



March 2023

POWER MARKETING ADMINISTRATIONS

Additional Steps Are Needed to Better Manage Climate- Related Risks

Accessible Version

Why GAO Did This Study

The four PMAs play a significant role in selling and transmitting electricity to public power utilities, cooperatives, and Indian Tribes, in over 30 states. However, more frequent extreme weather events and other risks associated with climate change could cost utilities and customers billions of dollars from power outages and infrastructure damage. DOE's Office of the Under Secretary for Infrastructure oversees the PMAs.

GAO was asked to examine U.S. energy infrastructure resilience to climate change. This report examines (1) the risks climate change poses to PMA operations and (2) steps the PMAs have taken to manage climate-related risks and additional steps needed. GAO analyzed relevant reports, including the *Fourth National Climate Assessment*; and interviewed PMA officials, as well as 18 knowledgeable stakeholders from risk management; consumer, trade association, and environmental groups; and staff from five DOE national laboratories.

What GAO Recommends

GAO is making seven recommendations, including that the Southeastern Power Administration and the Western Area Power Administration develop vulnerability assessments and resilience plans, as directed by DOE. DOE agreed with GAO's recommendations. The Southeastern Power Administration and the Western Area Power Administration plan to develop plans by December 31, 2023.

View [GAO-23-106224](#). For more information, contact Frank Rusco at (202) 512-3841 or RuscoF@gao.gov.

March 2023

POWER MARKETING ADMINISTRATIONS

Additional Steps Are Needed to Better Manage Climate-Related Risks

What GAO Found

The Power Marketing Administrations (PMA)—the Bonneville Power Administration, the Southeastern Power Administration, the Southwestern Power Administration, and the Western Area Power Administration—face several climate-related risks to their operations. For example, decreasing water availability resulting from drought could reduce electricity generation from federal hydropower dams, such as the Hoover Dam. Warmer temperatures and drier conditions could lead to more frequent wildfires, which could disrupt operations. For example, in September 2020, 38 of the Bonneville Power Administration's transmission lines were out of service because of wildfires, with some lines out of service momentarily and others for over a week. While it is not possible to attribute an individual event, such as a wildfire, to climate change, such events provide insights into the risks climate change poses to PMA operations.

Low Water Levels at the Hoover Dam in August 2021



Source: GAO. | GAO-23-106224

The PMAs have taken some steps to manage climate-related risks. For example, through a series of congressionally mandated assessments, all of the PMAs have identified risks that climate change poses to federal hydropower generation. In addition, the Bonneville Power Administration and the Southwestern Power Administration have conducted assessments of critical assets vulnerable to climate change and developed resilience plans to address climate-related risks, as called for by the Department of Energy's (DOE) *Vulnerability Assessment and Resilience Planning Guidance*. The Southeastern Power Administration and the Western Area Power Administration, however, have not yet done so. Identifying critical assets vulnerable to climate change would help these entities develop resilience measures to address climate-related risks and determine whether mitigating certain risks is worth the investment. As GAO and others have reported, investing in resilience can reduce the need for more costly actions in the future. This, in turn, would help the PMAs fulfill their mission of providing reliable and affordable power to their customers.

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Abbreviations

BPA	Bonneville Power Administration
DOE	Department of Energy
ISO	International Organization for Standardization
PMA	Power Marketing Administration
Reclamation	Bureau of Reclamation
RMJOC	River Management Joint Operating Committee
SEPA	Southeastern Power Administration
SWPA	Southwestern Power Administration
WAPA	Western Area Power Administration

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March 29, 2023

The Honorable Joe Manchin III
Chairman
Committee on Energy and Natural Resources
United States Senate

The Honorable Tom Carper
Chairman
Committee on Environment and Public Works
United States Senate

Climate change is expected to have far-reaching effects on every aspect of the electricity grid—including generation, transmission, and distribution, as well as consumer demand for electricity—as we reported in March 2021.¹ In that report, we noted that these effects could result in costs to utilities and customers in the billions of dollars, including costs from power outages and infrastructure damage. The nature and extent of climate change effects on the grid will vary by geographic location, energy source, condition of grid infrastructure, and other factors.

Four Power Marketing Administrations (PMA) market and deliver electricity generated by federally owned and operated dams.² The four PMAs are the Bonneville Power Administration (BPA), the Southeastern Power Administration (SEPA), the Southwestern Power Administration (SWPA), and the Western Area Power Administration (WAPA). The PMAs operate electric systems and sell the electricity primarily to wholesale customers, including public power utilities, rural electric cooperatives, and Indian Tribes, in over 30 states. The PMAs also play a significant role in the transmission of electricity, except for SEPA, which does not own or operate any transmission facilities. In this context, the potential effects of climate change on the PMAs' infrastructure and operations could have significant economic and social consequences.

¹GAO, *Electricity Grid Resilience: Climate Change Is Expected to Have Far-reaching Effects and DOE and FERC Should Take Actions*, [GAO-21-346](#) (Washington, D.C.: Mar. 5, 2021).

²BPA also markets power from a nonfederal nuclear power plant.

You asked us to examine efforts to enhance the resilience of U.S. energy infrastructure to climate change. This report examines (1) the risks climate change poses to PMA operations and (2) steps the PMAs have taken to manage climate-related risks and additional steps needed to manage these risks.

To conduct our work, we interviewed officials from the four PMAs as well as officials from the Department of Energy (DOE).³ We also interviewed officials from the Federal Energy Regulatory Commission and entities that own and operate the federal dams that generate hydropower—the Bureau of Reclamation (Reclamation), the U.S. Army Corps of Engineers, and the International Boundary and Water Commission.⁴ In addition, to address both objectives, we interviewed 18 knowledgeable stakeholders from risk management, consumer, trade association, and environmental groups, and staff from five DOE national laboratories.⁵

We identified these stakeholders through our review of relevant reports and by asking federal officials and other stakeholders for recommendations about whom we should interview. We selected stakeholders based on their knowledge of the PMAs and their expertise related to risk management, electricity grid resilience, and climate change. Findings from the selected stakeholders we interviewed cannot be generalized to stakeholders we did not interview. Rather our interviews provide insights about selected stakeholders' perspectives on issues related to how climate change could affect PMA operations, steps the PMAs have taken to manage climate-related risks to their operations, and additional steps that may be needed. We generally asked the same questions during each interview, including asking for recommendations for other stakeholders and organizations we should interview.

To examine the risks climate change poses to PMA operations, we reviewed the U.S. Global Change Research Program's *Fourth National Climate Assessment*; National Academies of Sciences, Engineering, and

³DOE's Office of the Under Secretary for Infrastructure oversees the PMAs and approves SEPA, SWPA, and WAPA power and transmission rates on an interim basis.

⁴The Federal Energy Regulatory Commission confirms, approves, and places into effect on a final basis PMA power and transmission rates, with some exceptions.

⁵The five national laboratories included Oak Ridge National Laboratory, Argonne National Laboratory, Pacific Northwest National Laboratory, National Renewable Energy Laboratory, and Idaho National Laboratory.

Medicine reports; prior GAO, Congressional Research Service, and Congressional Budget Office reports; and relevant DOE and PMA reports and assessments.⁶ We identified these reports by conducting a literature search, asking PMA and federal officials and stakeholders for recommendations, and reviewing GAO prior work.

To examine the steps that the PMAs have taken to manage climate-related risks to their operations, we reviewed relevant PMA plans and annual reports.⁷ We compared the steps the PMAs have taken with GAO's *Enterprise Risk Management Framework* and DOE's *Vulnerability Assessment and Resilience Planning Guidance* to assess the extent to which the PMAs are managing climate-related risks and to identify additional steps that may be needed.⁸

⁶U.S. Global Change Research Program, *Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment*, vol. 2 (Washington, D.C.: November 2018). The Global Change Research Act of 1990 requires that a scientific assessment analyzing the effects of global change on the natural environment, agriculture, and energy production and use be provided to the President and Congress not less frequently than every 4 years. Pub. L. No. 101-606, § 106, 104 Stat. 3096, 3101. The U.S. Global Change Research Program prepares this National Climate Assessment, the most recent of which was released in 2018. The U.S. Global Change Research Program coordinates and integrates global change research across 14 federal agencies. The Office of Science and Technology Policy within the Executive Office of the President oversees the program. National Academies of Sciences, Engineering, and Medicine, *Attribution of Extreme Weather Events in the Context of Climate Change* (Washington D.C.: 2016); and National Research Council of the National Academies, *America's Climate Choices: Panel on Adapting to the Impacts of Climate Change, Adapting to the Impacts of Climate Change* (Washington, D.C.: 2010).

⁷In this report, we focus on the PMAs' efforts to enhance the resilience of their operations to climate change, also referred to as adaptation. We did not review the PMAs' efforts to lower greenhouse gas emissions, also known as mitigation.

⁸GAO, *Enterprise Risk Management: Selected Agencies' Experiences Illustrate Good Practices in Managing Risk*, [GAO-17-63](#) (Washington, D.C.: Dec. 1, 2016); and U.S. Department of Energy, Sustainability Performance Division, *Vulnerability Assessment and Resilience Planning Guidance Version 1.2* (Updated February 2022).

We also reviewed GAO's *Disaster Resilience Framework* to identify opportunities to manage climate-related risks.⁹ Given our methodology, we did not intend to identify every additional step that the PMAs could take to better manage climate-related risks.

We conducted this performance audit from August 2021 to March 2023 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

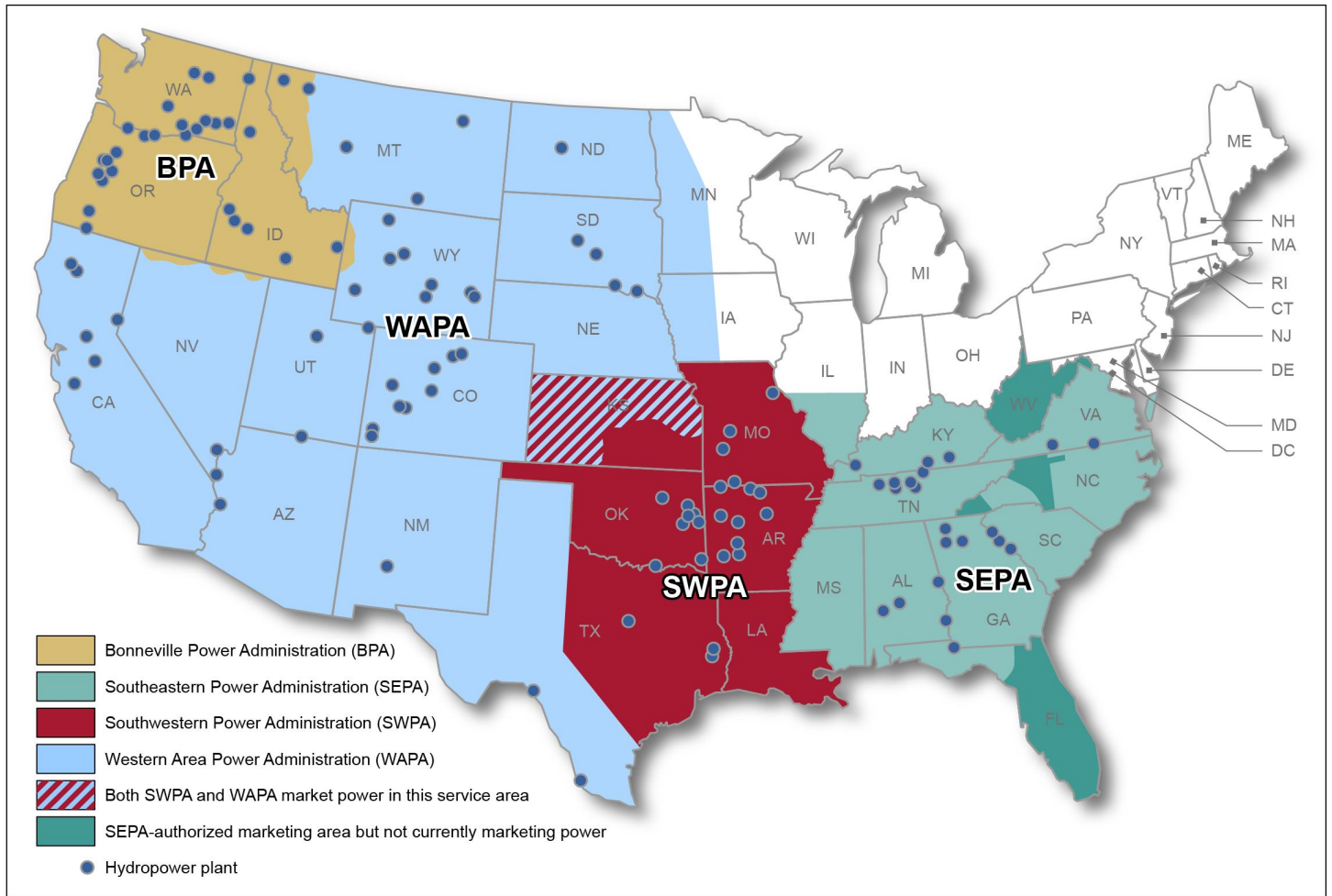
Background

PMA Operations

The PMAs operate in over 30 states. See figure 1 below for the PMAs' service areas and hydropower plant locations.

⁹In October 2019, GAO issued our *Disaster Resilience Framework* to serve as a guide for assessing federal actions to facilitate and promote resilience to natural disasters. The principles in this framework can help identify opportunities to enhance efforts to promote disaster resilience, including building resilience to climate change. The framework is organized around three broad overlapping principles—information, incentives, and integration—and a series of questions to guide analyses that can help agencies and other users consider opportunities for enhancing federal efforts to promote disaster resilience. GAO, *Disaster Resilience Framework: Principles for Analyzing Federal Efforts to Facilitate and Promote Resilience to Natural Disasters*, [GAO-20-100SP](#) (Washington, D.C.: Oct. 23, 2019).

Figure 1: Power Marketing Administrations' Service Areas and Hydropower Plant Locations



Sources: GAO analysis of Department of Energy, Energy Information Administration, Oak Ridge National Laboratory, and Western Area Power Administration documents; Map Resources (base map). | GAO-23-106224

Note: Although the Southeastern Power Administration's (SEPA) service area includes West Virginia and Florida, SEPA does not currently market power in West Virginia and only markets power in the Florida panhandle. The International Boundary and Water Commission, the Bureau of Reclamation, and the U.S. Army Corps of Engineers own and operate these hydropower plants.

The Flood Control Act of 1944 requires that the PMAs sell and distribute electricity at the lowest possible rate consistent with sound business

practices. The PMAs must give preference to public bodies and cooperatives when selling electricity.¹⁰

The PMAs vary in size and geographic coverage. PMAs' assets consist primarily of transmission infrastructure, specifically substations and high-voltage transmission lines.¹¹ SEPA does not own any transmission assets but relies on transmission infrastructure owned by other utilities. Table 1 provides more information about each PMA.

Table 1: Power Marketing Administrations

Power Marketing Administration	Description
Bonneville Power Administration	<ul style="list-style-type: none"> Markets power from several sources, including 31 federally owned hydropower plants and one nonfederal nuclear power plant. Provides electricity to 142 power customers, including cooperatives, municipalities, public utilities, federal agencies, investor-owned utilities, direct-service industries (e.g., aluminum plants), port districts, and Indian Tribes; 323 transmission customers; and 212 power marketers.^a Operates and maintains more than 15,000 circuit miles of high-voltage transmission lines in its service territory, and owns about 260 substations. Acts as a balancing authority in the Northwest, and provides about 28 percent of the electricity generated in the region.^b
Southeastern Power Administration	<ul style="list-style-type: none"> Markets power from 22 federally owned hydropower plants. Does not own or operate substations or transmission assets. Instead, SEPA delivers power through transmission lines and substations owned and operated by other utilities. Provides electricity to 472 public power customers.^c
Southwestern Power Administration	<ul style="list-style-type: none"> Markets power from 24 federally owned hydropower plants. Owns 26 substations and about 1,400 miles of high-voltage transmission lines. Provides electricity to 102 customers, including municipal utilities, electric cooperatives, and military installations in six states.^d

¹⁰Flood Control Act of 1944, Pub. L. No. 78-534, § 5, 58 Stat. 887, 890 (codified as amended at 16 U.S.C. § 825s). Preference—the opportunity to obtain first access to power—gives priority to public utilities and other public bodies to ensure that the federal hydropower projects are operated for the benefit of the general public, particularly residential and rural customers. Congressional Research Service, *The Power Marketing Administrations: Background and Current Issues*, R45548 (Washington, D.C.: Mar. 1, 2019); and GAO, *Federal Power: The Evolution of Preference in Marketing Federal Power*, [GAO-01-373](#) (Washington, D.C. Feb. 8, 2001).

¹¹Substations provide crucial links for electricity generation and serve as key nodes for linking transmission and distribution networks to end-use customers. Additionally, a substation generally contains transformers, protective equipment (e.g., relays and circuit breakers), switches for controlling high-voltage connections, and electronic instrumentation to monitor system performance and record data. DOE, Office of Electricity Delivery and Energy Reliability, *United States Electricity Industry Primer*, DOE/OE-0017 (July 2015).

Power Marketing Administration	Description
Western Area Power Administration ^e	<ul style="list-style-type: none"> Markets power from 57 federally owned hydropower plants. Owns approximately 320 substations and roughly 17,000 miles of high-voltage transmission lines. Provides electricity to cities and towns, electric cooperatives, public utility and irrigation districts, Indian Tribes and Tribal utilities in 15 states.

Source: GAO analysis of Department of Energy and Power Marketing Administrations' documents. | GAO-23-106224

^aMarketers generally do not own generation or transmission assets. Instead, they buy electricity from utilities, such as the Bonneville Power Administration (BPA), and sell it to other utilities. BPA is required to meet certain customers' electricity needs, if customers request it—meaning these customers meet their demand with power purchased from BPA, as opposed to purchasing electricity from another entity.

^bA balancing authority maintains the balance of electricity resources and electricity demand in real time.

^cSoutheastern Power Administration (SEPA) customers rely on SEPA for a small percentage of their electricity needs.

^dAccording to the Southwestern Power Administration's (SWPA) *2020 Annual Report*, SWPA generally sells power to customers under long-term contracts of 15 years, the majority of which require SWPA to provide power to customers during times of peak demand. Southwestern Power Administration, *2020 Annual Report* (September 2022).

^eThe Western Area Power Administration (WAPA) covers the largest service area of the four PMAs. There are five WAPA regions: (1) Sierra Nevada, (2) Desert Southwest, (3) Colorado River Storage Project Management Center, (4) Upper Great Plains, and (5) Rocky Mountain.

Climate Resilience and Risk Management

Enhancing climate resilience means taking actions to manage climate-related risks and reduce potential future losses by planning and preparing for potential climate hazards, such as extreme rainfall, drought, and other events.¹² Moreover, according to the *Fourth National Climate Assessment*, enhancing climate resilience entails a continuing risk management process through which individuals and organizations become aware of and assess the risks and vulnerabilities from climate and other drivers of change, take actions to reduce those risks, and learn

¹²For the purposes of this report, we use the definition of “resilience” in Presidential Policy Directive 21, which established a national policy for critical infrastructure security and resilience. Specifically, Presidential Policy Directive 21 defines “resilience” as the ability to prepare for, adapt to changing conditions, withstand, and recover rapidly from disruptions, including naturally occurring threats or incidents. Presidential Policy Directive 21, *Critical Infrastructure Security and Resilience* (Feb. 12, 2013).

over time. As we and others have reported, investing in climate resilience measures can reduce the need to take more costly steps in the future.¹³

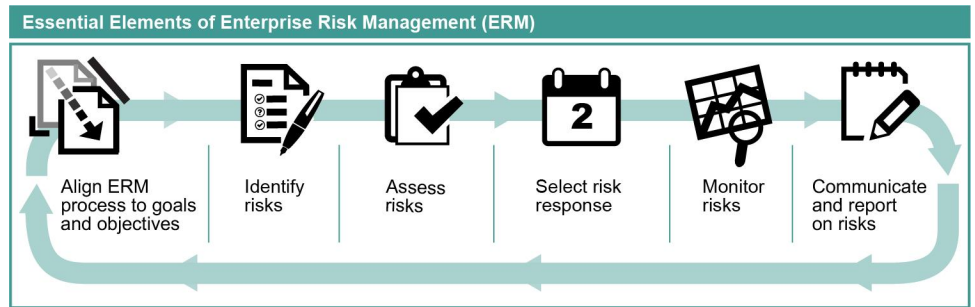
Enterprise risk management can help entities identify, assess, and manage risks, such as preparing for and responding to climate change.¹⁴ In addition, enterprise risk management can help these entities' leaders make better, more effective decisions when prioritizing risks and locating resources to manage risks. In 2016, we identified six essential elements of enterprise risk management.¹⁵ See figure 2 below.

¹³GAO, *Climate Change: Opportunities to Reduce Federal Fiscal Exposure*, [GAO-19-625T](#) (Washington, D.C.: June 11, 2019); *Climate Change: Selected Governments Have Approached Adaptation through Laws and Long-Term Plans*, [GAO-16-454](#) (Washington, D.C.: May 12, 2016); and National Research Council of the National Academies, *America's Climate Choices: Panel on Adapting to the Impacts of Climate Change*, *Adapting to the Impacts of Climate Change* (Washington, D.C.: 2010). As we reported in March 2021, evaluating resilience investments can be challenging and the benefits difficult to quantify. Moreover, utilities must balance the need to enhance resilience with the associated costs, which could result in increases to the rates charged to customers. In addition, increases in rates could disproportionately affect low-income populations that spend a greater portion of their income on energy expenses. [GAO-21-346](#).

¹⁴[GAO-17-63](#). According to the National Academies of Sciences, Engineering, and Medicine, climate resilience actions should address climate hazards that are acute—more frequent or intense extreme weather—and chronic—gradual, long-term changes, such as ecosystem shifts or sea level rise. National Research Council of the National Academies, *America's Climate Choices*. Similarly, according to the International Organization for Standardization (ISO) Standard 14090, an organization's assessment of how it will be affected by climate change should consider chronic, slow-onset impacts as well as acute, sudden impacts from extreme events. International Organization for Standardization, ISO 14090:2019, *Adaptation to Climate Change—Principles, Requirements and Guidelines* (June 2019). The International Organization for Standardization is a worldwide federation of national standards bodies.

¹⁵[GAO-17-63](#).

Figure 2: GAO’s Enterprise Risk Management Framework



Source: GAO. | GAO-23-106224

The six essential elements of enterprise risk management are generally consistent with the steps outlined in several resilience planning frameworks we reviewed, including DOE’s *Vulnerability Assessment and Resilience Planning Guidance*.¹⁶ DOE’s *Vulnerability Assessment and Resilience Planning Guidance* directs all DOE entities—including the four PMAs—to develop climate change vulnerability assessments and resilience plans and to update these documents at least every 4 years.¹⁷ In addition, Section 9505 of the Secure Water Act requires DOE to assess the effects of climate change on federal hydropower and report to Congress every 5 years.¹⁸

¹⁶U.S. Department of Energy, Sustainability Performance Division, *Vulnerability Assessment and Resilience Planning Guidance Version 1.2* (Updated February 2022); Office of Energy Policy and Systems Analysis, *Climate Change and the Electricity Sector: Guide for Climate Change Resilience Planning* (September 2016); International Organization for Standardization, ISO 14090:2019, *Adaptation to Climate Change*; and ASTM International, Standard ASTM E3032-15e1: *Guide for Climate Resiliency Planning and Strategy* (2016). ASTM International develops voluntary consensus industry standards.

¹⁷According to DOE, the agency is updating DOE Order 436.1 (Departmental Sustainability) with completion targeted for fiscal year 2023. The updated order will institutionalize sustainability, environmental stewardship, and climate resilience planning at DOE, as well as integrate new sustainability requirements. U.S. Department of Energy, *Climate Adaptation and Resilience Plan: 2022 Progress Report. Report to the White House Federal Chief Sustainability Officer* (August 2022).

¹⁸Section 9505 of the Omnibus Public Land Management Act of 2009, sometimes called the Secure Water Act, requires DOE to evaluate each effect of, and risk resulting from, global climate change with respect to water supplies used for hydropower generation, and power supplies marketed by the PMAs. Pub. L. No. 111-11, § 9505, 123 Stat. 991, 1336–37 (codified at 42 U.S.C. § 10365). DOE conducts this assessment in consultation with the PMAs and other federal and state agencies every 5 years.

Increasing Temperatures, Drought, and Other Climate-Related Effects Pose Risks to the PMAs' Operations

Increasing temperatures, drought, and other effects of climate change pose risks to the PMAs' operations, according to reports we reviewed and stakeholders we interviewed. The type and extent of these effects on the PMAs' operations vary by geographic region and other factors.¹⁹ We have previously reported that while it is not possible to link any individual weather event to climate change, these events provide insight into the potential climate-related vulnerabilities the United States faces.²⁰

Increasing temperatures. Increasing temperatures are likely to result in increasing summer electricity demand during periods of already low summer streamflow generation.²¹ Specifically, increasing temperatures in the western United States are expected to result in earlier snowmelt and more precipitation falling as rain rather than snow, according to the *Fourth National Climate Assessment*. As a result of early snowmelt, BPA is projected to have increased hydropower generation in the late winter and spring but decreased hydropower generation in the summer, when

¹⁹Climate-related effects are expected to create added costs for the PMAs, including costs associated with the need to purchase additional power and make infrastructure investments. These costs may affect the PMAs' ability to keep electricity rates low. Specifically, when federal dams do not generate enough hydropower to meet contractual power delivery obligations, the PMAs purchase power to meet their obligations. Purchase power prices can spike when extreme weather events put stress on the electricity grid, which can lead to higher costs for the PMAs as they try to fulfill their contractual obligations.

²⁰GAO, *Extreme Weather Events: Limiting Federal Fiscal Exposure and Increasing the Nation's Resilience*, [GAO-14-364T](#) (Washington, D.C.: Feb. 12, 2014).

²¹U.S. Department of Energy, *Effects of Climate Change on Federal Hydropower, The Second Report to Congress* (Washington, D.C.: January 2017). Increasing temperatures will affect all of the PMAs. As we reported in 2014, increasing temperatures can reduce the amount of water available for hydropower—due to increased evaporation—and degrade habitats for fish and wildlife. GAO, *Climate Change: Energy Infrastructure Risks and Adaptation Efforts*, [GAO-14-74](#) (Washington, D.C.: Jan. 31, 2014). According to the *Third Assessment of the Effects of Climate Change on Federal Hydropower*, the extent of warmer temperatures causing increasingly drier soils and greater evapotranspiration is a significant uncertainty. Nevertheless, even in the case of higher precipitation, drier soils and greater evapotranspiration will lead to reduced water availability and lower average generation. Oak Ridge National Laboratory, *The Third Assessment of the Effects of Climate Change on Federal Hydropower*, ORNL/TM-2021/2278 (September 2022).

increased demand for electricity is expected, according to documents we reviewed.²² As a result, BPA may need to purchase replacement power.²³ Similarly, WAPA's service area is expected to experience a decrease in summertime runoff, which will coincide with an increase in summer electricity demand, according to documents we reviewed.

Drought. Decreasing water availability resulting from drought could reduce hydropower generation.²⁴ For example, in the summer of 2010, below-normal water volumes in the Columbia River Basin resulted in insufficient hydropower generation to fulfill BPA's obligations to provide power. As a result, BPA experienced a net loss of \$233 million, or 10 percent, from the prior year.²⁵

According to DOE, the extent to which drought will affect the PMAs' ability to generate electricity varies based on the storage capacity of the utility's

²²In contrast, winter electricity demand is likely to decrease with increasing temperatures, along with increasing winter streamflows and generation in some areas of the country, such as the BPA region. River Management Joint Operating Committee (RMJOC), *Climate and Hydrology Datasets for RMJOC Long-Term Planning Studies: Second Edition (RMJOC-II), Part II: Columbia River Reservoir Regulation and Operations—Modeling and Analyses* (August 2020).

²³According to DOE, higher replacement power expenditures during low-flow periods would need to be offset by larger surplus power sales revenue in the rest of the year to avoid altering customer rates. U.S. Department of Energy, *Effects of Climate Change on Federal Hydropower, The Second Report to Congress*.

²⁴All of the PMAs will experience drought, but the length and intensity will vary by region.

²⁵According to BPA's *2010 Annual Report*, BPA's gross purchased power costs increased \$104 million, or 37 percent, from 2009, mainly because of below-normal basin-wide precipitation and streamflows, resulting in insufficient power generation to fulfill BPA's obligations. Bonneville Power Administration, *2010 Annual Report*, DOE/BP-4224 (Portland, OR: November 2010) and U.S. Department of Homeland Security and U.S. Department of Energy, *Dams and Energy Sectors Interdependency Study* (September 2011). According to BPA officials, while in this particular event the region was experiencing short-term drought conditions, not all below-normal precipitation periods are considered droughts. Generally, the PMAs are under contractual obligations to deliver a specified amount of electricity, which, if not generated, must be purchased. The authority to purchase electricity to shore up and deliver a utility's contractually obligated amount of electricity is referred to as purchased power. The PMAs use the Purchase Power and Wheeling Program as the source of funds to supply customers with power when there is not enough federal hydropower. U.S. Department of Energy, *Power Marketing Administrations Execution of Current Receipt Authority for Purchase Power and Wheeling Expenditures, Report to Congress* (Washington, D.C.: September 2009).

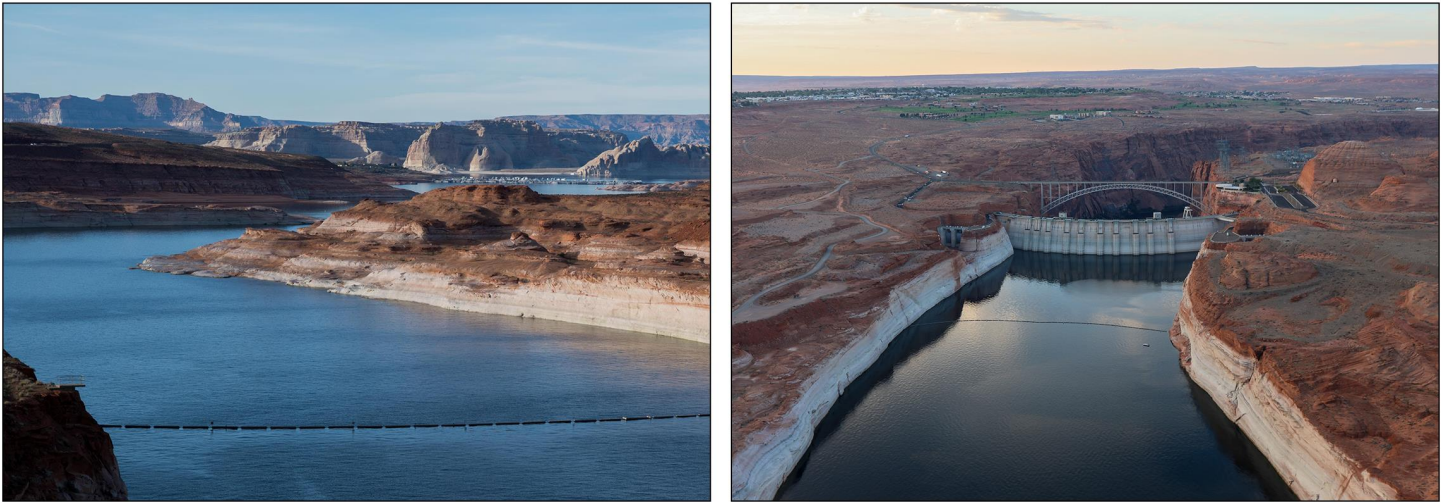
respective reservoir.²⁶ Specifically, BPA and WAPA have large reservoirs that allow them to store water for future hydropower generation, according to DOE.²⁷ However, SEPA and SWPA's ability to manage risk from drought is constrained by the much more limited storage capacity of the federally owned reservoirs. Nevertheless, in WAPA's region, drought on the Colorado River since 2000 has resulted in hydrological conditions that have not produced enough water to return to full reservoir conditions at Lake Powell. The reservoir—located in the Upper Colorado River Basin—stores water and feeds into Glen Canyon Dam to produce hydropower.²⁸ According to Reclamation, Glen Canyon Dam was operating at 33 percent capacity as of December 2022. Figure 3 shows low water levels at Lake Powell and Glen Canyon Dam in 2017 and 2021.

²⁶U.S. Department of Energy, *Effects of Climate Change on Federal Hydropower: The Second Report to Congress*. Section 9505 of the Omnibus Public Land Management Act of 2009, sometimes called the Secure Water Act, requires DOE to evaluate each effect of, and risk resulting from, global climate change with respect to water supplies used for hydropower generation and power supplies marketed by the PMAs. Pub. L. No. 111-11, § 9505, 123 Stat. 991, 1336–37 (codified at 42 U.S.C. § 10365). DOE conducts this assessment in consultation with the PMAs and other federal and state agencies every 5 years.

²⁷According to WAPA officials, WAPA receives hydropower from federal dams with large reservoirs. The U.S. Army Corps of Engineers and Reclamation manage the water in the reservoirs, which has many competing needs, one of which is hydropower. According to WAPA officials, the amount of water released for hydropower must be balanced with fish, wildlife, and agriculture needs. Nevertheless, BPA and WAPA could better manage a decrease in runoff and precipitation because of their larger storage capacity, according to DOE, assuming that there will be no significant change in the future installed capacity and operation. Growing competition for water uses, and environmental services that are likely to be under greater future stresses because of climate change, may reduce the U.S. hydropower fleet's ability to mitigate runoff variability and increase the difficulty of future operations. U.S. Department of Energy, *Effects of Climate Change on Federal Hydropower: The Second Report to Congress*.

²⁸The Colorado River Basin covers more than 246,000 square miles in seven U.S. states and Mexico. The Colorado River Compact of 1922 established a framework to apportion water supplies between the river's Upper and Lower Basins. Congressional Research Service, *Responding to Drought in the Colorado River Basin: Federal and State Efforts*, IN11982 (Washington, D.C.: Oct. 14, 2022).

Figure 3: Low Water Levels at Lake Powell (left, 2017) and Glen Canyon Dam (right, 2021)



Sources: Bureau of Reclamation (left photo); Western Area Power Administration (right photo). | GAO-23-106224

Drought is also affecting the Lower Colorado River Basin. To minimize any customer rate increases because of the drought, WAPA deferred \$4 million in maintenance projects for fiscal year 2022 for its Boulder Canyon Project.²⁹ Otherwise, the base charge would have increased by about \$6 million instead of about \$2 million.³⁰ Figure 4 shows low water levels at the Hoover Dam—part of WAPA’s Boulder Canyon Project—in August 2021.³¹

²⁹According to DOE, projections of energy and capacity were decreasing in fiscal year 2022 due to the ongoing drought in the Lower Colorado River Basin. Reclamation and WAPA work collaboratively each year to minimize budget increases to moderate the financial impacts of drought on the rates customers pay. U.S. Department of Energy, Office of Electricity, Western Area Power Administration, “Notice concerning fiscal year 2022 Boulder Canyon Project base charge and rates for electric service,” 6450-01-P, filed as Accession No. 20210820-5001, Doc. 002 Rate Order.rtf (filed Aug. 20, 2021) in FERC Docket EF21-5-000.

³⁰U.S. Department of Energy, Office of Electricity. Western Area Power Administration, “Notice concerning fiscal year 2022 Boulder Canyon Project base charge and rates for electric service,” 6450-01-P, filed as Accession No. 20210820-5001, Doc. 002 Rate Order.rtf (filed Aug. 20, 2021) in FERC Docket EF21-5-000. The rate-setting methodology for the Boulder Canyon Project calculates an annual base charge rather than a unit rate for Hoover Dam hydropower.

³¹According to WAPA officials, all of the Boulder Canyon Projects—including Hoover Dam—are almost completely customer funded (through rates).

Figure 4: Low Water Levels at the Hoover Dam in August 2021



Source: GAO. | GAO-23-106224

More frequent and intense wildfires. According to the *Fourth National Climate Assessment*, drought contributes to an increased risk of wildfire, which can threaten transmission lines and other energy infrastructure. Furthermore, more frequent and intense wildfires are expected to disrupt the PMAs' operations.³² For example, in 2016, a wildfire melted spools of aluminum conductor wire that BPA maintains in storage to rebuild transmission lines. As a result of the wildfire, BPA lost approximately \$1 million in materials.³³ In 2018, the Carr Fire in northern California directly

³²The *Fourth National Climate Assessment* indicates that climate change has caused an increase in the severity and frequency of wildfires, particularly by drying forests and making them more susceptible to burning. Furthermore, according to the *Fourth National Climate Assessment*, although the total area burned by wildfire is greatest in the western United States, the Southeast has the highest number of wildfires. According to BPA, increased large forest fire incidents over the past decade are projected to continue as temperatures rise. Projected warmer and drier summers, as well as declining snowpack and related decreases in summer soil moisture, will increase the risk of wildfires, particularly in forested areas where fuels are abundant.

³³Bonneville Power Administration, *Vulnerability Assessment and Resilience Plan* (September 2022).

affected WAPA's system and its customers.³⁴ Specifically, WAPA's Sierra Nevada region had 15 high-voltage transmission lines and a dozen hydropower generators out of service, and fires at the gates of its substations. In addition, in September 2020, BPA had 38 transmission lines out of service because of wildfires, with some lines out of service momentarily and others for over a week. Figure 5 shows wildfires threatening BPA assets in October 2012 (left) and September 2020 (right).

Figure 5: Wildfires Threatened Bonneville Power Administration Assets (October 2012 and September 2020)



Source: Bonneville Power Administration. | GAO-23-106224

Wildfires can also threaten the PMA workforce. For example, according to BPA, particulate matter from wildfire smoke could clog heating, ventilation, and air conditioning filters and cause poor indoor air quality.³⁵ If filtration systems clog, it could adversely affect personnel and equipment housed in affected facilities.

³⁴*Issues and Challenges at the Power Marketing Administrations, Hearing Before the Subcommittee on Water and Power of the Committee on Energy and Natural Resources, United States Senate, First Session to Examine Issues and Challenges at the Power Marketing Administrations, 116th Cong.10 (2019) (Statement of Mark Gabriel, WAPA Administrator, Department of Energy).*

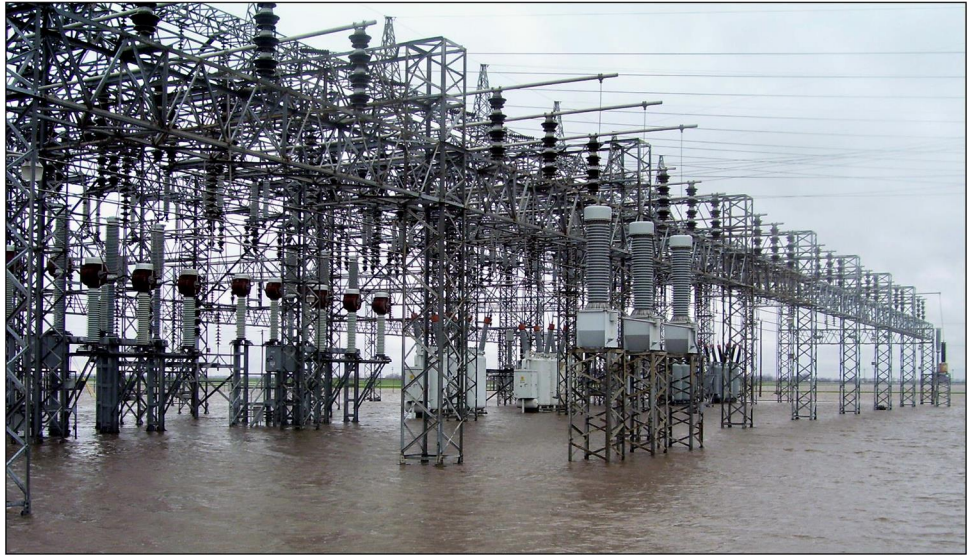
³⁵Bonneville Public Administration, *Vulnerability Assessment and Resilience Plan*.

Extreme weather. Extreme weather, such as heavy precipitation and extreme heat, poses risks to the PMAs' operations. Extreme weather events will affect all of the PMAs, although the type of event and the extent of damage will vary by PMA region.

According to the *Fourth National Climate Assessment*, the frequency and intensity of heavy precipitation events across the United States have increased and are expected to continue to increase in the future.³⁶ Increased flooding associated with heavy precipitation events can affect PMA operations and damage their transmission and generation assets. For example, according to SWPA officials, heavy rains flooded a substation in Missouri in 2008, damaging assets. See figure 6 below.

³⁶According to the *Fourth National Climate Assessment*, extreme weather events—including high winds, thunderstorms, hurricanes, heat waves, intense cold, and snow and ice storms—can interrupt electricity generation, damage infrastructure, and cause electricity shortages or price spikes. According to DOE's third 9505 assessment, both historical observations and projections suggest that the intensity, frequency, and magnitude of extreme rainfall events will continue to increase, which will likely challenge conventional reservoir management practices. Although the reservoirs have been traditionally designed using conservative rainfall estimates, recent extreme events, such as the 2017 Hurricane Harvey near Houston, Texas, demonstrated that a large estimate can still be exceeded, suggesting the potential need for more comprehensive evaluations, according to the assessment. Oak Ridge National Laboratory, *The Third Assessment of the Effects of Climate Change on Federal Hydropower*.

Figure 6: Flooding Event at a Southwestern Power Administration Substation in Sikeston, Missouri (2008)



Source: Southwestern Power Administration. | GAO-23-106224

SWPA has also experienced flooding that resulted in reduced hydropower generation in its service area. For example, in June and July 2019, high water levels caused excessive vibration and water leakage in a powerhouse. According to SWPA officials, this required the otherwise available turbine generator at Keystone Dam in Oklahoma to be taken out of service, resulting in a loss of generation.³⁷

Furthermore, in BPA's service area, access roads to transmission assets may be susceptible to damage during heavy precipitation events and landslides, according to BPA.³⁸ This could affect BPA's ability to maintain these assets. The risks of landslides will also increase as rain mixes with snow in some areas. Slow-moving landslides can gradually deform

³⁷According to DOE, hydropower may become constrained during significant flood events because of release restrictions for reducing downstream flooding and loss of unit capability because of either too great or too low hydropower head conditions. U.S. Department of Energy, *Effects of Climate Change on Federal Hydropower, The Second Report to Congress*. Furthermore, one stakeholder we interviewed told us that floods are not good for turbines, which convert energy of flowing water into mechanical energy, because turbines cannot run when there is too much water, and the increased amount of trash can damage them.

³⁸Bonneville Power Administration, *Vulnerability Assessment and Resilience Plan*.

transmission structures' legs and negatively affect their structural integrity, according to BPA.

Extreme weather can also result in increased demand for electricity and reduce the efficiency of electricity generation and transmission infrastructure. For example, according to reports we reviewed and stakeholders we interviewed, extreme heat can reduce the capacity and efficiency of transmission lines.³⁹ According to BPA officials, in the summer of 2021, high temperatures during an extreme heat event contributed to the reduced capacity of BPA transmission lines. BPA avoided power outages by asking consumers in certain areas to conserve energy.⁴⁰ BPA officials also canceled planned work on the transmission system, which increased available transmission lines. According to BPA officials, these actions were successful in decreasing power demand and adding transmission capacity to counteract the effects of excessive heat.⁴¹ Extreme heat also poses risks to the health of utility company personnel working outdoors to maintain or repair transmission

³⁹According to an Oak Ridge National Laboratory report, the resistance of power lines increases with temperature, leading to greater resistive loss; however, the impact of ambient temperature on resistive losses is generally considered to be negligible compared to impacts on total carrying capacity. The line capacity is limited by the maximum normal operating temperature. The operating temperature of the line depends on several factors, including the ambient temperature, current in the line, and wind speed, which affects the ability of the line to get rid of excess heat and is generally much higher than the ambient temperature. M.R. Allen-Dumas et al., *Extreme Weather and Climate Vulnerabilities of the Electric Grid: A Summary of Environmental Sensitivity Quantification Methods*, Oak Ridge National Laboratory, ORNL/TM-2019/1252 (Oak Ridge, TN: Aug. 16, 2019).

⁴⁰According to a Federal Energy Regulatory Commission report, over a 4-day period in June 2021, daytime high temperatures rose to well over 100 degrees Fahrenheit, setting all-time records in dozens of locations. The extended period of high temperatures was the result of a so-called "heat dome" in which a high-pressure system—the strongest ever observed in the Pacific Northwest—sat over the region for several days, according to the commission. During this period, utilities issued several emergency alerts. Federal Energy Regulatory Commission, *Summer Energy Market and Reliability Assessment, 2022. A Staff Report for the Commission* (Washington, D.C.: May 19, 2022).

⁴¹According to BPA officials, transmission operators, like BPA, establish thermal rating limits for transmission conductors to ensure the safe and reliable operation of the system. Transmission operators constantly monitor power flow and ambient temperatures to ensure transmission infrastructure does not exceed its thermal rating limit for any specified air temperature. Excessively high temperatures may require transmission operators to take additional actions to ensure safe operation of the power system, according to these officials.

infrastructure. For example, workers servicing such equipment in extreme heat can be at risk of heat exhaustion or heat stroke.⁴²

Finally, according to BPA, storm surges pose risks to BPA's infrastructure in Oregon and Washington.⁴³

According to the *Fourth National Climate Assessment*, other types of extreme weather events, such as windstorms, can also interrupt electricity generation and damage infrastructure. For example, in May 2020, strong winds in SWPA's region in southeast Missouri damaged nearly 70 transmission structures, causing downed power lines and power outages. SWPA restored power in 15 days, despite challenging weather conditions and the extensive damage to the transmission line. Figure 7 shows damage to one of SWPA's transmission lines caused by strong winds.

⁴²Southwestern Power Administration, *Vulnerability Assessment and Resilience Plan* (November 2022).

⁴³Along the Northwest Coast where BPA markets power, sea level rise is projected to increase flood risks in low-lying areas and will likely magnify the potential for coastal erosion and infrastructure damage during extreme events with high storm surge and wave hazards, according to the *Fourth National Climate Assessment*. By the end of the century, sea level rise could affect significant infrastructure investments throughout the Northwest, particularly in the low-lying urban areas of the Puget Sound and Portland. Furthermore, according to the *Fourth National Climate Assessment*, sea level rise is already causing an increase in high tide flood events in the Southeast region, where SEPA markets power, and is adding to the impact of more extreme coastal flooding events. In the future, this flooding is projected to become more disruptive and costly as its frequency, depth, and inland extent grow with time. Finally, along the Texas Gulf Coast, where SWPA markets power, relative sea level rise of twice the global average will put coastal infrastructure at risk. However, according to SWPA officials, SWPA does not own any assets located in the Texas Gulf Coast. SWPA owns a short power line in Texas that is connected to the U.S. Army Corps of Engineers' Denison Dam. The dam is located on the Red River, between Texas and Oklahoma.

Figure 7: Strong Winds Damaged a Southwestern Power Administration Transmission Line (2020)



Source: Southwestern Power Administration. | GAO-23-106224

Trends and future projections for certain extreme weather events are uncertain.⁴⁴ However, such events highlight the potential vulnerabilities facing utilities.

⁴⁴According to the National Academies of Sciences, Engineering, and Medicine, severe storms—those that produce strong winds, hail, tornadoes, extensive lightning, or heavy precipitation—are the most challenging weather events to attribute to climate change because these events are poorly observed, cannot be simulated in climate models at present, and have a complex and subtle relationship to climate. National Academies of Sciences, Engineering, and Medicine, *Attribution of Extreme Weather Events in the Context of Climate Change* (Washington D.C.: Mar. 11, 2016).

The PMAs Have Taken Some Steps to Manage Climate-Related Risks, but Some PMAs Have Not Taken Other Important Steps

The PMAs have taken some steps to manage climate-related risks and implement certain measures to enhance resilience to climate change. However, SEPA and WAPA have not developed vulnerability assessments and resilience plans to identify all critical assets, infrastructure systems, and programs vulnerable to climate change or identified and prioritized resilience measures to address climate-related risks. In addition, DOE has not taken steps to determine whether it will continue to assess the effects of climate change on federal hydropower beyond 2023.⁴⁵

The PMAs Have Taken Some Steps to Manage Climate-Related Risks

The PMAs have taken some steps to manage climate-related risks to their operations. For example, all of the PMAs have identified and assessed climate-related risks to hydropower generation through a series of DOE-led congressionally mandated assessments.⁴⁶ These assessments examine the potential effects of climate change on water available for hydropower at federal facilities and on the marketing of power from these federal facilities. In addition, in 2022, BPA and SWPA developed vulnerability assessments and resilience plans, identifying critical assets and infrastructure systems vulnerable to climate change,

⁴⁵Section 9505 of the Secure Water Act does not authorize funding for these assessments beyond 2023. 42 U.S.C. § 10365(f) (2022).

⁴⁶DOE, in collaboration with the PMAs, has issued the 9505 technical assessments and reports to Congress since 2012. DOE issued the third technical assessment in September 2022 and expects to issue the report to Congress in 2023. Oak Ridge National Laboratory, *Assessment of the Effects of Climate Change on Federal Hydropower, An Assessment Prepared in Response to Section 9505 of the SECURE Water Act of 2009*, ORNL/TM-2011/251 (Oct. 3, 2012); U.S. Department of Energy, *Effects of Climate Change on Federal Hydropower: Report to Congress* (Washington, D.C.: August 2013); Oak Ridge National Laboratory, *The Second Assessment of the Effects of Climate Change on Federal Hydropower*, ORNL/SR-2015/357 (Oak Ridge, TN: September 2016); U.S. Department of Energy, *Effects of Climate Change on Federal Hydropower: The Second Report to Congress*; and Oak Ridge National Laboratory, *The Third Assessment of the Effects of Climate Change on Federal Hydropower*, ORNL/TM-2021/2278.

and potential resilience measures to address climate-related risks.⁴⁷ In addition, BPA and SWPA established plans to reassess these documents every 4 years.

The PMAs have also implemented some resilience measures. For example, SWPA created berms around facilities to prevent water intrusion and replaced wood power structures with steel. In addition, BPA has taken steps to address wildfire risks by hardening transmission infrastructure, such as by applying fire retardant coating to wooden poles. Furthermore, WAPA worked with Reclamation to install wide-head, high-efficiency turbines at the Hoover Dam to generate power more efficiently at lower water levels during times of drought.⁴⁸ Tables 2 through 5 outline steps the PMAs have taken relative to the six elements of enterprise risk management.

Table 2 below describes the six elements of enterprise risk management and examples of steps BPA has taken to manage climate-related risks.

Table 2: Bonneville Power Administration (BPA) Steps Taken to Manage Climate-Related Risks

Enterprise risk management element ^a	BPA steps taken
Align the process with goals and objectives Ensure the process maximizes the achievement of agency mission and results.	<ul style="list-style-type: none"> <li data-bbox="534 1180 1490 1257">• Developed its <i>Vulnerability Assessment and Resilience Plan</i> in 2022 to align with BPA’s mission—to maintain a reliable and stable transmission system for the Pacific Northwest.^b <li data-bbox="534 1266 1490 1375">• Established a team in 2011 to integrate climate change adaptation planning into operations, policies, and programs; and ensure that BPA resources are invested wisely and that services and operations remain highly effective in current and future climate conditions. However, this team is no longer active, according to BPA officials.^c

⁴⁷The National Renewable Energy Laboratory conducted the SWPA assessment and resilience plan. SWPA’s plan did not include an assessment of climate-related risks in Texas and Louisiana. According to SWPA officials, SWPA does not own assets in Texas or Louisiana. Both SWPA and BPA did not assess risks to generation in their 2022 plans, although BPA stated that it would do so in future plans.

⁴⁸Reclamation, which manages, operates, and maintains the Hoover Dam, coordinated with WAPA to install the newer and more efficient turbines, which WAPA customers financed through rates.

Enterprise risk management element^a

BPA steps taken

<p>Identify risks Assemble a comprehensive list of risks—both threats and opportunities—that could affect the agency from achieving its goals and objectives.</p>	<ul style="list-style-type: none"> Identified climate-related risks to hydropower generation through a series of congressionally mandated 9505 assessments led by the Department of Energy (DOE).^d Identified climate-related risks to transmission and hydropower in its 2012 <i>Climate Change Adaptation Action Plan</i>.^e Developed the <i>Wildfire Mitigation Plan</i> in 2020 and updated it in 2021 and 2022. The plan described wildfire risks in the region and identified key assets.^f Identified climate-related risks—heat waves, wildfires, and coastal and inland flooding—to critical assets and operations in its 2022 <i>Vulnerability Assessment and Resilience Plan</i>, as directed by DOE.
<p>Assess risks Examine risks and consider both the likelihood of the risk and the impact of the risk on the mission to help prioritize risk response.</p>	<ul style="list-style-type: none"> Assessed climate-related risks to critical systems (e.g., facilities, fleet, supply chains, transmission, and workforce) as part of its 2022 <i>Vulnerability Assessment and Resilience Plan</i>. For example, BPA classified risks on a scale of both likelihood (e.g., unlikely, anticipated, likely, almost certain) and consequence (e.g., no impact, low impact, medium impact, high impact). Together with the U.S Army Corps of Engineers and the Bureau of Reclamation, funded studies to assess the potential range of climate change effects on the Columbia River System.^g Classified risks as high, medium, or low and identified near- and long-term potential effects in its 2012 <i>Climate Change Adaptation Action Plan</i>. For example, BPA classified risks to regional planning and investment as a high priority, with projected near- and long-term effects.
<p>Select risk response Select a risk treatment response (based on risk appetite) that includes accepting, avoiding, reducing, sharing, or transferring risk.</p>	<ul style="list-style-type: none"> Added a Public Safety Power Shutoff option—the ability to shut down power during particularly hazardous conditions—to its <i>Wildfire Mitigation Plan</i> to prevent BPA transmission lines from igniting a wildfire. Modified contracts to address risks from drought and reduced power generation. The modified contracts allow customers to pay a fixed rate, entitling them to a percentage of the total power generation, regardless of variability; and reduces the need to purchase power to meet contractual obligations. Installed synchrophasors in substations that provide data to help operators identify and resolve problems, such as during wildfires or other extreme events.^h Planned for inspection of transmission and vegetation management to help address wildfire risk as part of its <i>Wildfire Mitigation Plan</i>. Updated its long-term power generation forecast methodology to include more recent data. Doing so allowed BPA to better forecast how climate change could affect water supplies.
<p>Monitor risks Monitor how risks are changing and if responses are successful.</p>	<ul style="list-style-type: none"> Participated in DOE’s congressionally mandated assessments on hydropower and climate change. BPA also established plans to update its <i>Vulnerability Assessment and Resilience Plan</i> every 4 years to expand the scope and refine assessment and planning methodologies. Monitors and reviews temperature, precipitation, and streamflow records on at least an annual basis and recommends operational and planning changes, as needed, through its weather and streamflow forecasting group. For example, according to BPA officials, after a 2021 heat wave, the group incorporated the new temperature records to update heat wave and cold snap alerting criteria for hydropower operations, planning, and agency situational awareness.

Enterprise risk management element ^a	BPA steps taken
Communicate and report risks Communicate risks with stakeholders and report on the status of addressing the risks.	<ul style="list-style-type: none"> • Shared information on climate-related risks with other federal agencies and coordinated with customers regarding wildfire risk through workshops and other venues. • Offers information on climate-related risks and resiliency efforts from their vulnerability assessment to industry stakeholders, by request.

Source: GAO analysis of GAO-17-63, interviews, and Bonneville Power Administration and DOE documents. | GAO-23-106224

^aGAO, *Enterprise Risk Management: Selected Agencies' Experiences Illustrate Good Practices in Managing Risk*, GAO-17-63 (Washington, D.C.: Dec. 1, 2016).

^bBonneville Power Administration, *Vulnerability Assessment and Resilience Plan* (September 2022).

^cAccording to BPA officials, this is because BPA has shifted from identifying adaptation work to implementation of this work, and ongoing efforts ensure operations continue to take into account climate change impacts. Climate change planning has evolved into an integral consideration for all BPA operational planning, according to these officials.

^dOak Ridge National Laboratory, *Assessment of the Effects of Climate Change on Federal Hydropower, An Assessment Prepared in Response to Section 9505(c) of the SECURE Water Act of 2009*, ORNL/TM-2011/251 (Oak Ridge, TN: Oct. 3, 2012); DOE, *Effects of Climate Change on Federal Hydropower: Report to Congress* (Washington, D.C: August 2013); Oak Ridge National Laboratory, *The Second Assessment of the Effects of Climate Change on Federal Hydropower*, ORNL/SR-2015/357 (Oak Ridge, TN: September 2016); DOE, *Effects of Climate Change on Federal Hydropower: The Second Report to Congress* (Washington, D.C: January 2017); and Oak Ridge National Laboratory, *The Third Assessment of the Effects of Climate Change on Federal Hydropower*, ORNL/TM-2021/2278 (Oak Ridge, TN: September 2022).

^eBonneville Power Administration, *Climate Change Adaptation Action Plan* (July 31, 2012).

^fThe Bonneville Power Administration updated its wildfire mitigation plan in May 2022. Bonneville Power Administration, *BPA 2022 Wildfire Mitigation Plan*, DOE/BPA-5189 (Portland, OR: May 2022). BPA is planning for an increasing number and intensity of wildfires, according to BPA. BPA is also taking steps to harden its transmission assets and respond quickly when wildfires threaten the system.

^gRiver Management Joint Operating Committee (RMJOC), *Climate and Hydrology Datasets for RMJOC Long-Term Planning Studies: Second Edition (RMJOC-II) Part I: Hydroclimate Projections and Analyses* (June 2018); *Climate and Hydrology Datasets for RMJOC Long-Term Planning Studies: Second Edition (RMJOC-II), Part II: Columbia River Reservoir Regulation and Operations—Modeling and Analyses* (August 2020). According to BPA, these studies are being used to guide BPA's risk informed decision-making. Furthermore, BPA and its federal partners have made the data from the RMJOC studies widely available to other utilities and planning organizations in the Pacific Northwest region. For example, the Northwest Power and Conservation Council used the data to inform their 2021 Northwest Power Plan, according to BPA.

^hSynchrophasor systems provide detailed data on the conditions of the transmission grid, which is used to improve power system reliability.

Table 3 below describes the six elements of enterprise risk management and examples of steps SEPA has taken to manage climate-related risks.

Table 3: Southeastern Power Administration (SEPA) Steps Taken to Manage Climate-Related Risks

Enterprise risk management element ^a	SEPA steps taken
Align the process with goals and objectives Ensure the process maximizes the achievement of agency mission and results.	<ul style="list-style-type: none"> • Has not identified any agency-wide goals or objectives for climate resilience. However, according to SEPA officials, SEPA implements several strategies to preserve operations and achieve its mission, such as replacement power purchases and customer contract flexibilities.

Enterprise risk management element ^a	SEPA steps taken
Identify risks Assemble a comprehensive list of risks—both threats and opportunities—that could affect the agency from achieving its goals and objectives.	<ul style="list-style-type: none"> Identified climate-related risks to hydropower generation through a series of congressionally mandated 9505 assessments led by the Department of Energy (DOE).^b
Assess risks Examine risks and consider both the likelihood of the risk and the impact of the risk on the mission to help prioritize risk response.	<ul style="list-style-type: none"> Assessed expected dam water levels and anticipated power generation based on National Weather Service hydrologic forecasting provided by the U.S. Army Corps of Engineers. SEPA uses this assessment to inform the timing of power purchases to minimize costs.
Select risk response Select a risk treatment response (based on risk appetite) that includes accepting, avoiding, reducing, sharing, or transferring risk.	<ul style="list-style-type: none"> Used customer funding to replace and refurbish generating equipment that had failed or was nearing life expectancy.
Monitor risks Monitor how risks are changing and if responses are successful.	<ul style="list-style-type: none"> Participated in DOE’s series of congressionally mandated assessments on hydropower and climate change.
Communicate and report risks Communicate risks with stakeholders and report on the status of addressing the risks.	<ul style="list-style-type: none"> Engaged with stakeholders through participation in the Drought Busters group—a group that discusses lake levels and drought possibilities—and meets on an as-needed basis.

Source: GAO analysis of GAO-17-63, interviews, and Southeastern Power Administration and DOE documents. | GAO-23-106224

^aGAO, Enterprise Risk Management: Selected Agencies’ Experiences Illustrate Good Practices in Managing Risk, GAO-17-63 (Washington, D.C.: Dec. 1, 2016).

^bOak Ridge National Laboratory, *Assessment of the Effects of Climate Change on Federal Hydropower, An Assessment Prepared in Response to Section 9505(c) of the SECURE Water Act of 2009*, ORNL/TM-2011/251 (Oak Ridge, TN: Oct. 3, 2012); DOE, *Effects of Climate Change on Federal Hydropower: Report to Congress* (Washington, D.C: August 2013); Oak Ridge National Laboratory, *The Second Assessment of the Effects of Climate Change on Federal Hydropower*, ORNL/SR-2015/357 (Oak Ridge, TN: September 2016); DOE, *Effects of Climate Change on Federal Hydropower: The Second Report to Congress* (Washington, D.C: January 2017); and Oak Ridge National Laboratory, *The Third Assessment of the Effects of Climate Change on Federal Hydropower*, ORNL/TM-2021/2278 (Oak Ridge, TN: September 2022).

Table 4 below describes the six elements of enterprise risk management and examples of steps SWPA has taken to manage climate-related risks.

Table 4: Southwestern Power Administration (SWPA) Steps Taken to Manage Climate-Related Risks

Enterprise risk management element ^a	SWPA steps taken
Align the process with goals and objectives Ensure the process maximizes the achievement of agency mission and results.	<ul style="list-style-type: none"> Developed its <i>Vulnerability Assessment and Resilience Plan</i> in 2022 to align with SWPA’s mission—to optimally use federal resources to safely and sustainably provide clean hydropower, transmission, and related services to benefit customers, regional communities, and the nation.
Identify risks Assemble a comprehensive list of risks—both threats and opportunities—that could affect the agency from achieving its goals and objectives.	<ul style="list-style-type: none"> Identified climate-related risks to hydropower generation through a series of congressionally mandated 9505 assessments led by the Department of Energy (DOE).^b Developed its <i>Vulnerability Assessment and Resilience Plan</i> in 2022 that identified climate-related risks—extreme heat and cold events, heavy precipitation, extreme wind events, and drought—to critical assets and infrastructure, as directed by DOE.

Enterprise risk management element ^a	SWPA steps taken
<p>Assess risks</p> <p>Examine risks and consider both the likelihood of the risk and the impact of the risk on the mission to help prioritize risk response.</p>	<ul style="list-style-type: none"> Assessed climate-related risks to critical assets and infrastructure (e.g., control centers, substations, office buildings, and transmission lines) as part of its 2022 <i>Vulnerability Assessment and Resilience Plan</i>. Assessed climate-related risks by collaborating with Oak Ridge National Laboratory on modeling that identified potential effects of drought and water variability on SWPA's operations and financial condition. SWPA officials told us that they use the information to make decisions (e.g., outage planning, purchasing power).
<p>Select risk response</p> <p>Select a risk treatment response (based on risk appetite) that includes accepting, avoiding, reducing, sharing, or transferring risk.</p>	<ul style="list-style-type: none"> Implemented a purchase power adder—an amount added to the rate customers pay for power—to manage the risks from drought. The amount generated through this purchase power adder will allow SWPA to purchase power when not enough power is generated to meet its contractual obligations. Relocated, hardened, or adapted infrastructure to enhance resilience. For example, hardened transmission assets by replacing wooden power structures with steel power structures, which are more resilient to wildfires.
<p>Monitor risks</p> <p>Monitor how risks are changing and if responses are successful.</p>	<ul style="list-style-type: none"> Participated in DOE's series of congressionally mandated assessments on hydropower and climate change. SWPA also established plans to update its 2022 <i>Vulnerability Assessment and Resilience Plan</i> every 4 years to reflect changing conditions and evaluate implemented resilience solutions.
<p>Communicate and report risks</p> <p>Communicate risks with stakeholders and report on the status of addressing the risks.</p>	<ul style="list-style-type: none"> Issued its 2022 <i>Vulnerability Assessment and Resilience Plan</i>, which it plans to update every 4 years. The plan included information on climate-related risks to critical assets and infrastructure and identified resilience measures to address risks.

Source: GAO analysis of [GAO-17-63](#), interviews, and Southwestern Power Administration and DOE documents. | GAO-23-106224

^aGAO, *Enterprise Risk Management: Selected Agencies' Experiences Illustrate Good Practices in Managing Risk*, [GAO-17-63](#) (Washington, D.C.: Dec. 1, 2016).

^bOak Ridge National Laboratory, *Assessment of the Effects of Climate Change on Federal Hydropower, An Assessment Prepared in Response to Section 9505(c) of the SECURE Water Act of 2009*, ORNL/TM-2011/251 (Oak Ridge, TN: Oct. 3, 2012); DOE, *Effects of Climate Change on Federal Hydropower: Report to Congress* (Washington, DC: August 2013); Oak Ridge National Laboratory, *The Second Assessment of the Effects of Climate Change on Federal Hydropower*, ORNL/SR-2015/357 (Oak Ridge, TN: September 2016); DOE, *Effects of Climate Change on Federal Hydropower: The Second Report to Congress* (Washington, D.C: January 2017); and Oak Ridge National Laboratory, *The Third Assessment of the Effects of Climate Change on Federal Hydropower*, ORNL/TM-2021/2278 (Oak Ridge, TN: September 2022).

Table 5 below describes the six essential elements of enterprise risk management and examples of steps WAPA has taken to manage climate-related risks.

Table 5: Western Area Power Administration (WAPA) Steps Taken to Manage Climate-Related Risks

Enterprise risk management element ^a	WAPA steps taken
Align the process with goals and objectives Ensure the process maximizes the achievement of agency mission and results.	<ul style="list-style-type: none"> Established a strategic objective—Prepare and Adapt to a Changing Energy Landscape—in <i>Power Forward 2030</i>, WAPA’s latest strategic plan. According to the plan, when hydropower is not available because of drought or other conditions, WAPA provides alternative energy sources, striving for the most cost-effective options.
Identify risks Assemble a comprehensive list of risks—both threats and opportunities—that could affect the agency from achieving its goals and objectives.	<ul style="list-style-type: none"> Identified climate-related risks to hydropower generation through a series of congressionally mandated 9505 assessments led by the Department of Energy (DOE).^b Identified prolonged drought as a risk in its <i>2022 Enterprise Risk Management Risk Profile</i> submitted to the Office of Management and Budget as part of the Circular A-123 process.^c Collaborated with Argonne National Laboratory to identify potential risks to transmission and operations from drought.
Assess risks Examine risks and consider both the likelihood of the risk and the impact of the risk on the mission to help prioritize risk response.	<ul style="list-style-type: none"> Worked with the U.S. Army Corps of Engineers, the Bureau of Reclamation, and the National Oceanic and Atmospheric Administration to assess rainfall projections and the potential effects of drought on hydropower generation. Sponsored an Argonne National Laboratory project to model and assess risks from variations in hydrology and other factors on WAPA’s ability to meet contractual obligations.
Select risk response Select a risk treatment response (based on risk appetite) that includes accepting, avoiding, reducing, sharing, or transferring risk.	<ul style="list-style-type: none"> Proposed a rate increase to address drought conditions in its Colorado River Storage Project region in 2021. In addition, WAPA also received approval from DOE to implement a new 5-year rate, which adjusted the drought adder for the Pick-Sloan Missouri Basin Program.^d Modified its rate structure through a public rate process, allowing customers to purchase power when insufficient hydropower is available to meet customer’s needs. Identified purchase power and wheeling reserve fund, and cost recovery charges as measures to address prolonged drought in its <i>2022 Enterprise Risk Management Risk Profile</i>. Staff from all of WAPA’s regions attended training on developing wildfire mitigation plans in 2022, according to WAPA. Furthermore, WAPA’s Sierra Nevada region developed a Wildfire Mitigation Plan that prioritizes mitigation efforts—annual inspections of equipment, coordination with state and federal agencies, and vegetation management on WAPA’s right-of-way and private lands.
Monitor risks Monitor how risks are changing and if responses are successful.	<ul style="list-style-type: none"> Participated in DOE’s series of congressionally mandated assessments on hydropower and climate change.
Communicate and report risks Communicate risks with stakeholders and report on the status of addressing the risks.	<ul style="list-style-type: none"> Officials from WAPA’s Colorado River Storage Project region met with customers biweekly to discuss and share information on various issues, including drought. According to officials, meeting with customers biweekly is their best strategy for addressing drought-related issues. Communicated risks from drought through its <i>2022 Enterprise Risk Management Risk Profile</i> submitted to the Office of Management and Budget as part of the Circular A-123 process.

Source: GAO analysis of GAO-17-63, interviews, and Western Area Power Administration and DOE documents. | GAO-23-106224

^aGAO, *Enterprise Risk Management: Selected Agencies' Experiences Illustrate Good Practices in Managing Risk*, [GAO-17-63](#) (Washington, D.C.: Dec. 1, 2016).

^bOak Ridge National Laboratory, *Assessment of the Effects of Climate Change on Federal Hydropower, An Assessment Prepared in Response to Section 9505(c) of the SECURE Water Act of 2009*, ORNL/TM-2011/251 (Oak Ridge, TN: Oct. 3, 2012); DOE, *Effects of Climate Change on Federal Hydropower: Report to Congress* (Washington, DC: August 2013); Oak Ridge National Laboratory, *The Second Assessment of the Effects of Climate Change on Federal Hydropower*, ORNL/SR-2015/357 (Oak Ridge, TN: September 2016); DOE, *Effects of Climate Change on Federal Hydropower: The Second Report to Congress* (Washington, D.C.: January 2017); and Oak Ridge National Laboratory, *The Third Assessment of the Effects of Climate Change on Federal Hydropower*, ORNL/TM-2021/2278 (Oak Ridge, TN: September 2022).

^cWAPA has continued to identify “Reduced Hydropower Generation” due to drought as a top risk in its Enterprise Risk Management profile for fiscal year 2023, according to WAPA.

^dThe drought adder was originally established in 2008 to collect revenue to pay for historical and/or projected drought costs for the Rocky Mountain Region and Upper Great Plains Region, according to WAPA. In 2018 the drought adder was repaid, according to WAPA. However, current hydrological conditions particularly in the Pick-Sloan Missouri Basin Program (Eastern Division), required adjustment of the drought adder again, beginning January 2023, according to WAPA.

Some PMAs Have Not Identified Critical Assets Vulnerable to Climate Change or Related Resilience Measures, and All PMAs Use DOE’s Assessments to Identify Hydropower Risks

Two of the PMAs—SEPA and WAPA—have not developed vulnerability assessments that identify all critical assets, infrastructure systems, and programs vulnerable to climate change. These PMAs also have not developed a resilience plan that includes measures to address climate-related risks. DOE’s *Vulnerability Assessment and Resilience Planning Guidance* calls for all DOE sites—including the PMAs—to do so.⁴⁹ In

⁴⁹Similarly, according to GAO’s *Enterprise Risk Management Framework*, entities should assemble a comprehensive list of risks, both threats and opportunities that could affect the entity from achieving its goals and objectives. Furthermore, categorizing risks can help agency leaders see how risks relate and to what extent the sources of the risks are similar. Risks are linked to relevant strategic objectives and documented in a risk register or some other comprehensive format that also identifies the relevant source and a risk owner to manage the treatment of the risk. Comprehensive risk identification is critical, even if the agency does not control the source of the risk. [GAO-17-63](#). Furthermore, according to ASTM International, creating a comprehensive list of risks based on available climate information is critical, because if a risk is not identified at this stage, it will not be included in further analysis. Further analysis could entail conducting a risk analysis to determine whether certain risks need to be treated (some identified risks may not require treatment at all because they fall within the agency’s risk appetite, defined as how much risk the organization is willing to accept relative to mission achievement). ASTM International, *Standard ASTM E3032-15e1: Guide for Climate Resiliency Planning and Strategy*.

addition, the guidance calls for monitoring progress and reassessing these efforts at least every 4 years.

SEPA officials told us that, initially, lack of clarity about the requirements and limited resources (e.g., staff to conduct the assessment in-house) had been obstacles in completing these documents. Nevertheless, as of December 2022, SEPA officials said that they were working on a vulnerability assessment and resilience plan and expected to issue it in 2023.⁵⁰ According to officials, SEPA is working to coordinate with DOE to determine the appropriate scope of such an assessment, given the limited scope of SEPA's infrastructure.⁵¹

WAPA officials told us that WAPA plans to conduct the assessment and develop the plan in fiscal year 2023. These officials said that WAPA did not develop such documents by DOE's deadline—September 30, 2022—because they did not have the staff available to do so. Specifically, WAPA officials told us that WAPA had significant staff turnover and ongoing staff vacancies.

Taking inventory of critical assets, infrastructure systems, and programs vulnerable to climate change can help SEPA and WAPA more accurately identify relevant hazards and the potential severity of disruptions or damages to critical assets, infrastructure systems, and programs.⁵² Doing so would better position them to identify and implement appropriate resilience measures to address climate-related vulnerabilities as these vulnerabilities become more acute. Identifying and assessing resilience measures could also help these PMAs determine whether mitigating certain risks is worth the investment. In addition, SEPA and WAPA would benefit from establishing plans to reassess the documents every 4 years,

⁵⁰SEPA officials stated that they have implemented several resilience measures. However, SEPA has not developed a resilience plan, as directed by DOE.

⁵¹SEPA does not own or operate transmission assets. Instead, SEPA delivers power through transmission lines and substations owned and operated by neighboring utilities.

⁵²According to DOE's *Guide for Climate Change Resilience Planning*, utilities undertaking a comprehensive vulnerability assessment may benefit from a complete, system-wide understanding of climate hazards. One critical input to the vulnerability assessment is an inventory of the assets and operations that could be affected by climate-related threats. Identifying, characterizing, and inventorying a utility's assets and operations will provide useful insights on the various ways in which climate impacts may disrupt services and how best to prioritize and implement operational resilience measures. U.S. Department of Energy, Office of Energy Policy and Systems Analysis, *Climate Change and the Electricity Sector: Guide for Climate Change Resilience Planning*.

as new information becomes available. Doing so would help ensure that SEPA and WAPA have the latest information on the risks climate change poses to their critical assets, infrastructure systems, and programs, and would further enhance their ability to build climate resilience.

Lastly, Section 9505 of the Secure Water Act requires DOE to assess the effects of climate change on federal hydropower and report to Congress every 5 years. In response, DOE has issued a series of assessments and reports.⁵³ However, DOE officials we interviewed told us that DOE does not plan to continue conducting the 9505 assessments beyond 2023 because the Secure Water Act authorization is expiring.⁵⁴ DOE officials said that they have been in discussions on how to continue efforts similar to the 9505 reporting outside of the Secure Water Act authorization. However, as of December 2022, DOE had not officially established any plans. Officials from two of the four PMAs told us they face challenges in identifying and assessing climate risks because they do not have in-house climate experts and rely on the 9505 assessments to identify risks.⁵⁵

GAO's *Enterprise Risk Management Framework* states that monitoring how risks are changing can provide information to help entities determine whether responses are successful. Assessing whether it should continue

⁵³Oak Ridge National Laboratory, *Assessment of the Effects of Climate Change on Federal Hydropower, An Assessment Prepared in Response to Section 9505(c) of the SECURE Water Act of 2009*, ORNL/TM-2011/251 (Oak Ridge, TN: Oct. 3, 2012); U.S. Department of Energy (DOE), *Effects of Climate Change on Federal Hydropower: Report to Congress*; Oak Ridge National Laboratory, *The Second Assessment of the Effects of Climate Change on Federal Hydropower*, ORNL/SR-2015/357; U.S. Department of Energy, *Effects of Climate Change on Federal Hydropower: The Second Report to Congress*; and Oak Ridge National Laboratory, *The Third Assessment of the Effects of Climate Change on Federal Hydropower*, ORNL/TM-2021/2278. *The Third Assessment of the Effects of Climate Change on Federal Hydropower*, issued in September 2022, will provide the technical basis for the third report to Congress, which DOE anticipates issuing in 2023.

⁵⁴Section 9505 of the Secure Water Act does not authorize funding for these assessments beyond 2023. 42 U.S.C. § 10365(f) (2022).

⁵⁵According to officials from several PMAs, the 9505 assessment yields benefits that should be discussed to inform any decisions to continue them beyond the Secure Water Act requirements. For example, PMA officials told us that the assessments provide information at the national level—something that a PMA could not do on its own—and is a valuable opportunity to collaborate with the other PMAs. In addition, officials from another PMA told us that they were concerned there will not be additional reports issued under the Secure Water Act and added that they would like to continue to study the effects of climate change on hydropower with DOE, Oak Ridge National Laboratory, and others with expertise.

to periodically conduct an effort like the 9505 assessments beyond 2023 would provide DOE with greater assurance that the PMAs have the information they need to better manage climate-related risks.

Conclusions

The four Power Marketing Administrations—BPA, SEPA, SWPA, and WAPA—play a significant role in selling and transmitting electricity to public power utilities, cooperatives, and Tribes, in over 30 states. However, more frequent extreme weather events and other risks associated with climate change could cost utilities and customers billions of dollars from power outages and infrastructure damage.

The PMAs have taken some steps to manage climate-related risks. However, SEPA and WAPA have not identified critical assets, infrastructure systems, and programs vulnerable to climate change. DOE's *Vulnerability Assessment and Resilience Planning Guidance* states that DOE entities—including the PMAs—should identify and assess climate-related vulnerabilities. Conducting a comprehensive inventory of the critical assets, infrastructure systems, and programs that are vulnerable to climate change would better position the PMAs to identify and implement resilience measures to address vulnerabilities as the risks from climate change become more acute.

Furthermore, SEPA and WAPA have not identified and assessed resilience measures to address climate-related risks to their operations and infrastructure. Identifying and assessing resilience measures could help these PMAs determine whether mitigating certain risks is worth the investment and prioritize which resilience measures they should adopt. As we and others have reported, investing in resilience measures now can reduce the need to take more costly actions in the future. This, in turn, would help the PMAs fulfill their mission of providing reliable and affordable power to their customers.

BPA and SWPA have established plans to periodically revise their vulnerability assessments and resilience plans. SEPA and WAPA, however, have not established plans to do so. Establishing a plan to periodically revise their vulnerability assessments and resilience plans would help ensure that SEPA and WAPA have the latest information about the risks climate change poses to their infrastructure and operations and thereby enhance their ability to adopt climate resilience measures.

Lastly, Section 9505 of the Secure Water Act requires DOE to conduct periodic assessments of the effects of climate change on federal hydropower and report to Congress every 5 years. However, DOE officials we interviewed told us that DOE does not plan to continue these assessments beyond 2023 because the Secure Water Act authorization is expiring. DOE should take steps to determine whether it should continue to periodically conduct an effort like the 9505 assessments beyond 2023. Doing so would give DOE greater assurance that the PMAs have the information they need to better manage climate-related risks.

Recommendations for Executive Action

We are making a total of seven recommendations, including three to SEPA, three to WAPA, and one to DOE.

The Administrator of the Southeastern Power Administration should direct staff to develop a climate change vulnerability assessment that identifies critical assets, infrastructure systems, and programs vulnerable to climate change. (Recommendation 1)

The Administrator of the Southeastern Power Administration should direct staff to develop a resilience plan that identifies and prioritizes climate resilience measures needed to address climate-related risks. (Recommendation 2)

The Administrator of the Southeastern Power Administration should direct staff to establish a plan to routinely reassess its vulnerability assessment and resilience plan to incorporate updated information about climate science and implemented resilience measures. (Recommendation 3)

The Administrator of the Western Area Power Administration should direct staff to develop a climate change vulnerability assessment that identifies critical assets, infrastructure systems, and programs vulnerable to climate change. (Recommendation 4)

The Administrator of the Western Area Power Administration should direct staff to develop a resilience plan that identifies and prioritizes climate resilience measures needed to address climate-related risks. (Recommendation 5)

The Administrator of the Western Area Power Administration should direct staff to establish a plan to routinely reassess its vulnerability

assessment and resilience plan to incorporate updated information about climate science and implemented resilience measures. (Recommendation 6)

The Secretary of Energy should take steps to determine the need for future assessments of the effects of climate change on federal hydropower and on the marketing of power from federal facilities. (Recommendation 7)

Agency Comments

We provided a draft of this report to DOE, BPA, SEPA, SWPA, and WAPA for review and comment.

We received written comments from DOE, which have been reproduced in appendix I. We also received written comments from BPA, which have been reproduced in appendix II. In addition, these entities also provided technical comments, which we incorporated as appropriate.

In its written comments, DOE agreed with our seven recommendations. In response to our first recommendation, that the SEPA Administrator direct staff to develop a climate change vulnerability assessment, DOE stated that SEPA will complete a Vulnerability Assessment and Resilience Plan in calendar year 2023 that will identify critical assets, infrastructure systems, and programs vulnerable to climate change. In response to our second recommendation, that the SEPA Administrator direct staff to develop a resilience plan, DOE stated that SEPA will complete a Vulnerability Assessment and Resilience Plan in calendar year 2023 that identifies and prioritizes climate resilience measures needed to address climate-related risks. In response to our third recommendation, that the SEPA Administrator direct staff to establish a plan to routinely reassess its vulnerability assessment and resilience plan, DOE stated that SEPA's Vulnerability Assessment and Resilience Plan will be reassessed every four years to incorporate updated information about climate science and implemented measures.

In response to our fourth recommendation, that the WAPA Administrator direct staff to develop a climate change vulnerability assessment, DOE stated that WAPA will complete a Vulnerability Assessment and Resilience Plan in calendar year 2023 that will identify critical assets, infrastructure systems, and programs vulnerable to climate change. In response to our fifth recommendation, that the WAPA Administrator direct

staff to develop a resilience plan, DOE stated that WAPA will complete a Vulnerability Assessment and Resilience Plan in calendar year 2023 that identifies and prioritizes climate resilience measures needed to address climate-related risks. In response to our sixth recommendation, that the WAPA Administrator direct staff to establish a plan to routinely reassess its vulnerability assessment and resilience plan, DOE stated that WAPA's Vulnerability Assessment and Resilience Plan will be reassessed every four years to incorporate updated information about climate science and implemented measures.

In response to our seventh recommendation, that the Secretary of Energy take steps to determine the need for future assessments of the effects of climate change on federal hydropower and on the marketing of power from federal facilities, DOE stated that the department will review the submitted assessments to determine the need for continued assessments. DOE added that the department will make its recommendations before the next cycle of assessments.

As agreed with your offices, unless you publicly announce the contents of this report earlier, we plan no further distribution until one day from the report date. At that time, we will send copies of this report to the appropriate congressional committees, the Secretary of the Department of Energy, the Administrators of the Bonneville Power Administration, the Southeastern Power Administration, the Southwestern Power Administration, and the Western Area Power Administration, and other interested parties. In addition, the report will be available at no charge on the GAO website at <http://www.gao.gov>.

If you or your staff have any questions about this report, please contact me at (202) 512-3841 or ruscof@gao.gov. Contact points for our Offices of Congressional Relations and Public Affairs may be found on the last page of this report. GAO staff who made key contributions to this report are listed in appendix III.



Frank Rusco,
Director, Natural Resources and Environment

Appendix I: Comments from the Department of Energy

Appendix I: Comments from the Department of Energy



The Under Secretary for Infrastructure

Washington, DC 20585

March 9, 2023

Mr. Frank Rusco
Director
Natural Resources and Environment
U.S. Government Accountability Office
441 G Street N.W.
Washington, DC 20548

Dear Mr. Rusco:

The Department of Energy (DOE or Department) appreciates the opportunity to comment on the Government Accountability Office's (GAO) draft report titled, "*Power Marketing Administrations: Additional Steps Are Needed to Better Manage Climate-Related Risks*" GAO-23-106224.

The draft report contained a total of seven recommendations, of which GAO directed three recommendations to Southeastern Power Administration, three to Western Power Administration and one to the Secretary of Energy. DOE concurred with GAO's recommendations.

GAO should direct any questions to Melissa Ardis, Power Marketing Administration Office, at melissa.ardis@hq.doe.gov.

Sincerely,

A handwritten signature in black ink, appearing to read "Kathleen M. Hogan".

Kathleen M. Hogan
Principal Deputy Under Secretary
for Infrastructure

Enclosure

Enclosure

Management Response
GAO Draft Report: Power Marketing Administrations:
Additional Steps Are Needed to Better Manage
Climate-Related Risks (GAO-23-106224)

Southeastern Power Administration

Recommendation 1: The Administrator of the Southeastern Power Administration (SEPA) should direct staff to develop a climate change vulnerability assessment that identifies critical assets, infrastructure systems, and programs vulnerable to climate change.

DOE Response: SEPA concurs with the recommendation.

SEPA will complete a Vulnerability Assessment and Resilience Plan (VARP) in calendar year 2023 that will identify critical assets, infrastructure systems, and programs vulnerable to climate change.

Estimated Completion Date: December 31, 2023

Recommendation 2: The Administrator of the Southeastern Power Administration (SEPA) should direct staff to develop a resilience plan that identifies and prioritizes climate resilience measures needed to address climate-related risks.

DOE Response: SEPA concurs with the recommendation.

SEPA will complete a Vulnerability Assessment and Resilience Plan (VARP) in calendar year 2023 that identifies and prioritizes climate resilience measures needed to address climate-related risks.

Estimated Completion Date: December 31, 2023

Recommendation 3: The Administrator of the Southeastern Power Administration (SEPA) should direct staff to establish a plan to routinely reassess its vulnerability assessment and resilience plan to incorporate updated information about climate science and implemented resilience measures.

DOE Response: SEPA concurs with the recommendation.

SEPA will complete a Vulnerability Assessment and Resilience Plan (VARP) in calendar year 2023 that will be reassessed every four years to incorporate updated information about climate science and implemented measures.

Estimated Completion Date: December 31, 2023

Enclosure

Management Response
GAO Draft Report: Power Marketing Administrations:
Additional Steps Are Needed to Better Manage
Climate-Related Risks (GAO-23-106224)

Western Area Power Administration

Recommendation 4: The Administrator of the Western Area Power Administration (WAPA) should direct WAPA staff to develop a climate change vulnerability assessment that identifies critical assets, infrastructure systems, and programs vulnerable to climate change.

DOE Response: WAPA concurs with the recommendation.

WAPA will complete a Vulnerability Assessment and Resilience Plan (VARP) in calendar year 2023 that will identify critical assets, infrastructure systems, and programs vulnerable to climate change.

Estimated Completion Date: December 31, 2023

Recommendation 5: The Administrator of the Western Area Power Administration (WAPA) should direct staff to develop a resilience plan that identifies and prioritizes climate resilience measures needed to address climate-related risks.

DOE Response: WAPA concurs with the recommendation. WAPA will complete a Vulnerability Assessment and Resilience Plan (VARP) in calendar year 2023 that identifies and prioritizes climate resilience measures needed to address climate-related risks.

Estimated Completion Date: December 31, 2023

Recommendation 6: The Administrator of the Western Area Power Administration (WAPA) should direct staff to establish a plan to routinely reassess its vulnerability assessment and resilience plan to incorporate updated information about climate science and implemented resilience measures.

DOE Response: WAPA concurs with the recommendation.

WAPA will complete a Vulnerability Assessment and Resilience Plan (VARP) in calendar year 2023 that will be reassessed every four years to incorporate updated information about climate science and implemented measures.

Estimated Completion Date: December 31, 2023

Enclosure

**Management Response
GAO Draft Report: Power Marketing Administrations:
Additional Steps Are Needed to Better Manage
Climate-Related Risks (GAO-23-106224)**

Power Marketing Administration Office

Recommendation 7: The Secretary of Energy should take steps to determine the need for future assessment of the effects of climate change on federal hydropower and on the marketing of power from federal facilities.

DOE Response: Concur with recommendation.

The Department will review the submitted assessments to determine the need for continued assessments regarding the effects of climate change on federal hydropower and on the marketing of power from federal hydropower facilities. The Department will make its recommendations before the next cycle of assessments.

Estimated Completion Date: December 31, 2023

Accessible Text for Appendix I: Comments from the Department of Energy

March 9, 2023

Mr. Frank Rusco Director
Natural Resources and Environment
U.S. Government Accountability
Office 441 G Street N.W.
Washington, DC 20548

Dear Mr. Rusco:

The Department of Energy (DOE or Department) appreciates the opportunity to comment on the Government Accountability Office's (GAO) draft report titled, "Power Marketing Administrations: Additional Steps Are Needed to Better Manage Climate-Related Risks GAO-23-106224.

The draft report contained a total of seven recommendations, of which GAO directed three recommendations to Southeastern Power Administration, three to Western Power Administration and one to the Secretary of Energy. DOE concurred with GAO's recommendations.

GAO should direct any questions to Melissa Ardis, Power Marketing Administration Office, at melissa.ardis@hq.doe.gov.

Sincerely,

Kathleen M. Hogan
Principal Deputy Under Secretary
for Infrastructure

Enclosure

Southeastern Power Administration

Recommendation 1: The Administrator of the Southeastern Power Administration (SEPA) should direct staff to develop a climate change vulnerability assessment that

identifies critical assets, infrastructure systems, and programs vulnerable to climate change.

DOE Response: SEPA concurs with the recommendation.

SEPA will complete a Vulnerability Assessment and Resilience Plan (VARP) in calendar year 2023 that will identify critical assets, infrastructure systems, and programs vulnerable to climate change.

Estimated Completion Date: December 31, 2023

Recommendation 2: The Administrator of the Southeastern Power Administration (SEPA) should direct staff to develop a resilience plan that identifies and prioritizes climate resilience measures needed to address climate-related risks.

DOE Response: SEPA concurs with the recommendation.

SEPA will complete a Vulnerability Assessment and Resilience Plan (VARP) in calendar year 2023 that identifies and prioritizes climate resilience measures needed to address climate-related risks.

Estimated Completion Date: December 31, 2023

Recommendation 3: The Administrator of the Southeastern Power Administration (SEPA) should direct staff to establish a plan to routinely reassess its vulnerability assessment and resilience plan to incorporate updated information about climate science and implemented resilience measures.

DOE Response: SEPA concurs with the recommendation.

SEPA will complete a Vulnerability Assessment and Resilience Plan (VARP) in calendar year 2023 that will be reassessed every four years to incorporate updated information about climate science and implemented measures.

Estimated Completion Date: December 31, 2023

Western Area Power Administration

Recommendation 4: The Administrator of the Western Area Power Administration (WAPA) should direct WAPA staff to develop a climate change vulnerability assessment that identifies critical assets, infrastructure systems, and programs vulnerable to climate change.

DOE Response: WAPA concurs with the recommendation.

WAPA will complete a Vulnerability Assessment and Resilience Plan (VARP) in calendar year 2023 that will identify critical assets, infrastructure systems, and programs vulnerable to climate change.

Estimated Completion Date: December 31, 2023

Recommendation 5: The Administrator of the Western Area Power Administration (WAPA) should direct staff to develop a resilience plan that identifies and prioritizes climate resilience measures needed to address climate-related risks.

DOE Response: WAPA concurs with the recommendation. WAPA will complete a Vulnerability Assessment and Resilience Plan (VARP) in calendar year 2023 that identifies and prioritizes climate resilience measures needed to address climate-related risks.

Estimated Completion Date: December 31, 2023

Recommendation 6: The Administrator of the Western Area Power Administration (WAPA) should direct staff to establish a plan to routinely reassess its vulnerability assessment and resilience plan to incorporate updated information about climate science and implemented resilience measures.

DOE Response: WAPA concurs with the recommendation.

WAPA will complete a Vulnerability Assessment and Resilience Plan (VARP) in calendar year 2023 that will be reassessed every four years to incorporate updated information about climate science and implemented measures.

Estimated Completion Date: December 31, 2023

Power Marketing Administration Office

Recommendation 7: The Secretary of Energy should take steps to determine the need for future assessment of the effects of climate change on federal hydropower and on the marketing of power from federal facilities.

DOE Response: Concurs with recommendation.

The Department will review the submitted assessments to determine the need for continued assessments regarding the effects of climate change on federal

hydropower and on the marketing of power from federal hydropower facilities. The Department will make its recommendations before the next cycle of assessments.

Estimated Completion Date: December 31, 2023

Appendix II: Comments from the Bonneville Power Administration

**Appendix II: Comments from the Bonneville
Power Administration**



Department of Energy

Bonneville Power Administration
P.O. Box 3621
Portland, Oregon 97208-3621

EXECUTIVE OFFICE

March 3, 2023

In reply refer to: A-7

Mr. Franklin W. Rusco
Director, Natural Resources and Environment
U.S. Government Accountability Office
441 G Street Northwest
Washington, DC 20548

RE: PMA Climate Resilience (GAO-23-106224)

Dear Director Rusco:

Thank you for the opportunity to comment on the report: *Power Marketing Administration: Additional Steps Are Needed to Better Manage Climate-Related Risks*.

In preparation of this report, we appreciated the opportunity to discuss with the GAO the many actions Bonneville Power Administration (BPA) has taken, and continues to take, to address both emerging and expected climate change impacts. We have reviewed the report and would like to emphasize that BPA takes seriously the impacts that climate change is having on the federal hydropower and transmission systems in the Pacific Northwest, and we are already mitigating for those growing impacts.

For almost 20 years, BPA has tracked both climate trends and the state of climate science as they have evolved, and has worked to respond in a prudent, risk-informed manner. BPA is adapting to not only a warming climate, but also the many climate change scenarios that could play out in the Columbia River Basin specifically. Changes in climate have been observed, are projected to continue, and have implications for many facets of BPA's operations. For example, changes in temperature and streamflow are a risk to our fuel supply (water), and events like wildfire are a risk to our transmission assets.

While the report captures many of the actions BPA has already taken to respond to climate change, we would like to offer some clarifications, and note the progress we have made to manage emerging and expected climate risks:

- As the GAO report notes, BPA continues to work closely with our partners, most notably the U.S. Army Corps of Engineers and Bureau of Reclamation, which comprise the River

Management Joint Operating Committee (RMJOC), to study climate change trends and projections. This [BPA fact sheet](#) provides an overview of the science and findings from our latest study, and the full reports can be found at [Climate Change & FCRPS \(bpa.gov\)](#). These studies, along with others like the recently published Oak Ridge National Lab technical report for the [9505 SECURE Water Act](#), are being used to guide our risk-informed decision-making. BPA and its federal partners have made the data from the RMJOC studies widely available to other utilities and planning organizations in the Pacific Northwest region. For example, the Northwest Power and Conservation Council used the data to inform their [2021 Northwest Power Plan](#).

- BPA has a good understanding of its range of climate related risks and how those risks may differ from other hydropower entities in other parts of the west. As our Pacific Northwest regional climate warms, winter streamflows and hydroelectric power generation are likely to increase in the Columbia Basin, while winter loads slightly decrease. Meanwhile, as the Pacific Northwest region experiences earlier peaks in high-elevation snowmelt, longer periods of already low summer flows are likely to coincide with increasing summer loads.
- BPA convened a Climate Change Risk Management Team in 2012 to evaluate risks across the enterprise. While the GAO report correctly notes this (see table 2, *BPA's steps to manage climate change related risks*), BPA has now shifted from identifying adaptation work into actual implementation of this work. Ongoing efforts across the agency ensure operations continue to take into account climate change impacts. Climate change planning has evolved into an integral consideration for all BPA operational planning.
- BPA has included climate considerations in its [BPA 2022 Wildfire Mitigation Plan](#). As the climate warms, BPA is planning for both an increasing number and intensity of wildfires. The agency is taking steps to harden its transmission assets and respond quickly when wildfires threaten its system. The plan covers end-to-end activities related to the mitigation of wildfires across the Federal Columbia River Transmission System. The scope of the plan includes vegetation and asset management programs, including: Operations and maintenance, replacement, disposal, and response and recovery.
- BPA responded to emerging streamflow signals in 2022 by working closely with our utility customers to adapt our rate case and longer-term hydropower planning processes. We are now using a shorter "period of record" for streamflow that better captures increasing and decreasing streamflows and generation in both winter, early spring and summer.
- BPA has updated the historical temperatures used for load forecasting to better align with emerging climate changes. Accordingly, load forecasting moved from a 35-year historical period (1970-2004) to a 15-year historical period (2005-2019) and due to a changing climate, we intend to update the period of record more frequently (about once every 5 years). Since September 2020, all long-term load forecasts have used this 15-year period of record.
- Evolving regional energy markets and resource adequacy programs could help BPA tap into a more diverse pool of power resources, helping address the climate change risks BPA may face in meeting load obligations. This is one of the many reasons BPA joined the Western Energy Imbalance Market in spring 2022. The agency also participates in the development of day ahead markets in the West, and joined as a non-binding participant the Western Resource Adequacy Program with binding participation starting in winter 2027-2028.

**Appendix II: Comments from the Bonneville
Power Administration**

3

- BPA also continues to collaborate with other hydropower utilities, not only regionally but also across North America through organizations such as the Electrical Power Research Institute (EPRI), the National Hydropower Association (NHA), and the Center for Energy Advancement through Innovation (CEATI), on best practices. While BPA has been at the forefront of climate change adaptation, we also learn from others, and consider best practices such as wildfire mitigation as we adapt our operations and business processes to a warming future.

BPA will continue to build on all of the efforts mentioned above with the goal of ensuring the Pacific Northwest federal hydro and transmission systems are resilient to climate change.

Sincerely,

DocuSigned by:

John Hairston

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John Hairston

Administrator and Chief Executive Officer

Accessible Text for Appendix II: Comments from the Bonneville Power Administration

March 3, 2023

In reply refer to: A-7

Mr. Franklin W. Rusco
Director, Natural Resources and Environment
U.S. Government Accountability Office
441 G Street Northwest
Washington, DC 20548

RE: PMA Climate Resilience (GAO-23-106224)

Dear Director Rusco:

Thank you for the opportunity to comment on the report: Power Marketing Administration: Additional Steps Are Needed to Better Manage Climate-Related Risks.

In preparation of this report, we appreciated the opportunity to discuss with the GAO the many actions Bonneville Power Administration (BPA) has taken, and continues to take, to address both emerging and expected climate change impacts. We have reviewed the report and would like to emphasize that BPA takes seriously the impacts that climate change is having on the federal hydropower and transmission systems in the Pacific Northwest, and we are already mitigating for those growing impacts.

For almost 20 years, BPA has tracked both climate trends and the state of climate science as they have evolved, and has worked to respond in a prudent, risk-informed manner. BPA is adapting to not only a warming climate, but also the many climate change scenarios that could play out in the Columbia River Basin specifically. Changes in climate have been observed, are projected to continue, and have implications for many facets of BPA's operations. For example, changes in temperature and streamflow are a risk to our fuel supply (water), and events like wildfire are a risk to our transmission assets.

While the report captures many of the actions BPA has already taken to respond to climate change, we would like to offer some clarifications, and note the progress we have made to manage emerging and expected climate risks:

- As the GAO report notes, BPA continues to work closely with our partners, most notably the U.S. Army Corps of Engineers and Bureau of Reclamation, which comprise the RiverManagement Joint Operating Committee (RMJOC), to study climate change trends and projections. This BPA fact sheet provides an overview of the science and findings from our latest study, and the full reports can be found at Climate Change & FCRPS (bpa.gov). These studies, along with others like the recently published Oak Ridge National Lab technical report for the 9505 SECURE Water Act, are being used to guide our risk-informed decision-making. BPA and its federal partners have made the data from the RMJOC studies widely available to other utilities and planning organizations in the Pacific Northwest region. For example, the Northwest Power and Conservation Council used the data to inform their 2021 Northwest Power Plan.
- BPA has a good understanding of its range of climate related risks and how those risks may differ from other hydropower entities in other parts of the west. As our Pacific Northwest regional climate warms, winter streamflows and hydroelectric power generation are likely to increase in the Columbia Basin, while winter loads slightly decrease. Meanwhile, as the Pacific Northwest region experiences earlier peaks in high-elevation snowmelt, longer periods of already low summer flows are likely to coincide with increasing summer loads.
- BPA convened a Climate Change Risk Management Team in 2012 to evaluate risks across the enterprise. While the GAO report correctly notes this (see table 2, BPA's steps to manage climate change related risks), BPA has now shifted from identifying adaptation work into actual implementation of this work. Ongoing efforts across the agency ensure operations continue to take into account climate change impacts. Climate change planning has evolved into an integral consideration for all BPA operational planning.
- BPA has included climate considerations in its BPA 2022 Wildfire Mitigation Plan. As the climate warms, BPA is planning for both an increasing number and intensity of wildfires. The agency is taking steps to harden its transmission assets and respond quickly when wildfires threaten its system. The plan covers end-to-end activities related to the mitigation of wildfires across the Federal Columbia River Transmission System. The scope of the plan includes vegetation and asset management programs, including: Operations and maintenance, replacement, disposal, and response and recovery.
- BPA responded to emerging streamflow signals in 2022 by working closely with our utility customers to adapt our rate case and longer-term hydropower planning processes. We are now using a shorter "period of record" for streamflow that

better captures increasing and decreasing streamflows and generation in both winter, early spring and summer.

- BPA has updated the historical temperatures used for load forecasting to better align with emerging climate changes. Accordingly, load forecasting moved from a 35-year historical period (1970-2004) to a 15-year historical period (2005-2019) and due to a changing climate, we intend to update the period of record more frequently (about once every 5 years). Since September 2020, all long-term load forecasts have used this 15-year period of record.
- Evolving regional energy markets and resource adequacy programs could help BPA tap into a more diverse pool of power resources, helping address the climate change risks BPA may face in meeting load obligations. This is one of the many reasons BPA joined the Western Energy Imbalance Market in spring 2022. The agency also participates in the development of day ahead markets in the West, and joined as a non-binding participant the Western Resource Adequacy Program with binding participation starting in winter 2027-2028.
- BPA also continues to collaborate with other hydropower utilities, not only regionally but also across North America through organizations such as the Electrical Power Research Institute (EPRI), the National Hydropower Association (NHA), and the Center for Energy Advancement through Innovation (CEATI), on best practices. While BPA has been at the forefront of climate change adaptation, we also learn from others, and consider best practices such as wildfire mitigation as we adapt our operations and business processes to a warming future.

BPA will continue to build on all of the efforts mentioned above with the goal of ensuring the Pacific Northwest federal hydro and transmission systems are resilient to climate change.

Sincerely,

John Hairston
Administrator and Chief Executive Officer

Appendix III: GAO Contact and Staff Acknowledgments

GAO Contact

Frank Rusco, (202) 512-3841 or ruscof@gao.gov.

Staff Acknowledgments

In addition to the contact named above, the following individuals made key contributions to this report: Janice Ceperich (Assistant Director), Celia Rosario Mendive (Analyst in Charge), Will Horowitz, and Anne Kolesnikoff. Also contributing to this report were Ben Atwater, Alicia Puente Cackley, Miriam Carroll Fenton, Nirmal Chaudhary, John Delicath, Philip Farah, William Gerard, Cindy Gilbert, Paige Gilbreath, Lijia Guo, Susan Irving, Rona Mendelsohn, Dan C. Royer, and Joe Thompson.

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