and
- Important persons associated with transmission line engineering and construction.

Additionally, the historic context provides the foundational material for a future evaluation framework to determine the eligibility of BPA's transmission lines for inclusion in the National Register of Historic Places. The historic context establishes the evaluation criteria for an individually eligible transmission line.

BPA is developing a program-level Section 106 Programmatic Agreement (PA) with consulting parties as part of its management of historic transmission lines consistent with the requirements of 36 CFR Part 800. BPA will use this historic context in the development of the PA.

1.1 General Information: The Bonneville Power Administration in the Pacific Northwest

BPA is a nonprofit federal power administration that markets wholesale hydroelectric energy throughout the Pacific Northwest, and is part of the U.S. Department of Energy. BPA's transmission system, which provides nearly one-third of the region's electric power, operates primarily in Idaho, Oregon, Western Montana, and Washington; as well as sections of California, Eastern Montana, Nevada, Utah, and Wyoming; it also interconnects with systems in British Columbia, Canada.[1]

BPA has had an integral role in the development of communities and industries throughout the Pacific Northwest since its creation in 1937. President Franklin Roosevelt's "New Deal" included a plan to generate power through the building of a dam system on the Columbia River, which

[1] BPA.gov, "BPA Facts," Bonneville Power Administration, August, 2021. Accessed July 7, 2022, bpa-facts.pdf,

would create jobs during the Great Depression. The construction of BPA's "Master Grid" transmission network (1938-1945) enabled the transmission of inexpensive power from the Bonneville and Grand Coulee Dams in Oregon and Washington to urban and rural communities (Figures 1-2). The network also attracted major industries to the region.[2] [3] BPA had an important role in national defense in its first years, supplying electricity that brought massive industrial development to the region and supporting the U.S. war effort. After World War II, as defense industries closed or converted to peacetime uses, BPA power continued to facilitate the significant development of the region's aluminum, agriculture, and timber industries, as well as its growing population centers.

The BPA transmission system is historically significant as the region's primary distributor of electrical power. The system developed in conjunction with community and economic growth throughout the Pacific Northwest and has made significant contributions to the broader history of electrical transmission.

Since its inception, BPA has continually adapted to evolving regional and national priorities by incorporating new electric distribution, management, and communication technologies through system upgrades and expansion.[4]

[2] Christine Anne Curran, "A Historic Context for the Transmission of Hydroelectricity by the Bonneville Power Administration, 1939-1945" (master's thesis, University of Oregon, 1998).

[3] George Kramer, *Bonneville Power Administration [BPA] Pacific Northwest Transmission System Multiple Property Documentation Form* [MPDF] (Washington, D.C.: National Park Service, U.S. Department of the Interior, 2012).

[4] Kramer, *BPA Transmission System MPDF.*

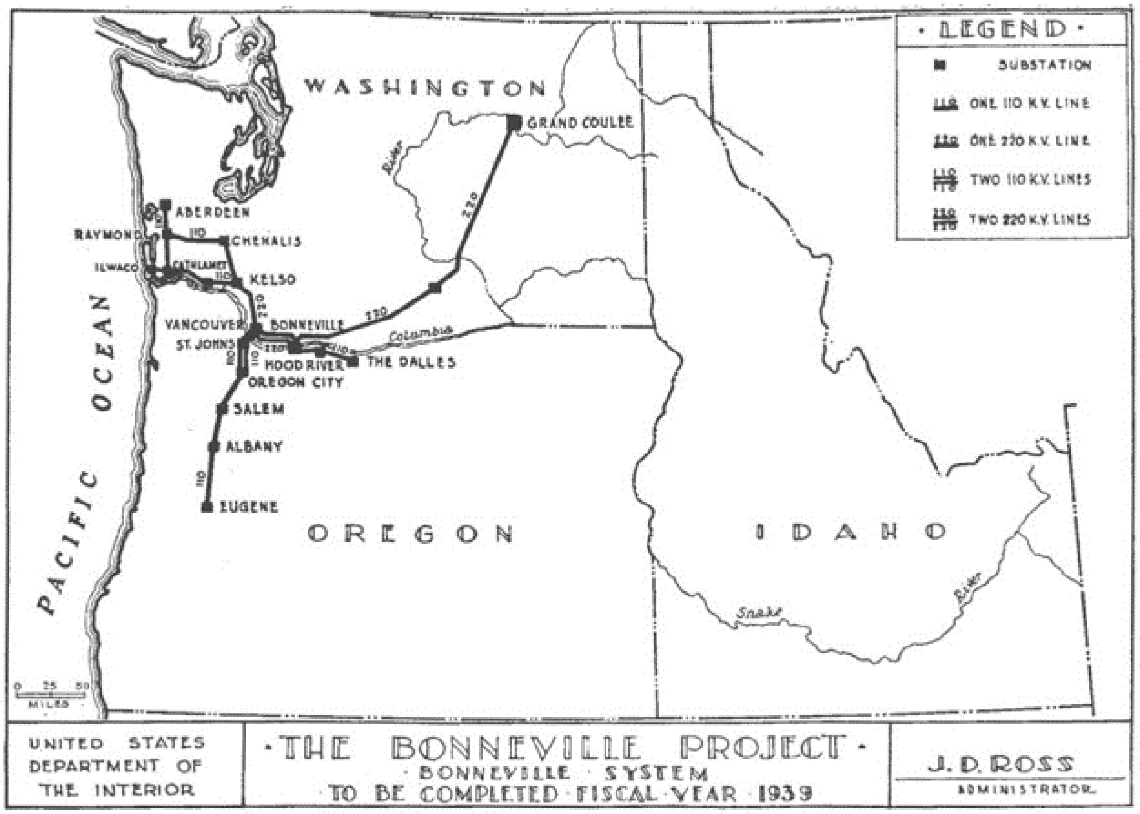


Figure 1. Proposed BPA transmission network expansion to be completed in 1939.[5]

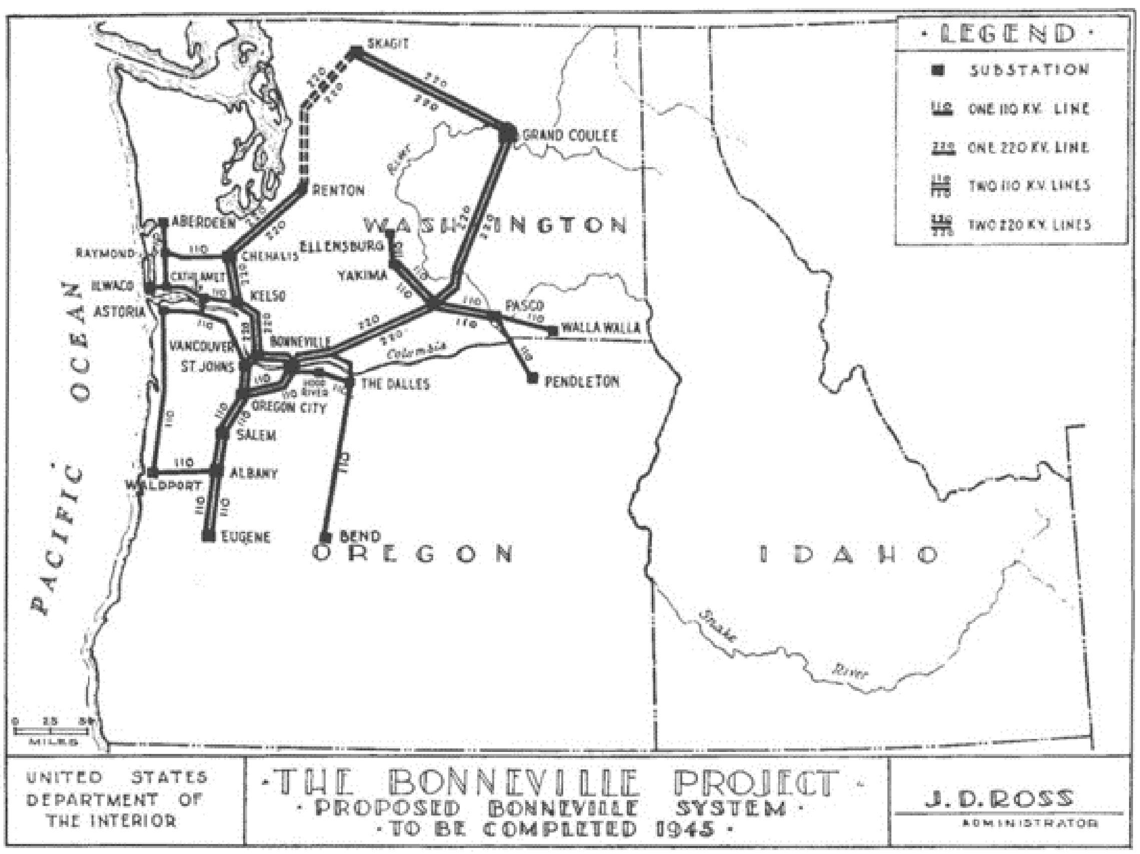


Figure 2. Proposed BPA transmission network expansion to be completed in 1945.[6]

1.2 Research Methodology

This context was developed through research in a variety of BPA source documents and incorporates past research. Research used primary and secondary sources, including—but not limited to—the BPA Library, BPA Central Records, the National Archives at Seattle, internal BPA records and databases from the Transmission Reference Entity Database, Transmission Line Engineering Data Management, Land Information System (Real Property Services), Geospatial Services, Survey and Mapping, Transmission Line Design, Structural Design, Project Engineering, and Transmission Line Maintenance organizations.

Primary source materials include historic newspapers, BPA Annual Reports, engineering technical reports, engineering design manuals, historic photographs and films in the BPA Collection and from National Archives and Records Administration (NARA), BPA's Owned and Operated Manuals, historic planning documents, and BPA's GIS database.

Existing BPA Historic Contexts incorporated as secondary materials include the following:

- "A Historic Context for the Transmission of Hydroelectricity by the Bonneville Power Administration, 1939-1945"[7]
- Corridors of Power, the Bonneville Power Administration Transmission Network Historic Context Statement[8]
- Bonneville Power Administration [BPA] Pacific Northwest Transmission System Multiple Property Documentation Form (MPDF)[9]
- Bonneville Power Administration Microwave Radio Stations Historic Resources Technical Report[10]
- BPA Historic Built Resources Field Guide[11]
- Bonneville Power Administration Manual for Built Resources[12]

This document relies on the MPDF as a foundation for historic context but expands the historic overview and evaluation framework following BPA's consultation with SHPOs. The context also incorporates more detailed research and an expanded identification typology for characterizing BPA's transmission lines and their components. A detailed identification and evaluation framework addresses significance and integrity considerations that are unique to determining the NRHP eligibility of BPA's transmission lines. Treatment strategies lay out the approach for BPA to identify, evaluate, and manage historic transmission lines within its system.

Transmission line names used in this report are those listed in their source documents and may not necessarily be the current operating names. Through the development of the historic context, it became clear that the names of some transmission lines have changed over time for a variety of reasons, including construction of new end points such as substations, and the merging of multiple lines. Therefore, not all historic names are current operating names. Furthermore, the naming of lines and their energizations dates vary depending on the source material. Energization dates reflect when a "new" line was first energized; however, the line may

---

[5] BPA, *Second Annual Report of the Administrator of the Bonneville Administration* (Washington, D.C.: U.S. Department of the Interior, 1939).

[6] BPA, *Report on the Columbia River Power System* (Washington, D.C.: U.S. Department of the Interior, 1945).

[7] Curran, "A Historic Context."

[8] George Kramer, *Corridors of Power: The Bonneville Power Administration Transmission Network Historic Context Statement* (Portland, OR: Bonneville Power Administration, 2010).

[9] Kramer, *BPA Transmission System MPDF.*

[10] AECOM, *Bonneville Power Administration Microwave Radio Stations Historic Resources Technical Report* (Portland, OR: prepared for BPA, 2019).

[11] AECOM, *Historic Built Resources Field Guide* (Portland, OR: prepared for BPA, 2021).

[12] AECOM, *Bonneville Power Administration Manual for Built Resources* (Portland, OR: prepared for BPA, 2019).

include a segment or segments that were constructed and initially energized at an earlier time. Therefore, this historic context refers to names and dates used in primary source materials and may not always align with BPA's current transmission line data. Additional research is needed to distinguish the current operating names associated with historic transmission lines.

1.3 Geographic Boundaries

BPA currently provides service to eight western states: Washington, Oregon, Idaho, Montana, Wyoming, Utah, Nevada, and California (Figure 3). However, the geographic boundaries for this MPD are limited to states that have historic-age BPA transmission lines; therefore, it excludes Utah, Wyoming and Nevada from the context of this report. Maps illustrating the BPA transmission line network in Washington, Oregon, Idaho, and Montana are provided in Appendix A.

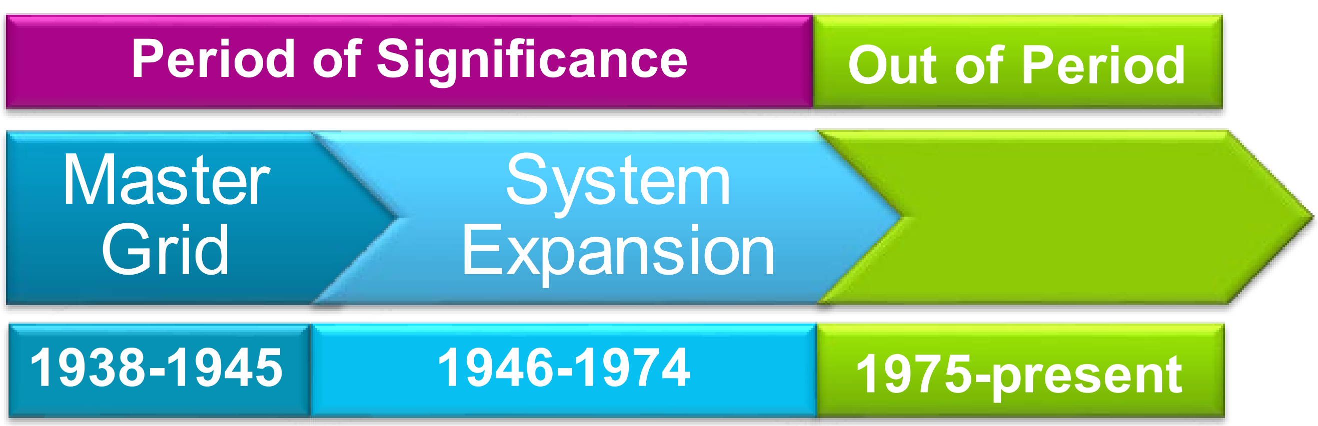
1.4 Temporal Boundaries

The period of significance for this historic context begins with the construction of the first BPA transmission line in 1938 and ends in 1974. The temporal boundary includes the Master Grid (1938 to 1945) and System Expansion (1946 to 1974) periods.

The **Master Grid** period represents BPA's initial development to provide hydropower from the Bonneville and Grand Coulee Dams to the region, enable rural electrification, and support the World War II-era defense industry.

The **System Expansion** period encompasses BPA's efforts to support population growth and the development of a new industrial base during the Pacific Northwest's postwar expansion.[13] The Period of Significance ends in 1974 with the dedication of the Dittmer Control Center's computer-based management systems for power transmission and implementation of Public Law 93-454 that transformed BPA's funding and operation.[14]

Lines associated with the Ultra High Voltage testing program (mostly completed in 1976) have a different period of significance and are covered under a separate historic context.



[13] Kramer, *BPA Transmission System MPDF.*

[14] Kramer, *BPA Transmission System MPDF.*

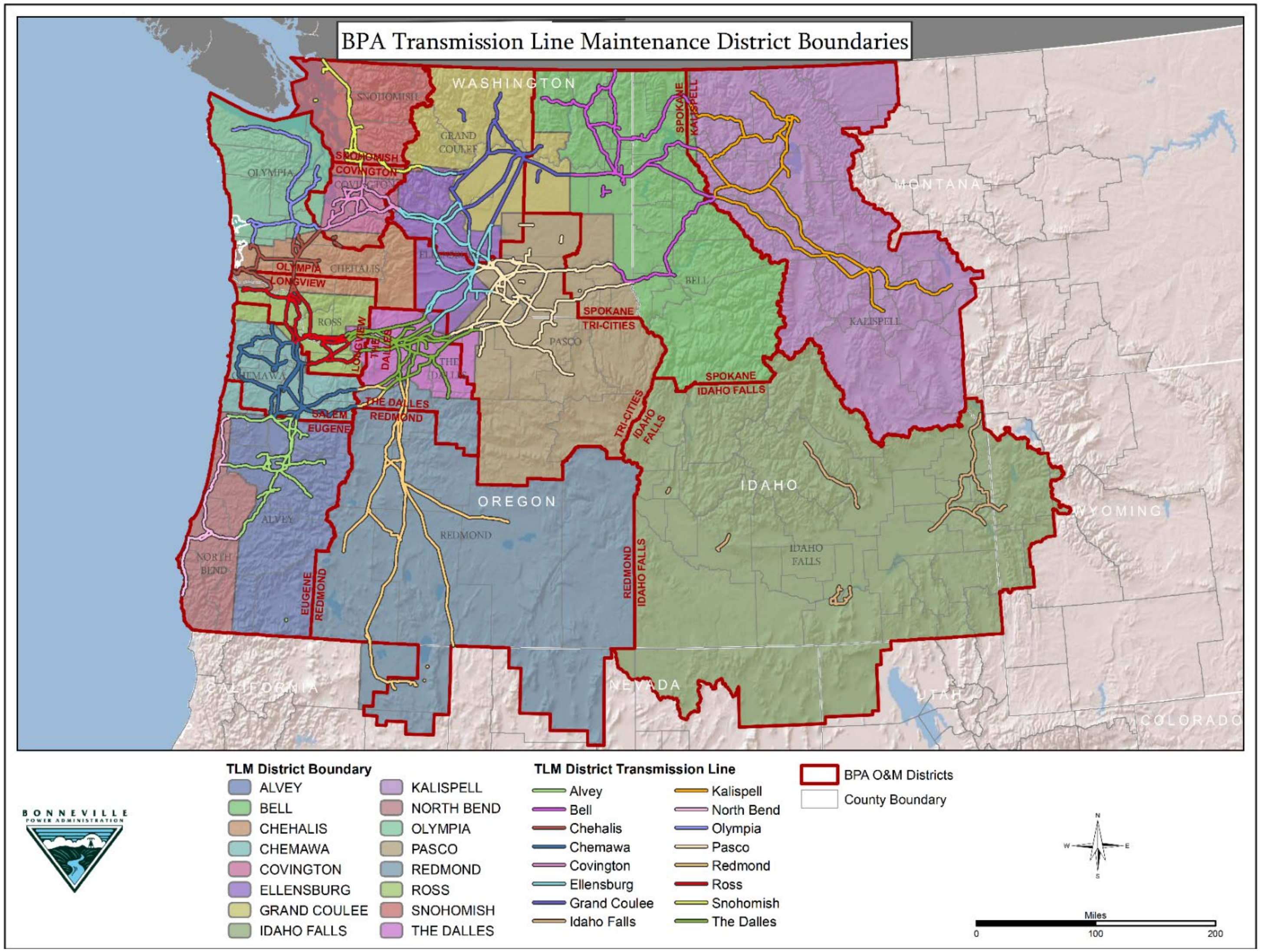


Figure 3. Current BPA service area delineated by Transmission Line Maintenance (TLM) districts.[15]

[15] AECOM, GIS Services (Portland, OR: AECOM, 2021).

2. Historical Overview: Chronological Development

This section summarizes the chronological development of BPA's transmission network during the period of significance. The chronological overview discusses the initial development of BPA's transmission network during the Master Grid period (1938 to 1945) and the growth occurring during System Expansion Period (1946 to 1974), while identifying key historical themes that are addressed in Section 3. Most of the chronological overview is derived from BPA's annual reports (Figure 4). Table 1 shows five-year increments of BPA's reported sources of revenue between 1940 and 1974 to illustrate the changing needs of BPA's transmission system during the period of significance.

A broader discussion of BPA's administrative history and development can be reviewed in Curran (1998), Kramer (2010), and Kramer (2012).

Figure 4. Collection of BPA Annual Report Covers from 1938-1974.[16]

[16] BPA, "Annual Reports" Annual Reports - Bonneville Power Administration (bpa.gov)

Table 1. BPA Sources of Revenue during the Period of Significance

Fiscal Year	Aluminum Industry		Publicly Owned Utilities		Privately Owned Utilities		Other Industry		Federal Agencies and Military Establishments		Wheeling Agreements and Other Revenue		Total
<1941	$0	0%	$12,347	2.9%	$413,922	97.0%	$275	0.1%	$0	0%	$0	0%	**$426,544**
1941	$1,075,809	57.4%	$119,659	6.4%	$686,882	36.7%	$12,899	6.9%	$254	0%	$120	0%	**$1,895,623**
1945	$11,838,156	51.5%	$2,141,635	9.3%	$4,752,021	20.7%	$3,780,727	16.5%	$390,742	1.7%	$86,737	0.4%	**$22,990,018**
1950	$12,133,254	38.9%	$8,409,428	27.0%	$7,587,963	24.3%	$2,677,580	8.6%	$0	0%	$389,291	1.3%	**$31,192,834**
1955	$16,909,588	32.5%	$17,601,135	33.8%	$9,926,150	19.1%	$6,821,850	13.1%	$0	0%	$807,759	1.6%	**$52,066,482**
1960	$17,460,841	24.5%	$28,537,729	40.1%	$12,566,587	17.7%	$10,378,893	14.6%	$0	0%	$2,256,513	3.2%	**$71,200,563**
1965	$22,998,000	28.1%	$41,738,000	50.9%	$5,537,000	6.8%	$4,950,000	6.1%	$6,746,000	8.3%	$5,316,000	6.5%	**$87,285,000**
1970	$44,614,000	30.2%	$58,420,000	39.6%	$20,319,000	13.8%	$5,449,000	3.7%	$4,090,000	2.8%	$10,028,000	10.0%	**$147,680,000**
1974	$41,291,000	22.3%	$83,034,000	44.9%	$25,380,000	13.7%	$4,870,000	2.60%	$6,699,000	3.6%	$23,725,000	12.9%	**$184,999,000**

2.1 Master Grid Period (1938 to 1945)

Between 1938 and 1945, BPA built 3,000 circuit miles of transmission lines in its Master Grid Transmission network to interconnect with existing public, private, and municipal distribution systems (Figure 5). The system supplied inexpensive Columbia River power to rural communities and attracted major industries to the region.[17] The Master Grid functioned through a network of high-voltage lines, as well as numerous substations and related facilities.[18]

During World War II (WWII), the Master Grid network advanced the region's significant wartime industries by supplying power to support shipyard production and aluminum manufacturing sites for aircraft construction.[19] BPA also powered the Hanford, Washington site where the U.S. produced the plutonium used in the atomic bomb dropped on Nagasaki, Japan in August, 1945. In 1942, war industries purchased 81.4 percent of BPA's power.[20]

To maximize wartime production, the federal government encouraged BPA to interconnect with other electrical systems, and in August, 1942 the Northwest Power Pool (now Western Power Pool) was formed with the region's major electrical utilities.[21] Revenues more than doubled in the year that followed increasing from $5,162,376 in 1942 to $11,265,468 in 1943.[22] After the war and the decline of the defense industry, BPA power facilitated the development of regional agriculture and industry, including mining, raw material processing, and timber.[23]

---

[17] Curran, "A Historic Context," 2, 58.

[18] Kramer, *BPA Transmission System MPDF*, 2.

[19] Kramer, *Corridors of Power*, 5.

[20] BPA, *Annual Report of the Administrator of the Bonneville Power Administration to the Secretary of the Interior* (Washington, D.C.: U.S. Department of the Interior, 1942), 29.

[21] BPA, *Annual Report of the Administrator of the Bonneville Power Administration to the Secretary of the Interior* (Washington, D.C.: U.S. Department of the Interior, 1943), 14.

[22] BPA, *Annual Report of the Administrator* (1943), 4-5.

[23] Kramer, *Corridors of Power*, 5.

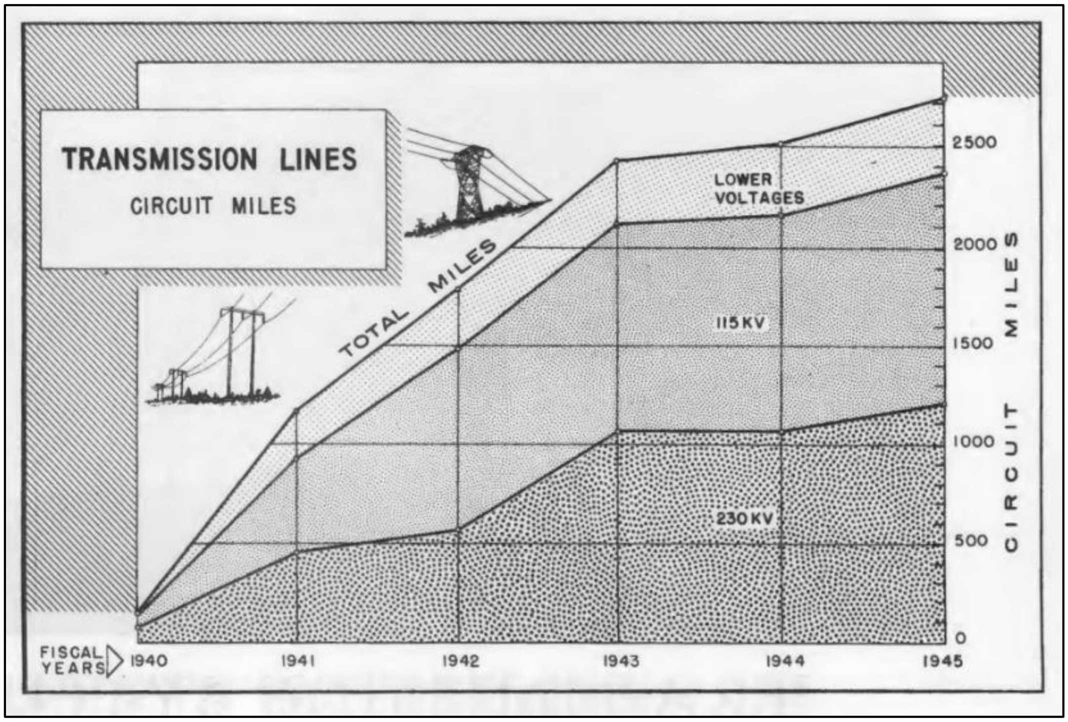


Figure 5. Completed BPA transmission network categorized by voltage and circuit miles (1940-1945).[24]

[24] BPA, *Annual Report* (1945), 14.

Significant developments in BPA history during the Master Grid period include the following:

- Construction of BPA's first steel tower line began in March 1939; by the end of the year, construction of the initial transmission lines were completed and partially energized.[25]
- Construction of two 500-foot steel towers in 1939 to provide 3,756 feet of coverage over the Columbia River (Figure 6); when completed, these were the highest crossing towers constructed for transmission line purposes at the time.[26]
- In 1940, 16 substations and 22 transmission lines were designed, 32 transmission lines spanning 1,750 miles were surveyed, and 12 transmission lines were completed.[27]
- In 1941, 1,176.8 miles of transmission lines had been constructed, energized, and placed in service along with 20 substations.
- In 1941, BPA established a network to provide electrical service to nearly every major power load center in Oregon and Washington.[28]
- Due to supply shortages of steel during World War II, BPA transitioned to constructing 230-kV lines with wood poles and a variety of crossarm materials (wood and aluminum) instead of the traditionally used steel that had long been adopted by the industry.[30]

Figure 6. Line workers completing a high-tension transmission line in the Columbia River Gorge circa 1941.[29]

[25] BPA, *Second Annual Report* (1939), 48; BPA, *Third Annual Report of the Bonneville Power Administration* (Washington, D.C.: U.S. Department of the Interior, 1940).

[26] BPA, *Bonneville Power Administration Inservice Training Series Volume 3: Building the System* (Portland, OR: U.S. Dept. of the Interior, Bonneville Power Administration, 1942).

[27] BPA, *Third Annual Report,* 109.

[28] BPA, *Annual Report of the Administrator of the Bonneville Power Administration to the Secretary of the Interior* (Washington, D.C.: U.S. Department of the Interior, 1941), 73-74.

[29] Ibid., 58.

[30] A. A. Osipovich, *H-frame 230-Kv Wood Pole Crossarm Design Practice* (Portland, OR: Bonneville Power Administration, 1948), 99.

- Power sales to the Pacific Northwest's publicly owned and operated distribution entities nearly doubled between 1942 and 1943.[31]
- In collaboration with BPA, the regional governors' association issued its Advance Program report in 1944 that included plans for a Columbia basin-wide program for hydroelectric developments in Oregon, Washington, Idaho, and Montana. The plans also included additional projects involving irrigation, navigation, and flood-control improvements as well as $100,000,000 for new transmission lines and substations to coordinate existing and proposed dams and load centers in a region-wide transmission grid system.[32]

Associated themes with this period include the Master Grid as its own significant theme, as well as Military, Industry, Population Growth and Community Development, and Integration with Utilities across the region.

2.2 System Expansion Period (1946 to 1974)

During the System Expansion Period (1946-1974), BPA connected new power generation facilities on the Columbia River and its tributaries to help accommodate the region's post-war growth. The Columbia River Treaty (1964) between the U.S. and Canada in addition to the establishment of the Pacific Northwest-Pacific Southwest Intertie enabled BPA to further expand its network and begin marketing surplus power to southern California.[33] [34] As BPA expanded its transmission and communication network during the 1950s and 1960s, it implemented technological innovations to increase capacity and reliability. Completion of the William A. Dittmer Control Center in 1974 marked the end of BPA's System Expansion Period, as well as the end of BPA's manual control systems. Dittmer housed new computer-based management systems that relied on microwave communication facilities to gather and transmit massive amounts of data.[35] The implementation of Public Law 93-454 in 1974, known as the Federal Columbia River Transmission Act, transformed BPA's funding and operations by allowing BPA to manage its own funds rather than going to Congress for appropriations. This helped mark the end of the System Expansion Period.[36]

2.2.1 1946 to 1950

The initial post-war era is characterized by a transition away from war industries, diversification of revenue sources, and focus on expanding BPA's transmission network to reach underserved areas and promote industrial and community development. Between 1946 and 1950, BPA's transmission line system became the largest in the nation, expanding from two to five states and from 2,737 to 4,040 circuit miles of transmission lines with 70 substations.[37] The Pacific Northwest's population grew by 44 percent during the 1940s, far outpacing the nation's average growth of 13 percent, partially due to the available employment in war industries, which had attracted new residents from other parts of the country. Farms and businesses found new uses for electric power, and in American homes the need for electricity steadily increased as new all-electric labor-saving devices were added, kitchens and laundries were upgraded, and better lighting was introduced. Between 1946 and 1950, BPA experienced massive growth in revenue from publicly owned utilities. These customers increased nearly 5-fold, comprising 26.96

[31] BPA, *Annual Report of the Administrator* (1943), 7.

[32] BPA, *Annual Report of the Administrator of the Bonneville Power Administration* (Washington, D.C.: U.S. Department of the Interior, 1944), 44.

[33] Kramer, *Corridors of Power*, 5.

[34] Kramer, *BPA Transmission System MPDF*, 3.

[35] BPA 1972, 24

[36] Kramer, *BPA Transmission System MPDF,* 3.

[37] BPA, *Columbia River Power System* (1945), 13; BPA, *Report on the Columbia River Power System* (Portland, OR: Bonneville Power Administration, 1950), 29-30.

percent of BPA's revenue in 1950 compared to 8.61 percent in 1946.[38] Industrial revenue, led by aluminum manufacturing plants but including other industries also increased year-over-year, although the overall percentages slightly dropped.[39]

Significant developments in BPA history during this period include the following:

- Connection with the British Columbia Electric Company in 1947 to permit the flow of excess power to and from Canada, when available.[40]
- Development of new transmission lines in southwest Oregon in 1948 to create a connection with the center of the region's timber industry.[41]
- Construction of Grand Coulee-Snohomish Line and the North Bonneville-Troutdale Line, which delivered power from Grand Coulee to major coast load centers in the Puget Sound and lower Columbia areas in 1949 (Figure 7).[42]
- Three-fold increase in Pacific Northwest power requirements in terms of energy use between 1940 and 1949.[43]
- BPA's wheeling agreement policy: originated in the 1950s when Grant and Chelan County Public Utility Districts (PUDs) built Priest Rapids and Rocky Reach dams; BPA agreed to wheel power from the dams to utilities who owned a fractional share of their output.[44]
- Completion of Hungry Horse Dam in 1950, which began BPA's agreement to supply uninterrupted power to several manufacturers in western Montana.[45]
- Completion of lines in March 1947 to serve power shortage areas in central Washington.[46]

[38] BPA, *Columbia River Power System* (1950), 2.

[39] BPA, *Report on the Columbia River Power System* (Washington, D.C.: U.S. Department of the Interior, 1949), 41.

[40] BPA, *Report on the Columbia River Power System* (Washington, D.C.: U.S. Department of the Interior, 1947), iv.

[41] BPA, *Report on the Columbia River Power System* (Washington, D.C.: U.S. Department of the Interior, 1948), 27.

[42] BPA, *Columbia River Power System* (1949), 33.

[43] BPA, *Columbia River Power System* (1949), 41.

[44] BPA, *1966 Report: U.S. Columbia River Power System* (Washington, D.C.: U.S. Department of the Interior, 1966), 20.

[45] BPA, *Columbia River Power System* (1950), iii.

[46] BPA, *Columbia River Power System* (1947), 6-7.

Figure 7. Workers Installing Transmission Structure at Grand Coulee Dam, 1949.[47]

Associated themes with this period include Industry, Population Growth and Community Development, Power Generation Diversification, and Integration with Utilities across the region.

2.2.2 1951 to 1955

By 1951, 9,233 circuit miles of transmission Lins at 220-kV or higher were operating in the United States. The Pacific Northwest accounted for 2,699 circuit miles (29 percent) and BPA owned 80 percent of these transmission lines.[48] Between 1951 and 1955, BPA's network grew throughout the region to 6,702 circuit miles of transmission lines and 51 new substations (Figure 8 8).[49] The aluminum industry's incremental growth began slowing down, generating smaller revenue increases. The percentage of revenue from the aluminum industry dropped from 37.37 to 32.48 percent, caused by an increased share in revenue from publicly owned utilities, which grew from 27.49 to 33.81 percent (Table 1).

[47] NARA, "Grand Coulee Dam-49-10-6-(E20026)," Seattle, Wash.: NARA), 1949.

[48] S. E. Schultz, *High Voltage Power Transmission in the Pacific Northwest* (Portland, OR: Bonneville Power Administration), 1953.

[49] BPA, *Bonneville Power Administration 1955 Report* (Washington, D.C.: U.S. Department of the Interior, 1955), 37.

Significant developments in BPA history during this period include the following:

- Completion of the final links in BPA's 230-kV backbone grid in late 1952[50]
- Expansion of BPA's network in 1952 to connect with central and southwest Oregon[51]
- Completion of the Hot Springs-Anaconda 230-kV Line in 1952, bringing low-cost BPA power to western Montana industries and public agencies[52]
- Completion of the first extra-high-voltage 345-kV test transmission line and construction on the first two 345-kV transmission lines (Chief Joseph-Snohomish and McNary-Ross) in 1954;[53] the Washington lines were the first 345-kV lines west of the Rocky Mountains and facilitated transmission to major load centers in Seattle and Portland-Vancouver.[54]
- An expanded "wheeling" program instituted in 1954 integrated and coordinated with Columbia River Basin generating and transmission facilities; the expanded program made it possible to integrate all plants contributing to the Northwest Power Pool[55]

Associated themes with this period include Industry, Population Growth and Community Development, Integration with Utilities across the region, Power Generation Diversification, and Technology and Design.

Figure 8. Clearing of right-of-way for the Olympia–Grand Coulee transmission line ca. 1953.[56]

2.2.3 1956 to 1960

By the mid-1950s, BPA determined their power system had sufficient capacity in some areas to permit the addition of 345-kV circuits into the grid.[57] By the late 1950s, economic studies indicated 500-kV was the most economical voltage and would serve the needs of the Northwest

[50] BPA, *1962 Report on the U.S. Columbia River Power System* (Washington, D.C.: U.S. Department of the Interior, 1962), 20-21.

[51] BPA, *1962 Report*, 20-21.

[52] BPA, *1962 Report*, 20-21.

[53] A.A. Osipovich, "Full Scale Tests Prove BPA's 345-Kv." *Electrical World,* February 8, 1954.

[54] BPA, *1962 Report*, 20-21.

[55] BPA, *1960 Report on the U.S. Columbia River Power System* (Washington, D.C.: U.S. Department of the Interior, 1960), 9.

[56] BPA, *1953 Report on the Columbia River Power* System (Washington, D.C.: U.S. Department of the Interior, 1953), 35.

[57] W.L. Colhouer and G.C. Conner, "Bonneville Power Administration's Planning and Economic Considerations for a 500-kV Pacific Northwest Transmission Grid" (presented at the IEEE Summer General Meeting and Nuclear Radiation Effects Conference, Toronto, Ontario, Canada, June 16-21, 1963), 4.

for many years.[58] During this period, BPA continued to expand its network geographically, increasing the supply of reliable power to urban and rural areas while introducing higher voltage transmission lines and new substations (Figure 9). Between 1956 and 1960, BPA's network expanded from 7,680 to 8,028 miles of transmission lines with 15 more substations for a total of 201.[59] Revenue from the aluminum industry continued to decline from 32.96 to 24.52 percent, as revenue from publicly owned utilities increased from 31.98 to 40.08 percent.

Significant developments in BPA history during this period include the following:

- In 1956, construction was competed to integrate new power generation from McNary Dam, Chief Joseph Dam and other federal power plants with BPA's grid and carry it to major load centers.[60]
- In 1957, two 345-kV lines were added to the system, the first of their kind in the nation. The lines connected power to urban centers: the McNary-Ross Line served the Portland-Vancouver load centers and Chief Joseph–Covington Line served the Puget Sound area.[61]
- In 1957, 230-kV lines reinforced the power supply to rural communities in the Willamette Valley, southwest Oregon, Puget Sound and Olympic Peninsula.[62]
- In 1960, the U.S. and Canada reached an agreement on the terms of their treaty for cooperative development of water resources, setting in motion power development of Canadian storage projects and Libby Dam that would bring low cost power to the U.S.[63]

Associated themes with this period include Industry, Population Growth and Community Development, Integration with Utilities across the Region, and Power Generation Diversification.

[58] Colhouer and Conner, "Planning and Economic Considerations," 4.

[59] BPA, *Bonneville Power Administration 1956 Report* (Washington, D.C.: U.S. Department of the Interior, 1956), 4; BPA, *1960 Report*, 6.

[60] BPA, *1956 Report,* 3.

[61] BPA, *1957 Report on the Columbia River Power System* (Washington, D.C.: U.S. Department of the Interior, 1957), 37.

[62] BPA, *1957 Report*, 39.

[63] BPA, *1959 Report on the Columbia River Power* System (Washington, D.C.: U.S. Department of the Interior, 1959), 2.

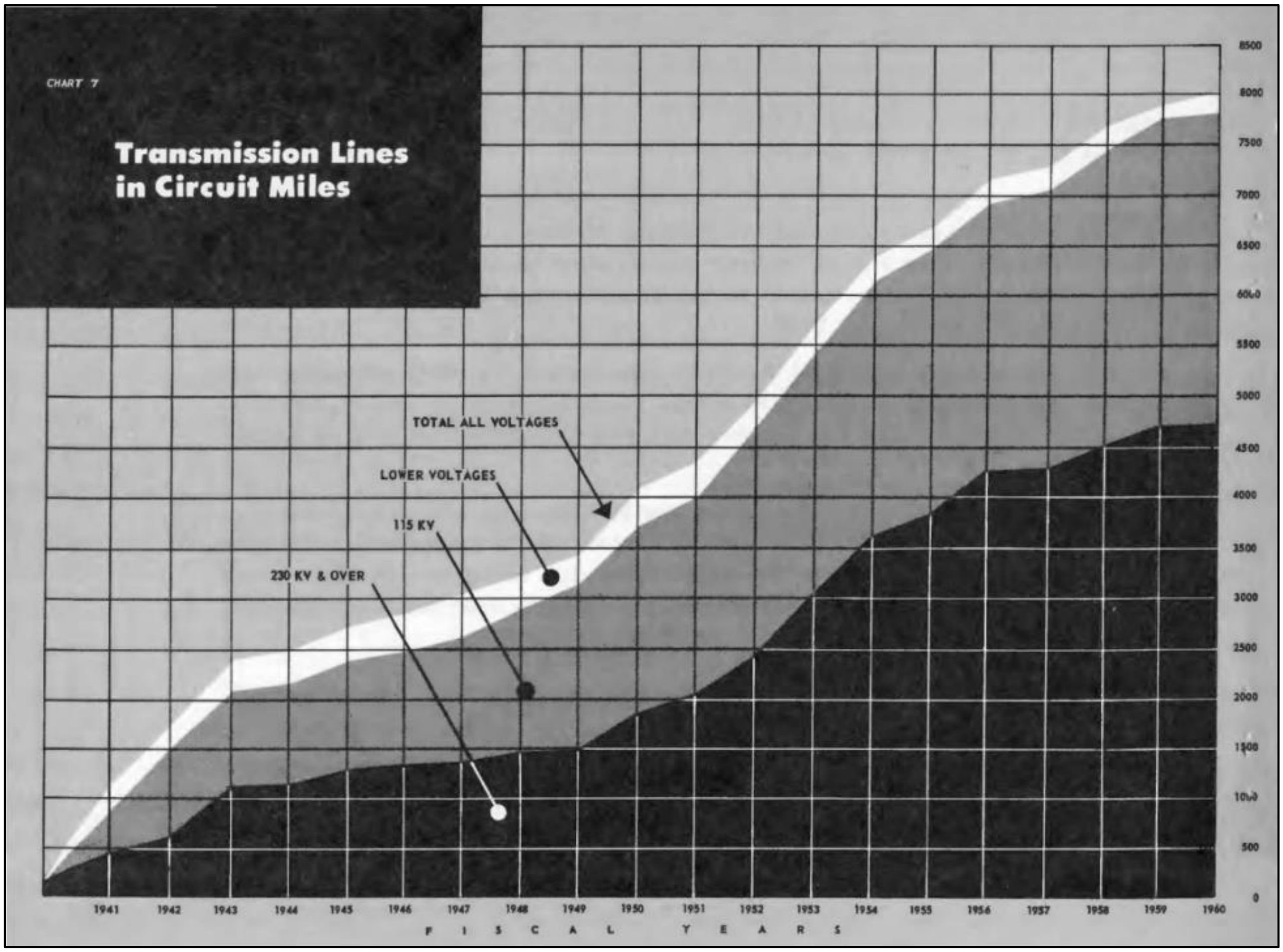


Figure 9. Comparison of BPA transmission lines' mileage by voltage (1941-1960).[64]

2.2.4 1961 to 1965

BPA's network continued to expand during the first half of the 1960s. Between 1961 and 1965, circuit mileage of transmission lines increased from 8,244 to 9,327; 55 new substations were constructed for a total of 263 (Figure 10).[65] In 1962, BPA decided to begin installing 500-kV lines over the existing system to reduce cost and deliver power from the John Day Dam, which was still under construction on the Columbia River and scheduled to be energized in 1967.[66] During this period, revenue from aluminum industries rebounded from the previous decade as revenue from publicly owned utilities dramatically increased from 31.98 percent in 1956 to 50.92 percent in 1965.[67]

[64] BPA, *1960 Report,* 26.

[65] BPA, *1961 Report*, 3; BPA, *1965 Report,* 13.

[66] BPA, *1962 Report on the U.S. Columbia River Power System* (Washington, D.C.: U.S. Department of the Interior, 1962), 4.

[67] BPA, *1961 Report on the U.S. Columbia River Power System* (Washington, D.C.: U.S. Department of the Interior, 1961), 20; BPA, *1965 Report, U.S. Columbia River Power System*. U.S. Department of the Interior, 1965.

Significant developments in BPA history during this period include the following:

- President Eisenhower and Canadian Prime Minister John Diefenbaker signing the Columbia River Treaty on January 17, 1961.[68]
- President Lyndon Johnson and Canadian Prime Minister Lester Pearson sign the Columbia Treaty Protocols on September 16, 1964, ratifying the treaty.
- Congress authorizing development of the Bruces Eddy (Dworshak) and Asotin dams on the Columbia River in Idaho.[69]
- BPA conducts a feasibility study regarding the potential of interregional transmission interties and experimental testing facilities for 500-kV alternating current (AC) and 750-kV direct current (DC) transmission in 1962.[70]
- The Columbia River Treaty allowed for the construction of three large storage dams in Canada and the Libby Dam in Montana, which backs water up into Canada. The three Canadian storage dams were designed to hold back flood waters and release them as needed to produce additional power at dams downstream in the U.S.[71]
- Beginning of construction on a new $2 million extra-high-voltage DC test center at the Big Eddy Substation near The Dalles, Oregon in February 1963 (Energized on November 4, 1963).[72] BPA's purpose was to gather information for best practices in conducting HVDC power from Big Eddy to southern California. The substation includes 5-mile test line, large domed power-supply, and flashover and insulator test areas.
- Construction of a 500-kV line between Arlington and Blaine, Washington and a 230-kV line from Bell Substation to the Canadian border to provide transmission capacity for delivery to the Canadian border and interconnect with the West Kootenay Power and Light Company.[73]
- Congress approving the Pacific Northwest-Pacific Southwest extra-high-voltage interties in August 1964.[74]
- Beginning of construction on 750-kV AC lines between the John Day Substation in Oregon to California, and two DC lines connecting the Big Eddy Substation in Oregon with Nevada in 1964.[75]
- New "Delta Configuration" tower type first erected outside Bend, Oregon in 1965.[76]
- Approval of BPA's first rate increase (between 2.4 and 2.9 percent) by the Federal Power Commission went into effect December 20, 1965.[77]

Associated themes with this period include Population Growth and Community Development, Integration with Utilities across the Region, Power Generation Diversification, and Innovative Technology and Design.

---

[68] Kramer, *Corridors of Power,* 81.

[69] BPA, *1962 Report,* iv. The Asotin Dam project was canceled in 1980.

[70] BPA, *1962 Report,* 12.

[71] BPA, *1962 Report,* iv; BPA, *1964 Report on the U.S. Columbia River Power System* (Washington, D.C.: U.S. Department of the Interior, 1964), 7-8.

[72] BPA, *1963 Report on the U.S. Columbia River Power System* (Washington, D.C.: U.S. Department of the Interior, 1963), iii.

[73] BPA, *1963 Report,* 5.

[74] BPA, *1964 Report,* i.

[75] BPA, *1964 Report,* 28.

[76] BPA, *1965 Report,* 17.

[77] BPA, *1965 Report,* i.

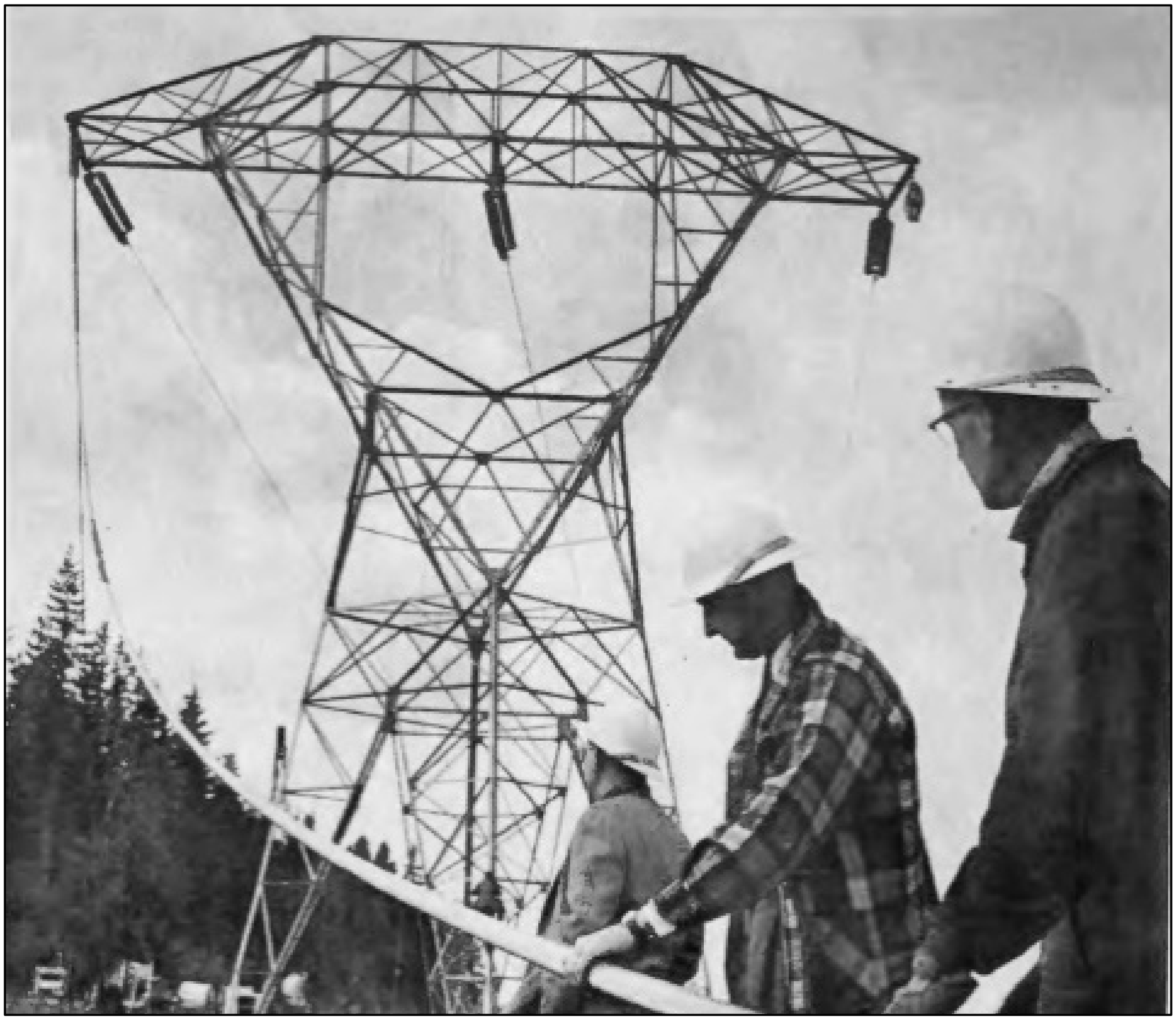


Figure 10. BPA engineers checking the experimental 500-kV conductor as the first string of the test installation is being pulled into place ca. 1961.[78]

2.2.5 1966 to 1970

During the second half of the 1960s, BPA continued the expansion of their transmission network throughout the Pacific Northwest, while replacing older lower-voltage transmission lines with 500-kV lines, experimenting with higher-voltage 800-kV transmission lines and implementing a new beautility program for the design of transmission lines and substations.[79] During this time consumption of electrical power in the U.S. continued a pattern of doubling approximately every 10 years.[80] To meet this power demand, eight federal dams were under construction in 1967, marking the biggest construction year in BPA's history to date (Section 3.5.1).[81] By 1970, BPA's network expanded to include 11,378 circuit miles of transmission lines, with 208 miles of 500-kV lines and 265 miles of 800-kV lines added in 1970 alone.[82]

---

[78] BPA, *1961 Report*.

[79] BPA, 1970 *Annual Report: Federal Columbia River Power System* (Washington, D.C.: U.S. Department of the Interior, 1970), 22.

[80] Matthew Marjerrison, "Electrical Transmission Tower Design" (presented at the American Society of Civil Engineers Structural Engineering Conference in Seattle, Washington, May 8-12, 1967), 1.

[81] BPA, *1967 Annual Report: U.S. Columbia River Power System* (Washington, D.C.: U.S. Department of the Interior, 1967), 23.

[82] BPA, 1970 *Annual Report*, 4.

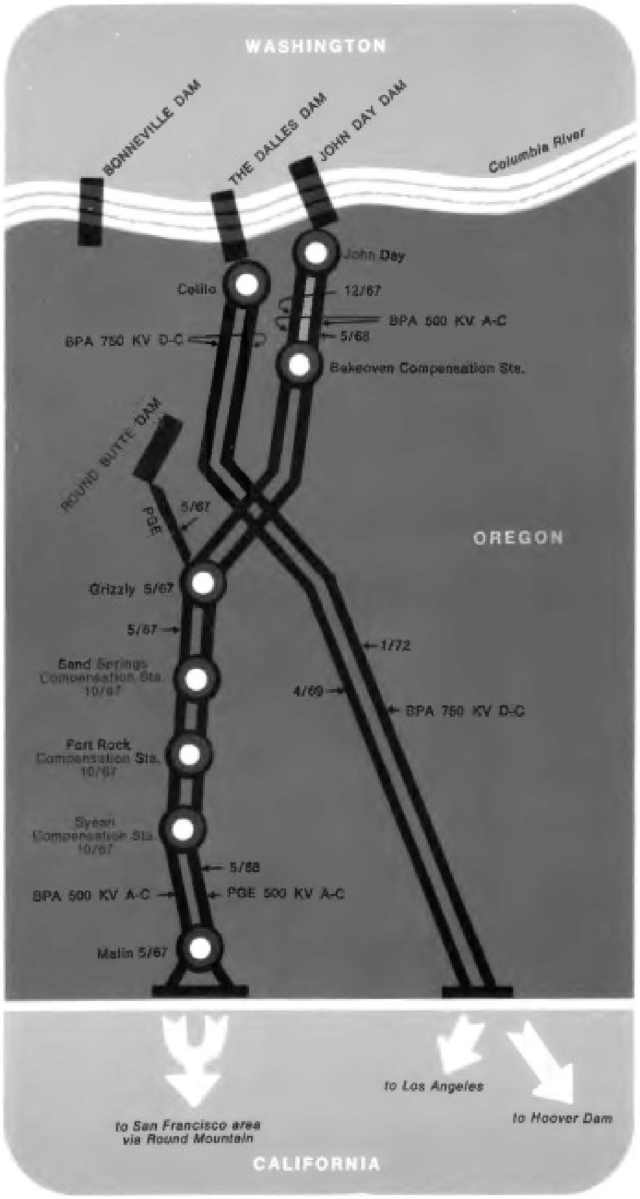


Figure 11. Diagram of the original proposal for the Pacific Northwest-Pacific Southwest Intertie system circa 1966, the year the first 500-kV section of the Intertie was completed. The line to Hoover Dam was never built.

Significant developments in BPA history during this period include the following:

- Stanton, Boles, Maguire, and Church released a report in 1966 on their beautility concept for BPA, including changes in BPA's paint color scheme to reflect new "design excellence" requirements.
- April 8, 1966: the first 25,000 kilowatts of power from the Hanford, Wash. nuclear power plant came online at 5:25 p.m.[83]
- BPA completed the northern section of the first 500-kV line for the Pacific Northwest-Pacific Southwest Intertie on September 20, 1967. The 89-mile transmission line connected John Day Dam with the Grizzly Substation near Madras, Oregon (Figure 11).[84]
- Duncan Dam in British Columbia came online July 31, 1967, the first of four projects funded by the Columbia River Treaty.[85]
- BPA established the Advanced Control and Dispatch Program to implement a comprehensive computer system across their network.[86]
- In 1968, BPA began selling federally generated and marketed power in southern Idaho. This designation allowed BPA to offer lower rates and create opportunities for industrial expansion in this region.[87]
- The first AC line of the Pacific Northwest-Pacific Southwest Intertie goes into operation in January 1968 and the second in May 1968. These lines were constructed by six different power organizations and were approximately 2,000 miles long.[88]

---

[83] BPA, *1966 Annual Report,* 11.
[84] BPA, *1967 Annual Report,* 10.
[85] BPA, *1967 Annual Report,* 15.
[86] David S. Black, "Northwest Power Program," *Power Engineering* (August 1967), 38-39.
[87] BPA, *1963 Report,* ii, 1.
[88] BPA, *1968 Annual Report: Federal Columbia River Power System* (Washington, D.C.: U.S. Department of the Interior, 1968), 15.

- High Arrow Dam (known today as Keenleyside Dam) in British Columbia was completed on October 10, 1968, the second of four Columbia River Treaty projects.[89]
- Construction was initiated on the 116-mile 500-kV Raver-Paul-Allston transmission line to connect the Seattle and Portland areas.[90]
- On May 21, 1970, the Pacific Northwest-Pacific Southwest DC Intertie was energized between the Celilo Converter Station above The Dalles Dam on the Columbia River in Oregon and Sylmar, California near Los Angeles. At 846 miles, it was the world's longest high-voltage direct-current transmission line.[91]

Associated themes with this period include Population Growth and Community Development, Integration with Utilities across the Region, Power Generation Diversification, BPA's Growing Environmental Ethic, and Innovative Technology and Design.

2.2.6 1971 to 1974

In the 1970s BPA and other federal agencies began focusing more attention on the environmental effects of their actions, mainly due to the enactment of the National Environmental Policy Act (NEPA), which was signed into law by President Richard M. Nixon on January 1, 1970. NEPA solidified a change in BPA's construction practices by requiring more careful consideration of environmental impacts. Like the previous decade, BPA continued the installation of 500-kV lines into their network, but introduced new environmental procedures and transmission siting policies to limit pollution and the amount of timber necessary to be cleared for new transmission lines.[92] The transmission network expanded from 11,482 miles in 1971 to 12,074 miles in 1974 with 500-kV transmission lines accounting for 20 percent.[93]

Significant developments in BPA history during this period include the following:

- The use of a helicopter for the first time in 1973 to clear timber and construct the 500-kV Hanford-Ostrander Line in order to limit impacts on the environment.[94]
- Energization of BPA's first 500-kV transmission lines in Idaho and Montana in 1973: the 143-mile Dworshak-Hot Springs Line in Idaho and Montana, and the 94-mile Little Goose-Dworshak Line between Washington and Idaho.[95]
- Adoption of multiple-bundle conductors as standard designs for high-voltage lines to minimize audible and radio noise.[96]
- Completion of the 230-kV line between the Toledo and Wendson substations along the Oregon coast in January 1973 closed the Santiam-Toledo-Wendson-Eugene area loop, improving service reliability for coastal communities and helping meet increasing load demands.[97]

---

[89] BPA, *1968 Annual Report,* 21.

[90] BPA, *1969 Annual Report: Federal Columbia River Power System* (Washington, D.C.: U.S. Department of the Interior, 1969), 21.

[91] BPA, *1970 Annual Report*, 3.

[92] BPA, *1971 Annual Report: Federal Columbia River Power System* (Washington, D.C.: U.S. Department of the Interior, 1971), 23; BPA, *1972 Annual Report: Federal Columbia River Power System* (Washington, D.C.: U.S. Department of the Interior, 1972), 30-31; BPA, *1973 Federal Columbia River Power System Annual Report* (Washington, D.C.: U.S. Department of the Interior, 1973), 18.

[93] BPA, *1971 Annual Report*, 23; BPA, *Annual Report on the U.S. Columbia River Power System* (Washington, D.C.: U.S. Department of the Interior, 1976), 9.

[94] BPA, *1973 Annual Report*, 15-16.

[95] BPA, *1973 Annual Report*, 15-16.

[96] BPA, *1972 Annual Report*, 31.

[97] BPA, *1973 Annual Report*, 15.

- The Mica Dam in British Columbia, the last Columbia River Treaty project, is completed in March 1973.[98]
- Dedication of the Dittmer Control Center in August 1974.[99]
- Passage of the Federal Columbia River Transmission System Act, which allows BPA to use its revenues to operate and maintain the transmission system rather than seek annual appropriations from Congress, 1974.
- Implementation of Hydrothermal Power Program Phase 1 activities, including planning and early construction of nuclear and coal facilities that would mostly go into operation after the period of significance.[100]
- Test operation of the first 700-kV unit at the Centralia, Washington coal-fired steam plant began August 13, 1971, with energy generated during test periods delivered to BPA.[101] Commercial operation of the plant began in 1973.[102]
- Energization of the first 500-kV Compressed Gas Insulated Transmission System (CGITS) in the United States on August 13, 1975.[103]

Associated themes with this period include Population Growth and Community Development, Integration with Utilities across the Region, Power Generation Diversification, BPA's Growing Environmental Ethic, and Innovative Technology and Design.

[98] BPA, *1973 Annual Report*, 32.

[99] BPA, *1974 Annual Report*, 10.

[100] BPA, *1974 Annual Report*, 9.

[101] BPA, *1972 Annual Report*, 11.

[102] BPA, *1971 Annual Report*, 8-9; BPA, *1974 Annual Report*, 9.

[103] BPA, *Annual Report on the U.S. Columbia River Power System* (Washington, D.C.: U.S. Department of the Interior, 1975), 13.

3. Historical Overview: Significant Historic Themes

This section summarizes the significant historic themes associated with BPA's transmission line development. Many overlap. The summaries can be applied to BPA's transmission lines when assessing their historic significance. Key historic themes in this section include the following:

- BPA's Master Grid, including the Bonneville Project Act and BPA's efforts to generate a basis for regional power, as well as initial construction and development
- Military, including BPA's role in World War II and the Cold War
- Industry, including BPA's power supply to aluminum and other regional industries
- Population growth, including rural electrification and urban growth and development
- Integration with utilities across the region, including BPA's involvement in the Northwest Power Pool, wheeling agreements and the Columbia River Treaty
- Power generation diversification, including hydroelectric developments and BPA's role in the Hydrothermal Power Program
- BPA's growing environmental ethic
- Technology and design, including design engineering, BPA's beautility movement, the Pacific Northwest-Southwest Intertie, transmission testing, and computers and automation

Other contextual themes may exist within BPA's history that are more relevant to other resource types in BPA's system, such as substations.

3.1 Developing BPA's Master Grid

BPA's initial Master Grid development created a regional power grid in Oregon and Washington to provide hydropower from the Bonneville and Grand Coulee Dams to the region, enable rural electrification, and support the World War II-era defense industry.

3.1.1 The Bonneville Project Act and Generating a Basis for Regional Power

Bonneville Dam sited along the border of Oregon and Washington on the Columbia River was the first in a planned ten-dam chain on the Columbia River. The dam was intended to improve navigation on the river with its locks, but its primary function was the production of electric power. The project was funded by the Public Works Administration and provided many jobs as one of countless federal building projects undertaken during the Great Depression. In 1933, Secretary of the Interior Harold Ickes authorized the projects for Grand Coulee Dam and Bonneville Dam, and construction on both dams began that same year.[104] As the construction of Bonneville Dam was nearing completion, Congress enacted the Bonneville Project Act in 1937, providing for an organization to market federal Columbia River Power as a bureau in the Department of Interior.

In 1938, BPA's first administrator, James Delmage (J.D.) Ross (1872-1939), proposed a "Master Grid" transmission network to connect Bonneville Dam (on the border of Washington and Oregon) and the newer Grand Coulee Dam (in northeastern Washington on the Columbia River) with the Portland, Oregon and Puget Sound, Washington areas. This Master Grid design was envisioned by Charles Carey, BPA's first Chief Engineer.

[104] Curran, "A Historic Context," 36.

The proposed Master Grid plan would tie Pasco, Yakima, Spokane, and Ellensburg, Washington via a 230- kV circuit loop. The network also linked to Washington and Oregon coastal areas and extended south through Oregon's Willamette Valley to the California border through radiating 115-kV lines designed to deliver smaller loads. In May 1938, Congress's first appropriation of $3.5 million enabled BPA to begin Master Grid network construction.[105]

To determine the transmission needs of the Pacific Northwest, field surveyors traveled the region assessing local load conditions in every county within "economic transmission distance" of Bonneville Dam.[106] To calculate appropriate rate schedules, BPA studied the "electrical, physical, and economical factors surrounding the problem of encouraging the widest use of the electric energy generated on the Columbia River for the benefit of the entire general public."[107]

BPA sought construction funding from Works Progress Administration (WPA) and Public Works Administration (PWA) to clear all transmission line right-of-way and road construction in Oregon and Washington. The PWA financed the majority of construction projects during fiscal year 1939, including the following transmission lines and associated substations that would become the initial backbone of BPA's master grid:

- Bonneville–Grand Coulee
- Bonneville–The Dalles
- Bonneville–Vancouver Nos. 1 and 2
- Vancouver-Kelso
- Kelso-Chehalis
- Chehalis-Raymond
- Vancouver–Eugene[108]

Initial Construction and Development

BPA's Master Grid construction and development of its high voltage network can be divided into two stages. The first stage begins with the initial construction and development of the high-voltage network to deliver power from the Grand Coulee and Bonneville dams. As the region's power requirements increased and additional generating plants constructed, the second stage began to expand the 230-kV network. This permitted heavier loading on the 230-kV lines, resulting in more economical transmission with improved service.[109] BPA envisioned a transmission system that could transmit large blocks of power from the Bonneville and Grand Coulee dams and be capable of meeting future energy demands by increasing capacity through construction of additional projects on the Columbia River. The network was intended to allow for "complete integration of all facilities of the region" through unified operation in order to "obtain maximum utilization of the water resources of the various watersheds."[110]

The Master Grid functioned through a network of high-voltage lines as well as numerous substations and related facilities.[111] BPA built 55 substations and 2,736.8 miles of transmission lines in Washington and Oregon (Figures 12-14).[112] By the end of the Master Grid period,

---

[105] Curran, "A Historic Context," 2.

[106] BPA, *First Annual Report of the Bonneville Administrator* (Washington, D.C.: U.S. Department of the Interior, 1938), 30.

[107] BPA, *First Annual Report* (1938), 34.

[108] BPA, *First Annual Report* (1938), 30; BPA, *Second Annual Report* (1939), 49.

[109] Colhouer and Conner, "Planning and Economic Considerations", 4.

[110] BPA, *Third Annual Report* (1940), 70.

[111] Kramer, *BPA Transmission System MPDF*, 2.

[112] BPA, *Columbia River Power System* (1945), 13.

population growth in the Pacific Northwest was exceeding the national average by about 30 percent. Forecasting the region's power needs, BPA and the region's electric utilities and industrial enterprises concluded the demand for power would increase by 45 percent by 1949. In response, BPA entered a new phase in development to increase energy production while expanding their network to better serve customers and promote industrial and community development in the Pacific Northwest.[113]

Figure 12. WPA crew members cleared these trees for the Kelso-Raymond Line right-of-way, June 13, 1939.[114]

[113] BPA, *Highline: The Story of the Construction of a Major Northwest Transmission Line* (Portland, OR: Bonneville Power Administration, 1951).

[114] BPA, *Second Annual Report* (1939), 48.

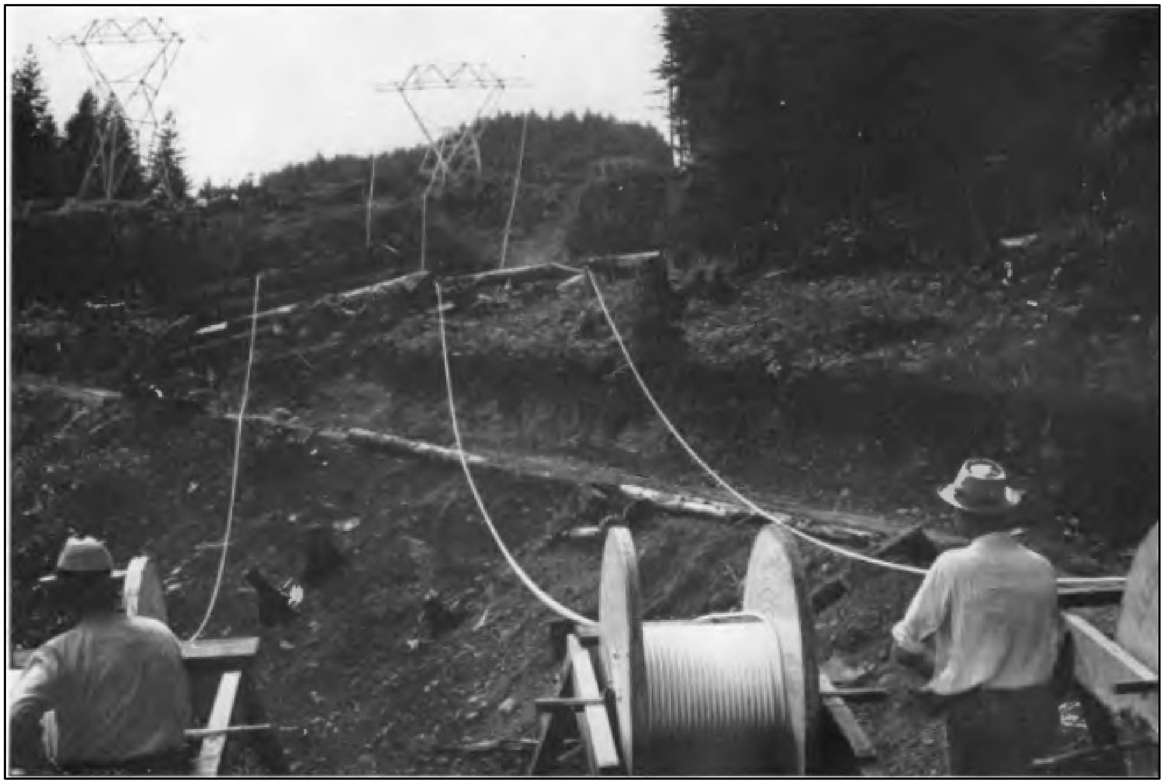


Figure 13. BPA crew stringing conductor for the Bonneville-Vancouver No. 2 Line, looking west near tower 48 ca. 1939.[115]

Figure 14. Completed lattice steel towers on the Bonneville-Grand Coulee line near Coulee City, Washington ca. 1939.[116]

[115] BPA, *Second Annual Report* (1939), 38.

[116] BPA, *Second Annual Report* (1939), 3.

3.2 Military: World War II and the Cold War

BPA's military involvement during World War II and the Cold War primarily involved supplying power to war production industries and government operations through direct service contracts. This section summarizes BPA's military-related transmission developments. Section 0.1 further describes the aluminum industry, one of BPA's key war-time and post-war revenue sources.

3.2.1 World War II

During WWII, BPA supplied power to the region's war-production industries on a massive scale (Figure 15). Aluminum reduction and fabrication (Section 3.3.1) and shipyards were major consumers of Columbia River power. By 1942, BPA was servicing three shipyards in Portland, Oregon and Vancouver, Washington with a supply of power that would not have been available without Bonneville projects.[117] BPA also supplied power to 11 military establishments in the northwest (4 Navy, 7 Army).[118] With each progressive year of the war, BPA continued to increase power generation supplied by the Bonneville and Grand Coulee plants. In 1945, nearly 70% of BPA's revenue was generated through industrial and military contracts (Table 1).

As WWII progressed and wartime facilities operated at capacity, so too were BPA facilities to meet demand. Transmission lines and transformer banks supplying power were repeatedly loaded at and beyond their rated capacity, sometimes 60 percent above their normal ratings. By operating their transmission facilities at maximum capacity in fiscal year 1944, BPA was able to meet all the power demands of their customers as well as supplying more than double the power to other utility systems in the Northwest Power Pool as in the previous year.[119]

BPA played an integral role in the production of 258 ships, including 48 escort carriers, 62 tankers and fleet oilers, Victory cargo ships, and 116 Liberty cargo ships. During the 1945 fiscal year alone, 181 ships were built in Pacific Northwest shipyards supplied by BPA power. Magnesium production for planes and incendiary bombs, calcium carbide for ship welding, and ferrosilicon for steel were also produced at plants using BPA power. These industries were essential in the country's war effort and were envisioned as playing an important role in post-war development of the northwest as a tool for the production of national and regional wealth.[120]

Figure 15. BPA posters from World War II were designed by BPA illustrator Lloyd Hoff to stimulate pride in BPA's military involvement among its employees.

[117] BPA, *Annual Report* (1942), 29.

[118] BPA, *Annual Report* (1943), 4-5.

[119] BPA, *Annual Report of the Administrator* (1944), 51-52.

[120] BPA, *Annual Report* (1944), 41-42.

3.2.2 Hanford Nuclear Site during WWII and the Cold War

BPA began providing power to the Hanford Site in 1941 on a 115-kV transmission line section from the Midway Substation. The connections were upgraded in 1944 with two 230-kV lines, named Hanford No. 1 and Hanford No. 2 in BPA's 1944 annual report. The U.S. Government War Department established the Hanford Site in 1943 to produce plutonium for the Manhattan Project (1943-1946). A total of nine plutonium production nuclear reactors were built at the Hanford Site for America's defense program.[121] Construction of the first three nuclear reactors (B, D, and F) began in March 1943 and was completed in 1944-45. The B Reactor was the world's first production-scale nuclear reactor, reaching criticality in September 1944. In the first nine months of its operation, Reactor B produced plutonium for the world's first atomic bomb, the Trinity test in July 1945. The reactor also produced the plutonium for the atomic bomb that was dropped on Nagasaki, Japan on August 9, 1945.[122]

Following the war, the federal Atomic energy Commission ramped up Hanford's plutonium production again to meet the challenges of the Cold War and explore nuclear power production, eventually contributing nuclear power to the BPA grid (Figure 16 and Figure 17). Additional reactors were constructed next to the Columbia River as the Soviet Union and the United States began to develop and stockpile nuclear weapons. From 1945 to the end of the Cold War, B Reactor and the other eight Hanford reactors produced the majority of the nation's weapons-grade plutonium.

Hanford's N reactor was constructed beginning in 1959 as a dual-purpose facility that produced plutonium for atomic weapons as well as steam for generating electricity. The Hanford atomic steam plant, constructed by Washington Public Power Supply System (WPPSS), began delivering power to the Bonneville main grid at 5:52p.m. April 8, 1966.[123] Starting in the mid-1960s through 1971, the older reactors were shut down leaving only N Reactor in operation. The N Reactor continued its mission producing plutonium and electricity until 1987. In December 1984, the nuclear Columbia Generating Station (known then as WNP-2) began commercial operations at Hanford and remains a BPA customer at present.

Figure 16. Nuclear reactors line the Columbia River at the Hanford Site (n.d.). The N Reactor is in the foreground, with the twin KE and KW Reactors in the immediate background. The historic B Reactor, the world's first plutonium production reactor, is visible in the distance.[124]

[121] PRC Environmental Management, Inc., *Hanford Generating Plant. Hanford Federal Facility, U.S. Department of Energy, Richland, Washington; Washington Public Power Supply System, Hanford Generating Plant; Resource Conservation and Recovery Act Facility Assessment; Final Report* (prepared for U.S. Environmental Protection Agency, work Assignment No. R10058. EPA I.D. No. Wash.D7890008967, August 18).

[122] Hanford.gov, "Hanford History," U.S. Department of Energy, https://www.hanford.gov/page.cfm/hanfordhistory .

[123] BPA, *1966 Report,* 18; BPA, *Columbia River Power System* (1945), 18.

[124] United States Department of Energy, "Hanford N Reactor," Wikipedia, https://en.wikipedia.org/w/index.php?title=File:Hanford_N_Reactor_adjusted.jpg

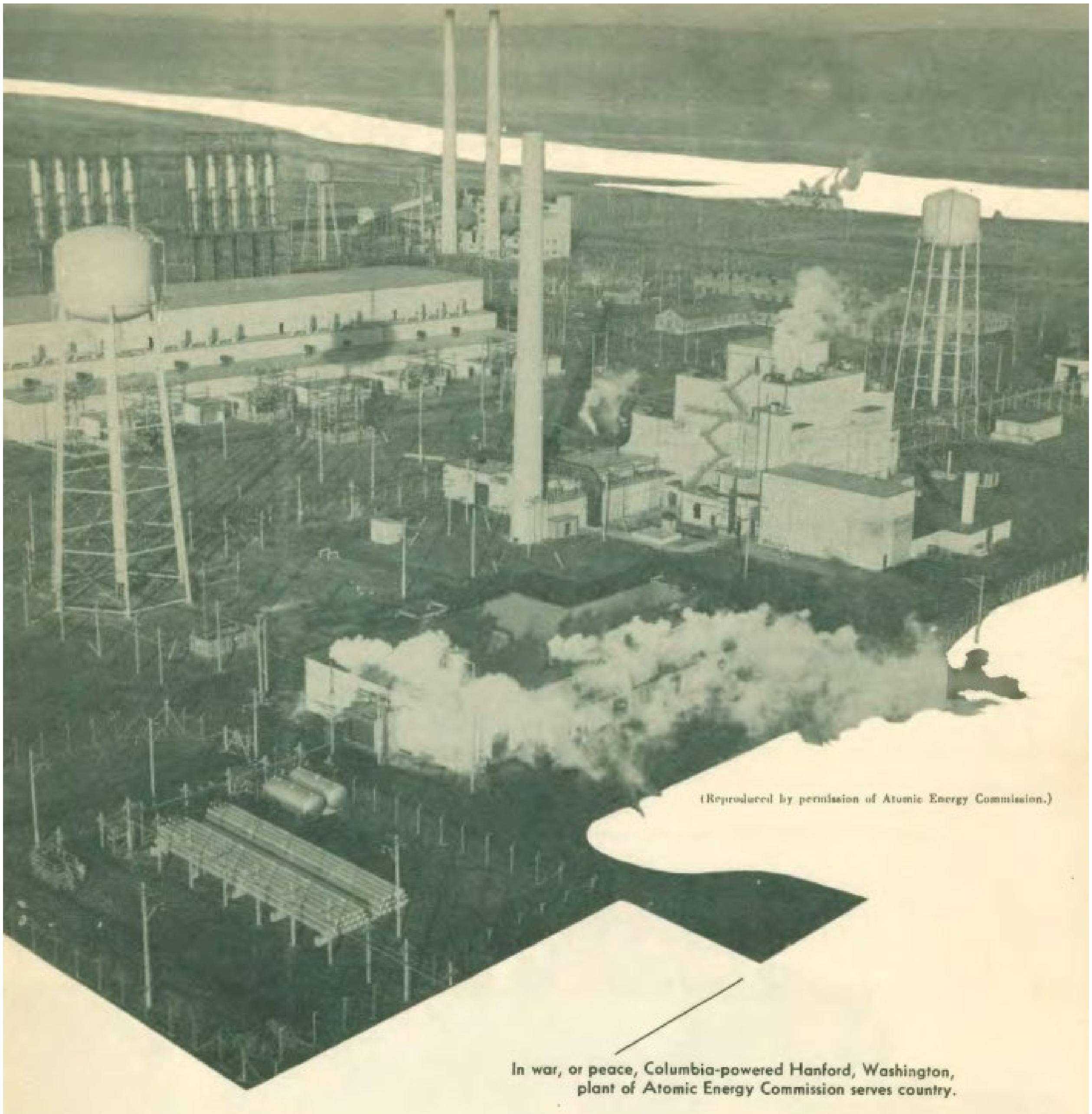


Figure 17. The Atomic Energy Commission Hanford Power Plant in 1947.[125]

3.3 Industry

During BPA's early years, existing and new industry in the Pacific Northwest was centered around large urban areas such as Seattle, Spokane, Portland, and Vancouver, all relying on Columbia River Power, many with direct service industrial contracts from BPA (Figure 188).

In the 1960s, BPA's revenues continued to rely heavily on its industrial contracts (Figure 199). In 1962, eighteen large industrial plants in the Northwest relied on BPA power, including eight

[125] BPA, *Annual Report of the Administrator of the Bonneville Power Administration* (Washington, D.C.: U.S. Department of the Interior, 1947), 26.

aluminum reduction plants which supplied 28 percent of the Nation's primary aluminum reduction.[126]

Due to energy shortages in 1973-1974 and ensuing energy curtailments, most of BPA's industrial customers were forced to reduce their production, "resulting in some 1,100 fewer jobs in the region. The curtailments also affected up to 8 percent of the United States aluminum production capacity. These firms estimate that their employment will decline by another 2,740 workers if their remaining interruptible capacity and one fourth of their modified firm power is cut back."[127]

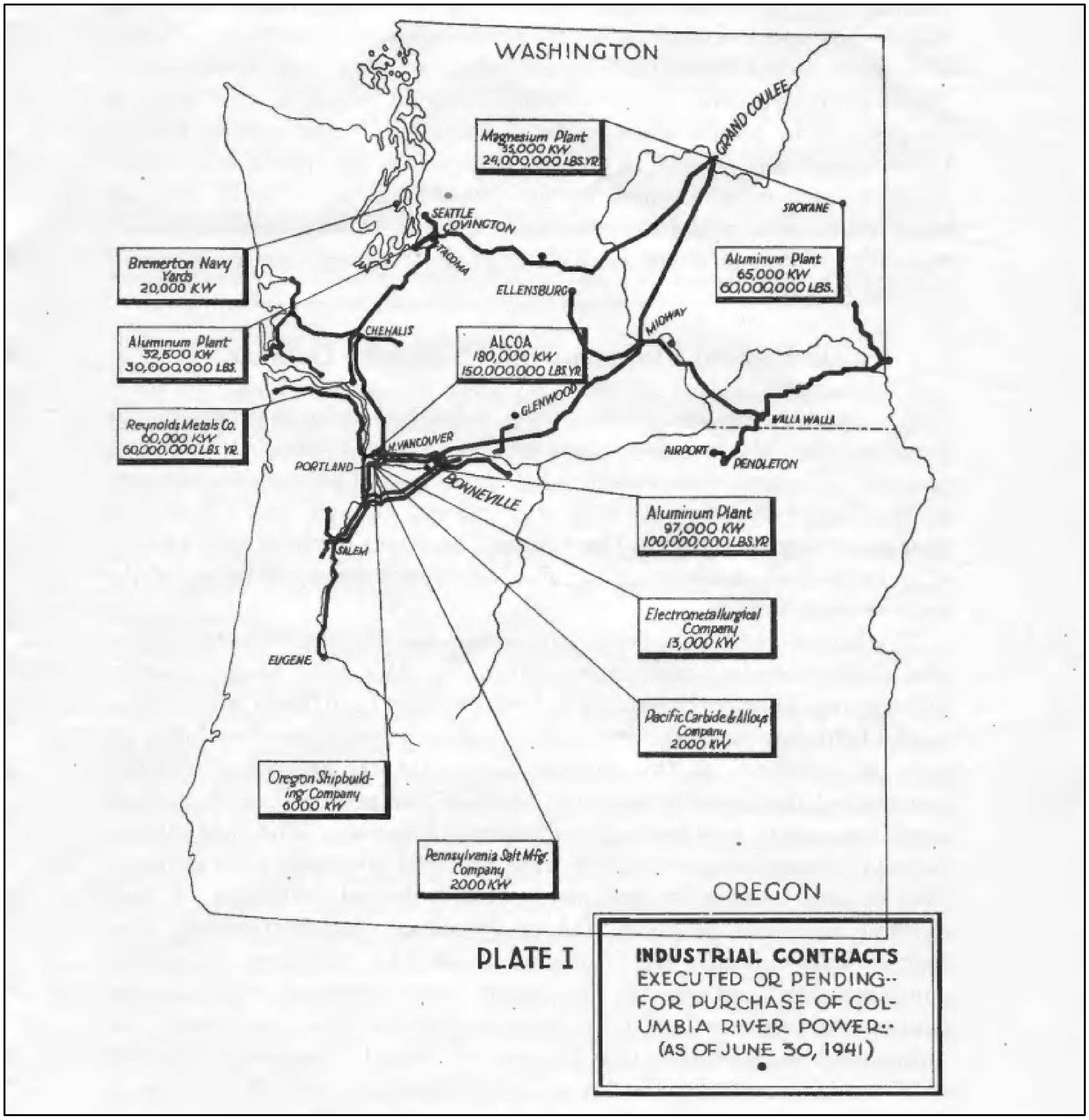


Figure 18. BPA transmission network in 1941 with locations of current and pending industrial contracts.[128]

[127] BPA, *1973 Annual Report*, 32.

[128] BPA, *Annual Report of the Administrator* (1941), 53.

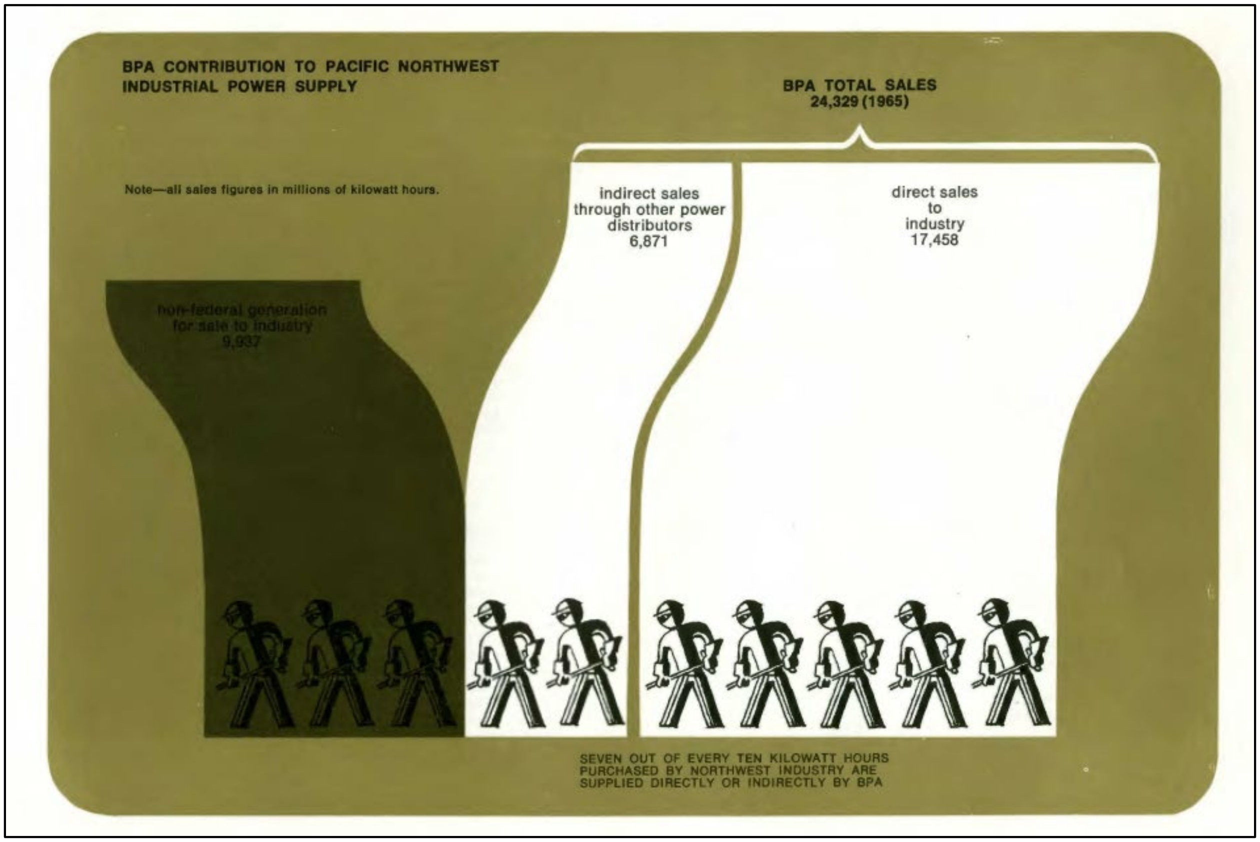


Figure 19. BPA's Contribution to Pacific Northwest Industrial Power Supply in 1966.[129]

3.3.1 Aluminum

The aluminum industry, which required intensive energy consumption, was the first major consumer of BPA's Columbia River power. When Bonneville Dam began operations in 1938, the Pacific Northwest became the ideal location for operating aluminum reduction plants. In addition to the availability of BPA's inexpensive energy, the region offered oceanic transport and port facilities, established rail lines, and abundant wood for fuel and facility construction. By late 1940, BPA had already constructed a 115-kV transmission line from Bonneville Dam to Alcoa Substation, and the Aluminum Company of America (Alcoa) aluminum plant was near completion. Construction of the St Johns-Astoria 115-kV line along the Columbia River's northern shore was being pushed to make power available through an area with "significant industrial potentialities."[130] The construction of BPA facilities to support production at more plants soon followed, and BPA signed direct service contracts with aluminum companies to deliver continuous power to their plants (Figure 20).[131]

The end of the war in August 1945 led to an expected significant drawback in power usage as wartime industries halted. However, industrial conversion, particularly in aluminum, competed with consumer demand to absorb the post-war power surpluses. By 1949, nearly half of primary aluminum production in the country was in the Pacific Northwest and required one-fourth of the total northwest energy.[132] The aluminum industry continued to grow in the Pacific Northwest and remained a leading source of revenue for BPA, even as the aluminum industry's percentage of

[129] BPA, *1966 Report,* 4.

[130] BPA, *Second Annual Report* (1939), 33.

[131] BPA, *Second Annual Report* (1939), 48.

[132] BPA, *Report on the Columbia River Power System* (Washington, D.C.: U.S. Department of the Interior, 1946), 22; BPA, *Columbia River Power System* (1949), 41.

overall revenue declined considerably as BPA began shifting its focus to meet changing customer demands. In 1945, aluminum contracts comprised 51.9 percent of gross revenues, dropping to less than 40 percent in 1946, and decreasing to 32.5 percent by 1955. The aluminum industry's contribution to overall revenue remained at approximately 30 percent well into the 1960s.[133]

The federal government remained a major aluminum purchaser, stockpiling the material for potential national emergencies.[134] Commercial aluminum use began after WWII but was not widespread until after the Korean War. With the Korean War's onset in 1950, the U.S. military was again the leading consumer of aluminum. During the early 1950s, annual aluminum production for the military accounted for nearly 30 percent of annual U.S. production.[135] Overall, U.S. aluminum production capacity increased by 70 percent, confirming that armed conflicts abroad were a major trigger for aluminum reduction plant development.[136] This time, the federal government used financial incentives, instead of facility construction and acquisition, to expand industrial capacity. By 1962, the incentives, such as accelerated depreciation of the plants and metal stockpile purchase contracts, increased the government's stockpile, including the Defense Production Administration's inventory, to 1.99 million tons.[137]

After the Korean War, while still riding the post-WWII economic wave, the aluminum industry continued its meteoric rise to meet domestic demand. New products were developed for construction and transportation (e.g., aluminum siding and windows), household uses (e.g., aluminum foil), and food and beverage packaging (e.g., cans and TV dinners), print advertising and labels.[138] The industry's upswing continued into the 1960s. From 1962 to 1967 U.S. shipments of aluminum products increased from 2.9 to 4.5 million tons, for a compound growth rate of nine percent per year.[139] With such high demand for aluminum products during that time period, two additional plants were erected in Washington – the Ferndale plant (1966) and the Goldendale plant (1970). The Goldendale facility would be the last major investment in new aluminum reduction plants in the Pacific Northwest.[140]

A total of nine aluminum facilities operated in the Pacific Northwest between 1939 and the present. This included Reynolds (Longview and Troutdale), Alcoa (Vancouver, Troutdale, Spokane, and Wenatchee), Olin Corporation (Tacoma), Kaiser (Tacoma and Spokane), Harvey Aluminum Company (The Dalles and Goldendale), and Intalco (Ferndale).[141]

---

[133] BPA, *1962 Report*, 4; BPA, *1968 Annual Report,* 23.

[134] Philip Farin, *Aluminum: Profile of an Industry* (New York: Metals Week, 1969), 14.

[135] Farin, *Aluminum*, 14.

[136] Richard S. Conway, Jr. *The Oregon State Aluminum Industry: Economic Impact Study* (Seattle: Conway and Associates), BPA Library:BPA3288 2000

[137] Farin, *Aluminum*, 14.

[138] Conway, *Aluminum Industry*.

[139] Farin, *Aluminum*, 28.

[140] AECOM, *Millennium Coal Export Terminal, Longview, Washington, Historic and Cultural Resources Assessment* (Portland, OR: prepared for Millennium Bulk Terminals,–Longview LLC, 2015.

[141] Ibid.

Figure 20. Transmission lines connecting with the Aluminum Company of America (ALCOA) in Vancouver, Washington, ca. 1940.[142]

3.3.2 Other Industries

Although the region's aluminum plants were BPA's largest industrial customer, the transmission system also contributed to development associated with other industries, such as mining, mineral processing and timber.

BPA had been exploring mining opportunities since its inception. In 1938-1939, BPA actively began systematically surveying its service area for available mineral deposits, as well as surveying areas for new industrial developments, available workforce, and other factors.[143]

When BPA expanded its transmission system into Montana, this opened up opportunities to untapped markets for mineral processing. In 1948, BPA projected that the power needs of large industries (such as phosphate fertilizer production, electro-chemical and non-ferrous metal production excluding aluminum) in the Pacific Northwest would more than double in the next ten years. BPA supplied power to Montana's elemental phosphorus production, electrolytic processing of low-grade ores, and farming.[144] During construction of the Hungry Horse dam, BPA projected that, with sufficient transmission lines, the state would see "rapid development of one of the largest phosphate industries in the nation".[145] By the late 1960s, BPA's industrial power supply also included southern Idaho's phosphate industry.

In 1953, BPA began a joint venture with California Oregon Power Co. to build new transmission lines in southwest Oregon with service to the M.A. Hanna Co. ferro-nickel smelter south of Roseburg. Terms of the agreement called for BPA and Copco to construct a 230-kV line to

[142] BPA, *Third Annual Report* (1940), 11.

[143] Kramer, *BPA Transmission System MPDF*, 14.

[144] "Montana Power Tops User List," *The Inter Lake*, March 22, 1950; "Project Well Past Half Way Mark," *The Inter Lake*, July 27, 1952.

[145] "Hungry Horse Will Aid State Industry," *The Inter Lake*, February 28, 1951.

Klamath Falls to reinforce power service to southwest Oregon and coastal areas and carry the nickel plant load. Secretary of the Interior Douglas McKay commented that the project was "an outstanding example of the working partnership between the government and public and private utilities in meeting their responsibilities for the growing domestic and industrial power needs of the Pacific Northwest."[146]

BPA's transmission lines are also associated with the region's timber industry, including pulp and paper operations. In 1944, new 230-kV facilities were proposed for the north Puget Sound area to deliver more energy for pulp and paper mills and to meet demands of expanding growth anticipated in the area.[147] Postwar population growth and housing demands led Pacific Northwest lumber companies to increase their harvests. Major construction projects in 1948 included construction of transmission lines in southwest Oregon to establish a connection with the center of region's timber industry.[148]

3.4 Population Growth and Community Development

As the backbone of the region's entire power grid, BPA's transmission system has been integral to population growth and community development. Since the Master Grid period, BPA has prioritized expanding its system into rural and urban areas to support the area's historical growth. From 1900 to 1950, the Pacific Northwest's population growth was approximately three times greater than the rate of the country as a whole. During the 1940s alone, the population of the Pacific Northwest grew by 33 percent while the country grew by 14 percent. Between 1950 and 1955, the migration leveled off and was about equal to the country as a whole at 9 percent.

3.4.1 Rural Electrification

Throughout much of the twentieth century, BPA's transmission system played an important role in shaping the growth of the Pacific Northwest. BPA enabled the region's communities and economies to flourish and helped bring the first electrical power to many rural areas. In 1938, BPA received $10.75 million from the Rural Electrification Administration (REA) to build transmission lines that linked Bonneville Dam to communities in Oregon and Washington. BPA and REA successfully helped citizens form electric cooperatives and public utility districts to receive power in rural communities and on farms.[149] BPA's drive to electrify the rural West first focused in Oregon and Washington through the 1940s and 1950s, and later expanded into Idaho, Montana, and Wyoming throughout the 1960s and 1970s. By the early 1970s, nearly all farms in the U.S. had electricity as a result of the REA.

BPA sought to expand service into more rural counties in Oregon and Washington to compensate for power deficiencies. Extension of the system and reinforcement of the various substations and feeder lines would help relieve overloaded conditions of existing facilities, and to provide necessary reserves and supply power for domestic, agricultural and industrial uses at the lowest rates available in the nation.[150] Arid lands in rural Oregon and Washington were seen as a significant economic opportunity for food production and more intensive cultivation.

BPA's grid connected Columbia River power from major hydroelectric sources to a multitude of rural communities. For example, when new generators were installed at Grand Coulee Dam, BPA needed to transmit that energy to areas west of the Cascade Mountains. This was accomplished through the construction of the 2-circuit lines from Grand Coulee Dam to

---

[146] "New Substation at Klamath Falls," *Medford Mail Tribune,* June 26, 1953.

[147] BPA, *Annual Report* (1944), 62.

[148] BPA, *Report on the Columbia River Power System* (1948), 19-20.

[149] Northwest Power and Conservation Council, "Bonneville Power Administration: History," accessed October 25, 2021, https://www.nwcouncil.org/reports/columbia-river-history/bpahistory.

[150] BPA, Annual Report (1944), 62.

Snohomish, Washington (Figure 21). The lines were energized in the fall of 1949 and 1950 and fed a network of coastal transmission lines, energizing a dozen communities.[151]

According to the 1950 U.S. census, 57 percent of Northwest residents lived in urban centers, substantially lower than the national average of 64 percent. Non-farm rural areas accounted for 28 percent in the region, as opposed to 21 percent nationally. These areas were favorable for industrial suburbanization and diversification, such as the construction of an aluminum reduction plant in Wenatchee, Washington, petroleum refinery north of Bellingham, Washington, and pulp mills throughout the region. These industries helped diversify the economies and limit dependence on lumber. The population of the Pacific Northwest was expected to continue to grow faster than the national average and small and medium-sized communities were envisioned as important to industrial development and creating industrial diversification and stability.[152]

Figure 21. Construction of the 230-kV Grand Coulee-Spokane Line, July 31, 1940.[153]

Washington

BPA's rural electrification efforts in Washington included the 1948 expansion of the transmission network to support growing industries in Shelton, Washington, primarily lumber, and mining in

[151] BPA, *Highline: The Story of Construction*.

[152] Bernard Goldhammer, "The Economic Outlook of the Pacific Northwest," *Pacific Northwest Business* 16, no. 11, 1957, 5-6.

[153] BPA, *Third Annual Report* (1940), 48.

the Metaline district of Washington.[154] In 1963, BPA constructed a 230-kV line from Bell substation near Spokane to the Canadian border north of Metaline Falls to interconnect with the West Kootenay Power and Light Company.[155] That same year, construction was under way for a 70-mile 500-kV line (which originally operated at 230-kV) between Arlington and Blaine, Washington to provide additional transmission capacity for delivery to the Canadian border.

BPA began a significant rural electrification project in 1950 to construct a high-voltage submarine power cable to connect the San Juan Islands with BPA's mainland power system. Beginning at Fidalgo Head near Anacortes, Washington, the 7.5-mile power line traveled underwater through the Puget Sound to Decatur Island where it was strung overhead to the load center on Lopez Island.[156] Initially carrying 24-kV, the cable was specifically designed for this span with special rubber coating.[157] When completed on April 17, 1951, BPA engineers had laid the world's longest submarine power cable line ever manufactured in one continuous length for that voltage.[158] The cable weighed approximately 720,000 pounds and required a specially equipped barge to position it at the bottom of Rosario Strait (Figure 22). Approximately 500 people gathered along the shorelines and in boats to witness engineers lay the last five miles of the line. BPA estimated the line would be energized by July 1 to serve Orcas Power and Light Company's 1,200 customers.[159]

Figure 22. Laying underwater cable in the San Juan Islands, 1951.[160]

Oregon

BPA's rural electrification efforts in Oregon included expansion to the state's isolated coastal communities. BPA's completion of 41.9 miles of line between Albany and Toledo, Oregon in October 1946, was the first step in meeting the critical power shortage in Oregon's coastal area.[161] During the 1940s and 1950s, BPA served the South Coast area with a 115-kV transmission line; the area's only large-scale power source. Completing construction of the Mapleton-Reedsport-Coos 65 mile 115-kV transmission line, Reedsport substation and Coos switching station on October 25, 1950, BPA established direct service to the coastal area

[154] BPA, *Columbia River Power System* (1948), 19-20.

[155] BPA, *1963 Report on the U.S. Columbia River Power System* (Washington, D.C.: U.S. Department of the Interior), 5.

[156] "Plan for Cable to Islands Told," *Spokesman Review*, March 12, 1950; BPA, *Report on the Columbia River Power System* (Washington, D.C.: U.S. Department of the Interior, 1951).

[157] *Spokesman Review*, "Plan for Cable to Islands"; BPA, *Columbia River Power System*.

[158] "7-mile-long Submarine Cable Moving by Train," *Spokesman Review*, March 27, 1951.

[159] "Longest Cable Laid," *Spokane Chronicle*, April 18, 1951; BPA, *Columbia River Power System*.

[160] BPA Archives, E25131

[161] BPA, *Columbia River Power System* (1947), 6-7.

(Figure 23).[162] Additional construction projects in 1952 expanded BPA's network to connect with southwest Oregon via Eugene, Bandon and Gold Beach.[163]

Figure 23. The Mapleton-Reedsport 115-kV Line through Reedsport business district in February 1962.[164]

The Bonneville-The Dalles Line represents early rural electrification efforts in Oregon. In early October 1940, BPA contracted with the Wasco Electric Cooperative, Wasco County's newly organized Rural Electrification Administration cooperative, to distribute power over rural transmission lines.[165] Later that month, BPA made a separate agreement to supply the Northern Wasco County People's Utility District (PUD) with "up to 4000 kilowatts of Columbia river power."[166] A letter dated May 31, 1941 from BPA's engineering division to administrator Paul Raver reported that, "The connection with the Wasco Electric Cooperative on May 24, at The Dalles Substation, which is supplied by the 38-mile, 115,000 volt, Bonneville – The Dalles Line marked the completion of facilities for serving the northern Oregon area."[167] The *Oregonian* noted that, with the new transmission line, "Simultaneously electricity will enter the homes of patrons along about 100 miles of a completed portion of a 265-mile distribution system under way by the REA [Wasco Electric] co-operative."[168] The Dalles Industrial Club and other local organizations sponsored "Bonneville Power Week" to celebrate the new BPA power transmission facilities (Figure 24). Community events that week included carnival attractions, appliance displays, and a banquet with BPA officials.[169] Construction of The Dalles-Redmond Line in 1952 further expanded BPA's network into central Oregon.[170]

[162] BPA, *Columbia River Power System* (1950), 41.

[163] BPA, *1962 Report on the U.S. Columbia River Power System* (Washington, D.C.: U.S. Department of the Interior, 1962), 20-21.

[164] NARA, 59533.

[165] "REA Contracts With Bonneville," *Oregonian*, October 5, 1940.

[166] "North Wasco PUD Signs," *Oregonian,* October 31, 1940.

[167] BPA, *Report of Accomplishments of the Engineering Division, Month Ending May 31, 1941* (Washington, D.C.: U.S. Department of the Interior, BPA Library: BPA51_1941_05).

[168] "The Dalles to Observe Bonneville Power Week," *Oregonian*, May 18, 1941.

[169] Ibid.

[170] BPA, *1962 Report*, 20-21.

Figure 24. Speakers at The Dalles Substation Celebrating BPA's Rural Electrification Program in Wasco County, 1941.[171]

Idaho

To establish a connection between BPA's existing transmission network and southern Idaho, BPA considered two options: obtaining wheeling rights over Idaho Power's backbone line or constructing a 500-kV AC or 750-kV DC transmission line between McNary Dam and La Grande. The new line would extend to the Soda Springs region of Idaho, passing through Idaho Power's service area and essentially recreating their backbone line. Idaho Power was reluctant to provide wheeling rights to BPA and lose significant sources of revenue and control of the region. Political pressure from Congress and the realistic potential of BPA constructing a 500-kV line through Idaho Power's territory facilitated negotiations. Following five years of negotiations, between 1963 and 1968, BPA and Idaho Power signed a wheeling agreement, allowing federal power to flow through Idaho Power transmission lines, serving preference customers it inherited from Bureau of Reclamation and backing up pumping loads. With BPA's federally subsidized power, 18 southern Idaho rural electric cooperatives and municipalities entered 20-year power sales agreements with BPA, reducing their wholesale power costs by 40 percent. BPA's establishment in southern Idaho facilitated economic growth in the region.[172]

In 1950, BPA began constructing the Newport-Sandpoint Line, with plans to subsequently extend the Line to the proposed Bonners Ferry Substation (Figure 25). According to BPA, construction of the Sandpoint and Newport substations would connect a 115-kV Line, provided "an important link of high-voltage transmission service into the Northern Idaho panhandle area."[173] In addition to connecting with Bonners Ferry, the planned 115-kV Line would also extend to Troy, Montana.[174] In September 1950, BPA publicized its $11.7 million construction

---

[171] NARA, E13358.

[172] Rodney A. Aho, *A History of Federal Power in the Southern Idaho Region* (Portland, OR: Bonneville Power Administration, 2003), 23-25.

[173] "Bids for Two Idaho Substations Opened by Bonneville Power," *Daily Interlake*, July 2, 1950.

[174] Ibid.

program for 1951-1952, including the 33.7-mile, 115-kV transmission line between the Sandpoint and Bonners Ferry substations in Idaho.[175]

Figure 25. The Sandpoint—Bonners Ferry Line in 1951.[176]

On September 1, 1963, BPA signed contracts with 21 former Bureau of Reclamation customers to provide them with BPA's lower, standard wholesale power rates. BPA was able to serve these customers partly through transmission lines taken over from the Bureau of Reclamation, but the majority were served through wheeling over transmission lines of the Idaho Power Company and Utah Power and Light Company. Taking over for the Bureau of Reclamation, BPA was able to offer federal power and create opportunity for industrial expansion. Bureau of Reclamation plants in southern Idaho did not generate sufficient power to meet the load growth requirement of the customers, so BPA had to connect with their main grid or reach a wheeling agreement with Idaho Power, which culminated in 1968.[177]

Montana

Plans for extension of the BPA network into western Montana began in 1944 with the approval for the construction of Hungry Horse Dam, a concrete arch dam to be located on the South Fork of the Flathead River, upstream of Columbia Falls in northwestern Montana. BPA's Montana projects sought to "bring Columbia river and Hungry Horse dam power directly to the principal industrial and domestic load centers in western Montana".[178] The Hungry Horse Dam became the first post-World War II federal generation facility in the Northwest. The dam began to generate power in October 1952, with the stipulation that two-thirds of its power output was for use within Montana.[179] In 1949, BPA established its western Montana district headquarters in Kalispell.[180]

[175] "BPA Reveals Building Plans," *Oregonian*, September 7, 1950.

[176] BPA Archives, E24247.

[177] BPA, *1964 Report on the U.S. Columbia River Power System* (Washington, D.C.: U.S. Department of the Interior, 1964), 16.

[178] "Long Bonneville Line Nearing Finish," *Great Falls Tribune*, July 31, 1952.

[179] Kramer, *Corridors of Power*; Kramer, *BPA Transmission System MPDF*, 20-21.

[180] "BPA Offices Here to be Under Guidance of Manager R.H. Wood," *The Inter Lake*, February 26, 1952.

Construction of BPA's Montana power transmission facilities commenced with the 59-mile Hungry Horse-Kerr 115-kV Line and its associated substations at Kerr Dam, Kalispell, and Columbia Falls. The line, completed in 1947 to power construction of the Hungry Horse Dam, began at the Montana Power Company's Kerr Dam, and extended through Flathead and Lake counties to the dam site upstream of Columbia Falls (Figure 26). Following completion of the dam in 1952, the transmission line transmitted power generated at the Hungry Horse Dam.

Figure 26. Horses help erect a tower in a rural residential area during the construction of the Hungry Horse-Kerr Dam 115-kV Line, ca. 1947.[181]

During the early 1950s, BPA invested millions of dollars for additional power transmission infrastructure in Montana to integrate the state into the larger BPA system. The completed facilities powered Montana's industries (see Section 3.3) and transmitted "seasonal surplus power" not required in Montana to other system service areas.[182] BPA anticipated completion of several Montana transmission facilities by October 1, 1952, to coincide with the first power generation at Hungry Horse Dam. In anticipation of the new, low-cost BPA power in Montana, investors supplied over $60 million for plants and equipment related to aluminum and elemental phosphorus production.[183] The surplus electricity harnessed by the Hungry Horse Dam led to industrial development including the Kalispell aluminum plant and the Silver Bow elemental phosphorous plant.[184]

BPA designed Hot Springs Substation to serve as the main switching point for the three proposed 230-kV lines: Spokane-Hot Springs, Hungry Horse–Hot Springs and Hot Springs–Anaconda (Figure 27).[185] The Hot Springs–Anaconda Line would comprise about 147 of the nearly 400 miles of 230-kV transmission lines that BPA was building between northern Idaho and western Montana. At the time, the venture was one of the nation's largest power transmission line projects. BPA estimated the total cost of all its western Montana facilities at over $20 million.[186] Note: this would be $212.5 million in 2022 dollars.

BPA facilities for its 230-kV transmission line network in Montana required construction of 1,292 steel towers and installation of over 2,200 wood poles. According to BPA's western Montana District Manager R.H. Wood, construction also required:

---

[181] BPA Archives, E15145.

[182] Cantrell, Harold M. "Bonneville Power Makes Rapid Progress in 1951." *The Inter Lake,* February 27, 1952.

[183] Ibid.

[184] "Hungry Horse," *The Inter Lake*.

[185] "Washington Firms Low Bidders on BPA Substation," *Great Falls Tribune*, April 5, 1952.

[186] "Power Expected to Be Turned on Today For Cabinet Gorge-Hungry Horse Line," *Great Falls Tribune*, October 27, 1952.

> More than 1,200 miles of heavy aluminum cables . . . used in stringing the three conductors on the 400 miles of heavy circuits. More than 200 freight cars of insulators, hardware and substation equipment have been used, in addition to the steel towers, poles and conductors . . . Whenever possible, labor was secured locally by the contractors and all materials available in Western Montana, such as wood poles for line structures, were purchased locally whenever possible.[187]

BPA transmission line construction in Montana ultimately totaled 400.4 miles: 162.6 miles for the Spokane–Hot Springs Line, 78.3 miles for the Hot Springs–Hungry Horse Line, 146.5 miles for the Hot Springs–Anaconda Line. Right-of-way clearing contracts for the transmission lines totaled over $1 million, using primarily Montana firms. Clearing operations occurred in light timber as well as heavily forested areas. Some areas were easily accessible, while others were extremely mountainous and lacked road access.[188] By 1953, total sales of BPA power in western Montana exceeded $1.8 million, with an expected increase to over $3.5 million in 1954. BPA used much of the revenue to pay off federal investment in Hungry Horse Dam, transmission lines, and substations.[189]

Two decades later, additional lines were constructed to serve rural western Montana. The 500-kv Dworshak-Hot Springs Line, tying the Dworshak Dam and Lower Snake generation to Montana, was completed in mid-November 1972.[190] The 143-mile Dworshak-Hot Springs Line in Idaho and Montana and the 94-mile Little Goose-Dworshak Line between Washington and Idaho, was BPA's first 500-kV transmission into Idaho and Montana. The lines major use was to reliably serve electrical loads in western Montana, particularly during periods when Hungry Horse Dam was storing water and not generating power. This construction and other lower voltage transmission lines from Hot Springs to Spokane and back to Grand Coulee close the BPA loop through western Montana.[191]

---

[187] "Power Expected to Be Turned on Today," *Great Falls Tribune*.

[188] "Hungry Horse," *The Inter Lake*.

[189] "BPA Adds $9,000,000 in Services," *The Inter Lake,* February 28, 1954.

[190] BPA, *1972 Annual Report*, 23.

[191] BPA, *1973 Annual Report*, 15.

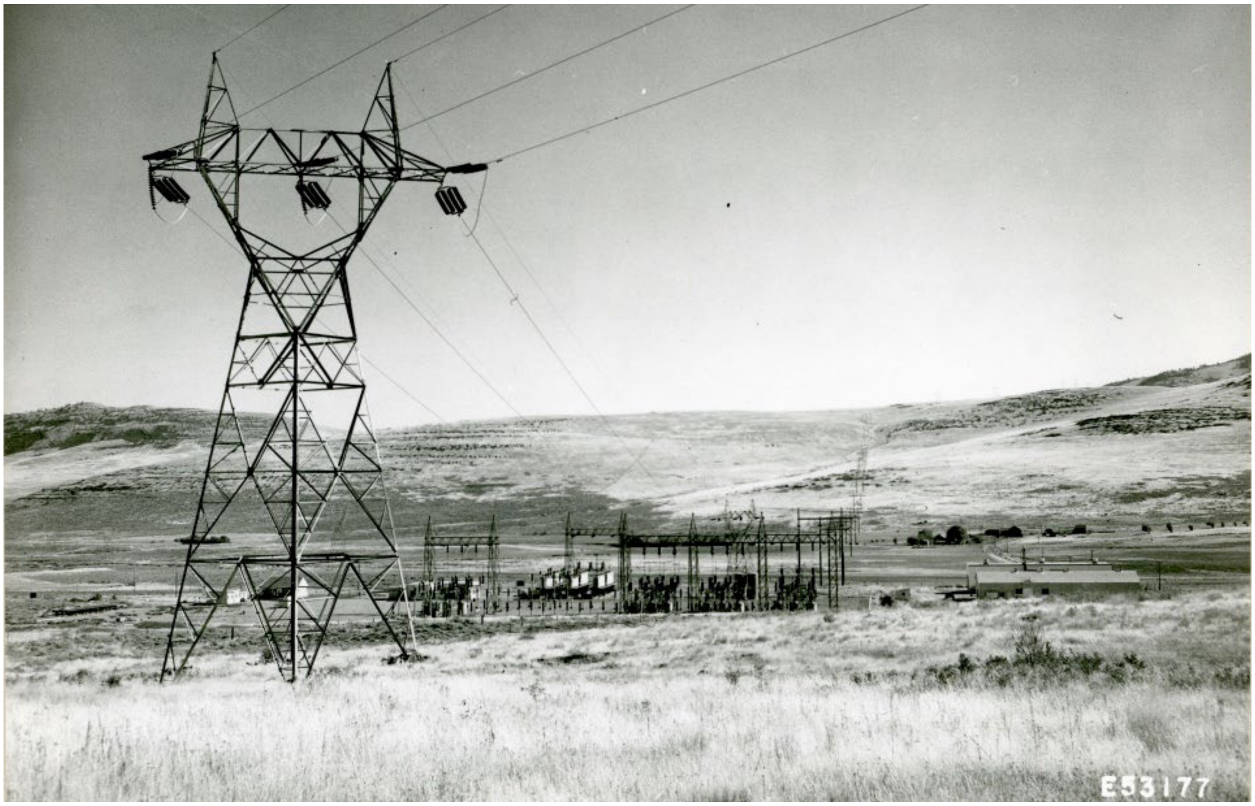


Figure 27. Transmission Line Connecting to Hot Springs Substation, 1960.[192]

Wyoming

Only one BPA transmission line in Wyoming was built during the period of significance—the Swan Valley-Teton extension (Figure 28). BPA scheduled construction of the $3.3 million Teton project, a 36-mile, 115-kV transmission line from Swan Valley, Idaho to Jackson, Wyoming, to begin in fall 1967. The new line and associated facilities constituted the first major BPA construction project in both southern Idaho and Wyoming.[193]

When energized in late 1968, the line would meet increasing power demands from Lower Valley Power and Light, Inc. (LVPL). LVPL, a rural electric cooperative based in Afton, Wyoming, served farms, homes and businesses within a large area of eastern Idaho and western Wyoming. BPA designed the new line to tap the existing Palisades–Goshen No. 2 Line through a substation near Swan Valley. The line's second substation, Teton Substation, was built near Jackson and Wilson, Wyoming, and served as the Teton line's terminus.[194] BPA officials reported that, during project construction, "care will be taken to protect the mountain scenery, and the transmission lines will be hidden from public view".[195] At the time BPA completed the project, the line included the highest point – 8,624 feet at Wyoming's Teton Pass – in the BPA system.[196]

BPA's Idaho Falls area manager, Bob Lee, described the new line and associated facilities construction as part of "a considerable investment to strengthen the power supply to consumer-owned electric utilities that serve thousands of residences, farms, and other businesses." He

[192] NARA, E53177.

[193] "Ogden Bidder Low," *Salt Lake Tribune*, June 6, 1968.

[194] "Electric Project on Slate." *Idaho Free Press*. July 9, 1966; "BPA To Build Power Line in S.E. Idaho," *Idaho Free Press*, March 3, 1967; "BPA Invites Clearing Bids," *Idaho Free Press*, June 21, 1967.

[195] "Tacoma Firm Bids Low on BPA Project," *Statesman Journal*, July 19, 1967.

[196] "Tacoma Firm," *Statesman Journal*.

noted that BPA contractors building the new power transmission facilities would "undoubtedly" hire local residents and purchase equipment and services from local communities.[197]

Figure 28. Dedication of Teton Substation and Swan Valley-Teton Line extension in 1968.[198]

3.4.2 Urban Growth and Development

During BPA's first decade of service in the 1940s, the Pacific Northwest experienced an increase in population of 44 percent as compared with a 13 percent increase for the nation. Oregon led population growth among all states in BPA's territory with an increase of 59 per cent, Washington 48 per cent, and Idaho 13 percent. With the rapid population increase was also an increase demand in power needs as farms, businesses, and industries also grew.[199] In 1948, BPA projected the power needs in the Pacific Northwest would more than double in the next ten years, especially as urban areas grew. Therefore, 1948 featured major construction projects for power deficit areas such as construction of a transmission line between Grand Coulee Dam and Snohomish, Washington to serve the densely populated urban areas of Seattle and Everett, Washington.[200]

In the late 1940s, construction work was rushed to complete two of the most important 230-kV circuits in the federal system to two major coast load centers in the state, Puget Sound and lower Columbia area. The 166-mile Grand Coulee-Snohomish and the North Bonneville-Troutdale steel tower lines were energized in late 1949 to provide new generation from the Grand Coulee dam.[201]

Major construction to bring power from Chief Joseph Dam in Bridgeport to the Puget Sound area via Snohomish and Covington substations began in 1954.[202] Once completed, the Entiat-

[197] "BPA Announces Schedule for $3.3 Million Line Project," *Idaho State Journal*. March 1, 1967.

[198] BPA Archives, "Teton Substation Dedication," 1968.

[199] BPA, *Columbia River Power System* (1949), 41.

[200] BPA, *Columbia River Power System* (1949), 1949, 42; BPA, *Columbia River Power System* (1948), 16.

[201] BPA, *Columbia River Power System* (1949), 33.

[202] BPA, *Report on the Columbia River Power System* (Washington, D.C.: U.S. Department of the Interior, 1954), 37.

Gold Bar Line, Chief Joseph-Entiat Line, and Gold Bar-Snohomish Line carried approximately half of the power generated from Chief Joseph Dam. William A. Pearl, BPA administrator (1954-1961), noted that once finished, the 345-kV lines under construction from Chief Joseph Dam to Puget Sound and from McNary Dam to the Portland-Vancouver area would be the highest voltage transmission lines operating in the United States.[203]

In the late 1960s, the BPA system was experiencing heavy load requirements in the Pacific Northwest. The winter of 1968-1969 was exceptionally cold, and unusually high power demands were placed on the system. Combined with reduced stream flows that curtailed hydroelectric generation, a severe shortage of hydro energy developed. A key line among those proposed for construction was the 123-mile 500,000-volt line from Chief Joseph Dam in north central Washington to Monroe Substation northeast of Seattle (Figure 29). Part of the electricity moved over this line came from the new Third Powerhouse at Grand Coulee Dam and the new line provided capacity to serve the growing loads in western Washington.[204]

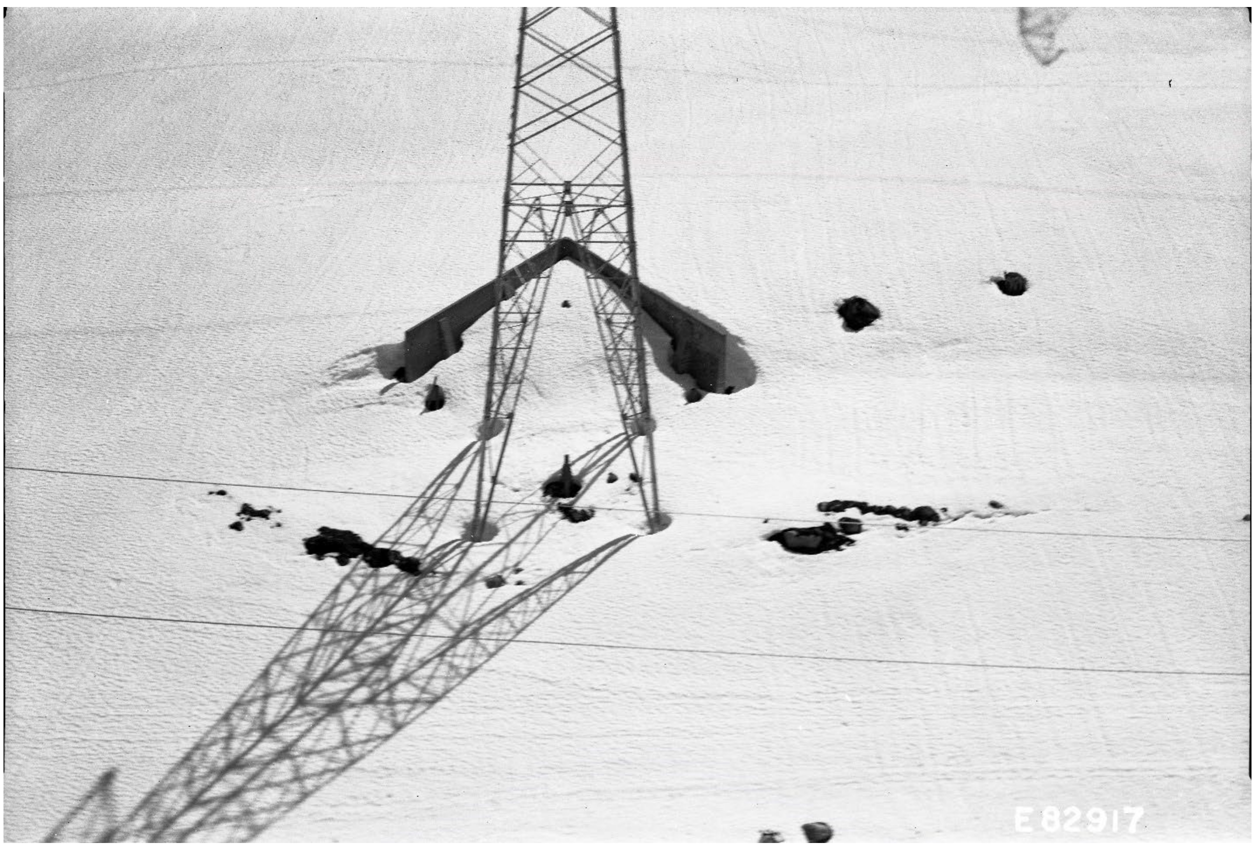


Figure 29. Chief Joseph-Monroe #1 Line, showing Tower 77-1 and its snow deflector, 1971.[205]

Another line under construction in the late 1960s was to serve the large urban areas of Seattle and Portland. The 116-mile 500,000-volt Raver-Paul-Allston Line was a main link to the volt grid and also integrates power from the coal-fired generation plant under construction in Centralia by the Pacific Power & Light and Washington Water Power Companies and shared by other utilities.[206]

[203] "Two Firms Share BPA Contract," *The Spokesman-Review*, June 11, 1954.

[204] BPA, *1969 Annual Report*, 21.

[205] NARA, E82917.

[206] BPA, *1969 Annual Report,* 21.

3.5 Integration with Utilities across the Region

To better serve the Northwest's growing population in the 1940s and 1950s, BPA sought to expand its network through partnerships with other major generating utilities and smaller non-generating utilities. The larger utilities contributed to the pool of energy available for distribution while the smaller utilities participated more indirectly through allowing these larger utilities to use their lines. Known as wheeling agreements, smaller utilities received more reliable power and at higher rates while larger utilities were able to utilize their existing transmission infrastructure. Through partnerships with large and small utilities in the United States and Canada, the regional organization facilitated its growth and development.

3.5.1 The Northwest Power Pool

Formed during WWII, the Northwest Power Pool (now known as the Western Power Pool) was established on August 1, 1942 and consisted of the region's major electrical utilities.[207] The group originally included BPA, Montana Power (NorthWestern Energy), Idaho Power, British Columbia Electric (BC Hydro), Tacoma City Light (Tacoma Public Utilities), Utah Power and Light (Rocky Mountain Power), Pacific Power and Light (Pacific Power), Seattle City Light, Washington Water Power (Avista), Puget Sound Power and Light (Puget Sound Energy), and Portland General Electric (Figure 30).[208] Through the combination of BPA and private utilities, the Pacific Northwest featured a multi-state power network that thrived on the region's water resources.[209] The Northwest Power Pool and associated network of transmission lines provided an invaluable asset to the country's war effort by providing sufficient power to the booming war industries, which in turn created thousands of jobs and facilitated future industrial and population expansion in Oregon, Washington, and Idaho. Although consisting of a group of major utilities, BPA's power generating facilities and transmission lines were essential to its operations (Figure 31).[210]

Until 1961, participation in the Northwest Power Pool was on an informal voluntary basis. In the beginning of 1961, the Columbia River Treaty with Canada was signed, which led to contractual obligations between the Northwest Power Pool's members. The treaty specified the coordination of water resources on the Columbia River Basin. It became official in 1964 as the Pacific Northwest Coordination Agreement – a binding contract between 17 utilities and agencies controlling power generating facilities in Washington, Oregon, part of Idaho, Montana, and California. The contract stipulated:

- Useable energy from the affected river system would be optimized on a regional basis regardless of plant ownership thus making energy available to all partners.
- How the water systems would be operated under the worst water conditions possible to ensure how the maximum power load will be carried out
- An agreement to determine downstream benefits due to water storage at upstream reservoirs under coordinated operation and how upstream reservoir owners would be paid.

Throughout the 1960s, the Northwest Power Pool investigated ways to maximize reliability and they determined sharing contingency reserves would reduce risk and enhance reliability in the system. By 1970, reserve sharing was occurring on an informal basis.[211] As part of the organization, BPA has expanded to connect with Canada to the north and California to the

[207] BPA, *Annual Report* (1943), 14.

[208] BPA, *Columbia River Power System* (1951), 28; Jim Kershner, "Northwest Power Pool," HistoryLink.org, March 29, 2016, http://www.historylink.org/File/11199.

[209] Kramer, *Corridors of Power,* 77.

[210] Kramer, *Corridors of Power,* 60, 65.

[211] *Western Power Pool (formerly Northwest Power Pool)* WPP (westernpowerpool.org)

south.[212] The name changed to Western Power Pool in 2022, and the organization now has 33 members.

Figure 31 illustrates the flow of energy from the power generating sites at Bonneville and Grand Coulee dams to the region's load centers. The darker grey lines identify the BPA transmission lines and the lighter grey represents the smaller non-generating utilities, such as PGE Co. and PSP & L Co. (now Puget Sound Energy) who are also part of the Western Power Pool.

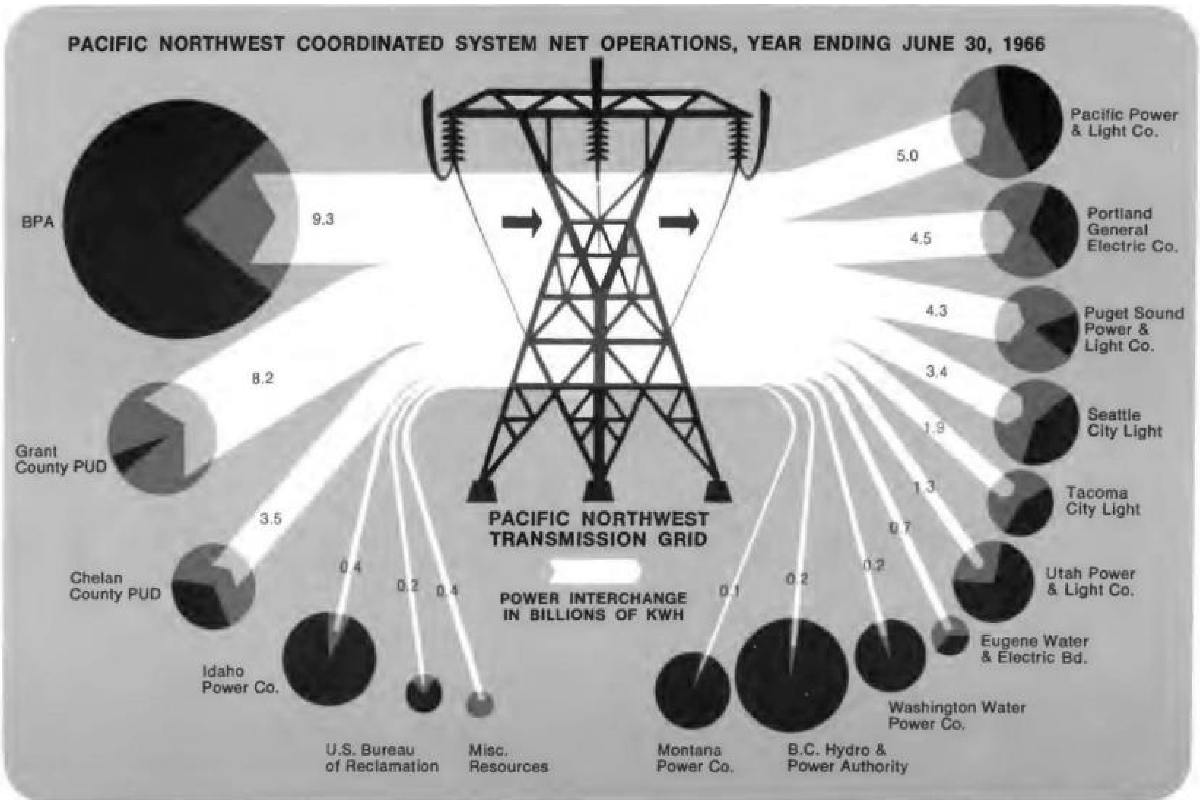


Figure 30. Northwest Power Pool interchange of power through the Pacific Northwest Transmission Grid, drawn by BPA illustrator Lloyd H. Hoff, 1966.[213]

[212] Kramer, *Corridors of Power,* 4.

[213] BPA, *1966 Report,* 21.

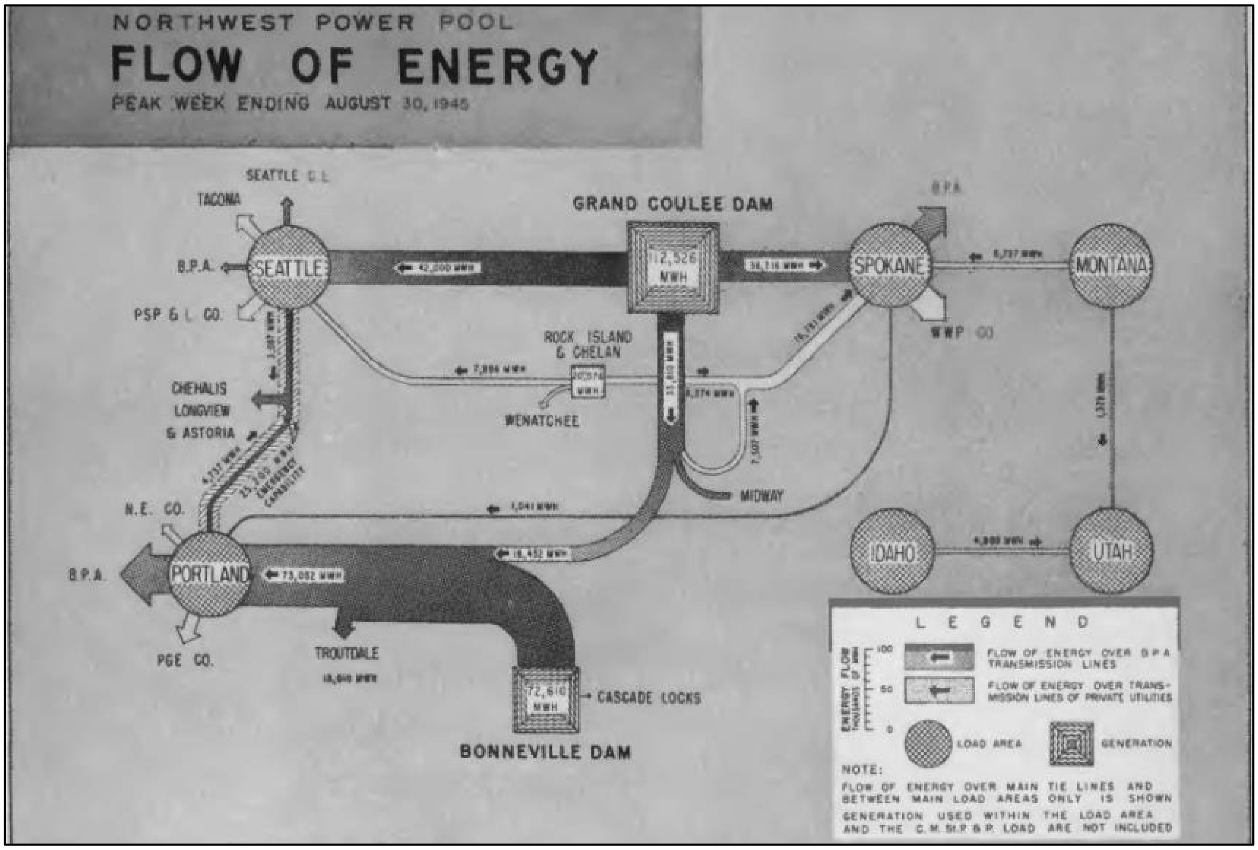


Figure 31. A 1946 diagram showing the Northwest Power Pool's flow of energy from BPA's Bonneville and Grand Coulee dams to load centers in the Pacific Northwest. Drawn by BPA illustrator Lloyd H. Hoff.[214]

3.5.2 Wheeling Agreements

Wheeling agreements allow other utilities to use BPA's transmission lines and also allow BPA to use non-federal utility lines to wheel BPA power. "Wheeling" describes the transportation of electric energy owned by one party over transmission lines owned by another. BPA's wheeling program has been an important cost-saving measure and revenue producer since it originated in the 1950s (Figure 32). To facilitate county PUD financing of Priest Rapids and Rocky Reach dams, BPA agreed to wheel power from the dams to utilities who owned a fractional share of their output. Later, when Grant County built Wanapum Dam, BPA agreed to wheel secondary power, although some of this power displaced its own sales.[215]

In 1954, BPA instituted an expanded "wheeling" program which made it possible to integrate and coordinate with Columbia River Basin generating and transmission facilities. The expanded program made it possible to integrate all plants contributing to the Northwest Power Pool.[216]

Lasting effects of BPA's wheeling program include the following:

[214] BPA, *Report on the Columbia River Power System* (Washington, D.C.: U.S. Department of the Interior, 1946), 14.

[215] BPA, *1966 Report,* 20.

[216] BPA, *1960 Annual,* 9.

- The authority to wheel power virtually eliminated proposals to build non-federal transmission lines which would duplicate federal lines.[217]
- Wheeling provides an additional income stream to BPA, allowing it to continue to meet its payments to the US Treasury as required by law.[218]

> "BPA's wheeling program is an important revenue producer. In fiscal 1965 it produced $4,397,000, or nearly 5 percent of our total revenues. By 1970 wheeling will account for about $11 million, or 9 percent of our total revenues."[219]

- Wheeling allowed the near unification of the private-public partnership within the Northwest Power Pool system.[220]

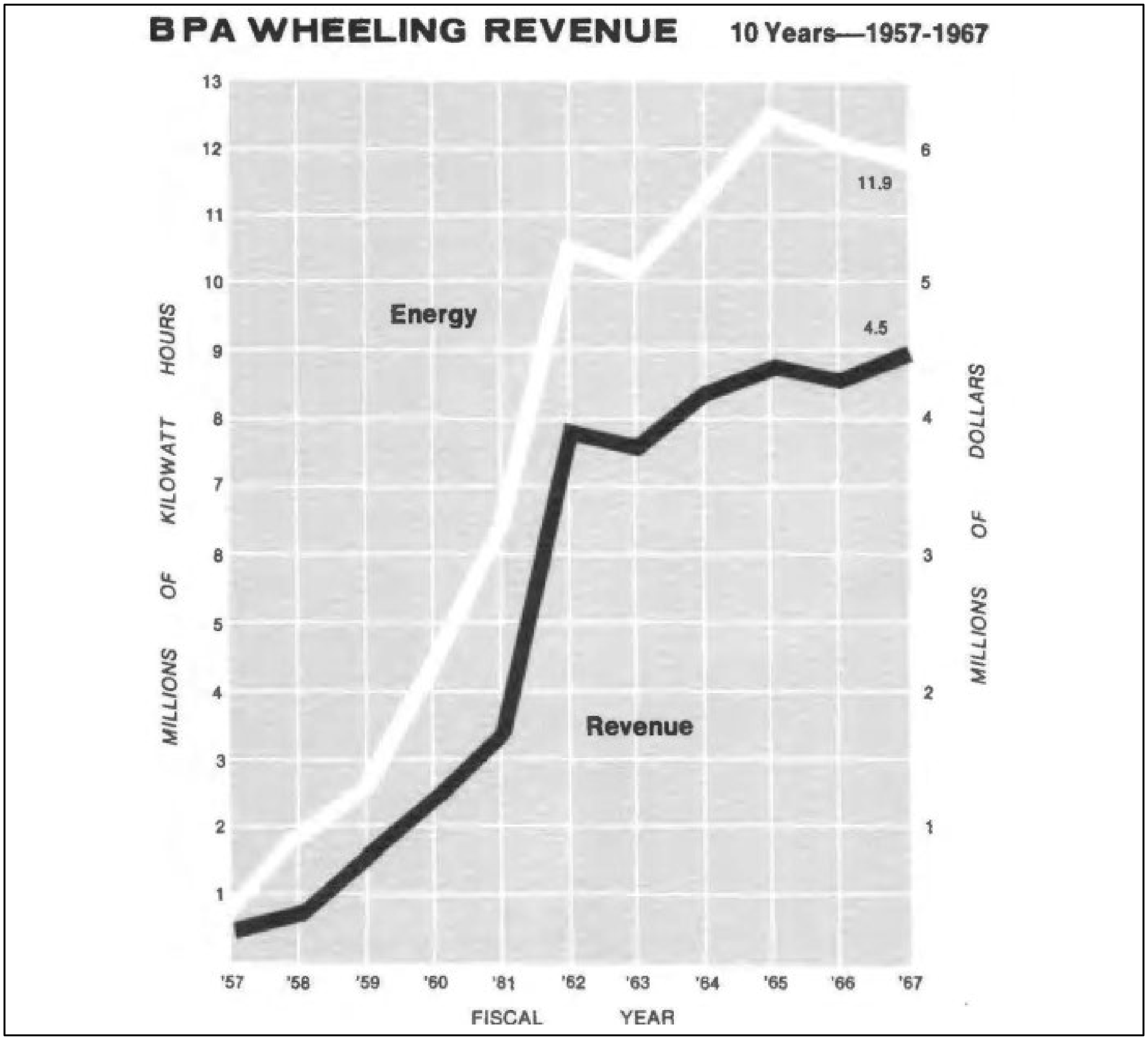


Figure 32. BPA's First Decade of Wheeling Revenue: 1957-1967.[221]

---

[217] Kramer, *Corridors of Power,* 78.
[218] Kramer, *Corridors of Power,* 77.
[219] BPA, *1965 Report,* 9.
[220] Kramer, *Corridors of Power,* 77.
[221] BPA, *1967 Annual Report,* 16.

3.5.3 The Columbia River Treaty

As early as 1947, the BPA transmission system had been inter-connected with Canadian utilities to allow the balancing of power generation and demand across the international border. Although initiated during the war to supply the Canadian defense industry, the 230-kV line (which connected the two power systems in Blaine, Washington) was completed after the war's end in August of 1947. The interconnection allowed BPA a market for its surplus power and provided Canadians with a low-cost power source.[222]

President Eisenhower and Canadian Prime Minister John Diefenbaker signed the Columbia River Treaty on January 17, 1961; however, it took more than three years of negotiations before the treaty was ultimately ratified.[223] President Lyndon Johnson and Canadian Prime Minister Lester Pearson signed the Columbia Treaty Protocols on September 16, 1964, formally acknowledging the near decade-long process of joint development and cooperation between the two nations in the Columbia River Basin (Figure 33).[224] The Columbia River Treaty resulted in the construction of Libby Dam in 1972, the reservoir behind the dam that backed water up 42 miles over the international boundary into Canada (Figure 34). The treaty also resulted in the construction of three water storage dams inside Canada: Duncan (completed 1967), Keenleyside (formerly called High Arrow Dam, completed 1968), and Mica (completed 1973). The three Canadian reservoirs were designed to hold back flood waters and release them as needed to produce additional power at dams downstream in the U.S.[225] BPA's 1968 annual report stated that

> Water released from the Canadian projects will increase the dependable capacity at 11 U.S. dams downstream by 2.8 million kilowatts. The additional power produced with this capacity is being shared equally by Canada and the United States. Canada has sold her share to purchasers in the United States for 30 years.[226]

Without the surplus power produced as a result of the Columbia River Treaty dams, BPA would not have had enough power to transmit to California for the Pacific Northwest-Pacific Southwest Intertie. Several other transmission lines were associated with the Columbia River Treaty including Bell-Boundary No. 2 and Boundary-Waneta No. 1. Energized in 1965 and 1967, respectively, these two 230-kV lines served as interconnections with Canada, integrating power from dams near the Canadian border into the BPA grid through Bell Substation near Spokane, Washington.[227] The Noxon-Conkelley Line, a 103-mile-long 230-kV line running from Noxon Dam to Conkelley substation in Montana, was energized in 1968 to serve new loads near Columbia Falls, Montana and to help integrate power from the Libby Dam.[228]

---

[222] Kramer, *Corridors of Power,* 79.

[223] Kramer, *Corridors of Power,* 81.

[224] Kramer, *Corridors of Power,* 83; BPA, *1962 Report,* 1962: iv.

[225] BPA, *1964 Report,* 7-8.

[226] BPA, *1969 Annual Report,* 27.

[227] BPA, *1964 Report,* 24-25.

[228] BPA, *1964 Report,* 25.

Figure 33. Secretary of the Interior Stewart Udall, Washington Governor Albert Rosellini, Senator Henry Jackson and Senator Warren Magnuson watch U.S. President Lyndon Johnson sign the Columbia River Treaty with Canada.[229]

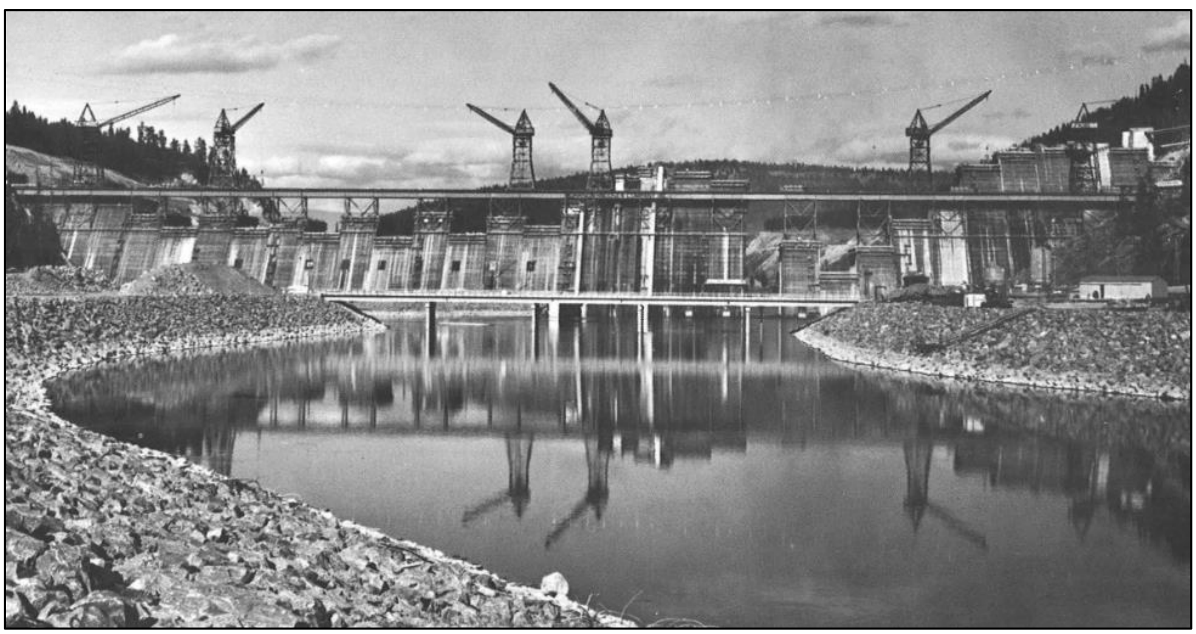


Figure 34. Libby Dam, in northern Montana, (the only project on U.S. soil associated with the Columbia River Treaty) under construction by USACE in 1970.[230]

3.6 Power Generation Diversification

As a federal agency that markets hydroelectric power, BPA history is closely intertwined with hydroelectric projects developed during the period of significance (Figure 35). Although minor

[229] BPA, *1964*.

[230] BPA, *1970 Annual Report*, 4.

compared to its hydroelectric involvement, BPA was also involved with hydrothermal power generations, where heat energy is converted to electricity by the burning of coal, oil or gas, or by nuclear fusion (see Hanford summary in Section 3.2.2).

3.6.1 Hydroelectric Developments

From the Depression era New Deal programs to the early 1970s, the federal government implemented an aggressive construction program to develop dams throughout the Pacific Northwest for hydroelectric power, flood management and irrigation. Following the end of WWII in 1945, Congress authorized six new federal dams on the Columbia River. Seven more dams were approved in 1950 and two more in 1954. From 1954 until 1962 no new projects were authorized; however, dams approved earlier were under construction. These dams supported the BPA transmission network by generating power, supporting industries, connecting with underserved markets, and fostering community development and growth. Between 1962 and 1974 only a few dams were approved because of several factors, including lack of funding, environmental impacts, and public opposition. Table 2 summarizes the development of Pacific Northwest hydroelectric projects in the twentieth century.[231]

Table 2. Hydroelectric Projects in the Pacific Northwest and Associated BPA Transmission Lines in 1974[232]

Dam Name	River	State	Built Date	Extant Associated BPA Transmission Lines
Albeni Falls	Pend Oreille	Idaho	1951-1955	Albeni Falls-Bonners Ferry, Albeni Falls-Sand Creek No 1, Albeni Falls-Pine Street No. 1, Sacheen-Albeni Falls No. 1
Anderson Ranch	South Fork Boise	Idaho	1941-1950	Anderson Ranch-Mountain Home No. 1
Big Cliff	North Santiam	Oregon	1951-1954	Benton-Taunton, Big Cliff-Detroit
Black Canyon	Payette	Idaho	1922-1924	Black Canyon-Emmett No 1
Boise Diversion	Boise	Idaho	1906-1909	No extant BPA transmission lines
Bonneville	Columbia	Oregon-Washington	1933-1938	Bonneville PH 1-Hood River No.1; Bonneville PH 1-North Bonneville No.1, and No. 2; Bonneville PH 1-North Camas No. 1; Bonneville PH 1-Alcoa 1 and 2 No. 2; Bonneville PH 2-North Bonneville No. 3 and 4;
Chandler	Yakima	Washington	1953-1956	Grandview-Richland
Chief Joseph	Columbia	Washington	1950-1958	Chief Joseph-Sickler No. 1, Chief Joseph-Snohomish No. 3, Chief Joseph-Snohomish No. 4, Chief Joseph-Monroe
Cougar	South Fork McKenzie	Oregon	1956-1963	Cougar-Willakenzie
Detroit	North Santiam	Oregon	1949-1953	Detroit-Santiam No. 1, Big Cliff-Detroit, Jones Canyon-Santiam No. 1, McNary-Santiam No. 1
Dexter	Middle Fork Willamette	Oregon	1953-1955	Lookout Point-Alvey No. 1
Dworshak	North Fork Clearwater	Idaho	1966-1973	Dworshak PH-Orofino No. 1,
Foster	South Santiam	Oregon	1961-1968	Foster Creek-Chief Joseph, Foster Tap to Green Peter-Lebanon No. 1, Grand Coulee-Okanogan No. 1, Midway-Grand Coulee No. 3, Olympia-Grand Coulee No. 1, Potholes-and Coulee-Bell No. 5

[231] BPA, *1962 Report*, 20-21.

[232] BPA, *1974 Report on the U.S. Columbia River Power System* (Washington, D.C.: U.S. Department of the Interior, 1974), 31.

Dam Name	River	State	Built Date	Extant Associated BPA Transmission Lines
Grand Coulee	Columbia	Washington	1933-1942	Columbia-Grand Coulee No. 1, Covington-Grand Coulee No. 3, Grand Coulee-Bell No. 1, 2, 3 and 5, Grand Coulee-Chief Joseph No. 1, Grand Coulee-Chief Joseph No. 2, Grand Coulee-Okanogan No. 1, Grand Coulee-Okanogan No. 2, Grand Coulee-Westside No. 1
Green Peter	Middle Santiam	Oregon	1961-1967	Green Peter-Lebanon No. 1
Hills Creek	Middle Fork Willamette	Oregon	1957-1962	Hills Creek-Lookout Point
Hungry Horse	South Fork Flathead	Montana	1948-1953	Hungry Horse-Conkelley No. 1, Hungry Horse-Columbia Falls No. 1
Ice Harbor	Snake	Washington	1957-1962	Ice Harbor-Franklin No. 1 and 2, Sacajawea-Sun Harbor No. 1
John Day	Columbia	Oregon-Washington	1958-1971	John Day-Big Eddy No. 1, John Day-Grizzly No. 1 and 2, John Day-Marion No. 1, John Day-Ostrander No. 1
Libby	Kootenai	Montana	1966-1975	Libby-Conkelley No. 1, Noxon-Libby No. 1, Libby-Bonners Ferry No. 1, Libby-Libby (PP&L) No. 1
Little Goose	Snake	Washington	1963-1970	Little Goose-Dworkshak No. 1, Lower Monumental-Little Goose No. 1 and 2
Lookout Point	Middle Fork Willamette	Oregon	1949-1955	Lookout Point-Alvey No. 1 and 2
Lost Creek (now William L. Jess)	Rogue	Oregon	1967-1977	No extant BPA transmission lines
Lower Granite	Snake	Washington	1965-1984	Little Goose-Dworkshak No. 1
Lower Monumental	Snake	Washington	1962-1969	Lower Monumental-Hanford, Lower Monumental-John Day, Lower Monumental-Little Goose No. 1 and 2
McNary	Columbia	Oregon-Washington	1947-1957	McNary-Alvey No. 1, McNary-Franklin No. 1 and 2, McNary-Harvalum No. 1, McNary-Richland, McNary-Ross, McNary-Roundup, McNary-Santiam No. 1
Minidoka	Snake	Idaho	1904-1906	Minidoka PH-Raft River, Minidoka PH-Rupert, Minidoka PH-Second Lift No. 1 and 2, Minidoka PH-Unity No. 1
Palisades	Snake	Idaho	1951-1957	Palisades-Goshen No. 1, Palisades-Swan Valley No. 1
Roza	Yakima	Washington	1956-1958	No extant BPA transmission lines
Teton	Teton	Idaho	1972-1975	Swan Valley-Goshen No. 1, Swan Valley-Teton
The Dalles	Columbia	Oregon	1952-1960	The Dalles PH-Big Eddy No. 1 - 6, Big Eddy-Chemawa, Big Eddy-Chenoweth No. 1, Big Eddy-McLoughlin No. 1, Big Eddy-Midway, Big Eddy-Redmond, Big Eddy-Troutdale

Figure 35. Columbia River Basin federal dams[233]

[233] AECOM, GIS Services.

Some highlights of hydroelectric developments associated with BPA's period of significance include the following:

- Construction began on the Grand Coulee and Bonneville dams in 1933. Both were multi-purpose dams intended to generate hydroelectric power and provide flood control. Bonneville Dam was completed in 1937 as the first dam on the mainstream Columbia River. BPA began marketing power from Bonneville Dam in 1938. Grand Coulee Dam's completion followed in 1941.
- In 1944, BPA proposed a basin-wide program for hydro-electric developments including Hungry Horse in Montana, the Cabinet Gorge and Albeni Falls projects in northern Idaho, the Foster Creek and Snake River projects in Washington, the Umatilla Dam (name changed to McNary before completion) on the Columbia and the Detroit project in Oregon. The program involved an expenditure of $600,000,000 in wartime emergency and post-war projects. The advance construction program included about $100,000,000 for new transmission lines and substations to coordinate existing and proposed dams and load centers in a region-wide transmission grid system.[234]
- In 1950, BPA agreed to supply uninterrupted power to several manufacturers of critical materials in western Montana following completion of the Hungry Horse Dam. BPA signed a firm power contract with the Montana Power Company for an initial term of five years beginning with first delivery of power from Hungry Horse in the fall of 1952.[235] The Hungry Horse Dam provided power to the Montana Power Company (now NorthWestern Energy), which then distributed the power to Montana electric cooperatives. The initial five-year contract between BPA and Montana Power began in fall 1952 with the first delivery of power from the dam. The contract also provided for "downward adjustments" of Montana Power's rural and domestic rates once BPA initiated power delivery.[236] According to BPA Administrator Paul J. Raver, western Montana would immediately experience "substantial annual savings for some 2,000 customers of three co-operatives," including the Missoula Electric Cooperative, the Ravalli Electric Cooperative, and Northern Lights, Inc. Lincoln Electric Cooperative would begin receiving service the following year.[237] On December 31, 1950, BPA Administrator Paul J. Raver wrote the U.S. Secretary of the Interior, stating that BPA had made commitments to several manufacturers of "critical materials" in western Montana for supplies of "uninterruptible power to become firm following the completion of Hungry Horse dam".[238]
- In 1954, major construction to bring power from Chief Joseph to the Puget Sound area, McNary Dam to Portland and Willamette Valley, and Lookout Point Dam to Alvey Substation.[239]
- In 1962, construction of the 18-mile 115-kV transmission line from Lebanon substation to the Army Corps of Engineers Green Peter Dam in western central Oregon. Initially installed to furnish construction power to the dam it later integrated generation from the dam into the BPA grid.[240]

---

[234] BPA, *Annual Report of the Administrator* (1944), 44.

[235] BPA, *Columbia River Power System* (1950), iii.

[236] BPA, *Columbia River Power System* (1950); "Montana Power," *The Inter Lake*.

[237] "Montana Power," *The Inter Lake*.

[238] BPA, *Columbia River Power System* (1950).

[239] BPA, *Columbia River Power System* (1954), 37.

[240] BPA, *1962 Report*, 9.

3.6.2 The Hydrothermal Power Program

As BPA's transmission system and the regions demand for power grew, reliance on water as the primary source of power generation began to appear unpredictable and problematic, and BPA began exploring hydrothermal power sources. Insufficient snowpack, early or late snow melt, late or early rains affected BPA's ability to generate a constant capacity of power, all while the power needs of BPA's customers were ever increasing. BPA's 1970 annual report proposed thermal plants as a solution to augment the region's hydroelectric sources:

> The forecast indicates that Northwest electric energy requirements will triple in the next 20 years and that within a few years virtually all of the economically feasible hydro energy potential in the region will have been built or will be under construction. Thereafter, thermal plants will have to be built to augment hydro projects in order to provide an adequate supply of energy. Additional hydro generation will have to be installed to meet the region's peak power needs. The plan requires integration of the region's present and future power facilities, both federal and non-federal, as though the entire power system were under a single ownership.[241]

The Hydrothermal Power Program was announced October 22, 1968, by the Joint Power Planning Council which was made up of 109 public and private utilities in the Northwest and the Bonneville Power Administration.[242] Within the new hydrothermal program, the federal government would continue to construct the high-voltage transmission system and additional hydro capacity; public and private utilities would build and operate thermal plants sized, located, and scheduled to meet regional loads; and BPA would acquire or exchange power from the utilities' plants.[243] In this way, higher cost thermal power will be melded with lower cost hydro power to meet the steadily increasing demand for power.

The Nixon administration approved the Hydrothermal Power Program for the Pacific Northwest on October 27, 1969. Passage of the fiscal year 1970 Public Works Appropriations bill provided congressional endorsement of the Hydrothermal Power Program and approved implementation of the program through 1981.[244] [245]

A coal-fired plant near Centralia, Washington, was the initial thermal plant of the hydrothermal program (Figure 36). The plant was sponsored by Pacific Power & Light Company and the Washington Water Power Company. The first of two 700,000-kilowatt generator units of the coal-fired Centralia Project went into test operation in August 1971, and the second unit was scheduled for completion in 1972, with the plant going online the same year. The initial operation was celebrated as a significant milestone in the evolution of the power system in the Northwest.[246] The 116-mile 500-kV Raver-Paul-Allston line was built to integrate the coal-fired power into BPA's transmission grid and connect to the Seattle and Portland areas.[247] One boiler of the Centralia plant was shut down in 2020 and the other will be shut down in 2025. Jim Bridger remains open due to a temporary order signed in December 2021.[248]

No other plants were completed during the period of significance although construction was underway on other plants (Table 3). Portland General Electric Company built the second thermal

---

[241] BPA, *1970 Annual Report* 1.

[242] BPA, *1968 Annual Report*, 6.

[243] BPA, *1968 Annual Report*, 1.

[244] BPA, *1969 Annual Report*, 1.

[245] BPA, *1970 Annual Report*, 2.

[246] BPA, *1971 Annual Report*, 6.

[247] BPA, *1969 Annual Report,* 21.

[248] *State of Wyoming*, "Governor Signs Order to Keep Jim Bridger Power Plant Unit Operating," December 28, 2021, https://governor.wyo.gov/media/news-releases/2021-news-releases/governor-signs-order-to-keep-jim-bridger-power-plant-unit-operating .

plant, a 1,100,000-kilowatt nuclear plant at the Company's Trojan site near Rainier, Oregon, which came online in December 1975.[249]

Table 3. Thermal Plants in the Hydrothermal Power Program

Thermal Plant Name	State	Construction Dates	Power Source
Centralia	Washington	1968-1972	Coal
Trojan	Oregon	1970-1975	Nuclear
Jim Bridger	Wyoming	1974-1979	Coal
Washington Public Power Supply System (WPPSS) Nuclear Project No. 1	Washington	Not completed	Nuclear
WPPSS Nuclear Project No. 2 (now Columbia Generating Station)	Washington	1975-1984	Nuclear
WPPSS Nuclear Project No. 3	Washington	Not completed	Nuclear
WPPSS Nuclear Project No. 4	Washington	Not completed	Nuclear
WPPSS Nuclear Project No. 5	Washington	Not completed	Nuclear

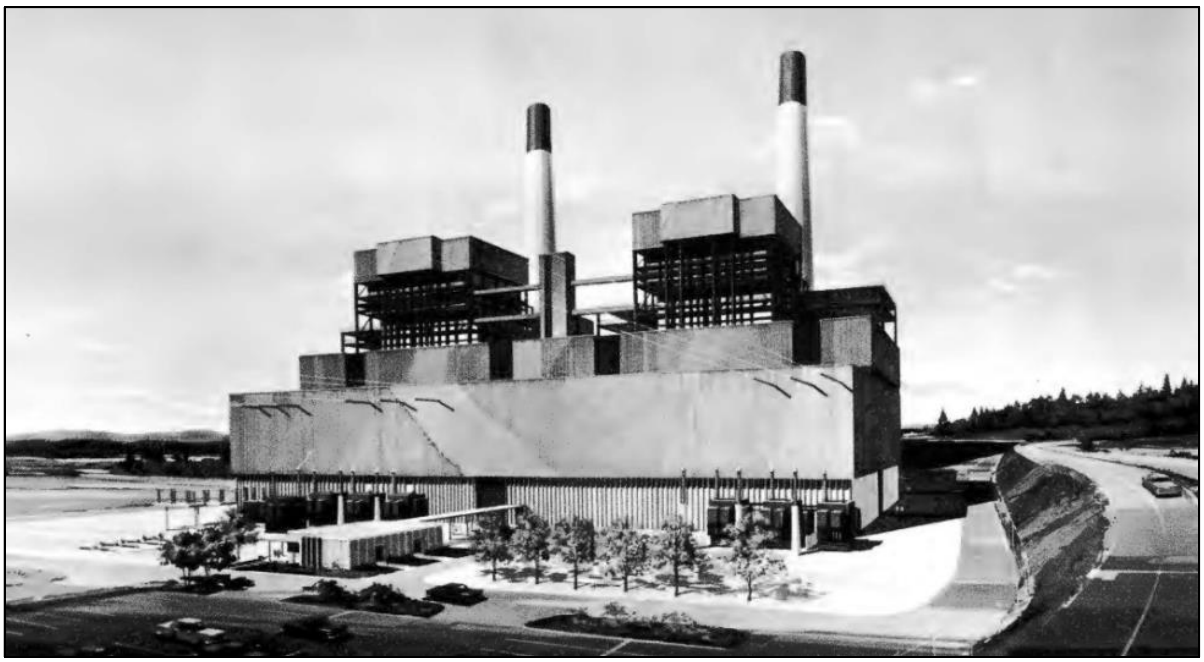


Figure 36. Architectural rendering of the coal-fired hydrothermal plant near Centralia, Washington. Completed in 1972, it was the first power plant constructed for the Hydrothermal Power Program.[250]

3.7 BPA's Growing Environmental Ethic

BPA's consideration for the environment and natural scenery influenced several aspects of its development, including transmission line design and construction. Since 1939, BPA had provisions in its contracts stating it could halt power delivery if a customer's actions polluted a river or detracted from the Columbia Gorge's scenic beauty, expanding these provisions in 1966 to include actions that did not comply with water quality standards.[251]

[249] BPA, *1968 Annual Report,* 8.

[250] BPA, *1967 Annual Report*, 2.

[251] BPA, *1970 Annual Report*, 26.

BPA and other federal and private utilities adopted new environmental policies as a result of NEPA's enactment in 1970 (Figures 37-39). NEPA policies changed the way BPA constructed transmission lines (and other facilities). BPA's first opportunity to follow NEPA came in 1970 when preparing its budget for fiscal year 1972. Federal, state, and local governmental agencies within the region solicited comments on the environmental impact of the proposed program. To inform the general public and receive comments, open meetings were held in eight cities throughout the region with a ninth region wide meeting held in Portland.[252]

Examples of new environmental policies at BPA included:

- eliminating any adverse impact of our facilities on air, and water quality
- minimizing environmental impact of rights-of-way clearing, construction, and transmission line maintenance
- employing special photogrammetry techniques to plan timber removal and create a more natural appearance
- improving the appearance of facilities
- replacing existing lines with higher capacity facilities to make greater use of existing rights-of-way [253]
- establishment of more stringent environmental standards for clearing operations by BPA contractors, including the use of special construction techniques such as hand cutting of vegetation, or controlled burning [254]
- helicopter erection of towers and lines in sensitive areas
- installation of multiple-bundle conductors for high-voltage lines to minimize audible and radio noise [255]
- special plantings for wildlife, visual screening
- maintenance policies for noxious weed and erosion control measures, and control of trees and brush on rights-of-way to prevent interference with operation of transmission lines [256]
- Require industrial customers to provide air and water pollution control plans and specifications to BPA for new or expanded plants, including proof of compliance with governmental pollution control agencies [257]

[252] BPA, *1970 Annual Report*, 9.
[253] BPA, *1970 Annual Report*, 8.
[254] BPA, *1972 Annual Report*, 30.
[255] BPA, *1972 Annual Report*, 31.
[256] BPA, *1971 Annual Report*, 20.
[257] BPA, *1970 Annual Report*, 26.

Figure 37. A sky crane is used to avoid scarring the hillside with access roads during installation of towers for the Lower Granite–Hatwai 500-kV Line near Lewiston, Idaho (1972). [258]

One example of a transmission line that employed these practices is the Hanford-Ostrander 500-kV line which crosses the Columbia River at North Bonneville. BPA's 1973 annual report described the project:

> In an area valued not only for its scenic beauty but also for its fish habitat, BPA decided to use helicopters for clearing as well as construction, the first time such right-of-way preparation had been performed by BPA. All clearing operations were accomplished by hand, with the saleable timber being hauled out by helicopter. The same was done with the logging debris, since burning it would have been too hazardous without fire control access roads. During the installation of the tower footings, large crib walls were erected to prevent soil and debris from slipping down the steep canyon into Tanner Creek. All of the towers along the creek were erected by helicopter, and the pulling lines for stringing the conductor were also installed from the air.[259]

In the 1973 annual report, BPA announced that it had implemented environmental concern into all phases of its design, construction, operating and maintenance activities.[260]

During the 1970s, BPA faced growing concerns for the environment, responding to new federal policies and a looming energy crisis. At a Seattle news conference in August 1973, the Secretary of the Interior said (as reported in the 1974 BPA annual report):

> It now becomes apparent that the Pacific Northwest faces the first real test of whether we as a nation can and will exercise the self-discipline to ward off the looming energy crisis. The contest begins right now, and the name of the game is energy conservation.[261]

---

[258] BPA 1972.

[259] BPA, *1973 Annual Report*, 15-16.

[260] BPA, *1973 Annual Report*, 17.

[261] BPA, *1974 Annual Report,* 21.

BPA's response to energy needs was to replace existing-low voltage transmission with higher capacity lines, enabling larger blocks of power to move over proportionately less right-of-way (ROW). Several lines were retired and replaced with new 500-kV lines based on the reasoning that the higher voltage replacements would "significantly reduce the environmental impact of the growing power supply system." [262]

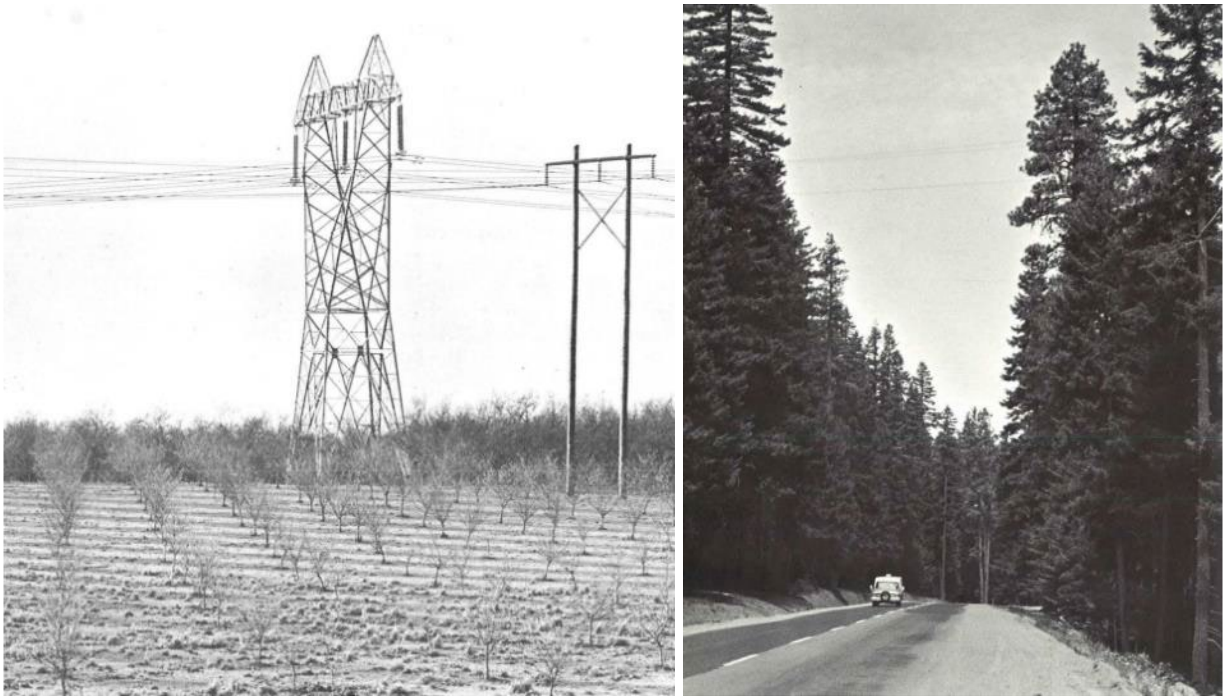


Figure 38. Left: An orchard growing under a transmission line near Keeler Substation in Oregon illustrates BPA's shift towards multi-use rights-of-way to minimize corridor impacts.[263]

Right: Screening of transmission lines along roadways was a method employed by BPA following the passage of NEPA to ensure a balance between BPA's "twin objectives of achieving an adequate and reliable power supply and protecting the environment."[264]

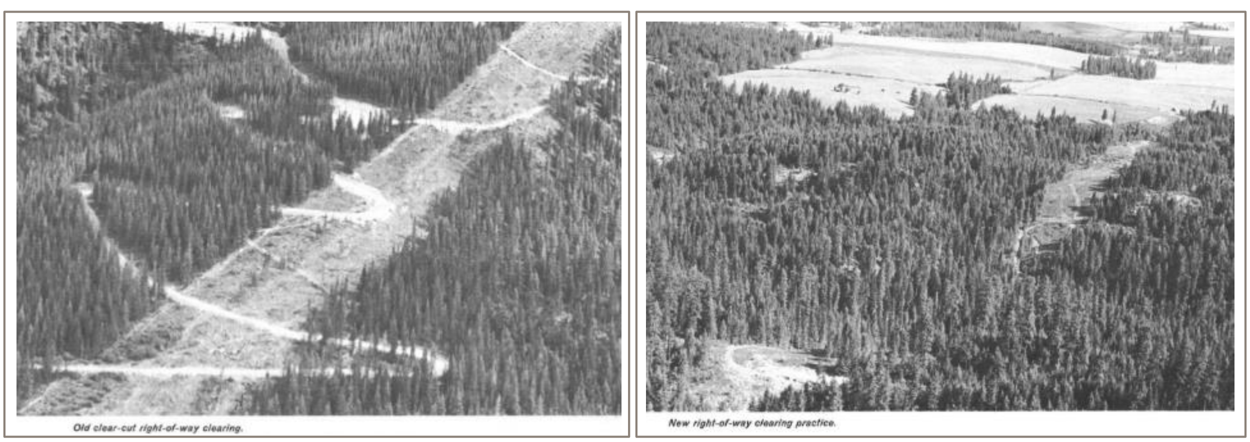


Figure 39. BPA's clearing practices illustrated in pre- and post-NEPA transmission line ROWs.[265]

[262] BPA, *1973 Annual Report*, 15.

[263] BPA, *1970 Annual Report*, 19.

[264] BPA, *1970 Annual Report*, 9-12.

[265] BPA, *1971 Annual Report*, 10-11.

3.8 Technology and Design

During the period of significance, BPA tested and implemented new technologies and design practices for its transmission system that were considered innovative at the time. Some of these led to widespread technological advances for BPA's transmission lines, while others remained only as prototype examples. Summaries are included below that address BPA's shifts in general transmission line design and engineering, beautility concepts, the Pacific Northwest-Pacific Southwest Intertie, transmission testing, and computers and automation at BPA.

3.8.1 Design Engineering

BPA began advancing its engineering practices during the Master Grid period. Motivated by aspirations to make transmission line constructure more affordable, BPA altered materials and industry practices used in transmission line construction. BPA's 1950 annual report describes the cost savings:

> Engineering advances within the last 10 years substantially lowered costs of transmission per-kV-ampere mile. The utility industry's acceptance of new low levels of insulation requirements, pioneered by Bonneville engineers, created savings of as much as 10 percent in the cost of transformers, circuit breakers and other high voltage equipment. These savings increased competition among equipment manufacturers in bids as much as 50 percent lower than 1947 and 1948 quotations. Development and use of light steel transmission towers in the late 1940s saved BPA over $4 million in costs of steel alone.[266]

While BPA's first lines were installed with 115-kv voltage, rising costs of labor and material drove BPA to investigate the design of the 230-kV steel towers. Wood poles were used due to a shortage of steel during wartime. A new light steel pole was developed to be used instead of wood pole for several 230-kV lines. Studies showed steel pole structures were both lighter and cheaper than wood structures. Studies in 1947 indicated light steel towers would cost about 24 percent less than wood poles for 230-kV lines per year. Wood structures were expected to have 25-year life spans while steel structures would last for 50 years.[267]

3.8.2 Beautility

From 1965 to 1974, BPA applied a series of beautility design concepts to its transmission system, incorporating aesthetics (beauty) into transmission line design as well as utilitarian factors of function, cost and safety. The concepts, recommended by Stanton, Boles, Maguire and Church Architects in their 1966 *Report on Appearance Planning,* followed modern design trends for buildings and landscape design, and considered scenery as an important characteristic to preserve. By 1975, BPA instituted several specific practices to make transmission lines more aesthetically pleasing, such as painting towers to match their background in scenic areas and high-visibility areas. Lines were also positioned behind natural features to block views of them such as on ridge lines where they would be silhouetted. BPA also avoided construction through parks, national monuments, and scenic recreational or historic areas. New tower designs were developed to be "more attractive."[268] BPA provided consideration of the planning principles in the 1966 Annual Report:

> A report from consulting architects Stanton, Boles, Maguire & Church "recommends that our main efforts at present be directed toward reducing the impact of transmission line rights of way on the natural landscape, a goal in which we concur. To heal the scars

[266] BPA, *Columbia River Power System* (1950), 34.

[267] F.W. Farr, *Light Steel Tower Design May Save One-tenth over Wood Pole Lines* (Portland, OR: Bonneville Power Administration, 1949), 86-87.

[268] BPA, *Strings of Energy: How BPA Builds Powerlines* (Washington, D.C.: U.S. Department of the Interior, 1975), 8.

made by rights of way, stumps are being cut flush with the ground; grass, deer browse and low-growing native shrubbery are being planted; water bars are being constructed to prevent soil erosion; and land owners are being encouraged to utilize rights of way for Christmas trees and other low-growing cover crops.[269]

The appearance planning recommendations for transmission lines included several recommendations. Considerations for **Route Selection** included the following criteria**:**

- Avoid routing a line along the top of a range of hills; especially when it is visible from the highway, body of water, park or populated area. This would mean increased use of volleys, canyons and draws.
- Wherever possible, avoid the sky as a background for the towers.
- In the open desert and plains, allow the line to contribute a positive feature to on otherwise monotonous view by respecting natural changes of elevation and by providing a change of scene along the highway.
- Avoid running a line across high points in the area (Figure 40).
- Avoid long views of transmission lines coming down hillsides adjacent to the highway.
- Where interference with the scene is unavoidable, an effort should be made to "feature" a tower and to accentuate its positive qualities, such as height, shape, structure or other special characteristics.
- Where a line route is near the highway and parallel to it, run the line on the other side of the hill and provide only occasional glances of its progress. Or run the line close to the highway on a "monotonous" stretch to provide the traveler with a sense of scale, speed, and companionship.
- In a forest, use high, long span towers to allow for the retention of the major part of growth standing in the right-of-way, adjacent to the highway.
- Avoid crossing at high points in the road so that the towers cannot be seen from a great distance. Instead, where possible, cross the highway between two high points, at a dip, or on a curve in the road (Figure 41).
- At road crossings of two or more circuits, and where only a portion of the line is visible from the highway, it is recommended that the lines be grouped together on double circuit towers to narrow the necessary corridor width at the crossing.[270]

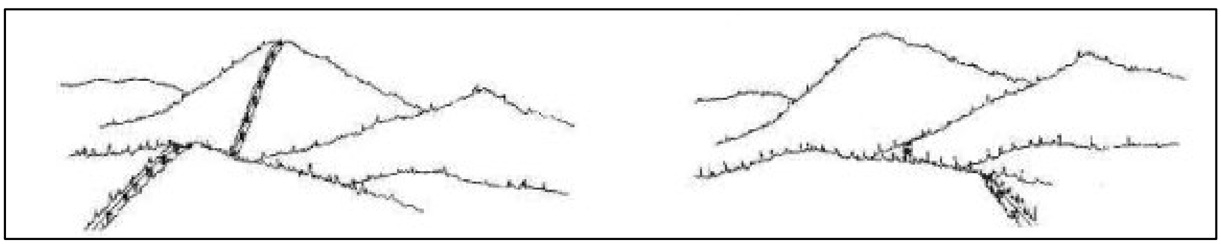


Figure 40. Beautility recommendations for route selection that emphasizes aesthetic concerns, such as having a transmission line run across high points to decrease visual impacts.[271]

[269] BPA, *1966 Report*: intro letter from Charles Luce.

[270] Stanton, Boles, Maguire & Church, *A Report on Appearance Planning* (prepared for BPA, 1966), 43-45.

[271] Stanton, Boles, Maguire & Church, *Appearance Planning*, 43.

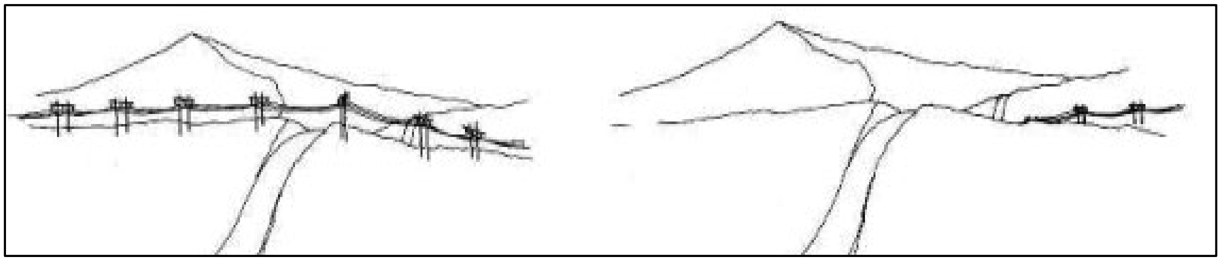


Figure 41. Beautility recommendation to have transmission lines cross highways (and other high visibility areas) between high points to decrease their visibility from a distance.[272]

Additional transmission line considerations included the following:

- **ROW:** Clearance requirements: a re-evaluation of clearance requirements under and on the side of transmission lines of various voltages. Based on these serious and factual clearance requirements, a number of varieties of native shrubs and small trees could probably be left in place."[273]
- **Vegetative Screening:** Low shrub material left in the foreground will, many times, relieve the severity of a clearing gash when viewed from a road or residential development. Transmission corridors crossing highways can be partially screened by plantings close -to or within the highway right-of-way (Figures 42-43). The closer the plant is to the viewer, the smaller it can be and still act as a screen. Also, a small plant on the top of a bank makes an effective screen."[274]
- **Multi-use ROW**: Directed BPA to conduct a feasibility study "to determine the feasibility of using semi-rural and urban rights-of-way for recreation purposes, park strips and open playground."[275]
- **Access road construction and maintenance**: Bare scars and scrapes left by access road construction be cleanly shaped and planted with locally indigenous plant materials to minimize the presence of the road. The road should be neatly graded and the surface material uniform. New access roads should be planned with safe and unobtrusive access from the highway and with a minimum of blighting cuts and fills."[276]
- **Transmission Lines Structures:** Structure design should not only consider engineering concerns but also how structural designs influence the width of right of ways. Incorporate expandability as a design criterion, noting how often BPA is working to deal with facility growth and expanding power needs (Figure 44). "We propose the development of an expandable transmission support for a variety of line configurations; some of its advantages might include a more unified and simple form, componentized parts, versatility of arrangement and ease of erection and maintenance. The last characteristic is essential in areas where mobility is difficult or impossible."[277]
- **Insulators:** Insulators are to be uniform in color. Although they are small, they are everywhere, so their visual impact is noticeable. At the time of the printing of this report, BPA was in the process of testing new materials including a lightweight fiberglass that might replace their older brown ceramic insulators. The report suggests that whatever

[272] Stanton, Boles, Maguire & Church, *Appearance Planning*, 45.
[273] Stanton, Boles, Maguire & Church, *Appearance Planning*, 38.
[274] Stanton, Boles, Maguire & Church, *Appearance Planning*, 39.
[275] Stanton, Boles, Maguire & Church, *Appearance Planning*, 40.
[276] Stanton, Boles, Maguire & Church, *Appearance Planning*, 41.
[277] Stanton, Boles, Maguire & Church, *Appearance Planning*, 42.

material they go with should be uniform in shape and color throughout all new construction. They also recommend a new color-code system for insulators as a means to identify line voltage and load for the public and employees.

- **Conductors:** Suggests that BPA research new ways to reduce the sheen from metal conductors, particularly aluminum. The report offers one potential solution in which the sheen is darkened by adding a low gloss color during the anodizing process but recommends further research.[278]

Figure 42. Illustration emphasizing the aesthetic benefits of replanting clearing scars.[279]

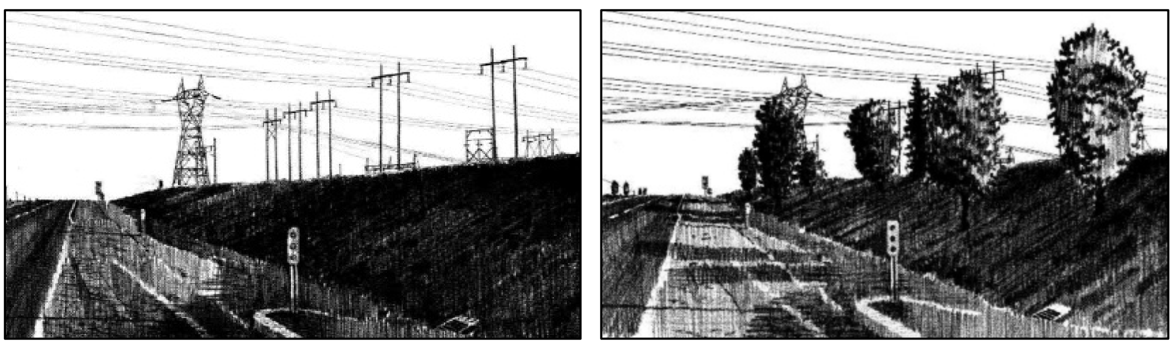
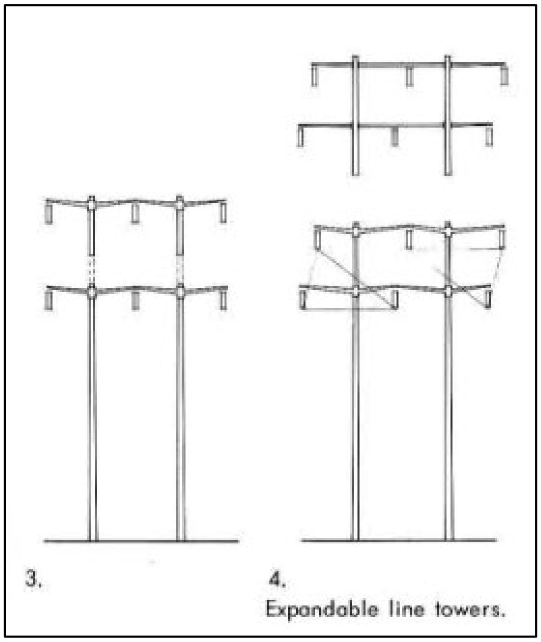


Figure 43. Architectural renderings illustrating effective use of screening plants near roadways.[280]

[278] Stanton, Boles, Maguire & Church, *Appearance Planning*, 42.
[279] Stanton, Boles, Maguire & Church, *Appearance Planning*, 40.
[280] Stanton, Boles, Maguire & Church, *Appearance Planning*, 39.



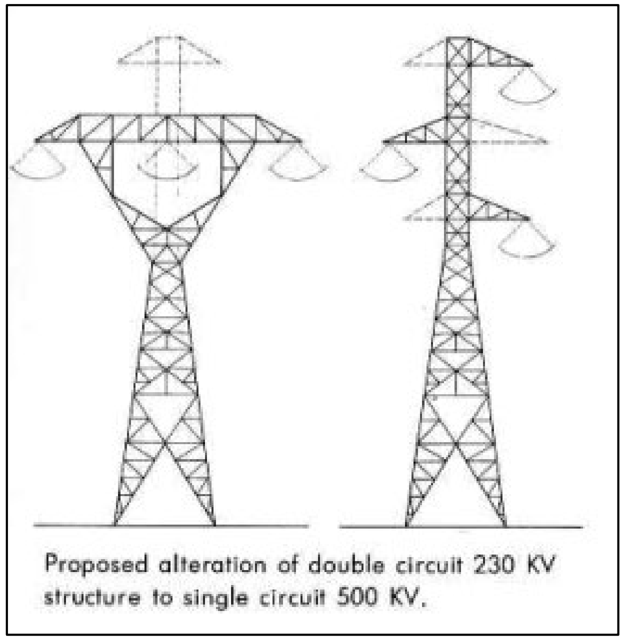


Figure 44. Beautility design recommendations for expandable line towers (left) and alterations to double circuit 230-kV structure to accommodate single circuit 500-kV voltage.[281]

3.8.3 Pacific Northwest – Pacific Southwest Intertie

The Pacific Northwest–Pacific Southwest Intertie ("the Intertie") was a monumental engineering achievement that connected the West Coast's main power grids (Figure 45). The largest transmission project in the nation's history, the Intertie was built to "balance power needs in the West" and permit the Northwest and Southwest to share surplus electrical power.[282] BPA's 1967 annual report described the project:

> "When complete, the Intertie will represent an investment of $660 million with $273 million coming from private utilities, $298 million from the federal government, and $89 million from the City of Los Angeles. BPA's share of the federal cost is $167 million and the Bureau of Reclamation's $131 million."[283]

Intertie construction lasted from 1965 to 1970. Upon completion, two 500-kV AC transmission lines (1967 and 1968) extended approximately 940 miles from the John Day Dam on the Columbia River southward through the Central Valley of California, terminating at the Lugo substation near Los Angeles, and a third transmission line, an 800-kV DC (1970) line, began at the Celilo Converter Station, near the Dalles Dam on the Columbia River, ran southward through Central Oregon and Nevada before terminating at the Sylmar Converter Station near Los Angeles.[284] At the time of completion, it was the United States' first and the world's longest DC transmission power line (846 miles).[285] A third 500-kV AC line came online in 1992, extending from the Alvey Substation near Eugene, Oregon south to the Tesla Substation near San Francisco. Today, the Intertie links electrical systems from utilities in eleven states plus British Columbia, including "the largest hydrosystem (BPA), the largest municipal system (Los

281 Stanton, Boles, Maguire & Church, *Appearance Planning*, 42.

282 "Pacific Intertie Map, The Oregon History Project," BPA, 1964, accessed February 23, 2021, https://oregonhistoryproject.org/articles/historical-records/pacific-intertie-map/#.XGWkuJXrvZN

283 BPA, *1967 Annual Report,* 12.

284 BPA, "Pacific Intertie Map, The Oregon History Project."

285 Larry Coffman, "Bonneville Flexes Its Muscles On its 30th Birthday," *Seattle Times*, August 20, 1967.

Angeles), and the largest privately-operated system (Pacific Gas and Electric) in the United States."[286] The 1970 annual report celebrated the accomplishment:

> On May 21, 1970, the first direct-current line of the Pacific Northwest-Pacific Southwest Intertie, stretching from The Dalles Dam on the Columbia River to Los Angeles, California, went into commercial operation. The Celilo-Sylmar d-c Line [287], as it is called, is unique in the United States and the world. It is the world's largest long-distance (846 miles), high-voltage (800,000 volts) direct-current transmission line. Together with terminal facilities at each end which convert AC to DC and vice versa, the Celilo-Sylmar d-c line represents a major breakthrough in electric transmission technology.[288]

The project allowed BPA and Northwest utilities to sell secondary (surplus) energy to the Pacific Southwest, generating extra revenue and, in 1975 alone, saving the Southwest utilities the "equivalent to more than 31 million barrels of costly, substantially imported oil."[289]

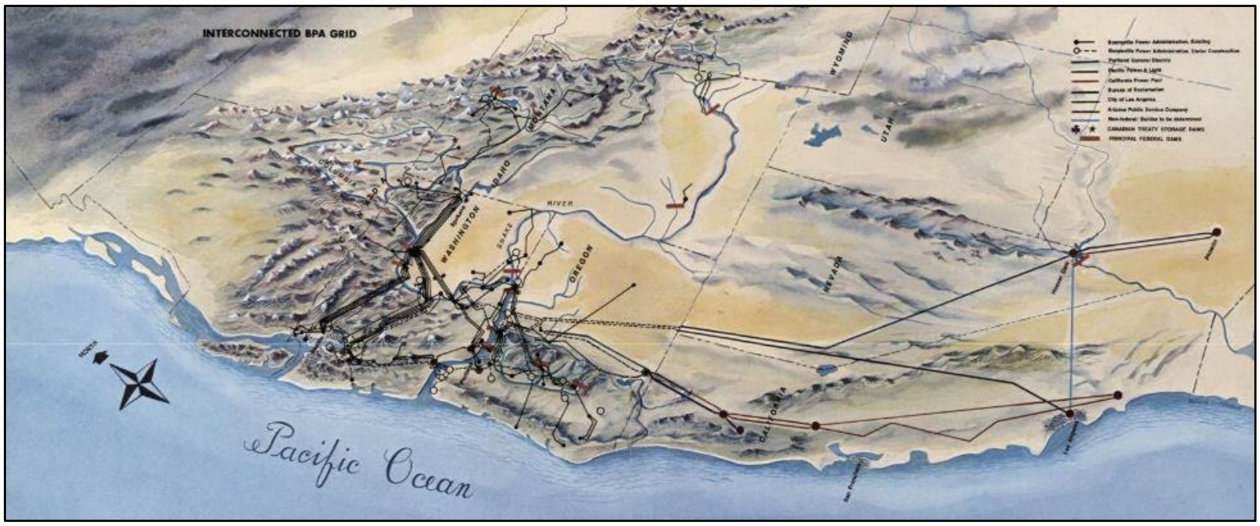


Figure 45. Illustration of the BPA Grid, including the future Intertie extending into California and Nevada. The Intertie connected various types of transmission facilities with the Columbia River's federal dams, including power, compensation, and converters. The line to Hoover Dam above was never built.[290]

Another significant innovation of the Pacific Northwest—Pacific Southwest Intertie was the development of the Delta configuration towers, the first of which were erected outside of Bend, Oregon, in October 1965 (Figure 46). BPA's Annual Report from that year described the new tower type and its advantages over previous design types:

> The upper part of the tower is a six-sided open frame. One model of this tower…stands on a single mast of lattice steel. Guy wires hold it upright. Another model has four legs and is self-supporting. One conductor splits the open frame. Two other conductors hang from the lower corners of the frame. The conductors thus form a triangle 40 feet wide at the base and 26 feet high. This delta arrangement offers several electrical advantages. Reactance in the line is reduced 6 to 7 percent which enables the line to carry more power with less serious compensation equipment.[291]

[286] BPA, "Pacific Intertie Map, The Oregon History Project."

[287] This line is currently known as the Pacific Direct-Current Intertie (PDCI).

[288] BPA, *1970 Annual Report*.

[289] BPA, *1976 Annual Report*, 8.

[290] BPA, *1966 Annual Report*.

[291] BPA, *1965 Report*, 17.

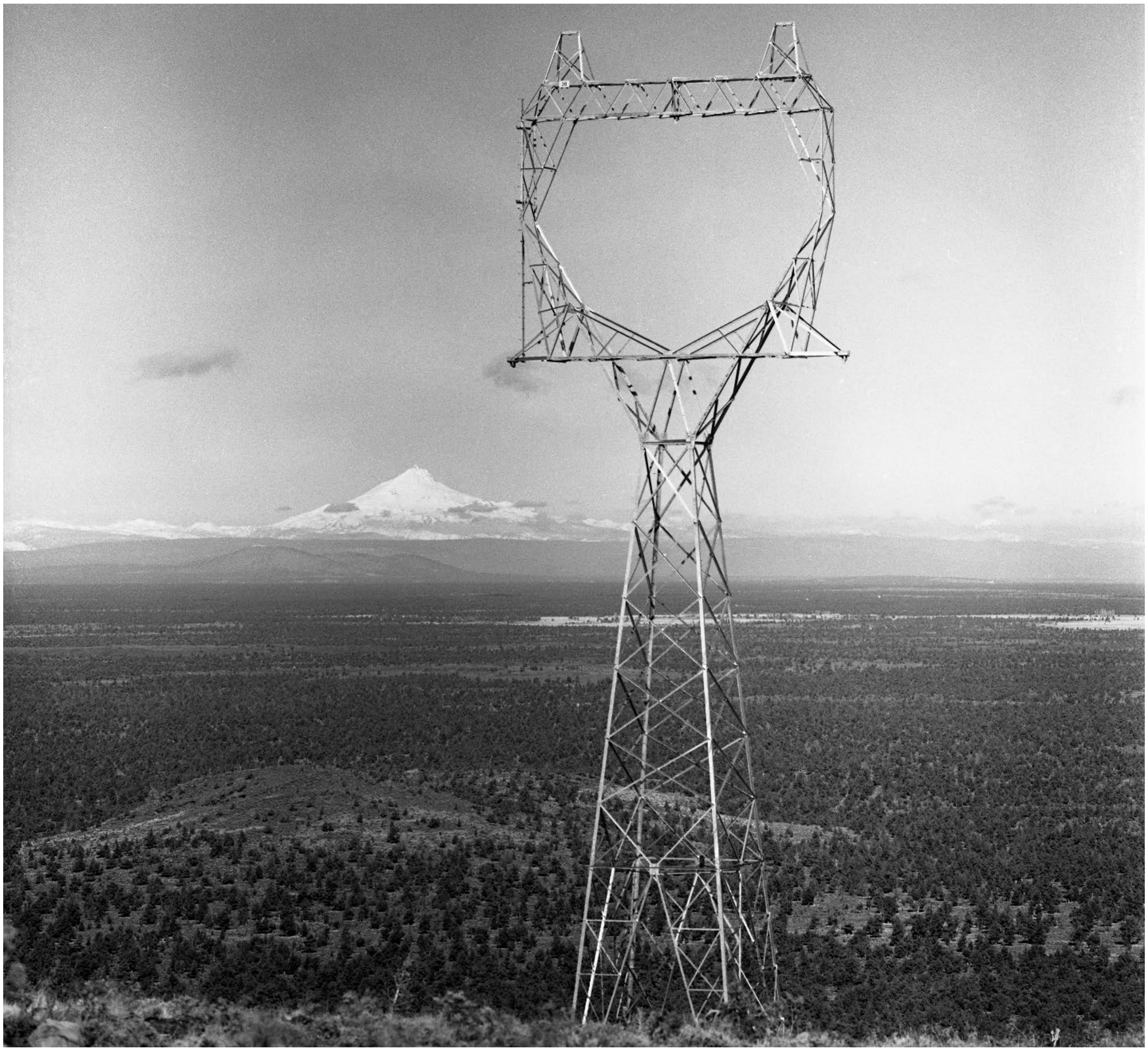


Figure 46. Construction of a Delta Configuration tower along the Pacific Direct Current Intertie near Bend, Oregon, October 1966. [292]

3.8.4 Transmission Testing

BPA invested in and tested new technologies, participating in several testing programs during the period of significance that led to innovations in technology and design. For some of BPA's transmission testing developments, planning and/or construction began during the period of significance, but the actual testing did not occur until after the period of significance.

BPA constructed and tested the nation's first **345-kV steel transmission structures** in 1954 on corridors that traversed difficult terrain in Washington's Cascade Mountains. The BPA's Chief Joseph-Snohomish Line was designed to be nearly 135 miles long and be predominantly of single-circuit construction. The McNary-Ross Line, was approximately 180 miles long and consisted of mixed single-circuit and double-circuit construction. [293]

[292] BPA Archives, "Intertie near Fulton Canyon," BPA10500-4.

[293] Osipovich, "Full Scale Tests."

The **High Voltage Direct Current Test Center (HVDC Test Center)** at BPA existed from 1963 to 2017 (Figures 47-48). Previous research on the HVDC Test Center was published in BPA's online newsroom:

> The HVDC Test Center, the first facility of its kind in the United States, was established to use emerging industry knowledge on conversion between alternating current and direct current. This conversion technology could enable stable long-distance electricity transmission that moved as a high voltage, direct current before it was converted to a lower voltage, alternating current when it reached the end-user home or business. Tests conducted at the HVDC Test Center gave BPA the information it needed to design a system to transmit power from what would become BPA's Celilo Converter Station, near The Dalles, Ore. to the Sylmar Converter Station at Los Angeles Water and Power in Calif. This, the Pacific Northwest-Southwest Intertie, used an 846-mile long direct current line that was heralded as the longest of its kind in the world.[294]

Figure 47. Ultra-high voltage testing equipment at Big Eddy HVDC Test Site, 1963.[295]

[294] BPA.gov. "High Voltage Exhibit Comes Home." BPA, 2022, accessed June 8, 2022, 20220629-high-voltage-exhibit-comes-home - Bonneville Power Administration (bpa.gov).

[295] BPA Archives, E67364.

Figure 48. The HVDC Test Center in The Dalles, Oregon, 1963.[296]

Test operation of the first 700,000-kilowatt unit at the **Centralia coal-fired steam plant** began August 13, 1971, with energy generated during test periods being delivered to BPA (See Section 3.6.2).[297]

As part of BPA's involvement in the Electric Power Research Institute study of **underground transmission**, BPA began construction in 1974 on a prototype Compressed Gas Insulated Transmission System near Ellensburg, Washington (Figure 49). The 600-foot length of 500-kV isolated phase cable was expected to be the first of its kind in commercial operation once it was completed in 1975. At the time, costs of installing underground transmission lines were found to be about 7-20 times more expensive than those above ground; therefore, BPA was investigating if costs could be reduced to a more economical range.[298]

BPA submitted a proposal in early 1974 to initiate a project for the design, construction and evaluation of two **prototype 1,100-kV transmission lines** and substation facilities near Lyons, Oregon and Moro, Oregon. The project received fiscal year 1975 funding of approximately $5.5 million under the Department's Research and Development budget. Both lines were completed in 1976. The Lyons site included a substation and a 1.3-mile electrical test line with towers

[296] BPA Archives, E67377.

[297] BPA, *1972 Annual Report*, 11.

[298] BPA, *Strings of Energy,* 4.

averaging 200 feet in height strung with two overhead ground wires and 8-conductor lines for each of three phases of 1,100-kV AC. The facility was established to evaluate the electrical characteristics and effects of 1,100-kV transmission, such as the production of audible noise and radio and TV interference and ecological effects. BPA also contracted with the Battelle Pacific Northwest Laboratories to monitor vegetation, wildlife, and domestic animals in the vicinity of the energized line as part of a 31-month biological study. The 1.1-mile UHV mechanical test line near Moro, Oregon was installed to measure the ability of bundled conductors to withstand severe weather conditions, including "worst case" stresses caused by icing and wind oscillations."[299] BPA is preparing a separate historic context regarding the UHV Test Lines, which were constructed outside the period of significance for this historic context but are considered historically significant under their own context.

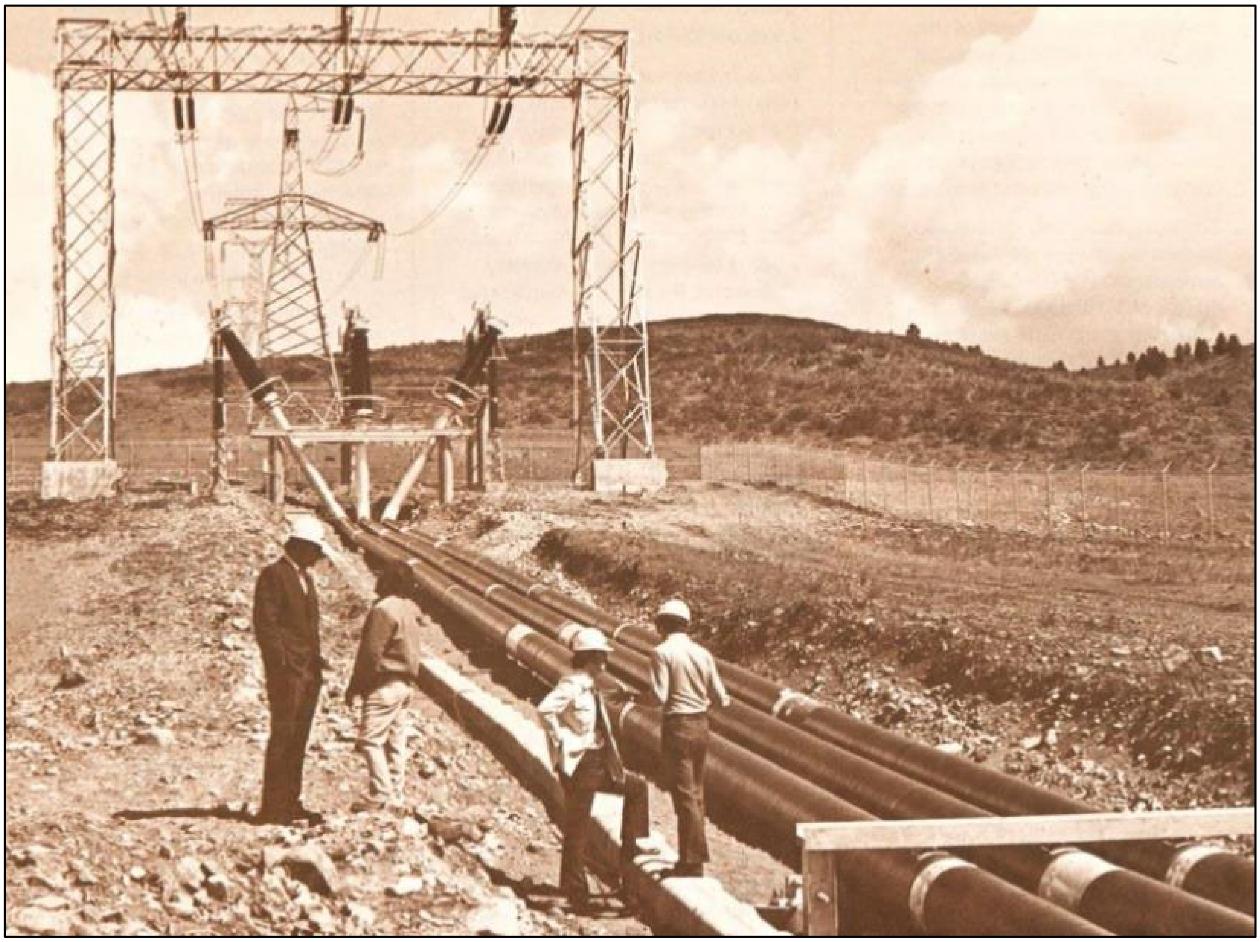


Figure 49. Underground bus in test phase, 1975.[300]

3.8.5 Computers and Automation at BPA

Computers and automation were critical for BPA to design and operate its transmission system. The first time a computer was used by BPA was in 1938, the same year Congress established the agency (Figure 50). That year, several BPA engineers built an AC calculating board to model and study power system faults. The board was an analog computer, and with it they determined ahead of construction, ratings for circuit breakers and other equipment.[301]

---

[299] BPA, *Annual Report* (1976), 9-10.

[300] BPA, *Annual Report* (1975), 13.

[301] BPA, *1967 Annual Report,* 4.

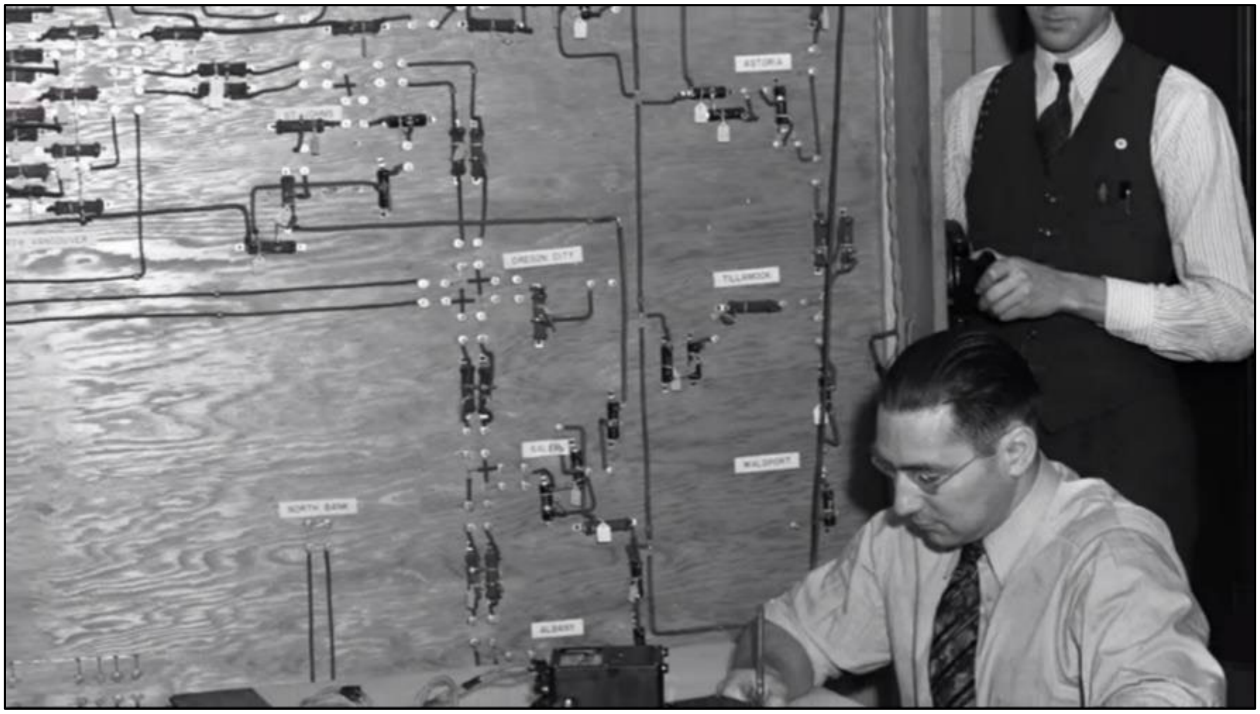


Figure 50. BPA's earliest computer, an AC calculating board, installed at BPA in 1938.[302]

BPA's Network Analyzer

First pioneered by the Massachusetts Institute of Technology in 1929, Network Analyzers were large-scale analog computers designed to model power system networks. These carefully constructed replicas developed out of early AC calculating boards and featured artificial lines to analyze transmission lines, power flow studies, short circuit calculations, and system stability. Network Analyzers were in use from the 1930s through the 1960s, providing real time modeling and analysis of increasingly complex power networks across the country. They were ultimately replaced by numerical solutions running on digital computers.

BPA's Network Analyzer was installed in 1942 and became a critical component of the Master Grid construction program. Essentially a small-scale model of the early BPA network, the computer informed design for transmission lines and network connections and was especially effective at analyzing dynamic responses to applied faults and changes in load and generation. As the system expanded, the analyzer grew. According to BPA's 1967 *Annual Report*, BPA's Network Analyzer was the largest of its kind in the world.[303]

The Network Analyzer was one of the primary tools used by the A-C Calculating Board Studies Unit, the core group assigned to the planning and development of BPA's Master Grid (Figure 51). One of the key members of this team was Florence Ango, BPA's first female engineer and an expert in load capacities.[304] BPA's 1967 annual report describes their accomplishments:

> In 1955 power oriented BPA mathematicians, using a digital computer, solved a complex problem of power flow and achieved a breakthrough of international import. Two employees earned $5,000 in awards. Their approach is still used for load flow and stability studies which enable BPA to plan years in advance of actual construction. For

---

[302] BPA, *Innovation and Engineering in Powering the Northwest* (digital presentation, 2018), accessed March 12, 2021. [Innovation and Engineering in Powering the Northwest - The Network Analyzer - YouTube]

[303] BPA, *1967 Annual Report*. 4.

[304] BPA, *Innovation and Engineering.*

example, digital computers helped prove that interconnection with systems in the Southwest and Midwest were technically feasible. These regional ties offer tremendous benefits - seasonal load diversity, the pooling of reserve generation, diversity of power sources, etc.[305]

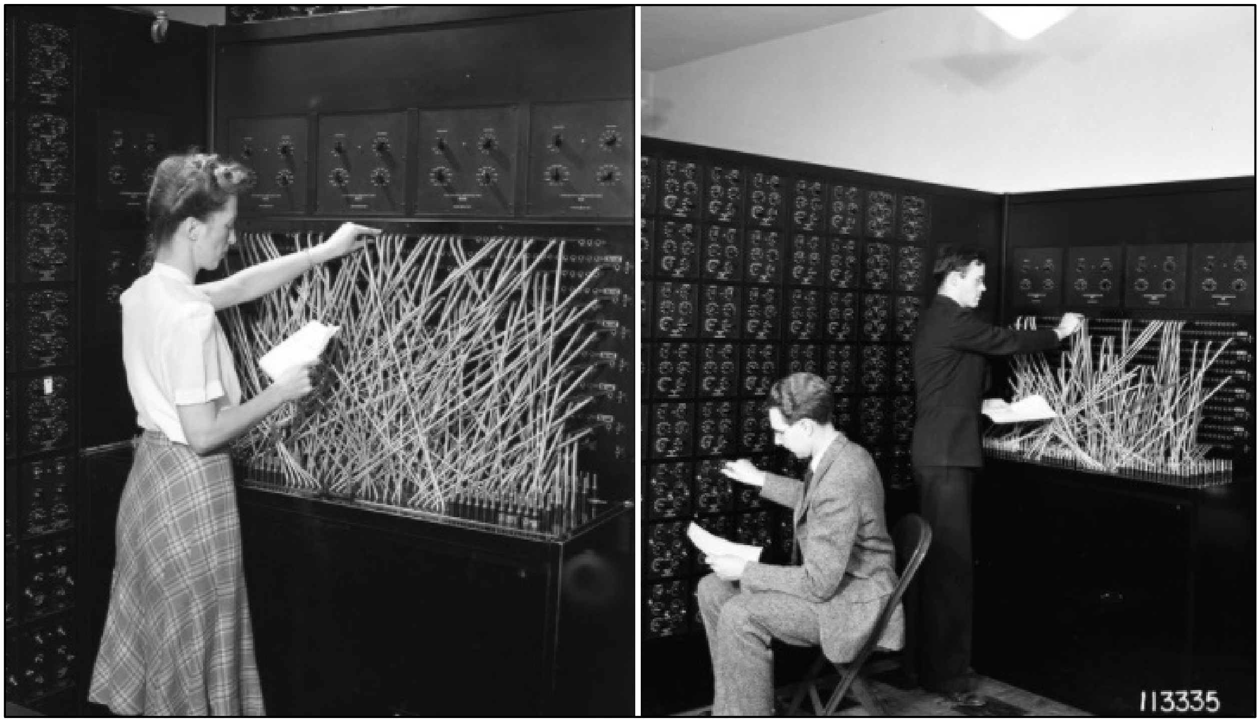


Figure 51. BPA's Network Analyzer: Florence Ango, BPA's first female engineer (left), unknown engineers (right), 1946.[306]

The Advanced Control and Dispatch Program (Power System Control Panel)

In the mid-1960s, BPA looked to the aerospace industry for technical advice in implementing an advanced computer system to increase reliability of their network. "We engaged North American Rockwell Corporation (NAR). After examining operations at BPA, one of the firm's experts commented that the concept of controlling BPA's system with computers presents a scientific challenge as formidable as the Apollo program, which will send astronauts to the moon."[307] BPA and NAR began developing the Advanced Control and Dispatch program in 1967.

A new large multipurpose computer was installed as part of the program just before the end of fiscal year 1968 (Figure 52). The computer, valued at $3,300,000, was used to solve problems in engineering, design, power scheduling, load forecasting, simulating stream flows, recording inventories, and many other areas.[308]

Renamed the Power System Control Program in 1970, the program moved rapidly ahead in fiscal year 1970. The program consisted of a number of computerized control systems whose purpose was to automatically control the BPA transmission system and partially replace the dispatch center. Information relative to system operation fed into the control center to be handled on an automatic or semi-automatic basis. The control center automatically generated

[305] BPA, *1967 Annual Report,* 4.

[306] BPA Archives, NARA E14101 (left), NARA 113335 (right).

[307] BPA, *1967 Annual Report,* 7.

[308] BPA, *1968 Annual Report,* 21.

data on streamflow, available generation, predicted loads, emergency outages, and shutdowns for repair and maintenance.[309]

Figure 52. Early computers at the Portland Control Center, 1969 (left) and 1970 (right).[310]

[309] BPA, *1970 Annual Report*, 31.

[310] BPA, Computers 1969-11-17 BPA I0616-17; Computers include systems control 1970-05-12.

4. Significant Individuals

The following section provides brief biographies of BPA Administrators, engineers, and designers that contributed to BPA's transmission system during the period of significance

4.1 BPA Administrators

Five individuals were appointed as BPA Administrators during the period of significance. Two acting administrators (Charles Carey and Frank Banks) temporarily served as administrators in 1939 during and following J.D. Ross's illness and death. They are not included below due to the short duration of their positions; however, Charles Carey is included in the Engineers section due to his significant role in the development of the Master Grid.

4.1.1 James D. (J.D.) Ross, BPA Administrator 1937 to 1939

James Delmage Ross (1872-1939) was appointed by President Roosevelt as The Bonneviille Project's first administrator, a role he held from 1937 to 1939 (Figure 53). Prior to his career at BPA, Ross was the superintendent of Seattle City Light, a role that he held simultaneously with that of Bonneville Project administrator until his death. Ross was a visionary and helped lay the groundwork for low rates and BPA's existing Transmission System.

Figure 53. J.D Ross (left) and Charles Carey (right), ca. 1938.[311]

4.1.2 Paul J. Raver, BPA Administrator 1939 to 1954

Paul J. Raver (1894-1963) served as BPA's second administrator from 1939 to 1954 (Figure 54). Raver contributed to the national policy for power and water resources, which was instrumental in connecting BPA with the aluminum industry and managing BPA during and after WWII. Raver received the U.S. Department of the Interior's Distinguished Service Award with Gold Medal in 1951.

[311] BPA Archives, E110031.

Figure 54. Paul Raver (left) and Sol Schultz (right), 1950. [312]

4.1.3 Dr. William A. Pearl, BPA Administrator 1954 to 1961

Dr. William A. Pearl (1893-1975) was BPA's third administrator, serving from 1954 to 1961. Pearl earned his doctorate in engineering at the University of Michigan and was a pioneer instructor of automotive and aeronautical engineering in the Northwest. Pearl worked as a consultant to industrial companies and to foreign governments in natural resource development, hydroelectric power, and antipollution procedures. Pearl was also a professor of engineering and director of research at the Illinois Institute of Technology in Chicago and had a brief tenure as dean of engineering and acting president of Washington State College. In 1954, the Eisenhower administration selected Pearl as BPA's administrator to implement new policies.

4.1.4 Charles F. Luce, BPA Administrator 1961 to 1966

Charles F. Luce (1917-2008) was BPA's fourth administrator, serving from 1961 to 1966. Luce had worked as an attorney for BPA during the 1940s before starting a private law practice in 1945. He returned to BPA in 1961 when Secretary of the Interior Stewart Udall appointed him Administrator in 1961. Luce's accomplishments during his BPA tenure include negotiating the treaty with Canada in order to store additional water, securing more dams along the Columbia River, and linking the northwest and southwest power systems through the Intertie. Luce left BPA in 1966 for an appointment as undersecretary of the interior and then finished his career as the chairman and chief executive officer of Consolidated Edison Company in New York.[313]

[312] BPA Archives, E115283.

[313] "Final Salute: Charles Luce excelled at running BPA, Con Edison," *Columbian,* February 2, 2008.

4.1.5 Donald P. Hodel, BPA Administrator 1972 to 1977

Don Hodel (b. 1935) was BPA's fifth Administrator, serving from 1972 to 1977 (Figure 55). He had worked as an attorney in natural resource and energy issues since 1960 and was appointed BPA's Deputy Administrator in 1969. Following his tenure at BPA, Hodel served as president of the North American Electric Reliability Council from 1978 to 1980, U.S. Secretary of Energy from 1982 to 1985, and Secretary of the Interior from 1985 to 1988. Hodel is the founder and Chairman Emeritus at Summit Power Group in Seattle, Washington.

Figure 55. BPA Staff in Conference Room; Don Hodel, foreground, Bernie Goldhammer to Hodel's right.[314]

4.2 Engineers

The Chief Engineers at BPA for the Period of Significance were Charles Carey (1938 to 1939), Sol Schultz (1939 to 1954), Eugene Starr (1954 to 1961), Eugene White (1961 to 1965), Kenneth Klein (1965 to 1970), and George Bingham (1970 to 1977) (Figures 56-59: Additional individuals are highlighted below for their significant contributions to BPA's transmission and

[314] BPA, *1974 Annual Report.*

engineering advancements including Florence Ango, Abraham Osipovich, Forest W. Farr, Matt Marjerrison and Ralph Gens.

Figure 56. Former Chief Engineers reunite in 1977. From left to right: Kenneth Klein (1965-1970), Eugene Starr (1954-1961), Sol Schultz (1939-1954), Don Hodel (BPA Administrator, 1972-1977), Eugene White (1961-1965), George Bingham (1970-1977) and Ralph Gens (1977-1980). [315]

4.2.1 Charles Carey

On November 1, 1935, Charles Carey of the Pacific Northwest Regional Planning Commission presented his drawing for the Northwest Grid. His ambitious vision held Seattle, Spokane and Portland as a sort of triangle of hubs (both Bonneville and Grand Coulee dams were under construction), with 230-kv lines radiating out to Montana, Salt Lake City, Vancouver, B.C. and California. J.D. Ross, then superintendent of Seattle City Light, shared Carey's ambitious plan for a NW Grid. When Ross was appointed administrator of the new Bonneville Project in 1937, he immediately brought on Carey as the first engineer. Ross and Carey redrew the NW Grid for the first Bonneville Project Annual Report (1938). This is what we know as the Bonneville System Master Plan. The position of chief engineer did not exist under Ross, as Ross considered himself chief. Carey was known as principal construction engineer and Ross's right-hand man. Carey authored an addition to the first Annual Report in 1938 for the Engineering and Construction Section. He continued to lay out the transmission system and to put together a team to build the Grid. He worked with Ross and Gene Starr on ideas for high voltage interties, although the technology did not yet exist to match their shared vision. Carey was appointed acting BPA administrator during J.D. Ross's sudden illness and after his death in March, 1939.

[315] "Chief Engineers Reunite, Reminisce for BPA's 75th," BPA.gov, accessed July 20, 2022, 20120629-chief-engineers-reunite-reminisce-for-bpas-75th - Bonneville Power Administration

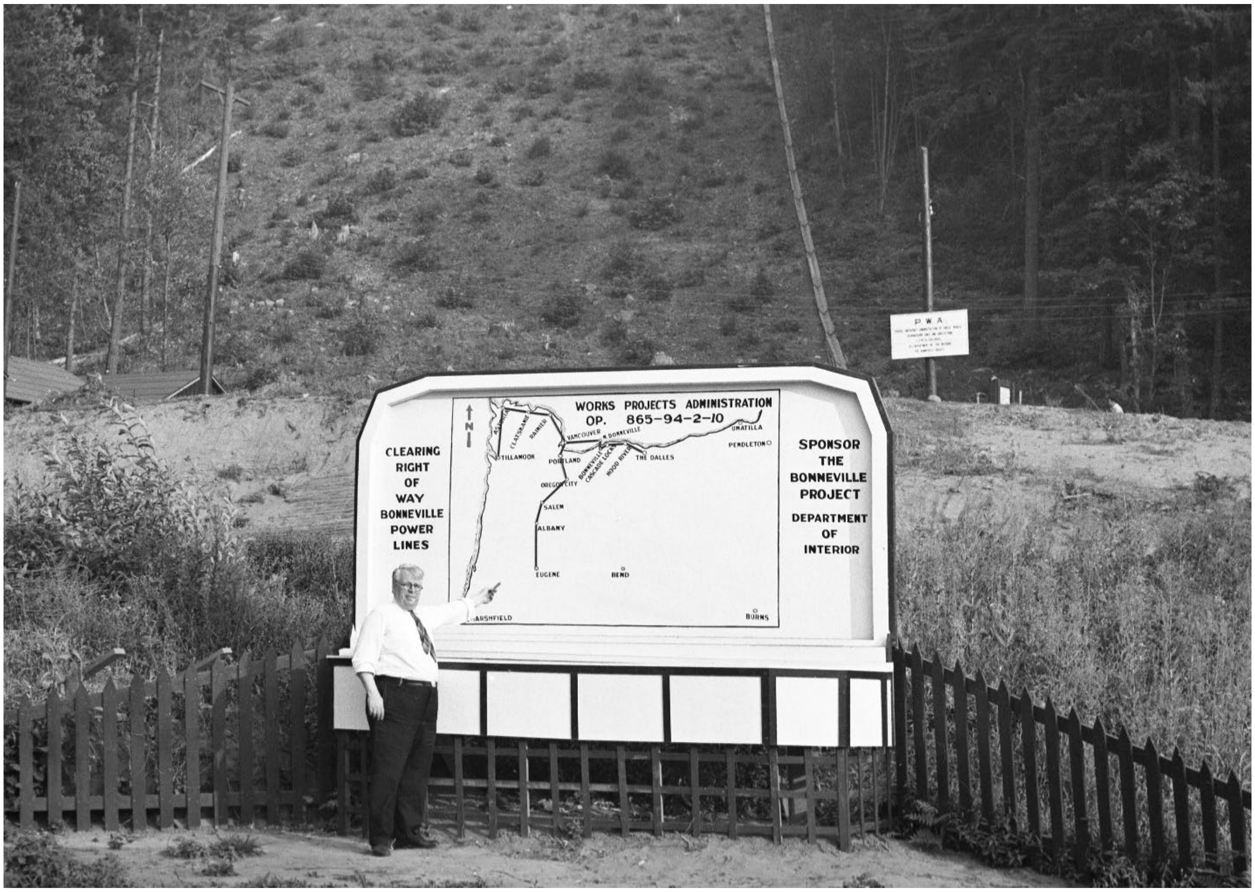


Figure 57. Charles Carey in 1939 in a ROW for the Bonneville—The Dalles Line.[316]

4.2.2 Sol Schultz

Sol Schultz was appointed as a BPA consultant in 1939 by Secretary of the Interior Harold Ickes and became chief engineer in 1940. During his 14 years with BPA, Schultz helped form the early beginnings of the Northwest Power Pool (now Western Power Pool) as a cooperative of public and private interests that helped supply power to the Northwest during World War II. BPA constructed its first 4,000 miles of transmission lines under Schultz's leadership.[317] After leaving BPA in 1954, Schultz moved from Portland to Seattle and became a founding partner of the engineering firm, H. Zinder and Associates, which later became part of CH2M Hill.[318]

[316] BPA Archives, C35-J3-341-39-8-19(1617).

[317] "Chief Engineers Reunite," BPA.gov.

[318] "Sol Schultz, BPA Chief Engineer," *The Seattle Times,* June 5, 1990, accessed April 26, 2021, https://archive.seattletimes.com/archive/?date=19900605&slug=1075622.

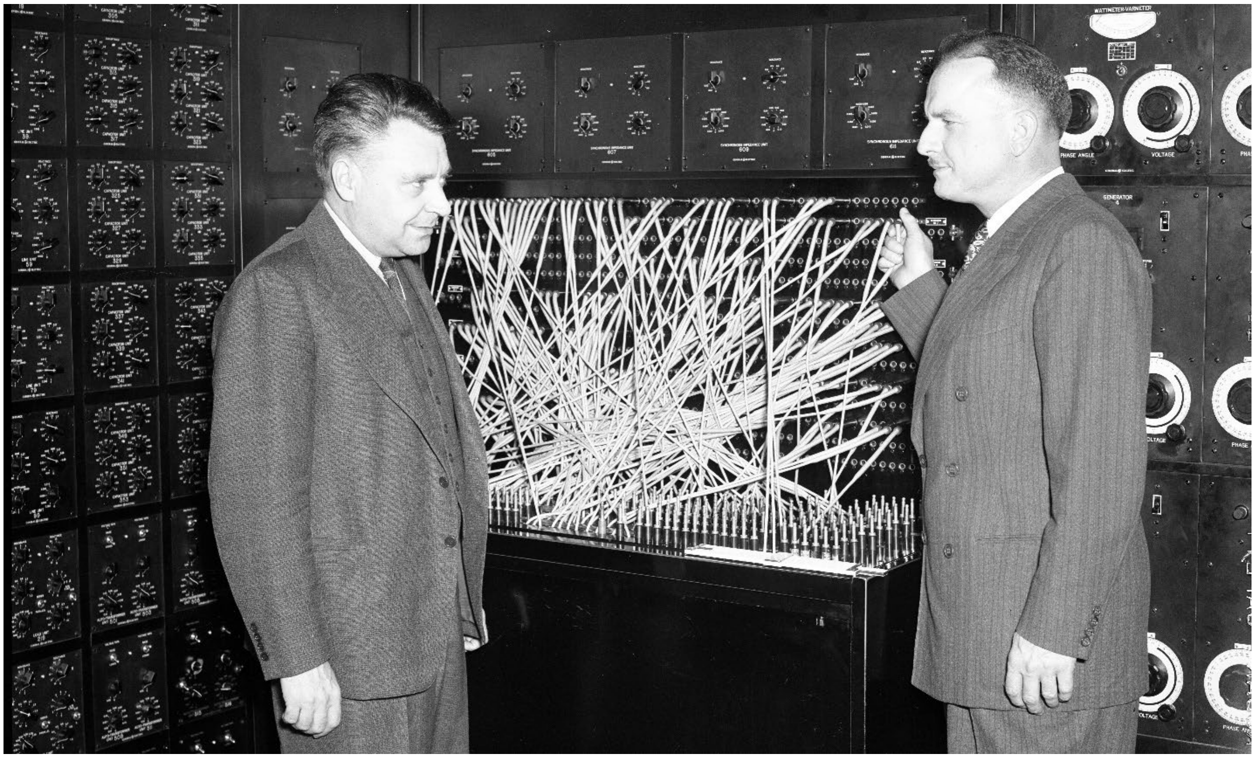


Figure 58. Sol Schultz (left) and Dr. Eugene Starr in front of BPA's AC Network Analyzer, 1945. [319]

4.2.3 Florence Ango

Ango was BPA's first female engineer and was instrumental in the development of the Network Analyzer in the 1940s (see figure 51). Ango's specialty was figuring out how loads could be combined without losing their electric characteristics within the system, essentially getting the system down to a size where it could be studied.[320]

4.2.4 Abraham A. Osipovich

Abraham A. Osipovich was a Russian émigré who fled the U.S.S.R in the 1930s, arriving in the US to work with the Army Corps of Engineers. Osipovich was hired as an electrical engineer by BPA in 1939 and eventually became Chief Engineer of Transmission Design. He authored several BPA documents and was influential in transmission design, leading the development of the first 345-kV system in the country and the 500-kV intertie lines. Osipovich also initiated the innovative solution of installing carefully-located vibration dampers on transmission towers to reduce wind noise and prevent direct short circuits caused by excessive vibrations.[321]

Abraham Osipovich examines cable samples, 1945.[322]

[319] BPA Archives, NARA_E114132-2

[320] "Celebrating BPA's trailblazers on Women's Equality Day," BPA.gov, accessed July 20, 2022. 20210311-womens-history-month-celebrating-bpas-trailblazers - Bonneville Power Administration

[321] "BPA Film Collection Vol. 1," YouTube, accessed July 12, 2022, Highline: Pacific Northwest's High-Voltage Transmission System (1950) - YouTube

[322] BPA Archives, NARA_E12168, 1945)

4.2.5 Eugene Starr

Eugene C. Starr, for which the Starr Complex at the Celilo Converter Station in The Dalles, Oregon was named, began working for BPA in 1944 as a consulting engineer, later encouraging many of his students at Oregon State to go to Bonneville as student apprentices, including Ralph Gens.[323] Starr specialized in extra high voltage alternating current – direct current transmission and in nuclear power development and was known for developing series capacitors used to store voltage along transmission lines, which was a critical element to keeping the 500-kV system voltage stable.[324] Starr won awards for his research in the field of high voltage engineering and aircraft radio coordination. In 1965 he was named Oregon's Engineer of the Year.[325] The highest award that BPA bestows on an engineer is named for him.

4.2.6 Eugene White

Eugene White earned an engineering degree in Nebraska in 1924 and began working for the General Electric Co. in Schenectady, New York following graduation. There he was assigned to work on the Conowingo Project, the first centrally controlled, multi-company dam and transmission system in the U.S. White began working at BPA in 1939; his first assignment was to lead the survey crews laying out the transmission corridors for the lines that would carry power from Bonneville and Grand Coulee Dams. White eventually served as Chief Engineer from 1961-1965.[326] His work at BPA earned him a gold medal service award from the U.S. Department of the Interior in 1962.[327]

4.2.7 Kenneth Klein

Kenneth Klein graduated from Oregon State University in 1934 as an electrical engineer and found work directly out of college with the Oregon State Highway Department. Klein was hired on by BPA in 1940 as an engineer in the Yakima and Walla Walla District offices but was called to serve as Merchant Marine Gunnery Officer in the Pacific during WWII and later as an engineer in the Korean War. Klein returned to work at BPA following his military service and was heavily involved in the planning, programming and development of the Extra High Voltage transmission system. He was appointed Chief Engineer in 1965 and retired from BPA in 1971.[328]

4.2.8 George Bingham

George Bingham was born in Fitchburg, Massachusetts in 1919 and studied civil engineering at Worchester Tech. Bingham worked on defense and power projects across the U.S. and Canada during World War II and managed several hydroelectric projects as part of the Marshall Plan in Greece in the early 1950s. He served as Chief Engineer at BPA between 1970-1977, at the time when the Dittmer Control Center was under construction and helped shepherd BPA into the computer era.[329]

---

[323] "Chief Engineers Reunite," BPA.gov.

[324] "Chief Engineers Reunite," BPA.gov.

[325] AECOM, *Field Guide: Historic Resources* (Portland, OR: prepared for BPA, 2020).

[326] Gene Tollefson, *BPA and the Struggle for Power at Cost* (Portland, OR: prepared for BPA, 1987). Download: https://bonpow2.ent.sirsi.net/custom/web/content/BPA and the Struggle for Power at Cost.pdf

[327] MacDonald Koler Morrison, "Eugene White House," City of Lake Oswego Cultural Resources Inventory Field Form, 1989, accessed January 22, 2022, https://www.ci.oswego.or.us/sites/default/files/fileattachments/boc_hrab/webpage/18285/whitehouse.pdf

[328] "Kenneth Klein [obituary]," *Watts News* [The Associates], December 1, 1986, 2.

[329] "Chief Engineers Reunite," BPA.gov.

Forest W. Farr

Forest Farr was born in Seattle, Washington in 1903 and studied Civil Engineering at the University of Washington. Farr worked for Puget Sound Bridge and Dredging Co. and Seattle City Light before joining on with BPA. Farr rose to the position of Chief of the Transmission Design Center and was a pioneer in the development of steel transmission structures.[330]

4.2.9 Matthew Marjerrison

Matt Marjerrison started at BPA in 1938, the first year of its existence. He was one of the first electrical engineers to earn a license in the State of Oregon. He began as a topographical draftsman, a job he had previously done for the Dept. of Agriculture. Marjerrison advanced through the ranks to Chief of the Branch of Transmission Design and was awarded the highest honor that the Department of Interior bestows, that of Distinguished Service, in 1971. He was known for his technical skill and leadership in the design of high-voltage transmission lines, including transmission towers, poles and conductors. He was an integral part of the designs that established BPA's international reputation in the field of extra-high-voltage line design. In 1951, Marjerrison designed a light steel tower (the delta configuration) that saved up to 50 tons of steel per mile. The construction of these lighter towers effected enormous cost savings to BPA and are still used in the present. He also was an early proponent of concern for the environmental impact of transmission lines, and actively endorsed efforts to improve the appearance of structures and rights-of-way throughout his career.

Figure 59. Matt Marjerrison (right) and Merle Poland perform ice unloading tests, July, 1956.[331]

4.2.10 Ralph Gens

Ralph Gens led BPA's development of the Pacific Northwest-Pacific Southwest Interties, both the 500-kV AC and the 800-kv DC lines to California. He earned his electrical engineering degree at Oregon State College. Ralph wanted to follow in the footsteps of his mentor, Eugene Starr, and started at BPA as an engineering aide during his senior year. He spent many years in

[330] "Forest Farr [obituary], Oregonlive.com, 2007, accessed January 19, 2022. https://obits.oregonlive.com/us/obituaries/oregon/name/forest-farr-obituary?pid=87404554

[331] BPA Archives, E42541.

the System Engineering Branch, where he became chief in 1966. He became Chief Engineer in 1977. Gens had considerable influence on the development of high-voltage technology, including early work that refined control of high-voltage insulation. He had the idea for BPA to build the HVDC test center at Big Eddy, and provided expertise that led to acceptance of high-voltage DC transmission in the U.S. Other innovations that came about under his direction included improved switching surge controls, insulation levels, series capacitors, large braking resistors, high-speed circuit breakers, staged system tests, advanced system computer programs, computer-aided design, and greatly reduced electrical losses. He received the Distinguished Service Award in 1978. His many contributions to the advancement of electric transmission technology have had a profound effect on the industry and on a national and international scale.

4.3 Designers

Two design firms are highlighted in this section for their important contributions to BPA's transmission development.

4.3.1 Stanton, Boles, Maguire, and Church

In 1966, the Portland architecture firm Stanton, Boles, Maguire, and Church completed *A Report on Appearance Planning* as a design guide for BPA substation and transmission line construction.[332] The report was highly acclaimed by the utility industry and laid the groundwork for BPA's beautility design concept. That year, BPA also hired the firm to prepare the master plan for J.D. Ross Substation in Clark County, Washington.[333]

4.3.2 H. Zinder and Associates

In 1961, the California Department of Water Resources hired H. Zinder and Associates to develop plans for the Pacific Northwest – Pacific Southwest Intertie. The Seattle based firm was known for its consulting services in electrical power and design, systems analysis, and economics and financial feasibility. Led by former BPA Chief Engineer Sol Schultz, the firm proposed connecting the BPA system to Southern California via two 500-kV transmission lines.[334] This proposal conflicted with that of BPA's engineering department, which advocated for a small intertie with Pacific Gas & Electric Co. lines in California.[335] The Zinder firm's plan was ultimately adopted and, upon completion in 1970, the Intertie constituted a major engineering accomplishment.[336]

[332] Stanton, Boles, Maguire & Church, *Appearance Planning*.

[333] "Bonneville Plans Move," *The Daily Olympian*, October 21, 1966.

[334] Conditional Okeh Given Power Sale," *Longview Daily News*, April 14, 1961.

[335] "Proposal for $227 Million Coast Power Tieup Readied," *The Spokesman Review*, December 20, 1961.

[336] *Longview Daily News* 1961; BPA, "Structure Type per Voltage Policy STD-DT-000092 REVISION 01 CN 01" (Portland, OR: Bonneville Power Administration, 2018), Standard/Technical Content Owner: TELD.

5. Characteristics of BPA's Transmission Lines

This section includes a summary of characteristics of transmission lines, followed by a more detailed analysis of each of the three main components of a transmission line: corridors, conductors, and transmission structures. Transmission structures are by far the most distinct element of transmission lines and also display the widest variety in materials and design.

5.1 Summary

A transmission line is a high-voltage, extra-high-voltage, or ultra-high-voltage power line used to carry electric power efficiently over long distances from one point to another. Within the BPA system transmission lines are generally identified by a name that is formed by their starting and ending point. Usually, starting points are identified as the substation nearest to the generation source, and ending points are named for the load center, though this is not always a hard and fast rule and can be named in the reverse order based on political or other less technical reasons. Thus, the Kelso-Chehalis Line runs between those two substations in Washington State while the Chehalis-Raymond Line terminates at Chehalis with its other terminus at Raymond. Where two lines run between the same two points, as in Bonneville-Vancouver, they are differentiated by number, for example, as in Bonneville-Vancouver No. 1 and No. 2. Despite the naming order, transmission lines can be operated bi-directionally in terms of energy flow, Transmission lines are further differentiated by the voltage that they carry, be it 115-kV, 230-kV, 345-kV, 500-kV or, in the case of the Intertie, High Voltage Direct Current (HVDC).

Named transmission lines in BPA's system may have historically been and sometimes still are segments of larger lines. For example, the Salem-Tillamook Line was constructed in 1946 but was later divided into three segments and renamed Salem-Grand Ronde No. 1, Grand Ronde-Boyer No. 1, and Boyer-Tillamook No. 1. Although each transmission line has a new name and energization date, it includes a portion of the original 1946 Salem-Tillamook Line.

In designing a line, BPA accounts for several electrical conditions to efficiently and economically transmit power. These conditions including voltage levels, conductor sizes, insulation standards, lightning protection, fault restorations, and minimizing radio and television interference. Location and design of lines is also dependent on many non-electrical factors such as climate conditions, terrain, population density, types of industry, extant of agriculture and forest in the area, and aesthetics.[337]

5.1.1 Character Defining Features

Every transmission line in BPA's network is made of multiple component parts that collectively form the named line (Figure 60). These elements are character-defining features and include the following:

> **Corridors**, which are the alignment's surrounding setting, right-of-way easements, and alignment that a transmission line follows from one endpoint to another. The corridor is mostly defined by its setting, characterized by the relationship of the line to the landscape, topography, adjacent transportation corridors, and surrounding uses. Transmission lines generally exist within extensive corridors that may contain multiple individual lines running parallel to each other. Many of BPA's transmission corridors exist on ROW easements that run through multiple parcels of land, including both privately-owned lands and land owned by other federal agencies, not BPA itself.
>
> **Conductors**, which are the cables that transmit power, as well as the insulators and mounting equipment that connect the conductor to the towers that carry it. Conductors are characterized by the materials, quantity, and visual character of the insulators and

[337] A. A. Osipovich, "Make the Steel Fit the Design," *Modern Designing with Steel* 3, no. 3, July 1957.

mounting equipment. Each circuit within a line has multiple conductors, typically three, each with its own insulators and related mounting equipment, further complicating the individual nature of any given, named, “line” within the system. Conductor voltages primarily include 115-kV, 230-kV, 345-kV and 500-kV.

Transmission Structures, called towers or poles, support a transmission line’s conductor along its corridor. Each structure is individually identified in the field with aluminum tags and signage and cataloged within the BPA system for management purposes. Transmission structures are by far the most evident characteristic of transmission lines and also convey the most variation in their design and appearance. BPA’s transmission network consists of an array of transmission structures, varying in material and design, depending on multiple factors including voltage, topography, proximity to other lines, and location on a line. Structures can be steel lattice, steel pole, wood pole, and various permutations thereof (Sections 5.4.4 and 5.4.5). They are anchored by plate, grillage, and rock footings, occasionally rising from poured concrete footings, with bolted legs (Section 5.4.3). The majority of the lines consist of tangent suspension and dead ends structures, used at angle points, long crossings, and terminal spans (last span into substation).

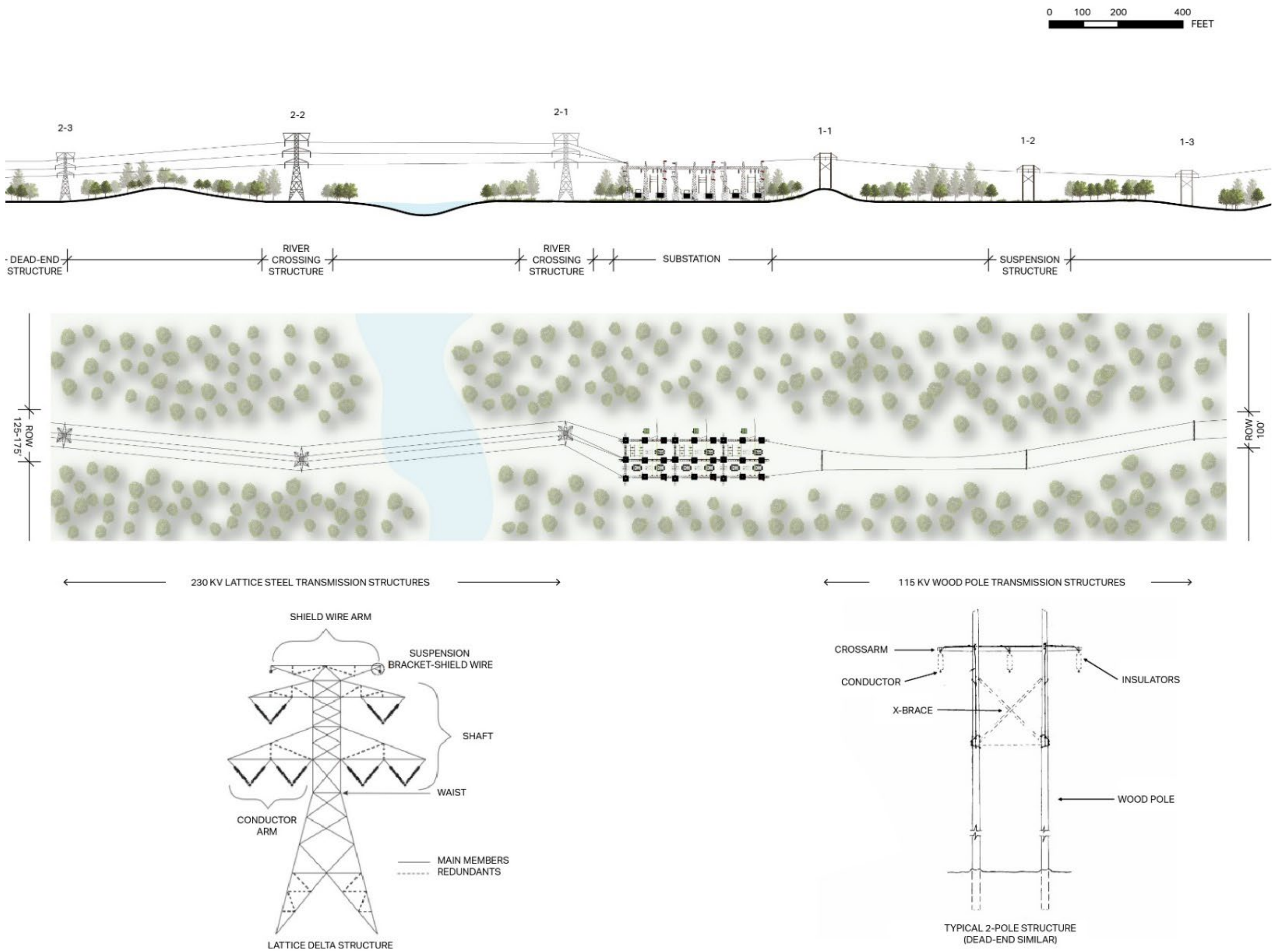


Figure 60. Characteristics of BPA's Transmission lines in section, plan, and detail.[338]

[338] AECOM, GIS Services.

5.1.2 Structure Classifications and Naming Conventions

BPA has an organized system that classifies the complex organization of components that comprise its transmission system and represents the multitude of variations in transmission line structures and characteristics. BPA uses standardized naming conventions for steel lattice towers and engineered steel and concrete structures/poles, wood structures and pre-engineered (light-duty) steel pole structures (wood pole equivalent), and substation switchyard structures[339]

The naming conventions, first implemented in 1952, are used to uniquely identify the transmission structure type and its corresponding engineering drawing. Naming conventions use a combination of numeric and alphabetic codes to indicate specific details of a design including, voltage classification, single or double circuit configuration, tower/structure type (function), number of poles, pole material, crossarm type, crossarm material, crossarm insulator configuration, tower arm types, tower generation, special conditions for use (e.g., river crossings), and whether it is a special structure type.[340]

Tower types have numeric designation (for structure class) and then a letter to distinguish between them (ex. “29M”). All single circuit are even numbers and double circuit are odd numbers. The numeric is the “series” number for the tower design, while the alpha character references how the conductor is attached to the tower (dead end, suspension, etc.).

5.2 Corridor

A transmission line’s path follows a corridor between two endpoints. The corridor is a cleared route that stretches the length of the transmission line. Corridors reduce potential hazards along the transmission line through isolation from adjacent uses and provide access for maintenance and repair by BPA personnel. The physical characteristics of a corridor may appear as cleared vegetation along a straight linear route, making strategically located turns for an optimal path. Sometimes, the corridor itself is visible only by the repetitive placement of transmission structures and conductors associated with the line.

Site selection for the corridor is determined by analyzing the path of least resistance between two endpoints, based on terrain, visual and environmental impacts, and access through rights of way (ROW) easements. For these reasons, the surrounding natural and built environment help to define the corridor and characterize its setting.

5.2.1 Right of Way

A BPA ROW is “the corridor of land under a transmission line(s) that is required for operation.[341] ROW includes land set aside as an easement or in fee, either by agreement or condemnation, and can also be used to describe the right itself to pass over the land of another.”

BPA does not own the ROW associated with the majority of its transmission lines, but rather BPA holds easement rights for the passage of the transmission line. Each ROW is a patchwork of stitched together easement agreements in place for each property or tax lot along a line’s alignment. The easements give BPA the right to access the land, maintain it (including grading and graveling if necessary), and to keep the land clear of structures, trees, brush, vegetation, and fire and electrical hazards (Figure 60).

The width of a BPA ROW is set to keep the conductor, which can sway in the wind, away from surrounding buildings, trees, and other vegetation to keep the line operating safely at all times.

---

[339] BPA, *Transmission Line Tower/Structure/Pole, Wood Pole and Substation Wire-support Structure*, *STD-DT-000038, Revision 01* (Portland, OR: Bonneville Power Administration, 2016), 2.

[340] BPA, *Transmission Line Tower/Structure/Pole,* 2-4.

[341] BPA, *Transmission System Standard “Right-of-Way (ROW) Width Policy* (STD-DT-000062, Revision 03).

ROW widths are determined by policy standards and the National Electrical Safety Code and can vary based on voltage, how the conductor is bundled, and the diameter of the conductor, among other factors. Notably, the standards and codes have all been revised multiple times over the course of history, and none presently match those in place during BPA's period of significance.

5.2.2 Access Roads

According to the MPDF, access roads, including the gates, access roads and similar transportation infrastructure systems that provide access from the public road system to a Transmission line corridor are not considered to be a part of the named line (Figure 61).[342]

Figure 61. Clearing the right-of-way and access roads for the construction of the Dworshak-Hot Springs Line, which was energized in 1973, date unknown.[343]

5.3 Conductors

Conductors are the cables or bars that carry electrical energy. A conductor is 1) any metallic material, usually in the form of wire, cable or bar, suitable for carrying an electrical current. 2) The wire cable strung between transmission towers. Conductors have several variations, most all of which are undetectable to the layperson. Materials can contain all-aluminum strands (AAC) or they can have reinforced steel cores around the strands (ACSR), and either can have trapezoidal cross sections (TW). Conductors can be bundled to use two or more conductors in a single phase, i.e., 500-kV lines have bundles of three or four conductors per phase (Figure 62). BPA often uses Pacific Northwest-inspired terminology to classify its conductors, including flower or river names for AAC and AAC/TW conductors, and bird species and mountain peaks for ACSR and ASCR/TW conductors.[344]

[342] Kramer, *BPA Transmission System MPDF*, 43-44.

[343] BPA Archives, Slide 3510.

[344] BPA, "BPA Definitions" (Portland, OR: Bonneville Power Administration, 1993), 16.

BPA conductors generally carry voltages of 115-kV, 230-kV, 345-kV, 500-kV or, in the case of the Intertie, HVDC. Insulators and marker balls are features of conductors.

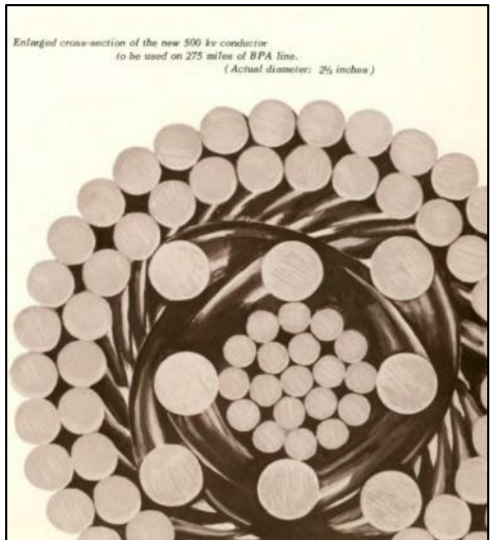


Figure 62. Cross-section of the new 500-kV conductor (BPA. *1965 Annual Report*).

By 1950, conductors came in a variety of sizes and types. The two most common types for high voltage transmission were stranded copper and stranded aluminum. Stranded aluminum featured a core of galvanized steel for greater strength. Other conductors were designed for specific purposes such as when high tension strength is important (copper clad steel) and or unnecessary (all aluminum). The choice of conductor depends on several factors including the amount of power to be transmitted, the voltage to be used, the distance the power is to be transmitted, mechanical stress on a conductor due to terrain and climatic conditions, and comparative cost. In designing a transmission line and selecting the appropriate conductor, engineers must calculate for factors such as ice accumulation and wind to ensure stability and reduce costs. With a stronger and/or lighter conductor a line can be brought up to a higher sag and still keep the strain in safe limits. Therefore, lower towers or a greater distance between towers can result in cost savings. The elimination of one steel tower could result in a cost savings of as much as $10,000. Copper has the best conductivity in transmission lines but by 1950, aluminum became more popular for high voltage applications due to its lightness, increasing availability, and favorable price. Choice of conductor is dependent upon a combination of capacity, diameter, strength, and weight.[345]

Insulators

An insulator is a device made of non-conducting material that is used to give support to conductors and shield them from the ground or other conductors (Figure 63).

Figure 63. Linemen working on insulators, 1968.[346]

[345] BPA, *Stringing and Sagging a High-Voltage Transmission Line*, (motion picture) (Washington, D.C.: U.S. Department of the Interior, 1950), Stringing and Sagging a High-Voltage Transmission Line (1950) - YouTube.

[346] BPA, *1968 Annual Report*, 15.

An insulator inhibits the flow of current from the conductor to the earth or to another conductor.[347] In general, insulators are constructed of porcelain, but some glass insulators remain in use. Insulators are commonly evenly-spaced along transmission structure's steel crossarm. The insulators connect to suspension shoes which support the conduit cables. BPA has transitioned away from glass insulators for porcelain ones in response to vandalism occurrences.[348] As a rough rule, one insulator unit is used in the suspension string for each 20-kV of line voltage.[349]

BPA currently has five insulator configurations and uses six types of insulators: porcelain disc, toughened disc, fog (porcelain and toughened glass), composite, line post (porcelain and composite), and silicone coated toughened glass disc (Figure 64). Both disc and fog insulators have a life expectancy of 50 years while and composite insulators have a life expectancy of 20 years.[350] BPA primarily uses porcelain and toughened glass insulators due to longer life expectancy. Every conductor position on a structure must include the same insulator type. BPA prefers to use the same type of insulator for the entire line or at least large sections of the line.[351]

[347] BPA, "BPA Definitions," 43.

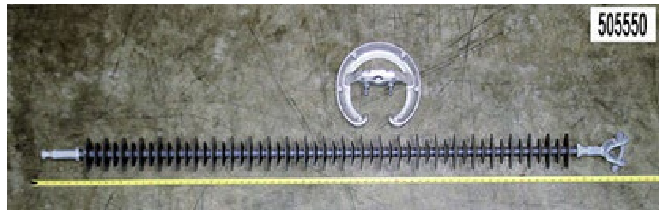
[348] Dustin Liebhaber, Email to AECOM, November 1, 2018.

[349] Marjerrison, *Transmission Tower Design*, 6.

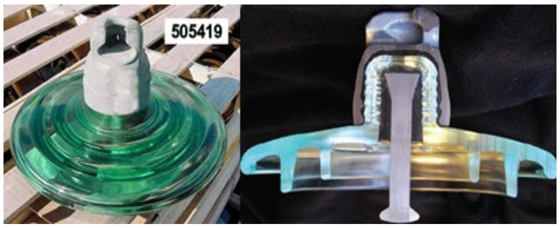
[350] BPA, *Insulator Selection STD-DT-000080 REVISION 01* (Washington, D.C.: U.S. Department of the Interior, 9/20/2019.), 4-5.

[351] BPA, *Insulator Selection,* 7.

Porcelain Disc Insulator

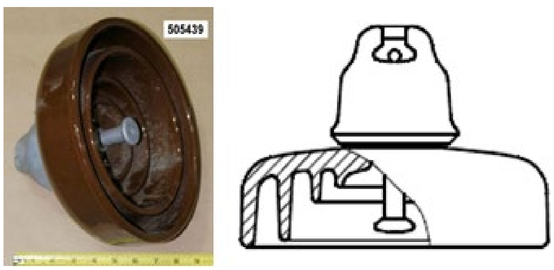


Composite Insulator (Porcelain and Composite)



Toughened Glass Disc Insulator

Line Post Insulator (Composite)



Fog Insulator (Porcelain)

Insulator configurations

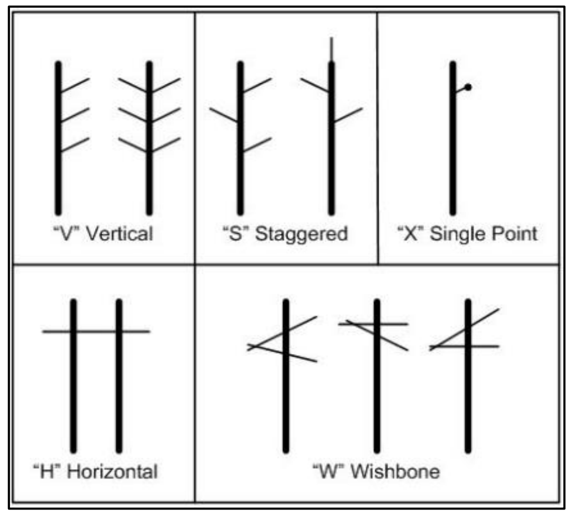


Figure 64. Different Insulators and Configurations used by BPA for wood pole structures[352]

Marker Balls

Marker balls are colored balls used to make transmission lines and guy wires more visible to low-flying planes and helicopters. They are often used near airport and heliport approach areas and where transmission lines span long distances across canyons, and bodies of water. Marker balls are typically constructed of plastic, fiberglass or aluminum and are painted with a white, yellow or orange exterior per FAA guidelines (Figure 65).

[352] BPA, *Insulator Selection*.

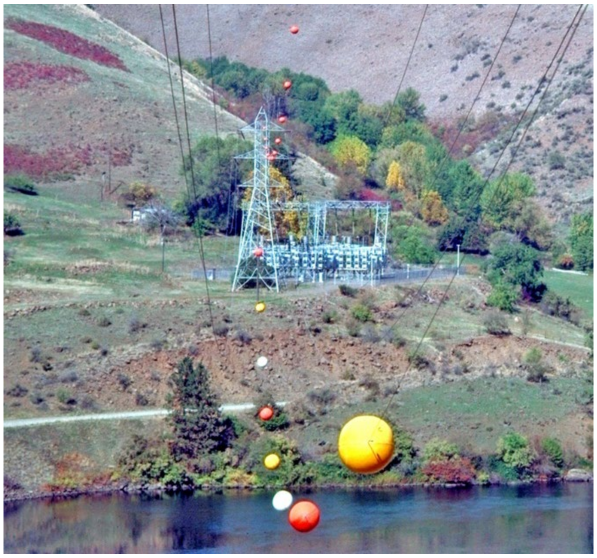


Figure 65. Marker balls near Oxbow Dam, Idaho (left); BPA installs an "Aviation Orange" colored Marker Ball (right), BPA.

5.4 Transmission Structures

Transmission structures serve as physical supports for electrical conductors, their insulation, and associated equipment. The design of transmission structures goes beyond structural engineering. Proportions are determined more by electrical factors than physical forces. Electrical factors that dictate design include voltage, corresponding insulation, number and configuration of circuit, phase spacing of conductors, and minimum electrical clearances between the conductor and the structure and the ground. Transmission structure design is also dependent upon its function on the line (Table 4).[353]

Table 4. Major Types of Steel Towers

By basic design type	By line position or function	By number of circuits carried	By circuit configuration	By base	By type of footings
Self-supporting **Guyed**	Light/Economy Tangent Suspension Standard Tangent Suspension Angle Suspension Heavy Angle Suspension Standard Dead-end Heavy Angle Dead-end Transposition	Single Double	Horizontal/Flat Vertical Delta, Single Circuit Delta, Double Circuit	Square Rotated	Concrete Drilled Pier Concrete Pad and Pier Earth Grillage Rock Anchor Pressed Plate Piling Foundations

Common characteristics of a transmission structure are design, materials, bracing and stability, and signage or identifying markers. The vast majority of transmission structures are either constructed of wood or steel but some concrete structures exist. There are hundreds of specific structure designs within the BPA network, but all of these designs can be broadly categorized into poles, H-frames, and lattice steel poles and towers. Some designs can only be constructed of specific materials but others are more adaptable to multiple construction materials. For example, lattice structures can only be constructed of steel but pole and H-frame structures can be constructed of steel, lattice steel, or wood poles (Figure 66). Non-historic features of transmission structures may include fiber or cellular communication equipment.

[353] Osipovich, "Make the Steel Fit."

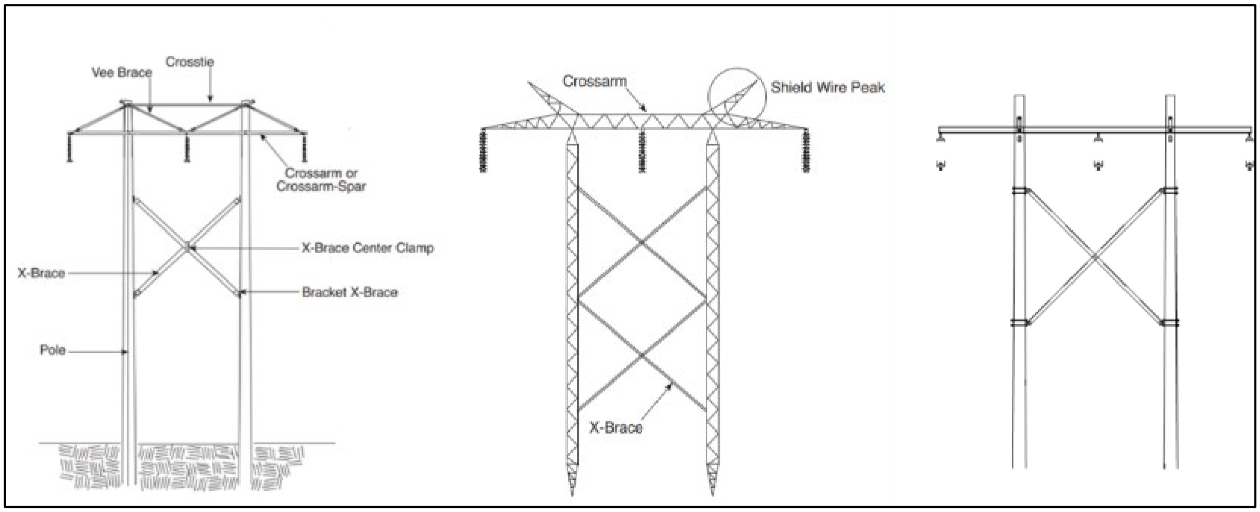


Figure 66. H-frame structure constructed of steel (left), lattice steel (center), and wood poles (right)

Since the initial construction phase of the late 1930s through the 1960s, wood pole or steel lattice structures were almost exclusively used.[354] Wood was often favored due to its lower cost than steel. Steel established dominance in high-voltage systems due to its greater strength, longer life, lesser need for maintenance, and greater reliability. Steel also provides greater malleability for special applications due to the variety of shapes, sizes, and grades which allows more leeway in tower design. The life expectancy of steel towers was two times as great as wood towers.[355]

Beginning in the 1970s, other transmission structures such as steel engineered monopoles and to a lesser extent concrete engineered pole structures were introduced into BPA's transmission network.[356]

By the late 1950s, power companies across the world began experimenting with newly developed construction materials for structure components, including prestressed concrete, fiber glass, and reinforced plastics. Aluminum towers were installed by the Aluminum Company of Canada and prestressed concrete structures replaced 110-kV wood pole structures in Florida.[357] However, BPA did not implement any of these alternative construction materials.

Towers vary in weight and complexity from light suspension towers used on level terrain through heavy tangent towers and dead-end or strain towers for medium and large line angles. On suspension towers, the conductor is supported by one or more strings of insulators hanging vertically from the tower crossarm. On dead-end towers, one or more strings of insulators anchor the conductor to the crossarm in a more or less horizontal position. Where changes in the line direction occur angle suspension towers may be used. Heavy line angles require dead-end towers. A minimum of four tower types is generally necessary for a transmission line. However, the optimum number varies between six and ten.[358]

With the need to conserve steel during WWII, BPA relied on wood pole design for 230-kV lines. To effectively replace the structural integrity of steel towers, BPA constructed H-frame structures

[354] BPA, "Structure Type."

[355] Osipovich, "Make the Steel Fit."

[356] BPA, "Structure Type."

[357] Osipovich, "Make the Steel Fit."

[358] Marjerrison, *Transmission Tower Design*, 2.

with Western red cedar poles and Douglas fir timber truss crossarms. These towers included variations for either a K- or X-brace between the two vertical poles.[359]

Double circuit steel structures became more common to maximize use of ROW and save on the expense of clearing and road construction for additional lines.[360]

5.4.1 Function

Transmission structures can serve several specific functions along a line. Structures are categorized as suspension, dead-end, and transposition.

- **Suspension structures** are categorized as structures that support conductors at an intermediate point usually strung along a virtually straight line (Figure 67).[361]
- **Dead-end structures** are categorized as a tower or pole where the line loads the tower in tension. This can be where a conductor is anchored at a point of heavy or sharp changes in direction or at the end of extremely long spans.[362] Heavy angle dead-end structures are implemented where the line turns at an angle greater than 45 degrees (Figure 68).[363]
- **Transposition structures** are used on transmission lines that operate in three phases: A, B, and C. The phases must periodically be rotated along the course of the line to ensure electrical reliability. The transposition structure crisscrosses the wires, changing their order from when they enter to when they leave the structure.[364] Figure 69 demonstrates how the phases are rotated along line. Figure 70 shows plans for two pole and three pole transposition structures. BPA's transmission network includes many types of transposition towers including single and double circuit. They can be constructed of wood or steel, often modifying the design of dead-end structures.

Both suspension and dead-end structures have subcategories to specific engineering details (Table 5). In addition, each type can vary in terms of materials and appearance. For example, a wood pole H-frame structure can serve as a suspension, dead end or heavy angle structure. Also, an H-frame structure can be constructed of wood or steel.

[359] A. A. Osipovich, *230-kV Wood Pole Structure Design and Tests* (Portland, OR: Bonneville Power Administration, 1945), 84-85.

[360] Osipovich, "Make the Steel Fit."

[361] BPA, *Stringing and Sagging a High-Voltage Transmission Line*.

[362] BPA, *Typical Engineering Details* (Washington, D.C.: U.S. Department of the Interior, 1940); BPA, *Stringing and Sagging*.

[363] BPA, *Typical Engineering Details*.

[364] Dustin Liebhaber, Email to AECOM, November 1, 2018. BPA, *Transmission Line Transposition Study* (Portland, OR: Bonneville Power Administration, n.d.), 1.

Table 5. BPA Structure Types and Variations

	Structure Type		
	Suspension	**Dead End**	**Transposition**
Variations	Light Tangent Suspension	Light Dead End	Based on Suspension and Dead End designs
	Standard Tangent Suspension	Dead End	
	Heavy Tangent Suspension	Strain Dead End	
	Angle Suspension	Heavy Angle Dead End	

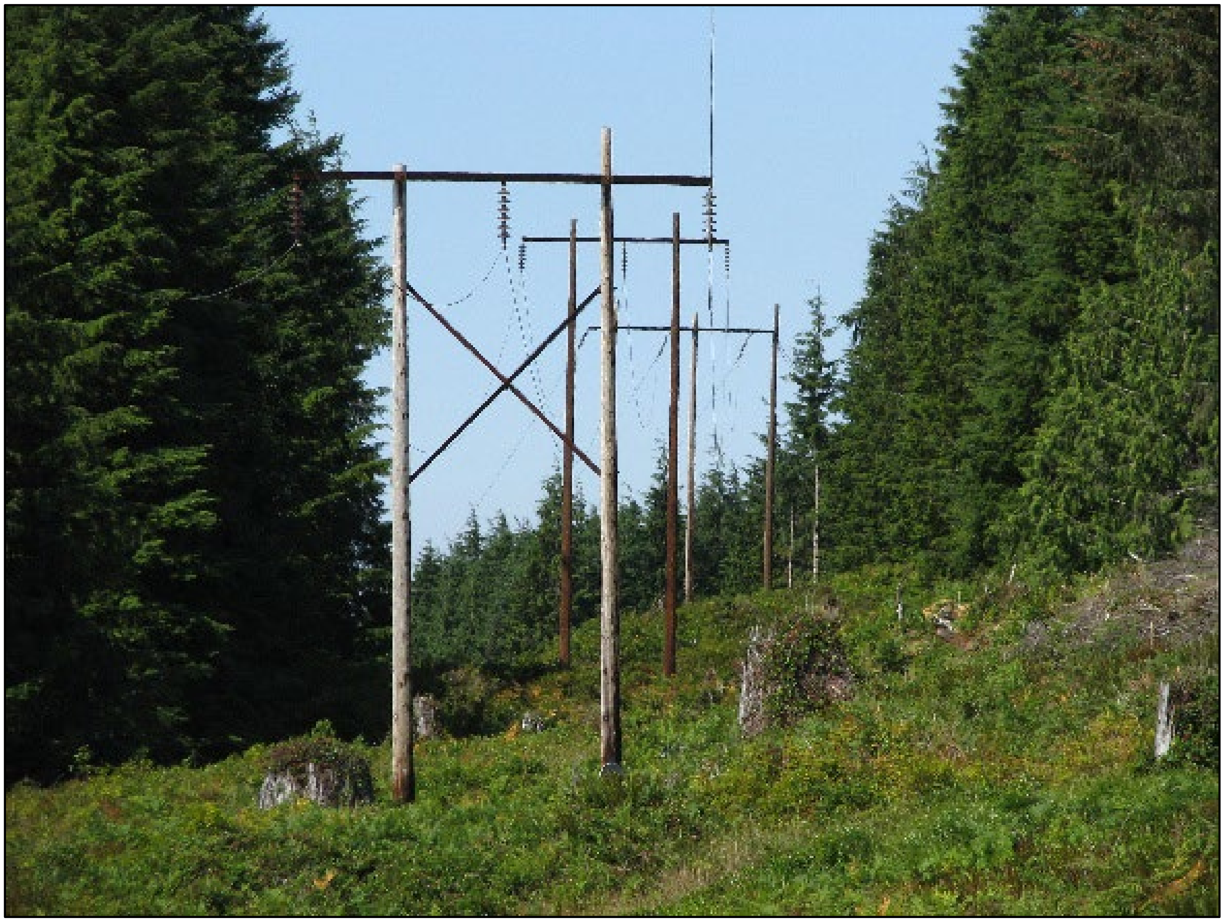


Figure 67. Suspension structures on Holcomb-Naselle Line.

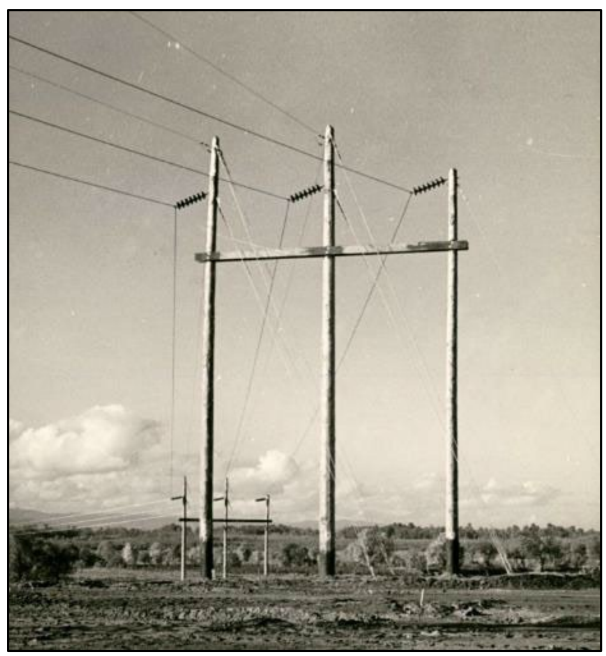


Figure 68. Left: Workers construct a dead-end tower circa 1940.[365] Right: Heavy angle dead end structure installed circa 1940 where the angle was too great for a dead-end tower.[366]

[365] BPA, *Typical Engineering Details*.
[366] BPA, *Typical Engineering Details*.

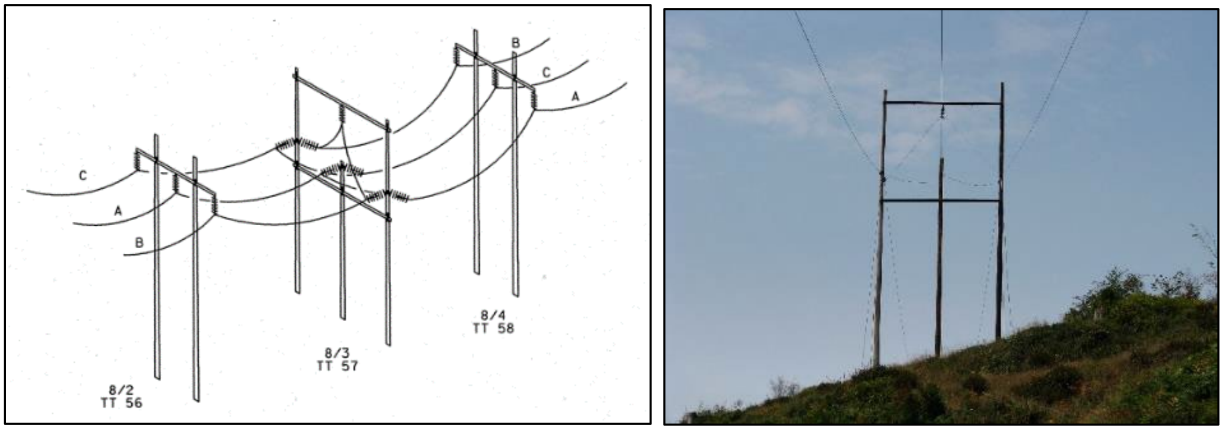


Figure 69. Transposition structure drawing and photograph of the Holcomb-Naselle Line.

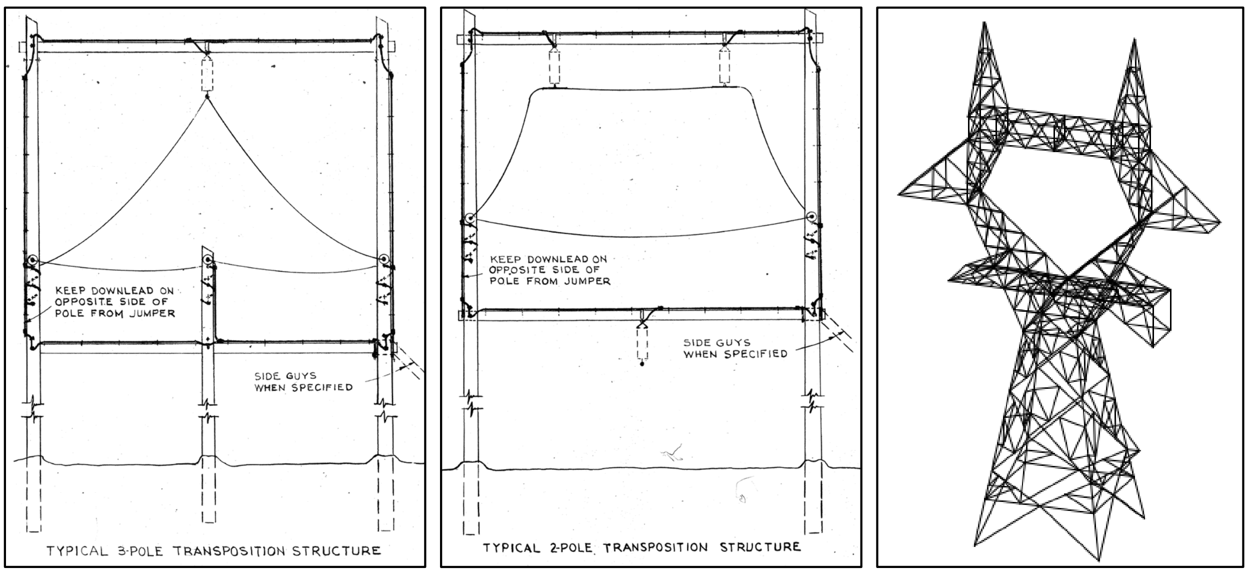


Figure 70. Wood two pole (left) and three pole (center) transposition tower. Single Circuit Lattice Steel Transposition Tower (right).

5.4.2 Signage and Identifying Markers

Transmission lines can include several standardized signs that identify the line name and number and its mile, tower, and serial number (Figure 71). Line names are generally abbreviated by four-letter capitalizations such KELS-CHEL, SANT-CHEM, etc.). The abbreviation is printed on a 5” x 7” metal sign with black lettering and a yellow/orange background.[367] Signage may also consist of similar sized metal lettering with simpler abbreviations such as “HN” for Holcomb-Naselle. The mile and tower number are generally identified with similar metal cut-outs and positioned below the line name. Transmission structures may also include its serial number printed on a rectangular 5” x 7” metal sign. Each physical transmission line and fiber-optic structure has unique serial number. The name plates capture a line’s current name, not the original, which, coupled with BPA’s frequent name changes and reclassification of lines, can pose challenges for relying on signage for historical information. However, the serial number does often capture the original line name.

[367] Kramer, *BPA Transmission System MPDF*, 45

Figure 71. Transmission Structure Signage on Holcomb-Naselle Transmission Line.

The individual poles are also identified with metal lettering as A or B for two-pole H-frame structures and A, B, or C for three-pole structures (Figure 72). Pole A usually contains the identifying information for the line and the mile/structure number. Similar to other utility poles in the United States, the Holcomb-Naselle Line's wood poles are marked with the supplier's code or trademark, plant and year of treatment, pole species, preservative use, circumference class, and length. The marks for this line are contained in aluminum tags affixed to the poles near eye level.

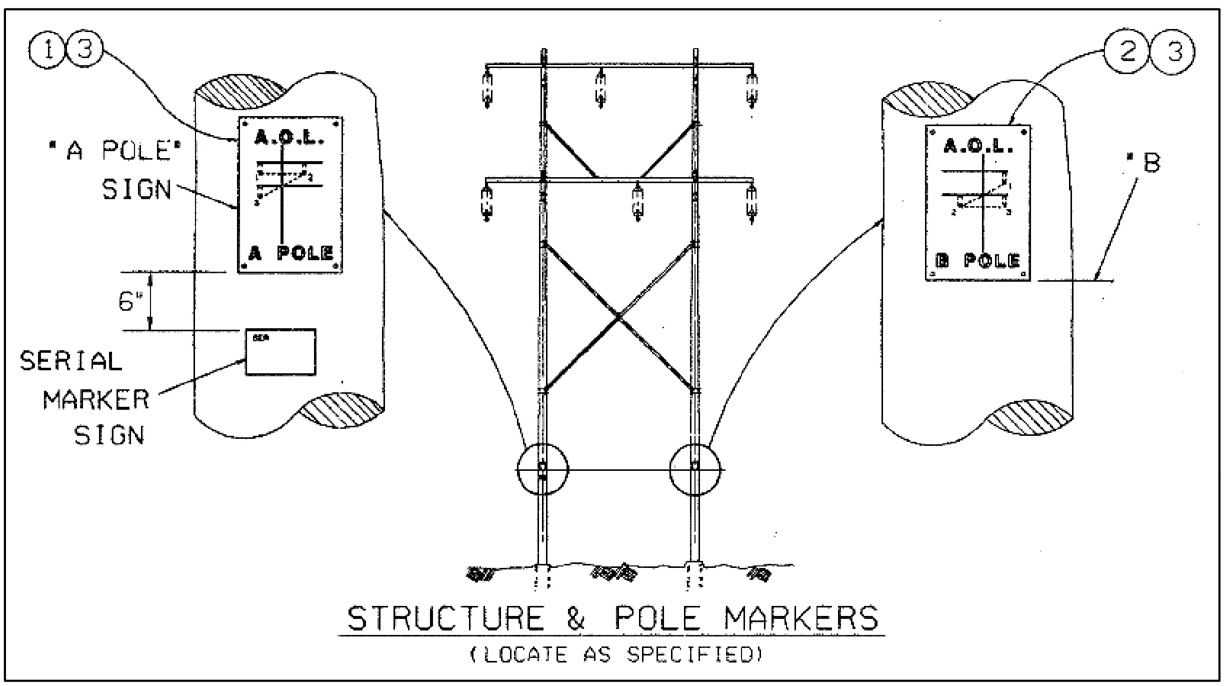


Figure 72. Drawing of Structure and Pole Markers.

In general, below the date of manufacture on each tag is a two-character wood species abbreviation and one- to three-character preservative (Figure 73). Some wood species may be marked "SP" for southern pine, "WC" for western cedar, or "DF" for Douglas fir. Common preservative abbreviations are "C" for creosote, "P" for pentachlorophenol, and "SK" for chromated copper arsenate. Some tags also included longer abbreviations for preservatives such as "PENTA" for pentachlorophenol. The next line of the brand is usually the pole's American National Standards Institute class, used to determine maximum load; this number ranges from 10 to H6 with a smaller number meaning higher strength. The majority of poles along the Holcomb-Naselle Line are class 2, with a few in class 1.

Figure 73. Aluminum Wood Pole Tags indicate supplier information, dates, wood species, preservatives, and other information.

5.4.3 Bracing and Stability

Bracing and stability are important to ensure the secure placement of a structure along a transmission line, and this can also vary among BPA's transmission structures. Wood poles are generally set below ground to a depth of ten percent of their height plus two feet.[368] In some instances, it is necessary to attach additional wood poles, ground supports, guy wires, anchors, or a combination to stabilize a structure. Figures 74 and 75 show the combination of wood ground bracing, guy wires, and swamp anchors to secure the structure in place.

Ground Braces

Ground braces, also referred to as swamp braces, are attached to structures in areas where the ground is very moist and at risk of not sufficiently supporting a structure. The design depicted in Figure 74 consists of wooden boards placed on opposing sides of each of a structure's wood poles. The wood boards are positioned perpendicular to each other forming an X-like configuration. The boards are secured with bolts that continue into the wood poles. The bracing in the center figure depicts a similar design but with additional wood boards connecting the two crossing boards and running parallel to the ground. BPA no longer implements this design and now installs a steel culvert in the ground, places the pole in the culvert, and surrounds it with rock.

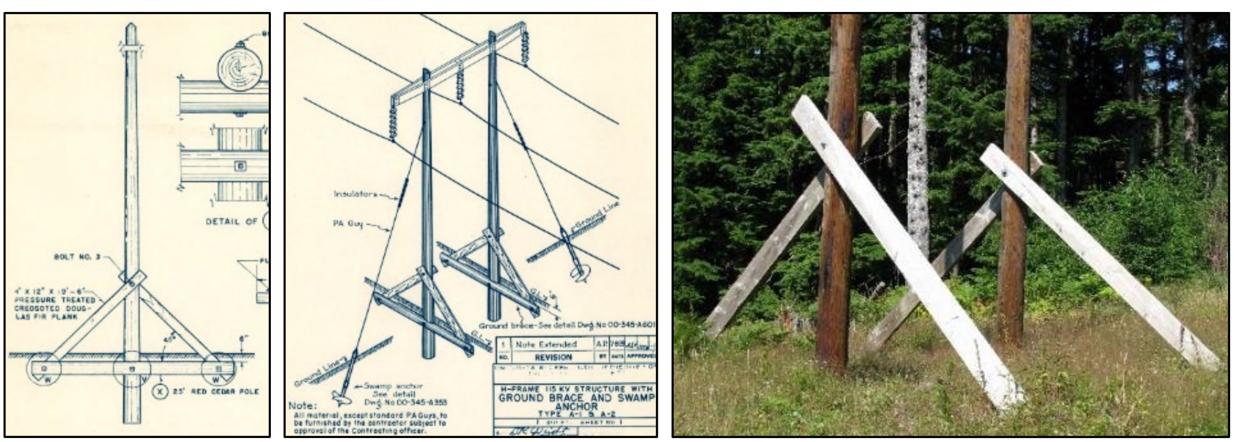


Figure 74. Ground brace (left) and ground brace with swamp anchors (right).[369]

[368] BPA, *Architectural Drawings* 24463 (Portland, OR: Bonneville Power Administration, 1946).

[369] Henry R. Stevens, *Wood Pole Standards* (Washington, D.C.: U.S. Department of the Interior, 1939).

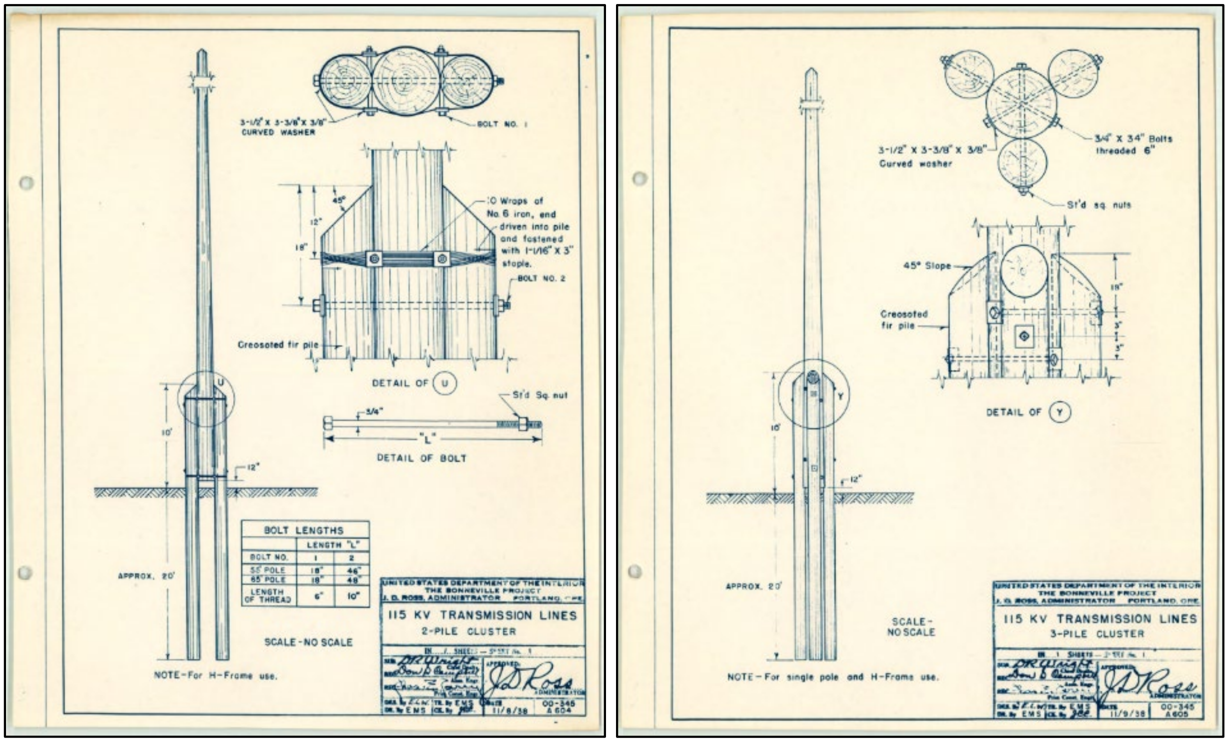


Figure 75. Two-pile (left) and three-pile (right) cluster bracing.[370]

Guy Wires

A guy wire is a tensioned cable designed to add stability to wood and steel structures. One end of the cable is attached to the structure, and the other is anchored to the ground at a suitable distance from the structure's base to maintain suitable tension. For installation on a wood pole structure, the guy wire is looped through an eyebolt which is threaded through the wood pole. The guy wire is attached to the ground by clamping it into a guy grip that is attached to a guy anchor buried below ground.[371] The installation of guy wires for wood and steel structures are very similar. They are often configured radially (equally spaced about the structure) in trios, quads (pairs of pairs) or other sets. This allows the tension of each guy wire to offset that of the others (Figure 76).

[370] Stevens, *Wood Pole Standards*.

[371] Dustin Liebhaber, Email to AECOM, November 1, 2018.

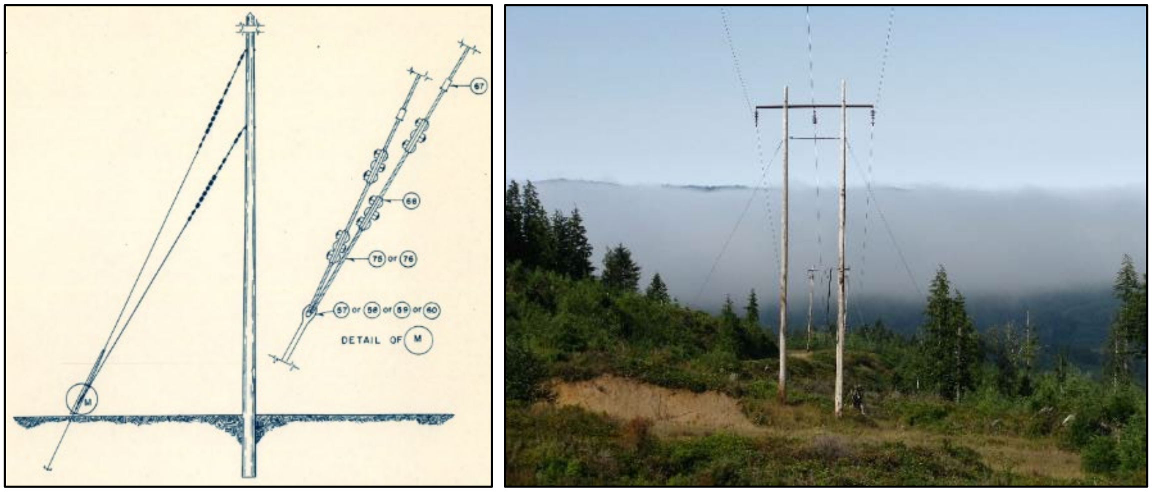


Figure 76. Typical guy wire installation for H-frame structure (left) and H-frame structure with guy wires on Holcomb-Naselle Line.[372]

5.4.4 Wood Pole Structures

Wood poles structures primarily consist of two basic design: single-pole and H-frame structures. H-frame structures can include two or three vertical wood poles. Each of these basic designs can be adapted for the voltage carried, crossarm configuration and functions (Figure 77). The following subsections provide examples of these basic designs and how they can be modified based on the requirements of the line.

[372] Stevens, *Wood Pole Standards*.

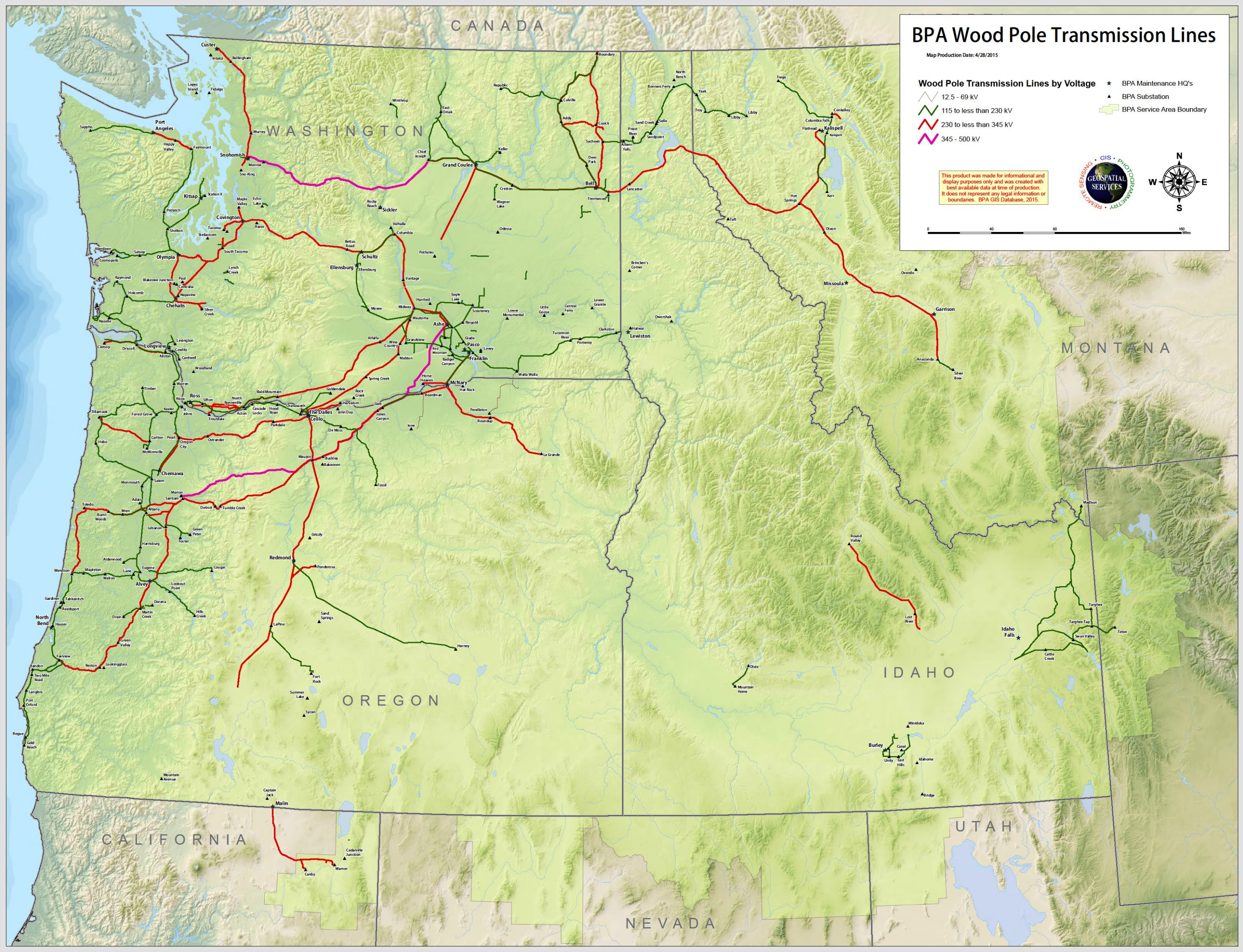


Figure 77. BPA's Wood Pole Transmission Lines delineated by voltage.

Wood Pole H-Frame Structures

The single-circuit H-frame structure is the most common wood pole structure used in the BPA system. H-frames can be either 2- or 3-pole structures (Figure 78). Two-pole structures are most often used for tangent or small line angle locations and three-pole structures are used for medium running angle and dead-end locations.[373]

Wood H-frames are typically 80 feet high but can vary between 40 and 125 feet in height depending on the electrical clearances required for the transmission line's voltage and surrounding environment.[374] Pole heights may also vary on individual structures if they are positioned on a slope. All wood H-frame structures include crossarms that connect the wood poles near the top of the structure. Some H-frame structures may also employ a cross brace, K-brace or X-brace to prevent tipping from horizontal loading. Cross braces are commonly included in H-frame structures to allow for longer spans between structures, heavier conductors, and to support the structures under transverse loading.[375] Crossarms and cross braces are bolted to the wooden poles. These structural elements have historically been comprised of wood but are now constructed of steel. The length of crossarms or cross braces depends upon the dimensions of each associated structure. For example, on the Holcomb-Naselle Line crossarms typically measure about 24-feet long, while the steel cross braces measure about 12 feet long.

These structures are generally classified as guyed or self-supporting. Guyed structures require less structural steel but require more space and often more construction effort. The self-supporting tower is inherently heavier but occupies less ground and provides greater reliability.[376]

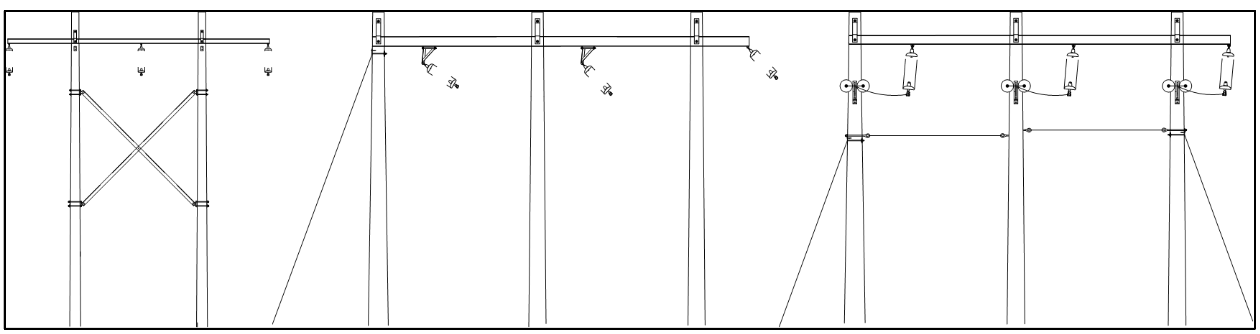


Figure 78. Two and three pole H-frame structures.[377]

Three-pole H-frame structures are designed for enhanced stability and share design characteristics with the more typical two-pole H-frame structure, such as crossarms with suspended insulator strings (Figures 79 and 80). Three-pole structures are often employed as dead-end structures designed to counteract horizontal forces created when the line changes direction.

[373] BPA, *Wood Pole Structure Analysis and Design Guide STD-DT-000068* (Portland, OR: Bonneville Power Administration, 2012).

[374] Jones and Jones, *Measuring the Visibility of High Voltage Transmission Facilities in the Pacific Northwest* (Portland, OR: Bonneville Power Administration contract 14.03.6017N, 1976), 11; Dustin Liebhaber, Email to AECOM, November 1, 2018.

[375] Holand H. Farr, *Transmission Line Design Manual, A Water Resources Technical Publication* (Washington, D.C.: Water and Power Resources Service, U.S. Department of the Interior, 1980).

[376] Dustin Liebhaber, Email to AECOM, November 1, 2018.

[377] BPA, *Wood Pole Structure Analysis*.

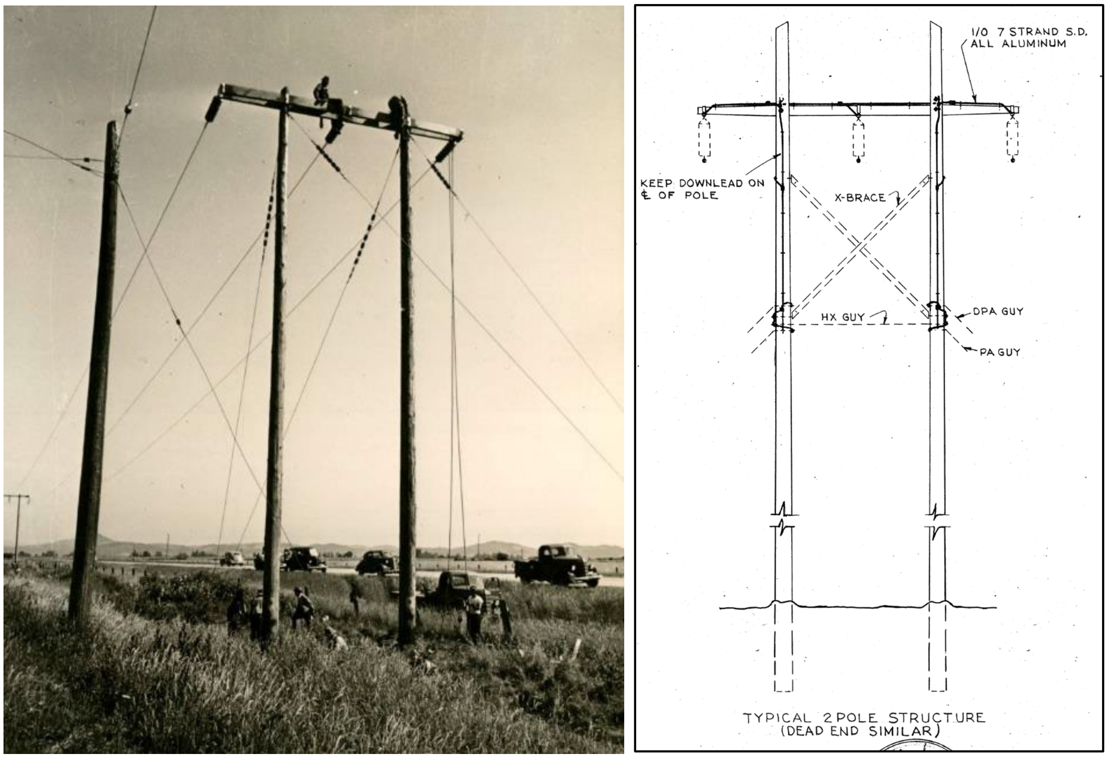


Figure 79. Two-pole H frame structure (left) and 1939 BPA drawing (right).[378]

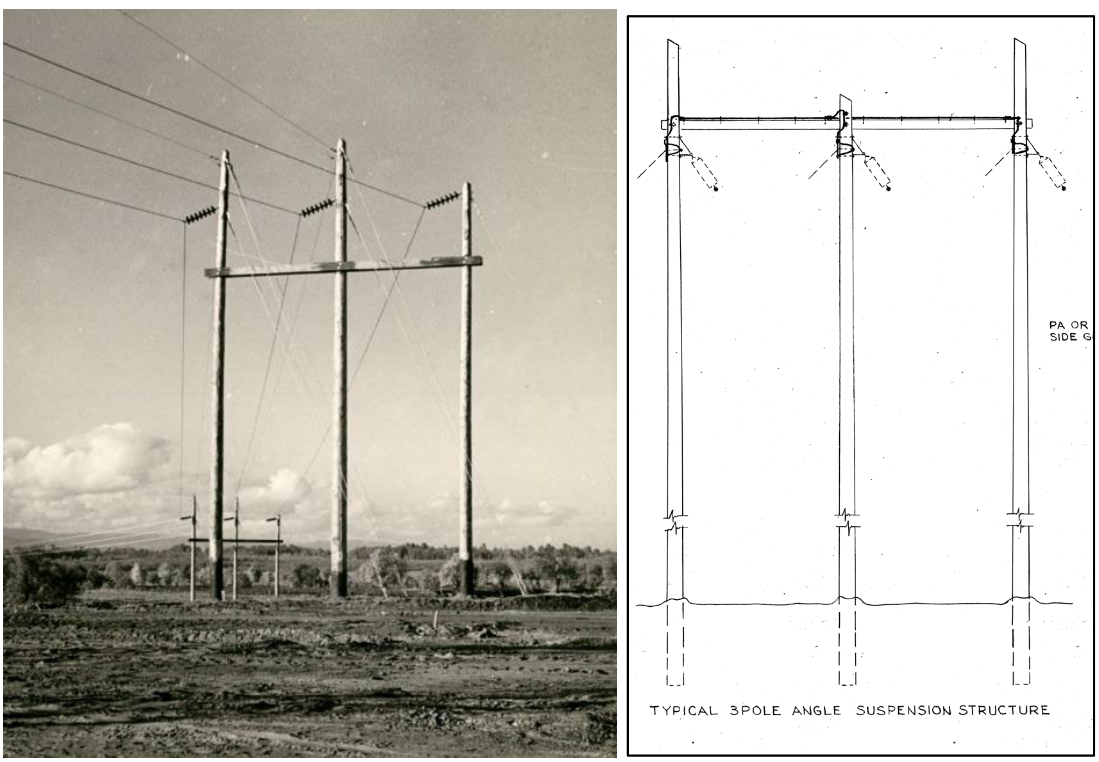


Figure 80. Three-pole H-frame heavy angle structure (left) and typical three-pole H-frame suspension structure (right).[379]

[378] BPA, *Typical Engineering Details*.

[379] Stevens, *Wood Pole Standards*.

Single Wood Pole Structures

Single wood pole structures are uncommon within the BPA transmission system. However, there are a variety of single wood pole designs depending on the voltage they carry, the number of circuits, and location within the surrounding environment (Figure 81).

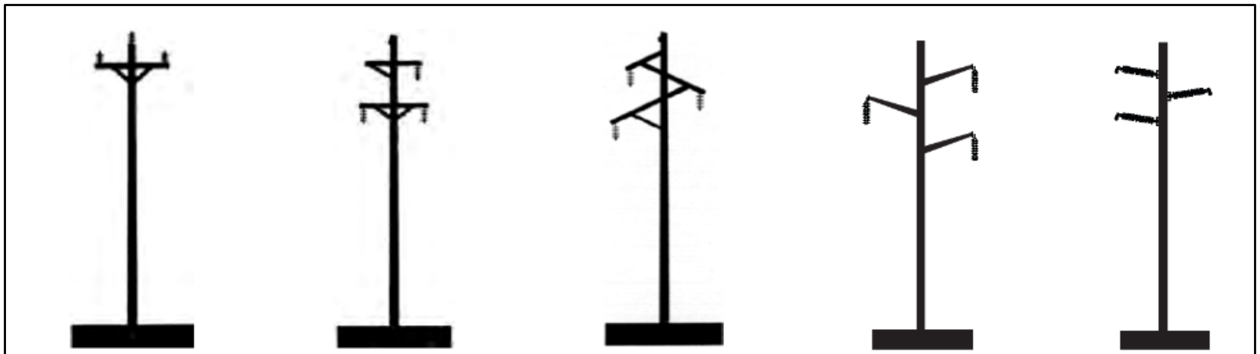


Figure 81. Single pole structures.[380]

5.4.5 Steel Transmission Structures

BPA's transmission network includes a wide variety of steel tower types that are broadly categorized as steel pole and lattice structures. Steel structures are additionally configured as monopoles, horizontal or flat, delta, vertical with single and double circuit designs, and lattice pole, with varied conductor supports, depending upon voltage and use.[381] Several designs are similar to the wood structures, such as monopole and H-frame structures. Like wood structures, the design of steel structures depends on multiple factors including, voltage, topography, climate, right-of-way, distance between towers, and design of the line. These design variations reflect the complex engineering components of transmission line design, construction, and operation. When first introduced, steel towers were generally designed in two heights, 50 and 70 feet. Each would include a 20-foot body extension placed underneath. There were also various types of leg extensions, running 0 to 25 feet in 2 ½ foot lengths. Extensions were commonly used for construction on steep hillsides.[382]

Steel Pole Structures

Steel pole structures include monopole and H-frame structures (Figure 82). Aside from their materials, the characteristics of steel pole structures are similar to those described for wood pole structures.

[380] Electric Power Research Institute, *Field Guide: Visual Inspection of Wood Structures* (Palo Alto, CA: Electric Power Research Institute, 2008).

[381] Kramer, *BPA Transmission System MPDF*.

[382] BPA, *Inservice Training Series*, 19.

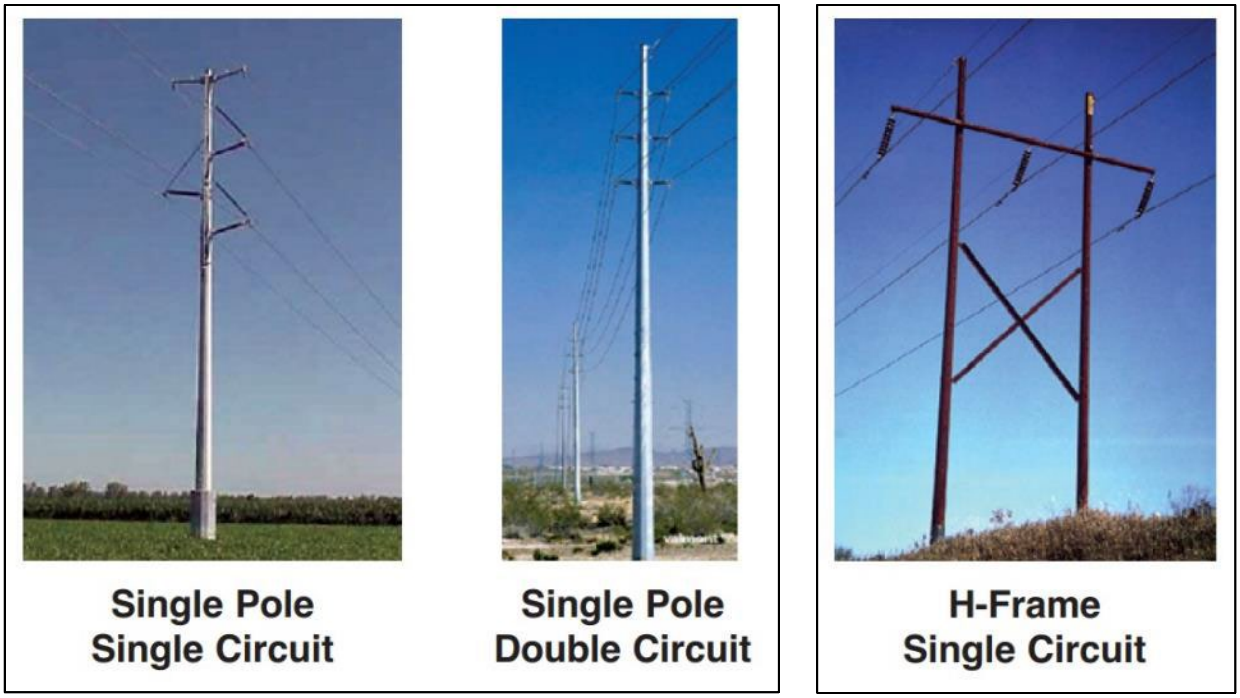


Figure 82. Steel pole structures, including monopole and H-Frame designs.[383]

Steel Lattice Structures

Steel lattice structures primarily consist of flat, vertical, and delta configuration towers but also includes H-frame structures (Figure 83). BPA's transmission network is comprised of a wide variety of flat and delta configuration towers with subtle variations. Although BPA's steel lattice towers have the greatest number of design variations, most share similar design components, such as lattice-work construction with a wide base that tapers upwards. The latticework is composed of steel poles that are interconnected by repetitive horizontal and diagonal steel cross braces.

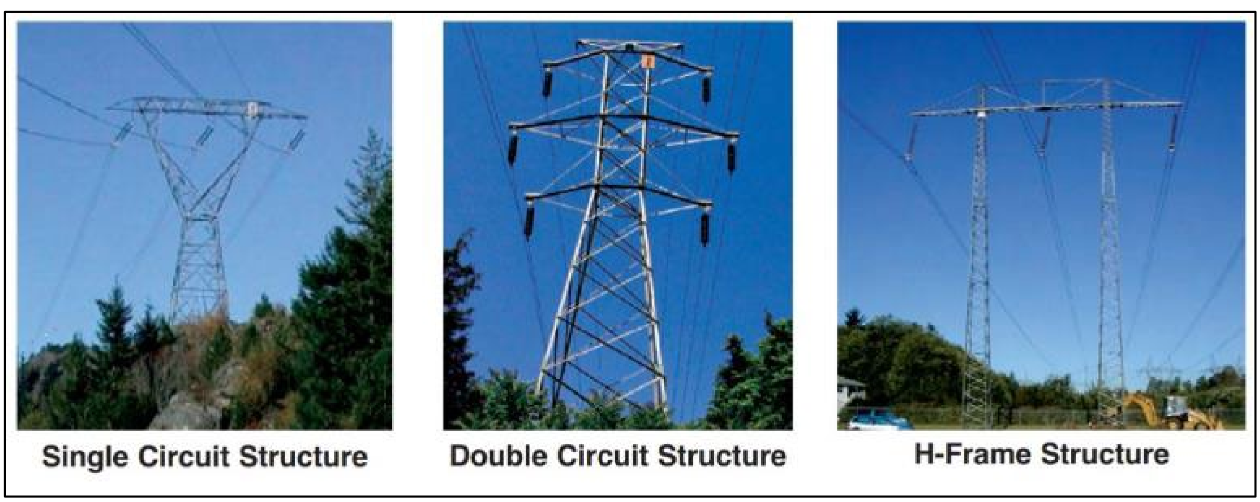


Figure 83. Steel lattice towers.[384]

Lattice towers can generally be categorized into three configurations types: flat, delta, and vertical and combinations thereof (Figure 84). Designed in the 1940s and 1950s, flat

[383] EDM International, *Field Guide: Visual Inspection of Steel Structures* (Fort Collins, CO: EDM International, 2008).

[384] EDM International, *Field Guide*.

configuration single circuit towers were common on BPA's 230-kV and 287-kV transmission lines. The vertical configuration double circuit towers were also introduced during that period. Additional variations were designed in the mid- to late-2000s. In the 1970s, the delta configuration single circuit towers were designed specifically for 500-kV lines.[385] The delta configuration helps reduce electrical field strength and reduces required right of way width. Each tower type features either a rotated or square base design.[386] Both designs are similar and are distinguished by whether the base is parallel with cross arm sections above (square) or not (rotated) (Figure 84). Until 1947, BPA only used rotated tower designs for single-circuit construction. Afterward they used light-steel towers except where the terrain or conditions required heavier construction. Light steel towers require about 30 percent less steel than the standard towers and were often considered more economical than wood pole construction.[387] More than 95 percent of towers on 500-kV lines are lattice steel designs.[388]

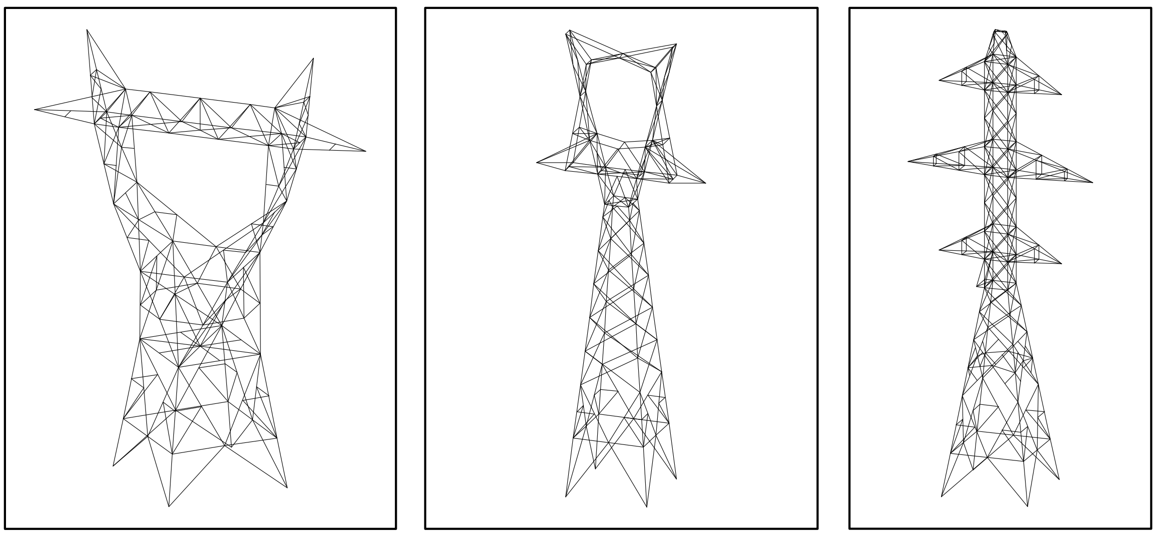


Figure 84. Flat configuration single circuit tower with rotated base (left), delta configuration single circuit tower with square base (center), and vertical configuration double circuit tower with square base (right).[389]

Although similar to the designs of 230-kV towers, 500-kV towers require larger minimum electrical clearances which made for larger tower designs. The delta tower configuration is primarily used for 500-kV transmission lines and has several advantages in comparison to the conventional flat tower including a narrower right-of-way (25 feet less than flat configuration). The narrower right-of-way creates a saving of about three acres of land per mile. The reduced crossarm width also decreases torsional stresses and reduces tower weight.[390]

By 1971, BPA's beautification program (beautility) began impacting the design of tower designs. As described by Matthew Marjerrison, a BPA civil engineer and head of line design unit, "The increased concern over environmental matters has brought an entirely new dimension into the design of transmission lines. Environmental critics both professional and amateur have sprung up like mushrooms. This, in the long run, is probably good but it has made life more difficult for

[385] David Hesse, *Recommended Major 230 kV Standard Design Parameters for Line Replacements and Grid Expansion Projects on the BPA System* (Portland, OR: Bonneville Power Administration, 2012).

[386] BPA, *Lattice Tower Analysis and Design STD_DT-000032 Revision 06* (Portland, OR: Bonneville Power Administration, 11/15/2019).

[387] Schultz, *High Voltage Power Transmission,* 6.

[388] Dave O'Claire, "BPA Lattice Tower Design a General Overview," BPA (presentation), 2013.

[389] Hesse, *Recommended 230 kV Standard Design Parameters.*

[390] M.N. Marjerrison and M.G. Poland, *Bonneville Power Administration's 500 kV Transmission Line Design* (presented at the Transmission Section of Canadian Electrical Association, Vancouver, B.C., March 24, 1971), 8-9.

transmission engineers."[391] Describing the design of the delta dead-end tower used at the time (28-D), Marjerrison reported "Although this tower is excellent from a purely structural standpoint it is unsymmetrical and offensive to some aesthetic eyes." A new delta dead end tower (38D) was designed to be more aesthetically compatible with the delta suspension tower (Figure 85). This new design was several tons heavier than the original.

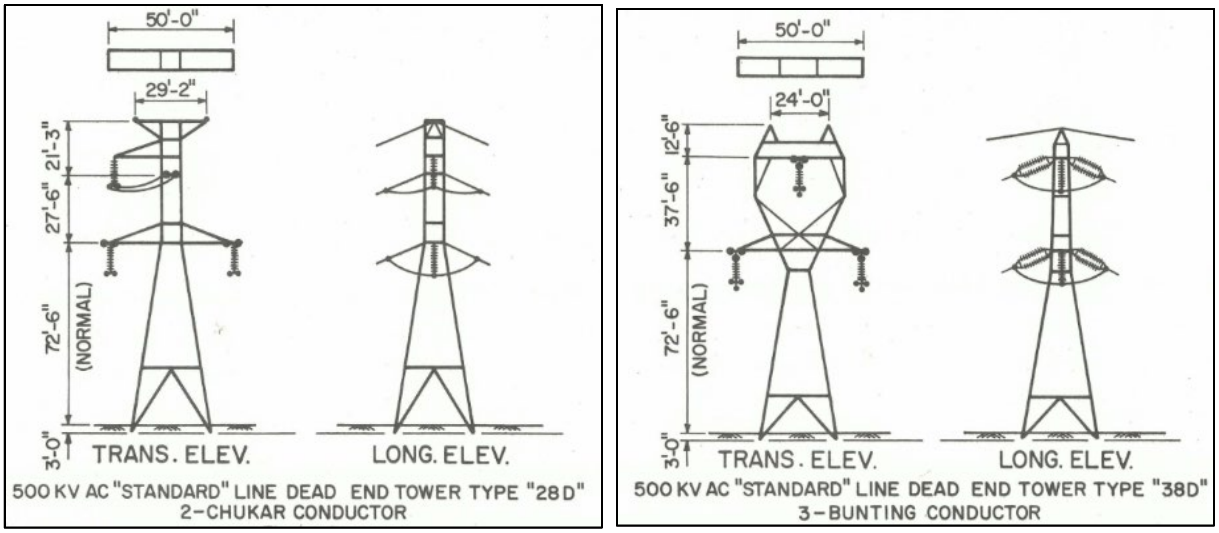


Figure 85. Delta dead-end tower 28D (left) and 38D (right).

5.4.6 Unique Characteristics

There are several uniquely classified characteristics that cause additional variations in transmission structures. These variations are implemented to address the circumstances or challenges of that structure's location, span, or other conditions. Although many of these characteristics are unique within BPA's structure classification organization, they share most of their characteristics with the more common structure types.

Some unique structures may include special structures for extremely long spans of large, high strength conductors over rivers, bays, and deep canyons; or near dams due to heavy mist conditions (ice). Examples of special towers include the suspension towers over the Columbia River near Portland, Oregon – 504 feet above their foundations, highest structures of their kind in the world when constructed in 1940.[392] These "river crossings" all have their own classification because they are specifically designed for the environmental conditions of their location (Figure 86).

[391] Marjerrison and Poland, *500 kV Transmission Line Design*, 9.

[392] A. A. Osipovich, "Make the Steel Fit."

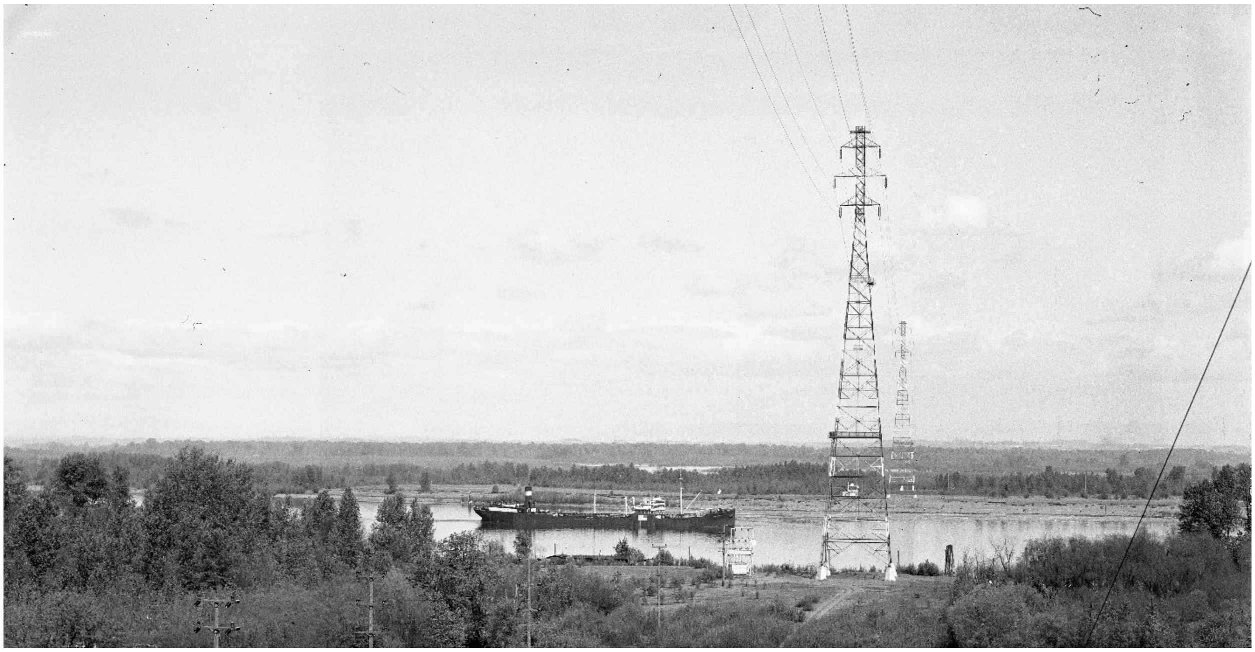


Figure 86. River crossing transmission structures on the Bonneville—Eugene Line, ca. 1940.[393]

Some transmission lines include switch stands, which are steel structures positioned adjacent to H-pole structures. These structures house a line disconnect or switch to open the circuit and de-energize a section of a transmission line. Two disconnects are usually used with a customer tap in the middle. This allows the tap to be fed from either direction or completely isolated as needed.[394]

Other unique or rare structure types, materials or features within the BPA system may include the following:

- Field-modified structures
- Lattice steel H-frame structures
- Concrete structures
- Aluminum structures
- Microwave communication equipment
- Single circuit direct current lattice steel tower

Although less common within the BPA system, aluminum, concrete, and lattice steel H-frame structures are standard designs purchased from a vendor. They represent a smaller percentage of BPA's structure types but are not considered unique designs (Figure 87).

[393] BPA Archives, E113284.

[394] Dustin Liebhaber, Email to AECOM, November 1, 2018.

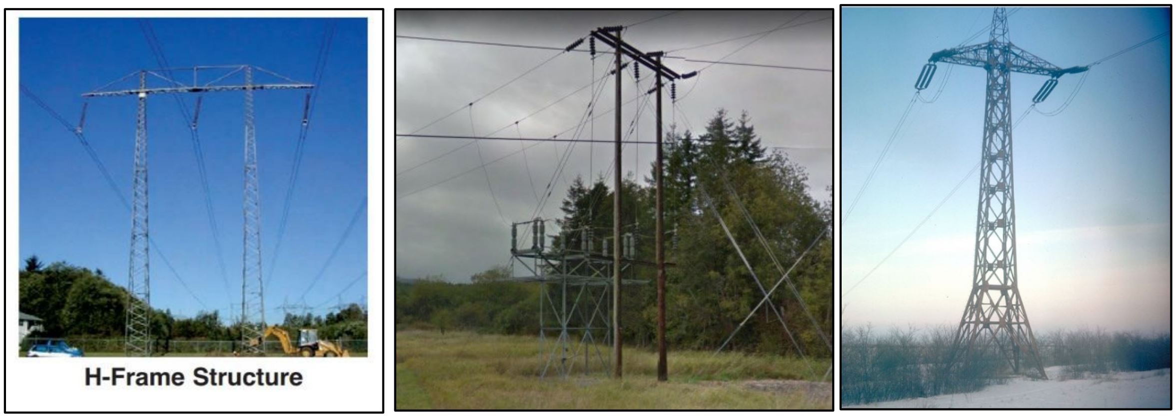


Figure 87. Unique Transmission Structure Types, including lattice steel H-frame structures (left), switch stands (middle) and single circuit direct current lattice steel structures (right), which are only used on direct current lines.[395]

[395] EDM International, *Field Guide*.

6. Identification

Identification efforts for BPA's historic transmission lines account for a complex system of resources. The BPA transmission network is comprised of over 700 transmission lines with a multitude of various structure types and designs based on function, voltage, number of circuits, construction material, location, and climate.

Each transmission line is its own resource and is identified as a **structure** for NRHP evaluation purposes. Lines constructed and energized during the period of significance (1938 – 1974) are potential historic properties.

While typically considered and managed as discrete features, in a larger sense, transmission lines are interconnected by design, blurring their individual aspect. No transmission line in BPA's system is independent. Each individually named line contributes to the overall system, although from a management and documentation standpoint, they are treated as individual resources.

Transmission lines include two **endpoints** (usually substations, but also power generation sources, customer facilities, or other locations). The lines may incorporate named segments or taps that are sections of the overall line**.** These named sections may include substations or other facilities that act as midpoints along the transmission line and/or may be in BPA's current data management systems as individual lines.

Tracking the **historic names** of transmission lines in BPA's data systems is challenging, because historic names are likely to differ from current operating names due to continual changes and additions to BPA's grid. BPA may operate what was once a historic transmission line as a section of a larger line with a different name. Alternatively, a historic line may also have been segmented into a series of smaller lines. Often, identification efforts attempt to trace a line back to the "original" name, but often the current line is a much shorter version because it was chopped up by new substations after the period of significance. Other difficulties arise when sections or lines are referenced in primary research sources instead of the historic operating line name.

Necessary components to identify historic transmission lines include the **name**, **voltage**, and **energization date**, as well as a description of **physical characteristics** that comprise a line's appearance. The most characteristic elements of transmission lines are the **alignment**, which is the line's route or path, and the **transmission structures** (towers and poles), which are distinguished by their materials (wood, steel, concrete, other), and design (class). The **conductors** are the cables that carry the power and are distinguished by voltage but lack individual distinction in their overall appearance.

Other aspects of identification may include its function (suspension, dead end, or transposition) and whether a transmission line has a single or double circuit. Modifications to lines are important to consider when identifying historic transmission lines, particularly changes to line names, lengths or paths, and endpoints. Other modifications may include changes to setting, construction materials, and addition of taps or intermediate substations that create new sections of the line.

ROW widths reflect current standards and codes and are not representative what they were historically. Therefore, ROW is not a factor in evaluating historic transmission lines. Even if they don't contribute to the eligibility of a historic transmission line, ROW legal records contain useful Real Property information that aids in researching a historic transmission line, such as ROW acquisition dates and data about what lines existed on a particular ROW over time. These acquisition records are helpful in narrowing down construction or energized dates when other records are scarce.

BPA's transmission lines are continually evolving as BPA adapts to regional, national, and maintenance priorities and incorporates new electric distribution and management technologies through system upgrades and expansion. Frequent maintenance activities include materials replacements; minor route realignments; introduction of new technologies; and grouping, separating, and renaming lines. These changes are expected given the dynamic nature of BPA's transmission lines and are considerations for identification efforts. Furthermore, identification requires the analysis and incorporation of both historical data and current BPA data management systems.

6.1 Distribution of BPA's Historic Transmission Lines

The MPDF describes the range and variation of BPA's historic transmission lines:

> As the primary electrical transmission system in the Pacific Northwest, responsible for the delivery of the entire output of the Federal Columbia River Power System, and more than 50% of the total generation capacity of the region, not to mention it's major role in wheeling power for other utilities, the Bonneville Power Administration Transmission System occurs in virtually all portions of BPA's primary four state service area, with specific concentrations in the Columbia and Snake river basins. Transmission lines stretch from the Canadian border, in northern Washington, to southern Oregon, and run east and west from western Montana to the Pacific Ocean. The BPA system includes more than 15,000 circuit miles of transmission line, more than 12,000 miles of which were completed during the period of significance. Other sections of transmission line, some contiguous with the main network and some not, occur in portions of California, Nevada, Wyoming and Utah.[396]

> Variation, as it is concerns BPA's transmission lines, largely relates to tower design and voltage, with the design/engineering responses that result from the technical requirements associated with the transmission of different voltages. These variations are generally reflected in tower height, spacing of towers both in linear fashion (dependent upon conductor types and topography) and laterally, when multiple lines occur within a single corridor. In terms of visual impact, the most obvious variation is limited to tower materials, metal or wood, and tower proximity to adjacent lines.[397]

Eighty percent of 115-kV and 230-kV lines consist of wood poles structures. Some lattice steel structures are used on 115-kV lines for double circuits and river crossings. There are relatively few tower designs for 230-kV lines. However, 500-kV lines include a variety of designs and more than 95 percent of towers are lattice steel.[398]

The "BPA Transmission Facilities Owned or Operated" report from 1974 provides a representation of all approximately 464 lines that were operating in the BPA system at the end of the period of significance. Several of these lines have associated named sections or taps that are indented below the line name. Although some historic lines may have been removed prior to 1974, this Owned or Operated report can be used as a basis to identify transmission lines from the historic period of significance that may remain in BPA's system. The report provides data for all transmission lines in BPA's system in 1974, including names of lines with associated sections and taps, location (state), voltage, counts of steel and wood circuit miles, energized dates, and remarks, as well as notations for changes and additions. The status of each line can be determined during future identification efforts and analysis with current transmission line data.

[396] Kramer, *BPA Transmission System MPDF*, 44.

[397] Kramer, *BPA Transmission System MPDF*, 44.

[398] O'Claire, "BPA Lattice Tower Design."

Most of the data is quantified in reference to circuit miles. The report does not include data that quantifies the total count of named transmission lines in the system or provides similarly quantified data for each state. A separate dataset is provided for substations.

The report indicates the following baseline data from June 30, 1974 (Table 6):

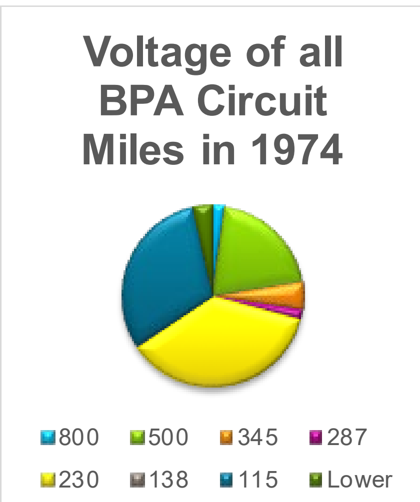
- Operating voltages included 800, 500, 345, 267, 230, 138, 115, and lower-kV circuits.
- Total energized lines in BPA system include 12,074 circuit miles 7,652 of which were steel and 4,422 were wood.
- Idaho contained 581 total energized circuit miles, 200 of which were steel and 381 of which were wood. The 115-kV voltage was most prevalent.
- Montana contained 613 total energized circuit miles, 364 or which were steel and 249 of which were wood. The 230-kV and 115-kV voltages were most prevalent.
- Oregon contained 4,206 total energized miles, 2,653 of which were steel and 1,553 of which were wood. The 230-kV and 115-kV voltages were most prevalent.
- Washington contained 6,660 total energized miles, 4,427 of which were steel and 2,233 of which were wood. The 230-kV and 115-kV voltages were most prevalent.
- Wyoming contained 13.5 total energized miles, 8.3 of which were steel and 5.2 of which were wood. All were 115-kV voltage.
- The majority of BPA's 500-kV lines were in Oregon and Washington, with fewer 500-kV circuit miles in Idaho (121 miles) and Montana (60 miles).

Table 6, as well as the charts on the following pages illustrate data from BPA's 1974 Owned and Operated report, including distribution of total circuit miles and voltages in BPA's system, circuit miles associated with each voltage, circuit miles of steel and wood materials, and a complex analysis of voltage and materials in each state (Figures 88-89). Figure 90 shows a map of the Northwest power system in 1974. Table 6 shows the total circuit miles and voltages in the BPA system in 1974, the end of the Period of Significance.

Figure 88. Distribution of Wood and Steel Circuit Miles and Voltages by State

Table 6. Circuit Miles and Voltages in BPA's System in 1974

	BPA System			Idaho			Montana			Oregon			Washington			Wyoming		
Voltage	Total (All)	Steel (All)	Wood (All)	Total (ID)	Steel (ID)	Wood (ID)	Total (MT)	Steel (MT)	Wood (MT)	Total (OR)	Steel (OR)	Wood (OR)	Total (WA)	Steel (WA)	Wood (WA)	Total (WY)	Steel (WY)	Wood (WY)
800	264	264	0	0	0	0	0	0	0	264	264	0	0	0	0	0	0	0
500	2457	2457	0	121	121	0	60	60	0	1028	1028	0	1248	1248	0	0	0	0
345	570	570	0	0	0	0	0	0	0	1	1	0	569	569	0	0	0	0
287	227	227	0	0	0	0	0	0	0	0	0	0	227	227	0	0	0	0
230	4380	3591	789	62	62	0	422	304	117	1575	1206	369	2322	2020	302	0	0	0
138	32	1	31	32	1	31	0	0	0	0	0	0	0	0	0	0	0	0
115	3731	528	3203	257	16	242	131	0	131	1207	148	1059	2122	356	1765	14	8	5
Low	413	14	399	110	1	109	0	0	0	131	6	125	173	8	166	0	0	0
Total	12074	7652	4422	581	200	382	613	364	249	4206	2653	1553	6660	4427	2233	14	8	5



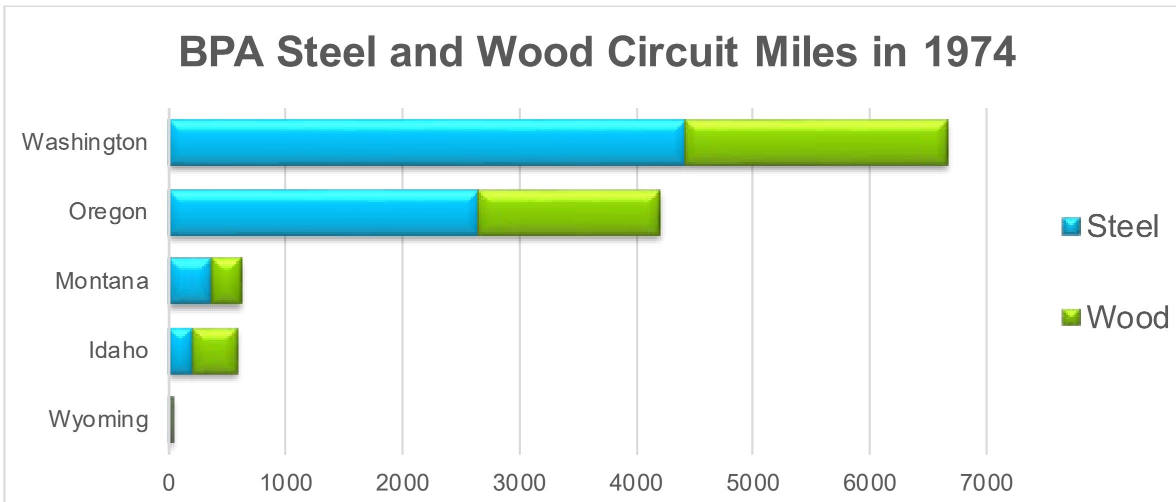


Figure 89. BPA circuit miles by voltage and transmission structure material type in 1974

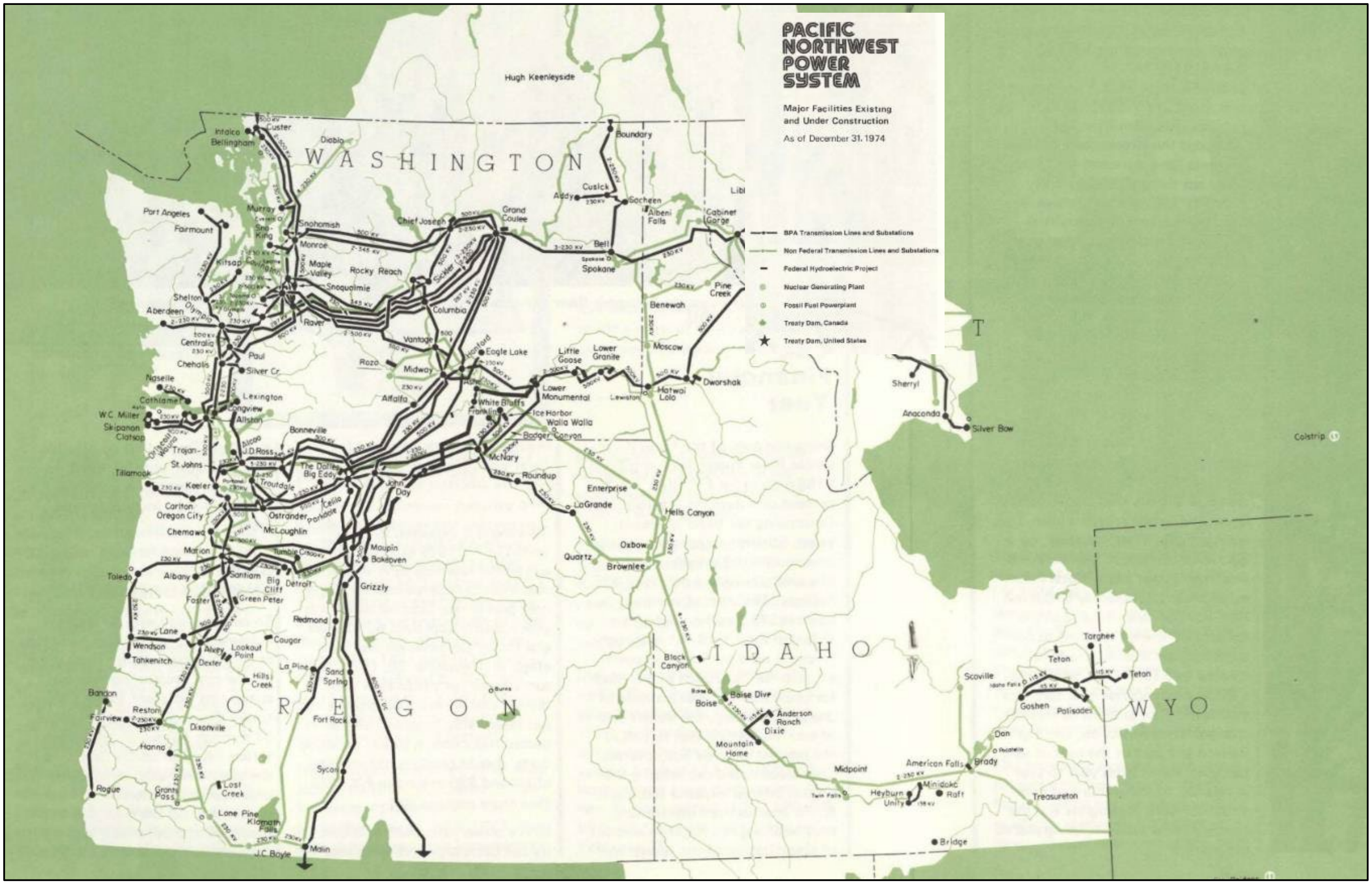


Figure 90. Pacific Northwest Power System in 1974, illustrating BPA's and non-federal transmission systems, federal hydroelectric projects, nuclear generating plants, and fossil fuel power plants[399]

[399] BPA. *1974 Annual Report*, 30-31.

6.2 Previous Surveys of BPA Transmission Lines

BPA has conducted previous surveys and initial NRHP evaluations for its transmission lines, though not all survey efforts have resulted in determinations of eligibility. BPA has records for 230 previously evaluated lines (173 eligible and 57 not eligible) that were surveyed as part of various Section 106 undertakings and other projects. BPA predicts that approximately 491 lines are unevaluated. Through a desktop data analysis, BPA has identified that 340 of the unevaluated lines fall within the period of significance and are potentially eligible, and 151 of the unevaluated lines are not eligible because they were not energized during the period of significance (Table 7).

Table 7. Results of BPA's Preliminary Evaluation Methods

Eligibility	Previously Evaluated Lines	Unevaluated Lines	TOTAL
Eligible/Potentially Eligible	173	340	513
Not Eligible/Not in Period of Significance	57	151	208
TOTAL	230	491	721

6.2.1 BPA's Baseline Identification Methodology

BPA uses internal databases to conduct baseline identification and evaluation of transmission lines when those lines intersect with the APE for a BPA undertaking. Energization dates can be tricky for BPA's transmission lines due to changes to line names caused by the addition of substations, changes to voltages, rebuilds, or general renaming practices. BPA uses the following three databases to cross-reference and determine if a line's construction or "energization" date aligns with the period of significance:

- Transmission Reference Entity Database (TRED) – provides information on voltage, length, and locations
- Transmission Line Design Database (TLDD) – provides information on the types, counts, installation dates, and serial numbers for specific structures present in the line
- Real Property Services Land Information System (LIS) database – provides general energized dates for a line's ROW.[400]

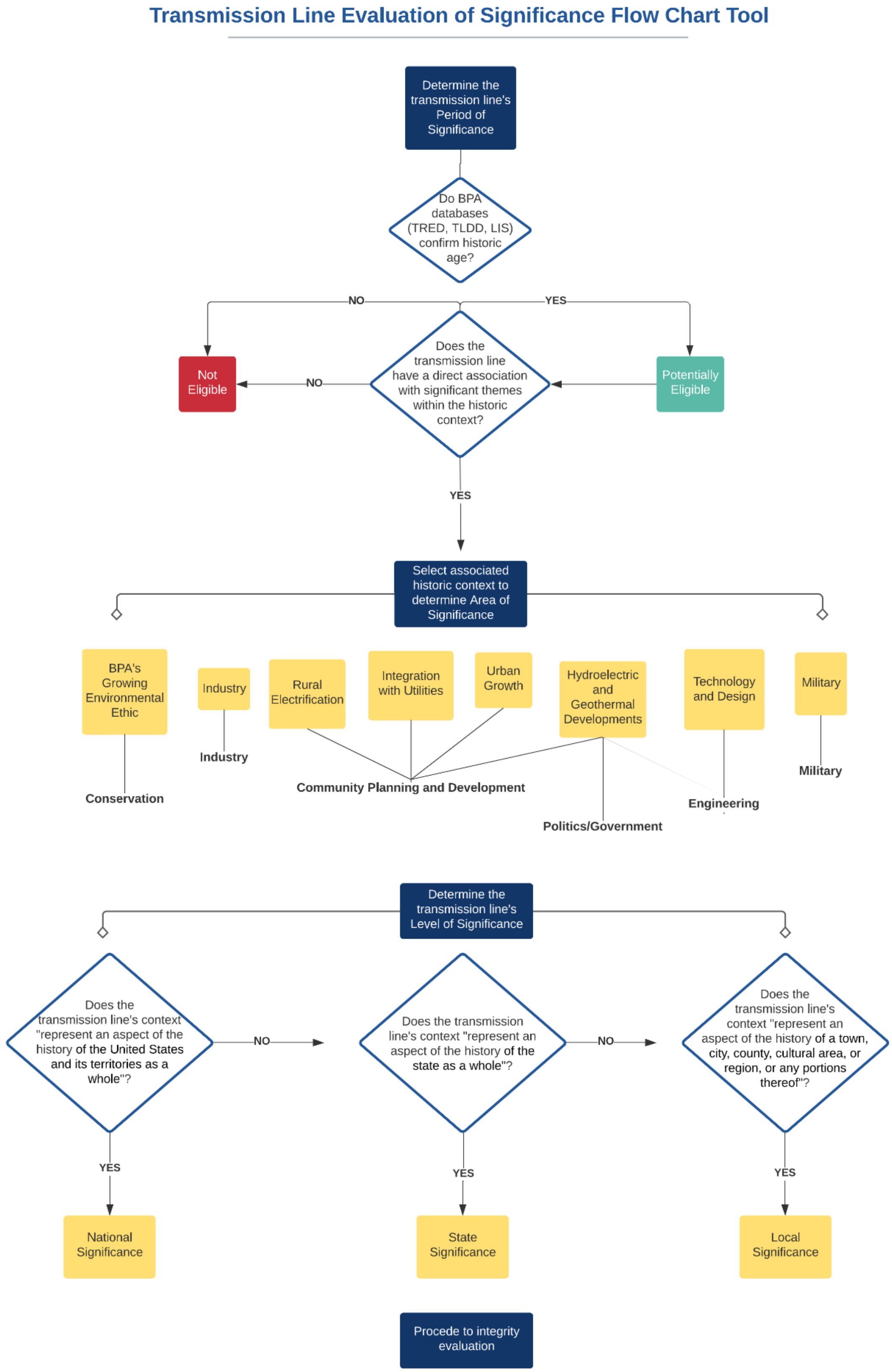
BPA also uses calibrated spreadsheets that provide the termination points of a line based on the operating line name. BPA verifies energized dates by cross-checking the LIS date with the installation dates of individual structures, or with schematic drawings and one-line diagrams that annotate a transmission line's power flows and equipment.

Identification and management of BPA's historic transmission lines poses several challenges, primarily caused by the dynamic and changing nature of the transmission grid. Identification methods include multiple BPA databases that each store different datasets and continually update names, dates, circuits, and lengths. These complexities make it difficult to track existing conditions against what is pertinent to identifying and delineating historic period resources and evaluating the integrity of those resources.

[400] Because the energized date is tied to the right-of-way in the LIS data, if the line shares a ROW or crosses through a substation, all of the associated energized dates will be linked to the line, so it still requires verification, but it is generally correct. In cases where the date doesn't line up with the energized date of the line, LIS will be giving an earlier date (for example, giving the energized date for a substation, not the line itself), but the date will not be earlier than what is given in LIS (i.e., if LIS gives the energized date as 1981, it might be later than that, but no earlier).

6.3 Evaluation Flow Chart

The following evaluation flow chart applies to BPA's transmission lines associated with this historic context that may be eligible for the NRHP, either individually or as a contributing resource to the overall transmission system.



6.4 Individually Significant Historic Transmission Lines

The historic transmission lines listed in Table 8 have been identified as possessing individual significance associated with BPA's historic context. The individually significant lines have not been evaluated for integrity, nor have determinations been made regarding the NRHP eligibility of each line. Some may have been removed or altered through line additions or segmentations. It is possible and likely that several of the operating line names changed during and after the period of significance. Further research and data analysis is necessary to understand and evaluate the existing status of these transmission lines.

This list relies on the research included in this context statement but may not be exhaustive. These resources are significant at the national and/or state levels. Lines that may have had an individually significant impact at the local level are not included in this list, though they are considered contributing to BPA's overall system-wide significance. Additional lines may rise to the level of individual national or state significance through further research. Those may include lines that directly supported World War II efforts or industrial activities, such as the Alcoa, Kaiser, or Reynolds aluminum plants; shipbuilding facilities; Bremerton Navy Yards (now Puget Sound Naval Shipyard); the magnesium plant in Spokane; Pacific Carbide & Alloys Company; or Pennsylvania Salt Manufacturing Co.[401] Other potentially significant lines may include those associated with dam construction or Grand Coulee Dam's connection to the larger circuit of load centers during the period of significance. If BPA's Network Analyzer computer still exists, it may be eligible as a historic object.

Themes considered for individual significance but ultimately determined to only contribute to the overall system include those associated with wheeling agreements and the Northwest Power Pool, overall industrial activity, and minor dam development.

Table 8. Individually Significant Historic Transmission Lines

Historic Line Name	Energized Date	Criteria	Area(s) of Significance	Notes
Albany-Toledo	1946	A	Community Planning and Development	Rural Electrification (Oregon); first step in meeting critical power shortage to southern Oregon coastal area
Anaconda-Silver Bow	1953	A	Industry	Significant for powering the Victor Chemical Works
Bell-Boundary No. 2	1965	A	Politics/Government	Significant for its role in helping integrate power from the Columbia River Treaty project into the BPA grid at Bell Substation near Spokane, Washington
Big Eddy-Keeler No. 1	1964	A and C	Engineering	First BPA transmission line built with 500-kV capacity, integral to Pacific Northwest—Pacific Southwest Intertie
Big Eddy-Ostrander No. 1	1969	A and C	Engineering	Part of 500-kV AC Pacific Northwest—Pacific Southwest Intertie
Bonneville PH-North Bonneville No. 1	1939	A	Politics/Government	Installed as Bradford Island Crossing No. 1; original 230-kV line from Bonneville Powerhouse
Bonneville- Grand Coulee	1939	A	Industry, Community Planning and Development, Military, Politics/Government	Original 230-kV Master Grid backbone; significant for its associations to the Master Grid, industry, military, and shipbuilding

[401] BPA, *1941 Annual Report,* 53.

Historic Line Name	Energized Date	Criteria	Area(s) of Significance	Notes
Bonneville-The Dalles	1939	A	Industry, Community Planning and Development, Military, Politics/Government	Original 230-kV Master Grid backbone; significant for its associations to the Master Grid, industry, military, and shipbuilding
Bonneville-Vancouver No. 1	1940	A	Industry, Community Planning and Development, Military, Politics/Government	Original 230-kV Master Grid backbone; significant for its associations to the Master Grid, industry, military, and shipbuilding
Bonneville-Vancouver No. 2	1939	A	Industry, Community Planning and Development, Military, Politics/Government	Original 230-kV Master Grid backbone; significant for its associations to the Master Grid, industry, military, and shipbuilding
Boundary-Waneta No. 1	1967	A	Politics/Government	This 2-mile section of Bell-Boundary No. 1 (built in 1964) was renamed as its own line in 1967. Significant for its role in helping integrate power from the Columbia River Treaty project into the BPA grid.
Celilo-Sylmar DC Line	1970	A and C	Engineering	Unique in the US and the world, the world's largest long-distance (846 miles), high-voltage (800-kV) direct-current transmission line. Now known as the Pacific Direct Current Intertie (PDCI)
Chehalis-Raymond	1939	A	Industry, Community Planning and Development, Military, Politics/Government	Original 230-kV Master Grid backbone; significant for its associations to the Master Grid, industry, military, and shipbuilding
Chief Joseph–Monroe	1972	A	Urban Growth, Community Planning and Development	Urban growth in Western Washington
Chief Joseph-Snohomish	1955	A and C	Community Planning and Development, Engineering	One of the original two BPA 345-kV lines (the other is McNary-Ross), the highest voltage transmission lines operating in the United States at the time. Also significant for its role in bringing power to rural Puget Sound areas
Dworshak-Hot Springs	1973	A	Community Planning and Development	Rural electrification (Montana); first BPA 500-kV line in Montana
Grand Coulee-Snohomish	1949	A	Community Planning and Development	Rural Electrification (Washington), fed a network of coastal transmission lines in Washington, energizing a dozen communities
Hanford-John Day No. 1	1968	A and C	Engineering	Part of 500-kV Pacific Northwest—Pacific Southwest AC Intertie
Hanford-Taunton Line	1944	A	Military	Associated with Hanford facility; Owned by U.S. Army
Hanford-Vantage	1966	A and C	Engineering	Part of 500-kV Pacific Northwest—Pacific Southwest Intertie
Hungry Horse-Kerr	1947	A	Community Planning and Development, Industry	Associated with construction of Hungry Horse Dam, also significant for bringing power to Montana PUDs

Historic Line Name	Energized Date	Criteria	Area(s) of Significance	Notes
International connection to Canada (Arlington and Blaine)	1947	A	Government/Politics, Military, Community Planning and Development	Part of Snohomish-Blaine Line; although initiated during the WWII to supply Canadian defense industry, the 230-kV line (which connected the two power systems in Blaine, Washington) not completed until August of 1947; allowed BPA a market for its surplus power and provided Canadians with a low-cost power source
John Day-Allston No. 1	1969	A and C	Engineering	Part of 500-kV Pacific Northwest—Pacific Southwest AC Intertie
John Day-Grizzly No. 1	1968	A and C	Engineering	First two 500-kV lines of the Pacific Northwest—Pacific Southwest AC Intertie
John Day-Grizzly No. 2	1968	A and C	Engineering	Part of 500-kV Pacific Northwest—Pacific Southwest AC Intertie
John Day-Marion No. 1	1970	A and C	Engineering	Part of 500-kV Pacific Northwest—Pacific Southwest AC Intertie
John Day- Big Eddy No. 1	1967	A and C	Engineering	First two 500-kV lines of the Pacific Northwest—Pacific Southwest AC Intertie
Kalispell-Kerr	1947	A	Community Planning and Development, Industry	First BPA transmission line in Montana
Kelso-Chehalis	1939	A	Industry, Community Planning and Development, Military, Politics/Government	Original 230-kV Master Grid backbone; significant for its associations to the Master Grid, industry, military, and shipbuilding
Little Goose--Dworshak	1973	A	Community Planning and Development	Rural electrification (Idaho), first BPA 500-kV line in Idaho
Lower Monumental-Hanford	1967	A and C	Engineering	Part of 500-kV Pacific Northwest—Pacific Southwest AC Intertie
Lower Monumental-John Day	1967	A and C	Engineering	Part of 500-kV Pacific Northwest—Pacific Southwest AC Intertie
Lower Monumental-Little Goose	1970	A and C	Engineering	Part of 500-kV Pacific Northwest—Pacific Southwest AC Intertie
Mapleton-Reedsport-Coos Bay	1950	A	Community Planning and Development	Rural Electrification (Oregon), expanded BPA network to Oregon coast
Marion-Alvey No.1	1969	A and C	Engineering	Part of 500-kV Pacific Northwest—Pacific Southwest AC Intertie

Historic Line Name	Energized Date	Criteria	Area(s) of Significance	Notes
McNary-Ross No.1	1955	A and C	Community Planning and Development, Engineering	One of the original two BPA 345-kV lines (the other is Chief Joseph-Snohomish), the highest voltage transmission lines operating in the United States at the time. Also significant for Rural Electrification (Washington)
Midway-Benton No. 1	1941	A	Military	Connected to Hanford facility; a section was renamed Benton-Hanford No. 1
Midway-Walla Walla	1941	A	Military	Midway-Hanford No. 1 section connected to Hanford facility
Newport-Sandpoint-Bonners Berry	1950	A	Community Planning and Development, Politics/Government	First BPA transmission line in Idaho
North Bonneville-Midway No. 1	1942	A	Community Planning and Development, Politics/Government	Associated with Master Grid
Noxon-Conkelley	1968	A	Politics/Government	Significant for its role in helping integrate power from the Columbia River Treaty project, specifically Libby Dam into the BPA grid
Oregon City-Alvey	1968	A and C	Engineering	Part of 500-kV Pacific Northwest—Pacific Southwest AC Intertie
Ostrander-McLoughlin	1970	A and C	Engineering	Part of 500-kV Pacific Northwest—Pacific Southwest AC Intertie
Raver-Covington No. 2	1969	A and C	Engineering	Part of 500-kV Pacific Northwest—Pacific Southwest AC Intertie
Raver-Paul-Allston	1970	A	Community Planning and Development	Main link in 500-kV grid, connects Portland and Seattle areas; associated with urban growth and development; connected to coal-fired generating plant, possibly associated with Hydrothermal Power Program
Ross-Vancouver Shipyard No. 1	1942	A	Industry, Military	Originally called Service to Vancouver Shipyard; Associated with WWII-era shipbuilding
San Juan Island Services (Fidalgo-Decatur Island-Lopez Island Submarine Cable)	1951	A and C	Engineering	Initially carrying 24-kV, the cable for this span was designed with special rubber coating; world's longest (at the time) submarine power cable line ever manufactured in one continuous length (7.5 miles)

Historic Line Name	Energized Date	Criteria	Area(s) of Significance	Notes
San Juan Island Services (Decatur Island and Lopez Island)	1951	A and C	Engineering	Initially carrying 24-kV, the cable for this span was designed with special rubber coating; world's longest (at the time) submarine power cable line ever manufactured in one continuous length (7.5 miles)
Sickler-Raver No. 1	1968	A and C	Engineering	Part of 500-kV Pacific Northwest—Pacific Southwest AC Intertie
Snohomish-Blaine	1965	A and C	Engineering	Originally called Gorge-Ingledow and later called Custer-Ingledow No. 2; part of 500-kV Pacific Northwest—Pacific Southwest AC Intertie
Spokane-Hot Springs	1952	A	Politics/Government, Community Planning and Development	230-kV line connected Idaho and Montana to the BPA grid
St. Johns-Alcoa	1940	A	Industry, Military	Significant for its role in powering Alcoa Aluminum
Swan Valley-Teton	1968	A	Community Planning and Development, Conservation,	BPA's first line and only historic line in Wyoming; also significant for conservation methods used to construct the line
The Dalles-Redmond	1952	A	Community Planning and Development	Rural Electrification (Oregon); expanded BPA network to central Oregon
UHV Test Line and Facility	1976	A and C	Engineering	Ultra-High Voltage Test Line (not within historic context period of significance)
Vancouver-Eugene	1939	A	Industry, Community Planning and Development, Military, Politics/Government	Original 230-kV Master Grid backbone; significant for its associations to the Master Grid, industry, military, and shipbuilding
Vancouver-Kelso	1939	A	Industry, Community Planning and Development, Military, Politics/Government	Original 230-kV Master Grid backbone; significant for its associations to the Master Grid, industry, military, and shipbuilding
Vantage-Covington No. 1	1966	A and C	Engineering	500-kV Pacific Northwest—Pacific Southwest AC Intertie

7. Criteria for Evaluating Historic Transmission Lines

BPA is working with consulting parties to develop a Section 106 Programmatic Agreement (PA) for historic transmission lines that will include criteria for evaluating the historical significance and integrity of BPA transmission lines. The evaluation framework will incorporate portions of the MPDF that address criteria, minimum eligibility requirements, and historical integrity, and include refined significance and integrity considerations for BPA's historic transmission lines. Appendix C provides an example transmission line evaluation that addresses the NRHP criteria for evaluating historic properties.

The NRHP is the official list of historic properties recognized as significant to the history of the U.S. at the national, state, or local level. A property is eligible for the NRHP if it meets one of four criteria (listed below) and maintains sufficient historic integrity based on its location, setting, design, materials, workmanship, feeling, and association. In order to be recognized as significant, a property must:

A. be associated with events that have made a significant contribution to the broad patterns of our history;

B. be associated with the life of a person significant in our past;

C. embody the distinctive characteristics of a type, period or method of construction, or represent the work of a master or display high artistic values; or

D. yield, or be likely to yield, information important in prehistory or history.

BPA's historic transmission lines found to be significant and retaining historic integrity may be eligible for the NRHP under Criterion A, and, in perhaps rare instances, under Criterion C. Criterion B and D are generally not considered applicable to BPA's historic resources. Significant resources associated with this historic context are eligible at the national and/or state levels and may be individually significant and/or a contributing resource to BPA's overall transmission system.

7.1 Areas of Significance

A property must be associated with one or more NRHP data categories that define an "area of significance" within the NRHP Criteria. This context addresses

7.1.1 NRHP Criterion A

BPA's transmission system represents a massive investment of capital over a period of more than 80 years, creating one of the largest unified electrical transmission networks in the world, a system that today accounts for approximately one-third of the power distribution in BPA's multi-state service area. Integral to virtually every aspect of economic development in the region, BPA transmission lines, as constructed and modified between 1938 and 1974 and retaining sufficient integrity, are eligible for inclusion in the NRHP under Criterion A for their association with the following areas of significance:

AGRICULTURE: association with the expansion or development of irrigation, agricultural production, animal husbandry, or the processing or storage of food stuffs. This area relates to the BPA's role in the establishment of rural electrical cooperatives and expanded irrigation uses that significantly transformed and expanded agriculture in rural areas.

COMMERCE: association with the development of goods, services and commodities.

INDUSTRY: association with the development of industry, manufacturing, and labor to produce, extract or process goods or services.

BPA's role in the development of regional Commerce and Industry is most clearly demonstrated by its powering of World War II-era shipyards and aluminum plants and, later, supplying power to the postwar aluminum industry. BPA also influenced the development and expansion of sawmills, mineral processing, and other industries dependent upon the availability of low-cost BPA power. These patterns of events reaffirmed BPA as a substantial and enduring economic force in the Pacific Northwest.

POLITICS/GOVERNMENT: association with federal programs or activities, political issues, or the development or expansion of government impacts. BPA's pivotal role in the development and expansion of public power in the Pacific Northwest is significant, both through the Federal Columbia River Power System (FCRPS) as well as the establishment and operation of dozens of local public utility districts, rural co-operatives, and municipally owned utilities.[402]

7.1.2 NRHP Criterion C – Engineering

BPA's development and construction of its transmission system relied upon breakthrough technology and design innovations from its staff and consultants.

The NRHP area of Engineering includes properties associated with the practical application of scientific principles to design, construct, and operate equipment, machinery, and structures to serve human needs.[403]

7.1.3 NRHP Criteria Considerations

Only one NRHP criteria consideration (G) is applicable to BPA's historic transmission line structures, while the others are irrelevant.

- **Criterion Consideration G** may be applicable when a transmission line has achieved significance within the past fifty years and are of exceptional importance.[404] Although the majority of BPA's NRHP-eligible transmission lines achieved significance within the period of significance (1938-1974) outlined in the MPDF[405] and this historic context, some transmission lines like those associated with high voltage testing may have achieved significance after this period. BPA is currently developing a historic context for high voltage transmission lines that extends beyond 1974.

BPA's historic transmission line network does not include any religious properties (Criteria Consideration A), relocated properties (Criteria Consideration B), birthplaces or graves (Criteria Consideration C), cemeteries (Criteria Consideration D), reconstructed properties (Criteria Consideration E) or commemorative properties (Criteria Consideration F). Although a transmission line may include a majority of or only in-kind replacement structures, this should not be reconsidered a reconstructed property. Transmission line structures are typically replaced as part of routine maintenance and are not intended to replicate "the exact form and detail" of the historic structure as it appeared at a specific period of time.[406]

[402] Kramer, *BPA Transmission System MPDF*, 37.

[403] National Park Service, *National Register Bulletin 16: How to Complete the National Register Registration Form*, 40.

[404] National Park Service, *National Register Bulletin 15: How to Apply the National Register Criteria for Evaluation* (Washington, D.C.: U.S. Government Printing Office, 2005), 41.

[405] Kramer, *BPA Transmission System MPDF*.

[406] National Park Service, *National Register Bulletin 15*, 37.

7.2 Minimum Eligibility Requirements

The MPDF's outlines four minimum eligibility requirements for the transmission line property type. Those are slightly modified for clarification (noted with italics) and include the following:

- Designed by, purchased, *or leased* at the direction of BPA *during the period of significance*.
- Owned or leased and operated all or in part by BPA during the period of significance.
- Energization prior to 1975.
- Continued and demonstrated original function.[407]

7.3 Integrity Considerations

BPA is continually upgrading and changing its transmission grid to adapt to constantly evolving technologies and regionally power demands. It is impossible to prescribe a set list of potential alterations and associated impacts to integrity. BPA plans, however, to define a framework of integrity considerations for the evaluation and management of its historic transmission lines. This framework will be developed as part of the PA consultation process.

8. Treatment Strategies

BPA's treatment strategies for historic transmission lines focus on clarifying identification protocols for its linear resources, conducting survey and evaluation, and developing a multi-state program-level Section 106 Programmatic Agreement (PA) with consulting parties.

8.1 Line Clarification for Linear Resources

Tracking the historic names of transmission lines in BPA's data systems is challenging. Often, identification efforts attempt to trace a line back to the "original" name, but often the current line is a much shorter version because it was chopped up by new substations after the period of significance. Other difficulties arise when sections or lines are referenced in historical documentation instead of the historic operating line name. Additional work is needed to distinguish the current operating names associated with historic transmission lines.

Oregon SHPO's guidance for linear resources sheds some light on how to best classify transmission lines. In respect to this guidance, BPA considers its entire transmission system an "interconnected grid" comprised of multiple linear resources. Each transmission line is identified as a "direct linear resource" composed of elements that characterize and convey the resource's integrity and significance. The line should therefore be evaluated as a single resource.[408]

8.2 Survey and Evaluation

BPA's survey and evaluation strategies include widespread evaluation of its historic transmission lines through a tiered approach that focuses on intensive level survey and baseline desktop evaluations.

8.3 Intensive Level Survey of Individually Significant Resources

BPA plans to conduct intensive level surveys of transmission lines that may be individually eligible for the NRHP at the state or national level. Table 8 provides a list of approximately 60

[407] Kramer, *BPA Transmission System MPDF*.

[408] Oregon State Historic Preservation Office. 2013. "Guidance for Recording and Evaluating Linear Cultural Resources". Oregon Parks and Recreation Department, https://www.oregon.gov/oprd/OH/Documents/OR_Linear_Resources_Guidance.pdf.

transmission lines that convey individual significance within the historic context, although the physical characteristics and integrity of these resources are currently unknown.

Intensive level survey evaluations would require additional research and documentation of individually significant lines and result in determinations of eligibility for these resources. Each intensive level survey would follow survey guidance provided by the SHPO associated with the state where that transmission line is located.

8.4 Baseline Desktop Evaluation of Potentially Contributing Resources

BPA completes Section 106 desktop evaluation efforts for historic transmission lines that may contribute to the significance of the overall transmission system but are unlikely to rise to a level of individual significance at the state or national level. Most of these lines have not been previously evaluated for the NRHP or have evaluations that are outdated or lack significant detail to assess a resource's eligibility.

8.5 Multi-State Programmatic Agreement

BPA is developing a program-level Section 106 PA with consulting parties to resolve the long-term potential for adverse effects to NRHP eligible transmission lines within the BPA transmission system consistent with the requirements of 36 CFR Part 800. The PA will be limited to built historic transmission line structures.

9. References

AECOM. Millennium Coal Export Terminal, Longview, Washington, Historic and Cultural Resources Assessment. Prepared for Millennium Bulk Terminals – Longview LLC, October 2015.

AECOM. *Bonneville Power Administration Microwave Radio Stations Historic Resources Technical Report*. Portland, Oregon: Prepared for the Bonneville Power Administration, 2019.

AECOM. *Bonneville Power Administration Manual for Built Resources*. Portland, OR: Prepared for the Bonneville Power Administration, 2019.

AECOM. *Field Guide: Historic Resources*. Portland, Ore.: Prepared for the Bonneville Power Administration, 2020.

AECOM. *Historic Built Resources Field Guide*. Portland, Ore.: Prepared for the Bonneville Power Administration, 2021.

Aho, Rodney A. *A History of Federal Power in the Southern Idaho Region*. Portland, Ore.: Bonneville Power Administration, 2003.

Black, David S. "Northwest Power Program." *Power Engineering.* August 1967.

BPA. (Bonneville Power Administration) *1953 Report on the Columbia River Power System*. Washington, D.C.: U.S. Department of the Interior, 1953.

BPA. *1957 Report: U.S. Columbia River Power System*. Washington, D.C.: U.S. Department of the Interior, 1957.

BPA. *1959 Report: U.S. Columbia River Power System*. Washington, D.C.: U.S. Department of the Interior, 1959.

BPA. *1960 Report on the U.S. Columbia River Power System*. Washington, D.C.: U.S. Department of the Interior, 1960.

BPA. *1961 Report on the U.S. Columbia River Power System*. Washington, D.C.: U.S. Department of the Interior, 1961.

BPA. *1962 Report on the U.S. Columbia River Power System*. Washington, D.C.: U.S. Department of the Interior, 1962.

BPA. *1963 Report: U.S. Columbia River Power System*. Washington, D.C.: U.S. Department of the Interior, 1963.

BPA. *1964 Report: U.S. Columbia River Power System*. Washington, D.C.: U.S. Department of the Interior, 1964.

BPA. *1965 Report: U.S. Columbia River Power System*. Washington, D.C.: U.S. Department of the Interior, 1965.

BPA. *1966 Report: U.S. Columbia River Power System*. Washington, D.C.: U.S. Department of the Interior, 1966.

BPA. *1967 Annual Report: U.S. Columbia River Power System*. Washington, D.C.: U.S. Department of the Interior, 1967.

BPA. *1972 Annual Report: U.S. Columbia River Power System*. Washington, D.C.: U.S. Department of the Interior, 1972.

BPA. *1974 Report: U.S. Columbia River Power System*. Washington, D.C.: U.S. Department of the Interior, 1974.

BPA. *Annual Report: Federal Columbia River Power System*. Washington, D.C.: U.S. Department of the Interior, 1968–1975.

BPA. *Annual Report of the Administrator of the Bonneville Power Administration to the Secretary of the Interior*. Washington, D.C.: U.S. Department of the Interior, 1941.

BPA. *Annual Report of the Administrator of the Bonneville Power Administration to the Secretary of the Interior*. Washington, D.C.: U.S. Department of the Interior, 1942.

BPA. *Annual Report of the Administrator of the Bonneville Power Administration to the Secretary of the Interior*. Washington, D.C.: U.S. Department of the Interior, 1943.

BPA. *Annual Report of the Administrator of the Bonneville Power Administration*. Washington, D.C.: U.S. Department of the Interior, 1944.

BPA. *Annual Report of the Administrator of the Bonneville Power Administration*. Washington, D.C.: U.S. Department of the Interior, 1947.

BPA. Carey, Charles E. *Annual Report to Congress: Engineering and Construction Section*, Portland Ore.: Bonneville Power Administration, Engineering and Construction Department, 1938.

BPA. *Annual Reports.* Various dates. Accessed July 26, 2022. Annual Reports - Bonneville Power Administration (bpa.gov)

BPA. *Architectural Drawings 24463*. Portland, Ore.: Copies on file at Bonneville Power Administration, 1946.

BPA. *Bonneville Power Administration 1955 Report*. Washington, D.C.: U.S. Department of the Interior, 1955.

BPA. *Bonneville Power Administration 1956 Report*. Washington, D.C.: U.S. Department of the Interior, 1956.

BPA. *Bonneville Power Administration Inservice Training Series 3: Building the System*. Portland, Ore.: Bonneville Power Administration, 1942.

BPA. *BPA Definitions*. Portland, Ore.: Bonneville Power Administration, 1993.

BPA. *Electrical Effects of Transmission Lines*. Portland, Ore.: Bonneville Power Administration, September 15, 1975.

BPA. *First Annual Report of the Bonneville Administrator*. Washington, D.C.: U.S. Department of the Interior, 1938.

BPA. *General Information Concerning Bonneville Power Administration and its Transmission System*. U.S. Department of the Interior, 1941.

BPA. *Highline: Construction of a Major Northwest Transmission Line*. (Motion Picture). Washington, D.C.: U.S. Department of the Interior, 1950. Accessed July 13, 2022, Highline: Pacific Northwest's High-Voltage Transmission System (1950) - YouTube

BPA. *Innovation and Engineering in Powering the Northwest*. (Digital), 2018. Accessed July 13, 2022, Innovation and Engineering in Powering the Northwest - The Network Analyzer - YouTube

BPA. *Insulator Selection STD-DT-000080 REVISION 01*. Portland, Ore.: Bonneville Power Administration, 9/20/2019.

BPA. *Lattice Tower Analysis and Design STD_DT-000032 Revision 06*. Portland, Ore.: Bonneville Power Administration, 11/15/2019

BPA. "Pacific Intertie Map, The Oregon History Project." 1964. Accessed February 23, 2021. https://oregonhistoryproject.org/articles/historical-records/pacific-intertie-map/#.XGWkuJXrvZN.

BPA. *Report of Accomplishments of the Engineering Division. Month Ending May 31, 1941*. Washington, D.C.: U.S. Department of the Interior.

BPA. *Report on the Columbia River Power System*. Washington, D.C.: U.S. Department of the Interior, 1945–1954, 1957, 1959.

BPA. *Second Annual Report of the Administrator of the Bonneville Administration*. Washington, D.C.: U.S. Department of the Interior, 1939.

BPA. *Third Annual Report of the Bonneville Power Administration*. Washington, D.C.: U.S. Department of the Interior, 1940.

BPA, *Transmission System Standard "Right-of-Way (ROW) Width Policy (STD-DT-000062, Revision 03)*.

BPA. *Stringing and Sagging a High-Voltage Transmission Line* (motion picture). Washington, D.C.: U.S. Department of the Interior. Accessed July 13, 2022, Stringing and Sagging a High-Voltage Transmission Line (1950) - YouTube.

BPA. *Structure Type per Voltage Policy STD-DT-000092 REVISION 01 CN 01*. Portland, Ore.: Bonneville Power Administration, 2018. Standard/Technical Content Owner: TELD.

BPA. *Transmission Line Tower/Structure/Pole, Wood Pole and Substation Wire-support* Structure. STD-DT-000038, Revision 01. Portland, Ore.: Bonneville Power Administration, 2016.

BPA. *Transmission Line Transposition Study*. Portland, Ore.: Bonneville Power Administration, n.d.

BPA. *Typical Engineering Details*. U.S. Department of the Interior, 1940.

BPA. *Wood Pole Structure Analysis and Design Guide STD-DT-000068*. Portland: Bonneville Power Administration, 2012.

BPA.gov. “BPA Facts” Accessed July 13, 2022. bpa-facts.pdf

BPA.gov. “BPA Film Collection Vol. 1,” Accessed July 13, 2022. BPA Film Collection, Volume One (1939-1954) - YouTube

BPA.gov. “BPA Film Collection Vol. 2,” Accessed July 13, 2022. BPA Film Collection, Volume Two (1950-1987) - YouTube

BPA.gov. “Celebrating BPA’s trailblazers on Women’s Equality Day,” BPA.gov, accessed July 20, 2022. 20210311-womens-history-month-celebrating-bpas-trailblazers - Bonneville Power Administration

BPA.gov. “Chief Engineers Reunite, Reminisce for BPA’s 75th,” BPA.gov, accessed July 20, 2022, 20120629-chief-engineers-reunite- reminisce-for-bpas-75th - Bonneville Power Administration

BPA.gov. “High Voltage Exhibit Comes Home.” 2022. Accessed July 13, 2022. 20220629-high-voltage-exhibit-comes-home - Bonneville Power Administration (bpa.gov)

BPA Library Archives. “Historic Photographs.” Copies on file at Bonneville Power Administration Library, Portland, Ore., various dates.

Cantrell, Harold M. “Bonneville Power Makes Rapid Progress in 1951.” *The Inter Lake*, February 27, 1952.

Coffman, Larry. “Bonneville Flexes Its Muscles On its 30th Birthday.” *Seattle Times*, August 20, 1967.

Colhouer, W. L., and G. C. Conner. “Bonneville Power Administration’s Planning and Economic Considerations for a 500-kV Pacific Northwest Transmission Grid.” IEEE Summer General Meeting and Nuclear Radiation Effects Conference, Toronto, Ontario, Canada, June 16-21, 1963.

The Columbian. “Final Salute: Charles Luce Excelled at Running BPA, Con Edison.” February 2, 2008.

Conway, Jr. Richard S. *The Oregon State Aluminum Industry: Economic Impact Study.* Seattle, Wash.: Conway and Associates, 2000. (BPA Library: BPA3288 2000)

Curran, Christine Ann. “A Historic Context for the Transmission of Hydroelectricity by the Bonneville Power Administration, 1939-1945.” Master’s thesis, University of Oregon, 1998.

The Daily Olympian. “Bonneville Plans Move.” October 21, 1966.

Daily Interlake. “Bids for Two Idaho Substations Opened by Bonneville Power.” July 2, 1950.

EDM International. *Field Guide: Visual Inspection of Steel Structures*. Fort Collins, CO: EDM International, 2008.

Electric Power Research Institute. *Field Guide: Visual Inspection of Wood Structures*. Palo Alto, Calif.: Electric Power Research Institute, 2008.

Farin, Philip. 1969. “Aluminum: Profile of an Industry.” New York: Metals Week. Available at the Multnomah County Library, Portland, Oregon.

Farr, F. W. *Light Steel Tower Design May Save One-Tenth Over Wood Pole Lines*. Portland, Ore.: Bonneville Power Administration, 1949.

Farr, Holand H. 1980. *Transmission Line Design Manual*. A Water Resources Technical Publication. Water and Power Resources Service. Washington, D.C.: U.S. Department of the Interior, 1980.

Goldhammer, Bernard. "The Economic Outlook of the Pacific Northwest." *Pacific Northwest Business* 16, no. 11. 1957.

Great Falls Tribune. "Long Bonneville Line Nearing Finish." July 31, 1952.

Great Falls Tribune. "Power Expected to Be Turned on Today for Cabinet Gorge-Hungry Horse Line." October 27, 1952.

Great Falls Tribune. "Washington Firms Low Bidders on BPA Substation." April 5, 1952.

Grimmer, Anne E. *The Secretary of the Interior's Standards for The Treatment of Historic Properties with Guidelines for Preserving, Rehabilitating, Restoring & Reconstructing Historic Buildings*. Washington, D.C.: U.S. Department of the Interior, National Park Service, Technical Preservation Services, 2017.

"Hanford History," United States Department of Energy, accessed July 22, 2021, https://www.hanford.gov/page.cfm/HanfordHistory

Hesse, David. *Recommended Major 230-kV Standard Design Parameters for Line Replacements and Grid Expansion Projects on the BPA System*. Portland: Bonneville Power Administration, 2012.

Idaho Free Press. "Electric Project On Slate." July 9, 1966.

Idaho Free Press. "BPA To Build Power Line in S.E. Idaho." March 3, 1967.

Idaho Free Press. "BPA Invites Clearing Bids." June 21, 1967.

Idaho State Journal. "BPA Announces Schedule For $3.3 Million Line Project." March 1, 1967.

The Inter Lake. "Montana Power Tops User List." March 22, 1950.

The Inter Lake. "Hungry Horse Will Aid State Industry." February 28, 1951.

The Inter Lake. "BPA Offices Here to be Under Guidance of Manager R.H. Wood." February 26, 1952.

The Inter Lake. "Project Well Past Half Way Mark." July 27, 1952.

The Inter Lake. "BPA Adds $9,000,000 in Services." February 28, 1954.

Jones and Jones. *Measuring the Visibility of High Voltage Transmission Facilities in the Pacific Northwest*. Portland, Ore.: Prepared for the Bonneville Power Association under Contract 14.03.6017N, 1976.

Kershner, Jim. "Northwest Power Pool," March 29, 2016. Accessed April 16, 2021. http://www.historylink.org/File/11199 .

Koler Morrison, MacDonald. 1989. "Eugene White House." City of Lake Oswego Cultural Resources Inventory Field Form. Accessed January 22, 2022. https://www.ci.oswego.or.us/sites/default/files/fileattachments/boc_hrab/webpage/18285/whitehouse.pdf

Kramer, George. *Bonneville Power Administration [BPA] Pacific Northwest Transmission System*. National Register of Historic Places, Multiple Property Documentation Form. Washington, D.C.: United States Department of the Interior, National Park Service, 2012.

Kramer, George. *Corridors of Power: The Bonneville Power Administration Transmission Network. Historic Context Statement*. Portland, Ore.: Prepared for the Bonneville Power Administration under Master Agreement #38010, 2010.

Longview Daily News. "Conditional Okeh Given Power Sale." April 14, 1961.

Marjerrison, Matthew. *Electrical Transmission Tower Design*. Presented at the American Society of Civil Engineers Structural Engineering Conference, Seattle, Washington, May 8-12, 1967.

Marjerrison, M. N., and M. G. Poland. *Bonneville Power Administration's 500-kV Transmission Line Design*. Presented at the Transmission Section of Canadian Electrical Association, Vancouver, B.C., March 24, 1971.

Medford Mail Tribune. "New Substation at Klamath Falls to be Constructed." June 26, 1953.

NARA (National Archives and Records Administration). Seattle, Washington, various dates.

National Park Service, *National Register Bulletin 15: How to Apply the National Register Criteria for Evaluation*. Washington, D.C.: U.S. Government Printing Office, 2005.

National Park Service, *National Register Bulletin 16: How to Complete the National Register Registration Form*. Washington, D.C.: U.S. Government Printing Office, 1991.

Northwest Power and Conservation Council. 2021. "Bonneville Power Administration: History." Accessed October 25, 2021. Bonneville Power Administration: History (nwcouncil.org)

O'Claire, Dave. *BPA Lattice Tower Design a General Overview*. Bonneville Power Administration Presentation, 2013.

Oregon State Historic Preservation Office. 2013. "Guidance for Recording and Evaluating Linear Cultural Resources". Oregon Parks and Recreation Department, Guidance for Recording and Evaluating Linear Cultural Resources (oregon.gov).

Oregonian. "REA Contracts With Bonneville." October 5, 1940

Oregonian. "North Wasco PUD Signs." October 31, 1940.

Oregonian. "The Dalles to Observe Bonneville Power Week." May 18, 1941.

Oregonian. "BPA Reveals Building Plans." September 7, 1950.

Oregonlive.com. Forest Farr. Obituary. 2007. Accessed August 4, 2022. Forest Farr Obituary (2007) - Portland, OR - The Oregonian (oregonlive.com).

Osipovich, A. A. *230—Kv. Wood Pole Structure Design and Tests*. Portland, Ore.: Bonneville Power Administration, 1945.

Osipovich, A. A. *H-Frame 230-Kv Wood Pole Crossarm Design Practice*. Portland, Ore.: Bonneville Power Administration, 1948.

Osipovich, A. A. “Full Scale Tests Prove BPA’s 345-Kv.” *Electrical World.* February 8, 1954.

Osipovich, A. A. “Make the Steel Fit the Design.” *Modern Designing with Steel* 3, no. 3. July 1957.

PRC (PRC Environmental Management, Inc.). *Hanford Generating Plant. Hanford Federal Facility*. Richland: U.S. Department of Energy. Washington Public Power Supply System. Hanford Generating Plant, Resource Conservation and Recovery Act Facility Assessment. Prepared for U.S. Environmental Protection Agency. Work Assignment No. R10058. EPA I.D. No. WAD7890008967. August 18, 1992.

Salt Lake Tribune. “Ogden Bidder Low.” June 6, 1968.

Schultz, S. E. *High Voltage Power Transmission in the Pacific Northwest*. Portland, Ore.: Bonneville Power Administration, 1953.

The Seattle Times. “Sol Schultz, BPA Chief Engineer.” June 5, 1990. https://archive.seattletimes.com/archive/?date=19900605&slug=1075622.

Spokane Chronicle. “Longest Cable Laid.” April 18, 1951.

Spokesman Review. “Plan for Cable to Islands Told.” March 12, 1950.

Spokesman Review. “7-mile-long Submarine Cable Moving by Train.” March 27, 1951. Stanton, Boles, Maguire & Church. *A Report on Appearance Planning*. Prepared for Bonneville Power Administration, 1966 (BPA Library: BPA451).

Spokesman Review. “Proposal for $227 Million Coast Power Tie-up Readied.” December 20, 1961.

State of Wyoming. “Governor Signs Order to Keep Jim Bridger Power Plant Unit Operating.” December 28, 2021. Accessed January 22, 2022, https://governor.wyo.gov/media/news-releases/2021-news-releases/governor-signs-order-to-keep-jim-bridger-power-plant-unit-operating.

Statesman Journal. “Tacoma Firm Bids Low on BPA Project.” July 19, 1967.

Stevens, Henry R. *Wood Pole Standards*. Washington, D.C.: U.S. Department of the Interior, 1939.

Tollefson, Gene. *BPA and the Struggle for Power at Cost*. Portland, Ore.: Prepared for the Bonneville Power Administration, 1987. Accessed August 4, 2022, Download: https://bonpow2.ent.sirsi.net/custom/web/content/BPA_and_the_Struggle_for_Power_at_Cost.pdf

United States Department of Energy. “Hanford N Reactor.” Image N1D0069267. Wikipedia, various dates. Accessed March 8, 2022, https://en.wikipedia.org/w/index.php?title=File:Hanford_N_Reactor_adjusted.jpg.

Watts News. [The Associates]. “Kenneth Klein.” Obituary. December 1, 1986.

Western Power Pool (formerly Northwest Power Pool), WPP (westernpowerpool.org)

AECOM
111 SW Columbia
Portland, Ore. 97201
aecom.com

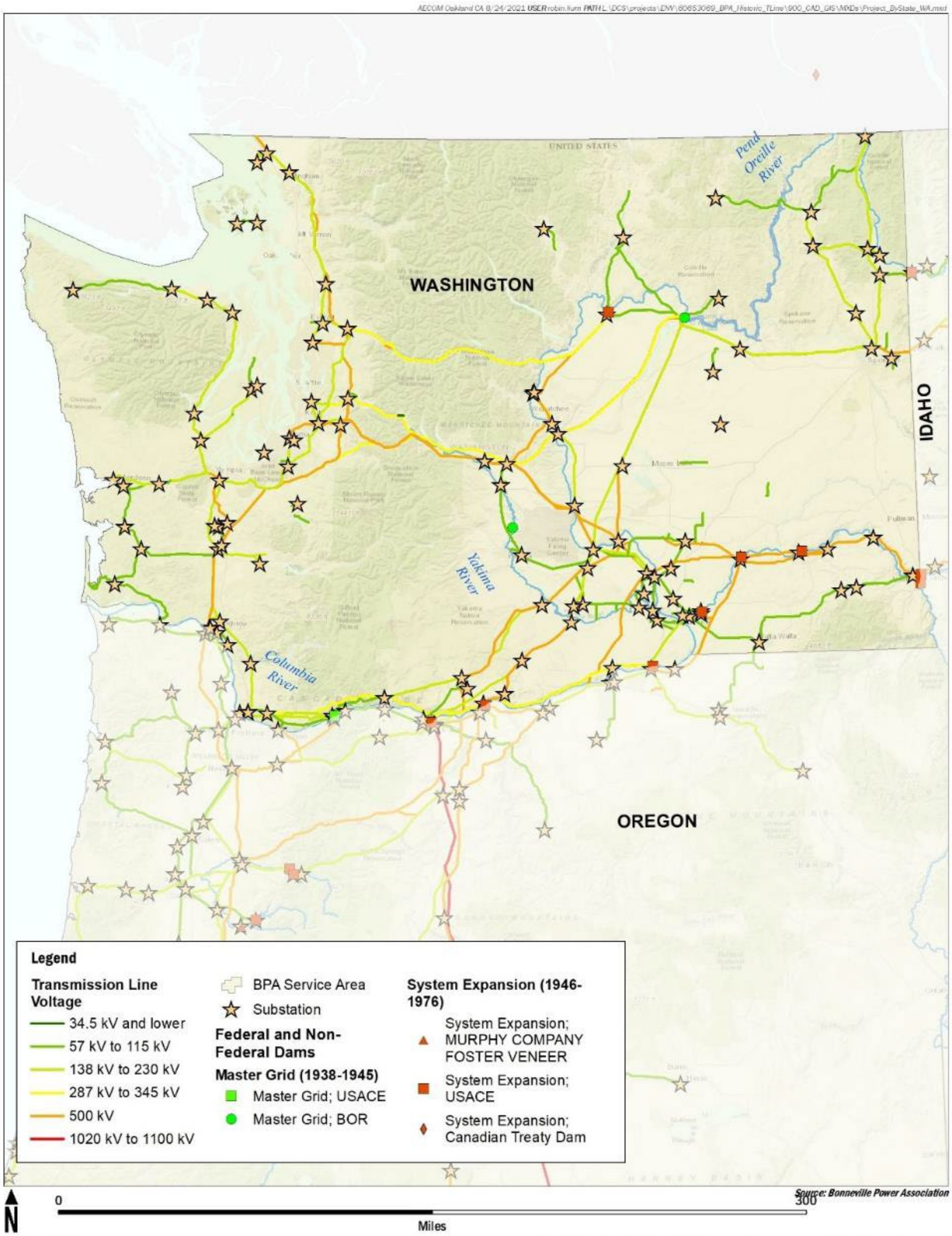
Appendices

Appendix A – BPA Transmission Line Maps Organized by State/Region

This appendix includes three maps of BPA transmission grid, organized by state:

1. Washington
2. Oregon
3. Idaho, Montana, Wyoming

The maps feature transmission line voltage ranges, BPA substations, and hydroelectric dams, which are symbolized according to their construction date.

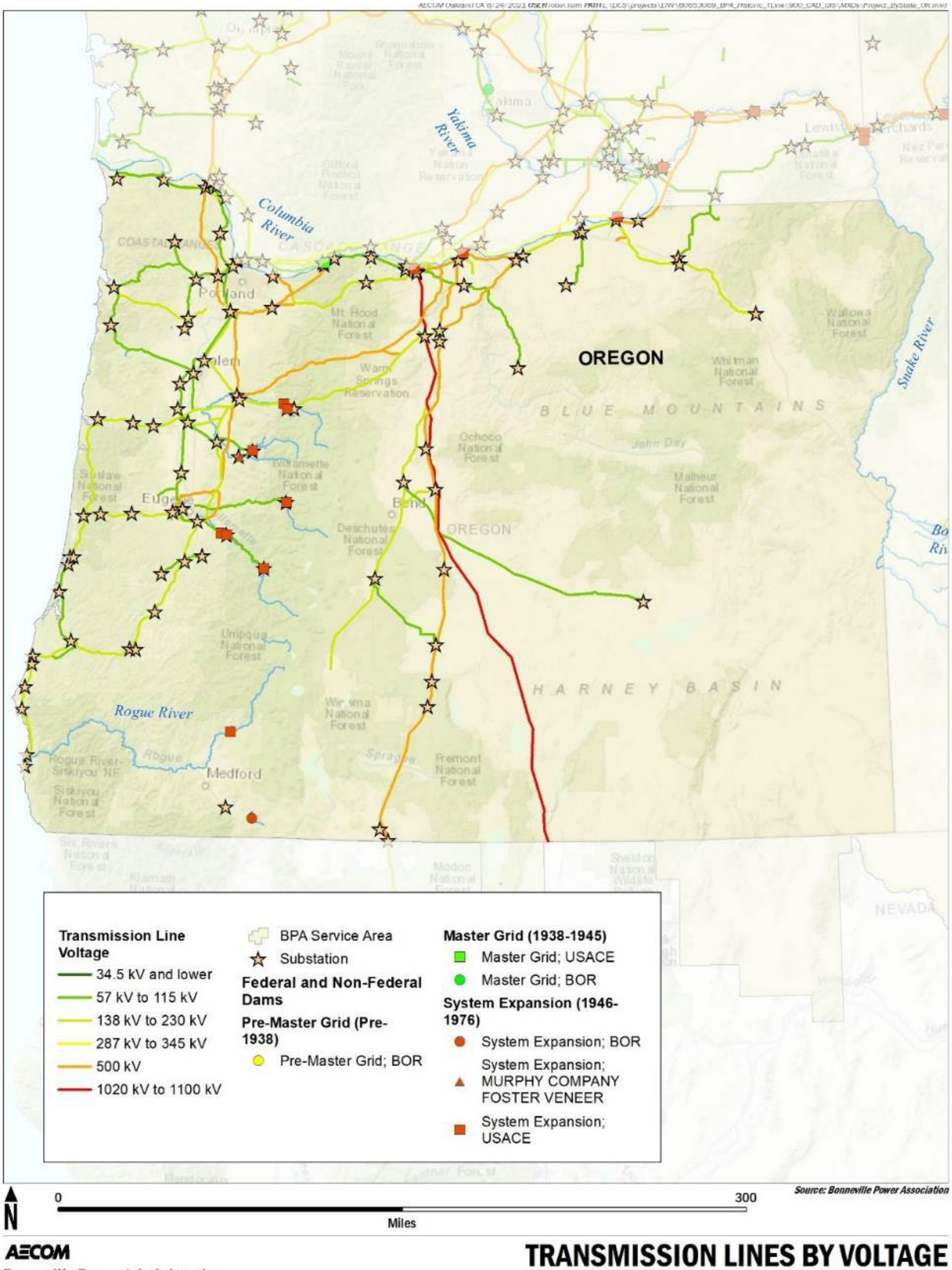


AECOM

Bonneville Power Administration

BPA Transmission Lines Historic Context

TRANSMISSION LINES BY VOLTAGE WASHINGTON



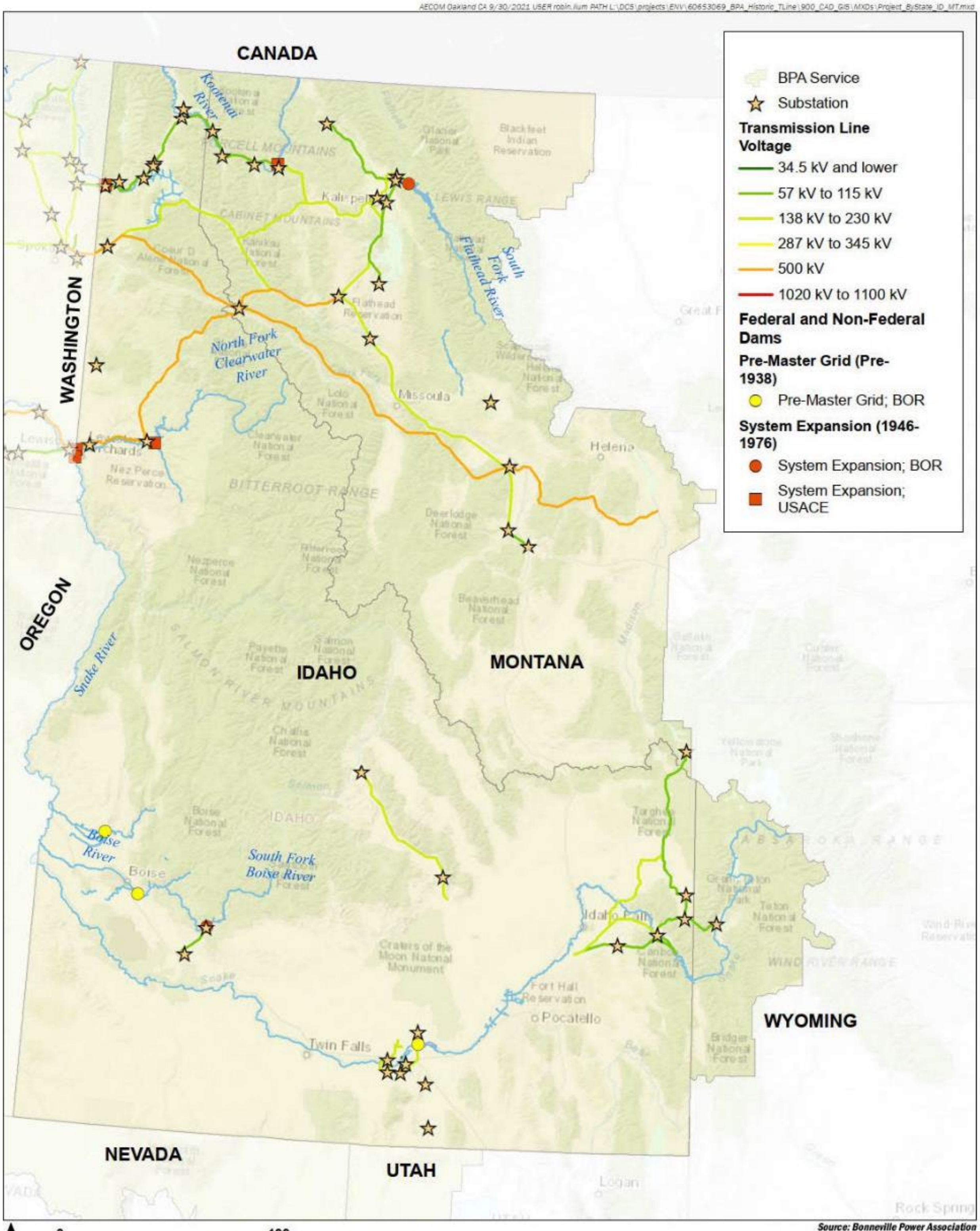
AECOM

Bonneville Power Administration

BPA Transmission Lines Historic Context

TRANSMISSION LINES BY VOLTAGE OREGON

AECOM Oakland CA 9/30/2021 USER robin.lium PATH L:\DCS\projects\ENV\60653069_BPA_Historic_TLine\900_CAD_GIS\MXDs\Project_ByState_ID_MT.mxd



Source: Bonneville Power Association

AECOM

Bonneville Power Administration

BPA Transmission Lines Historic Context

TRANSMISSION LINES BY VOLTAGE IDAHO, MONTANA, AND WYOMING

Appendix B – Sample Historic Transmission Line Evaluation

The following transmission line evaluation is provided as an example that can be adapted for future evaluations that address the NRHP Criteria for Evaluation. The original transmission line evaluation included the resource's physical description, historic overview, photographs, and other documentation, but are omitted from the excerpt below.

National Register of Historic Places Evaluation for the BPA Holcomb-Naselle Transmission Line

BPA's construction of the Holcomb-Naselle transmission line provided a crucial component to completing an important power loop in western Washington during the System Expansion period. The line represents a cohesive assembly of transmission structures that retains integrity of location, setting, feeling, association, design, workmanship, and materials.

The integrity of location is reflected by retention of the original alignment, including the BPA Holcomb Substation at the north end and the BPA Naselle Substation at the south end. Additionally, the line has not been altered by post-1949 construction of intermediate substations or generating features.

The line's rural setting, characterized by dense timber and logging activity, has remained mostly unchanged. The repetitiveness and uniformity of the line's wood pole structures within the BPA power corridor and its visual presence within the rural heavily forested landscape support integrity of feeling.

BPA has owned, operated, and maintained the line since its original construction and the line remains a functioning component of the BPA transmission system, thereby supporting integrity of association with BPA and the System Expansion period.

Although BPA has necessarily replaced most of the original wood structures, the line retains its original configuration. In addition, the wood-pole transmission structures have been repaired and replaced in-kind, which contributes to the line's integrity of design and workmanship.

Most of the line's original wood poles were replaced after the period of significance. These in-kind replacements contribute to integrity of materials because these structures appear similar to the originals "in basic type and material, and general design (Kramer 2012: F-46). The poles also have the same approximate dimensions and installation location, allowing the line to retain integrity of materials. Furthermore, the in-kind replacement of "structural systems" when the system is "extensively deteriorated" is consistent with the Secretary of Interior's Standards for the Treatment of Historic Properties when the new work matches "the old in material, design, scale, color, and finish."[409]

While the BPA MPDF does not specifically address how in-kind replacement of wood poles impacts integrity of materials, the MPDF does note that "Replacing a major percentage of the line with a *different pole design or material* [emphasis added] so adversely impacts character as to make the line not eligible."[410] Although in-kind wood pole replacement was not specifically addressed in the MPDF, it does not embody a "different pole design or material." In fact, the in-kind replacement of wood poles constitutes a "normal maintenance" activity for BPA transmission lines. When the Holcomb-Naselle line was originally constructed, BPA contemplated ongoing repair and replacement of wood pole line elements as part of necessary operational and safety activities to keep the line and overall system functioning properly.

Finally, in-kind replacement of the line's wood structural components is consistent with the Secretary of the Interior Standards for the preservation of historic properties. The standards for preservation provide that, "The existing condition of historic features will be evaluated to determine the appropriate level of intervention needed. Where the severity of deterioration requires repair or limited replacement of a distinctive feature, the new material will match the old

[409] Anne E. Grimmer, *The Secretary of the Interior's Standards for The Treatment of Historic Properties With Guidelines For Preserving, Rehabilitating, Restoring & Reconstructing Historic Buildings* (Washington, D.C.: U.S. Department of the Interior, National Park Service, Technical Preservation Services, 2017), 57.

[410] Kramer, *BPA Transmission System MPDF, F-46.*

in composition, design, color and texture."[411] With respect to wood features, the standards require limited replacement in kind, specifically "with wood, but not necessarily the same species.[412] BPA's efforts to accomplish in-kind replacement of the line's original structures with new structures appear consistent with the Secretary's standards for preservation.

Therefore, based on the above considerations, in-kind replacement of a line's wood poles does not defeat overall integrity, particularly in this case where other key aspects of integrity such as location, setting, design, feeling, and association are retained.

[411] Grimmer, *Secretary of Interior's Standards*, 28.

[412] Grimmer, *Secretary of Interior's Standards*, 40.