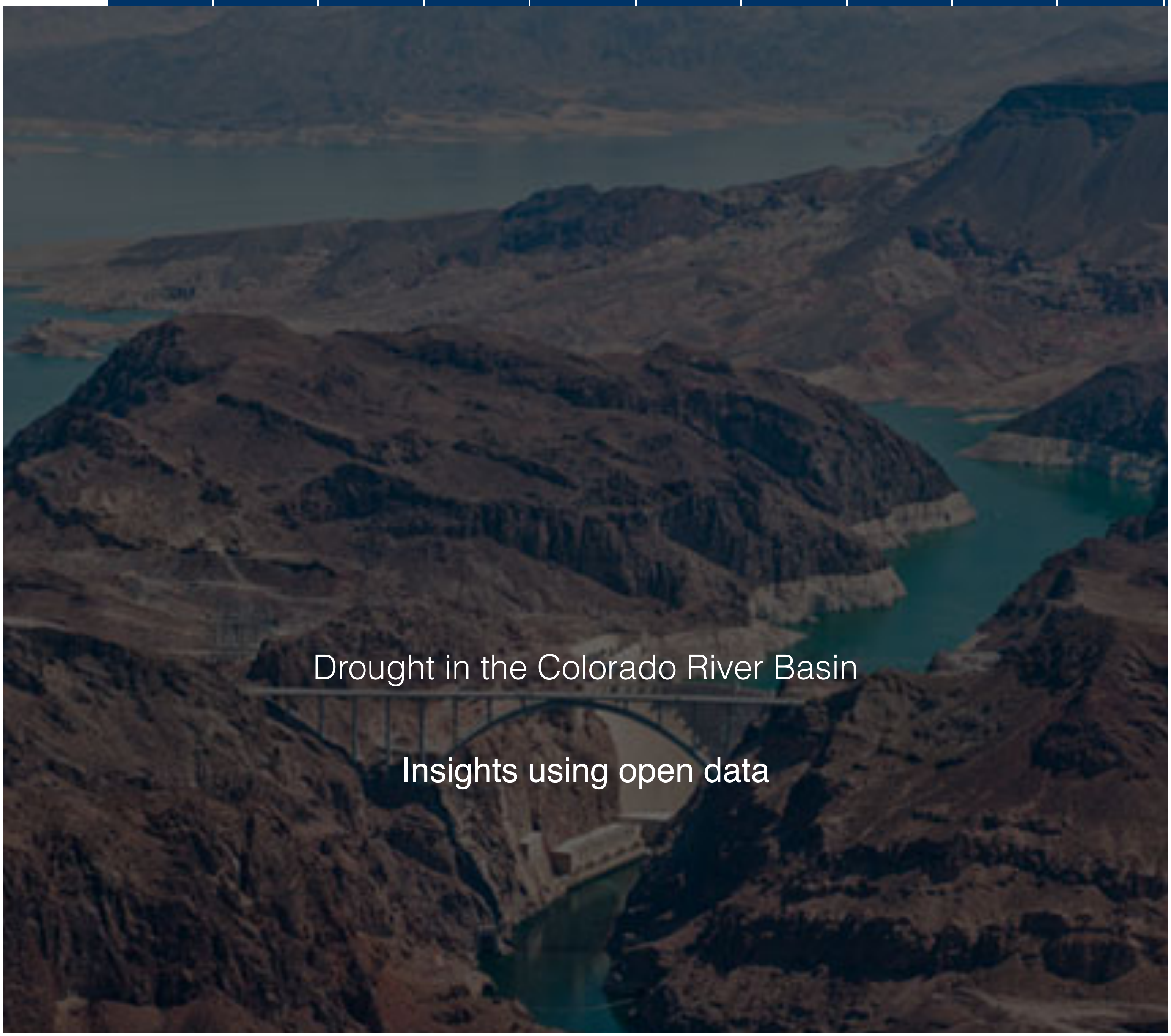
U.S. Department of the Interior



Drought in the Colorado River Basin

Insights using open data

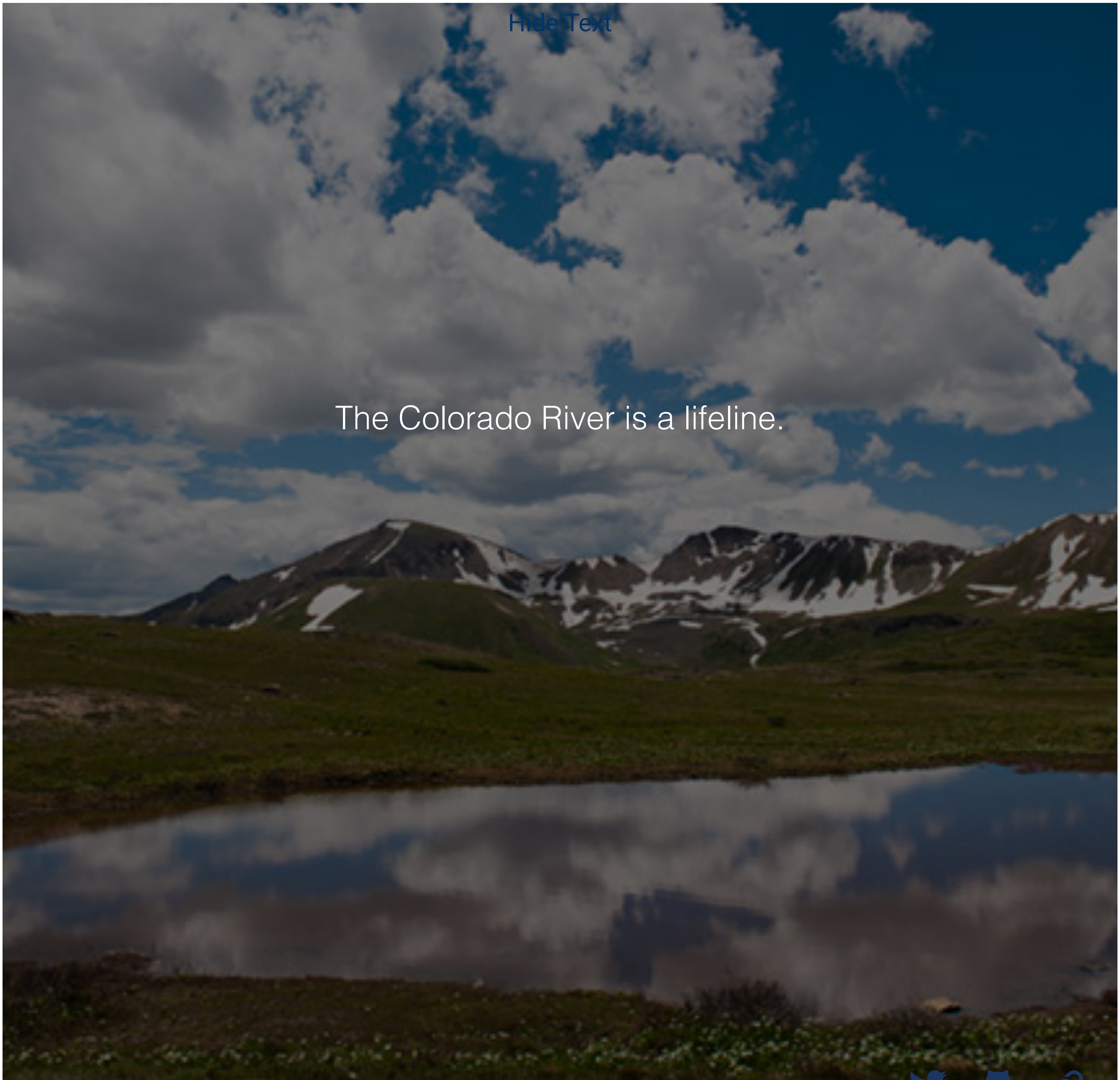
Since 2000, the Colorado River Basin (Basin) has been experiencing a historic, extended drought that has impacted regional water supply and other resources, such as hydropower, recreation, and ecologic services. During this time, the Basin has experienced its lowest 16-year period of inflow in over 100 years of record keeping, and reservoir storage in the Colorado River system has declined from nearly full to about half of capacity.

This application was developed by the U.S. Geological Survey and the Bureau of Reclamation in support of the Department of the Interior's **Open Water Data Initiative** (OWDI). This visualization is part of a multi-agency effort to showcase the usefulness of open data (i.e., data provided in a discoverable, sharable, and machine-readable format) by exploring the current 16-year drought and its effects on the Colorado River Basin.

Concern is growing about the impacts of the ongoing drought and declining reservoir levels, such as decreasing water supply and the possibility of a first-ever shortage condition of drinking water for the Lower Basin; decreasing hydropower capacities at Lake Powell and Lake Mead; the potential for loss of hydroelectric generation at Lake Powell; reduced recreational opportunities; and changes to in-stream flows that support ecosystems.

In response to drought conditions, Federal agencies and stakeholders throughout the Basin have been working together to find creative ways to reduce the effects of the drought on the people and resources that rely on water from the Colorado River.

Scroll down to learn more about the importance of the Colorado River, the impacts of the current drought, and the ways in which the drought is being managed in the Basin.



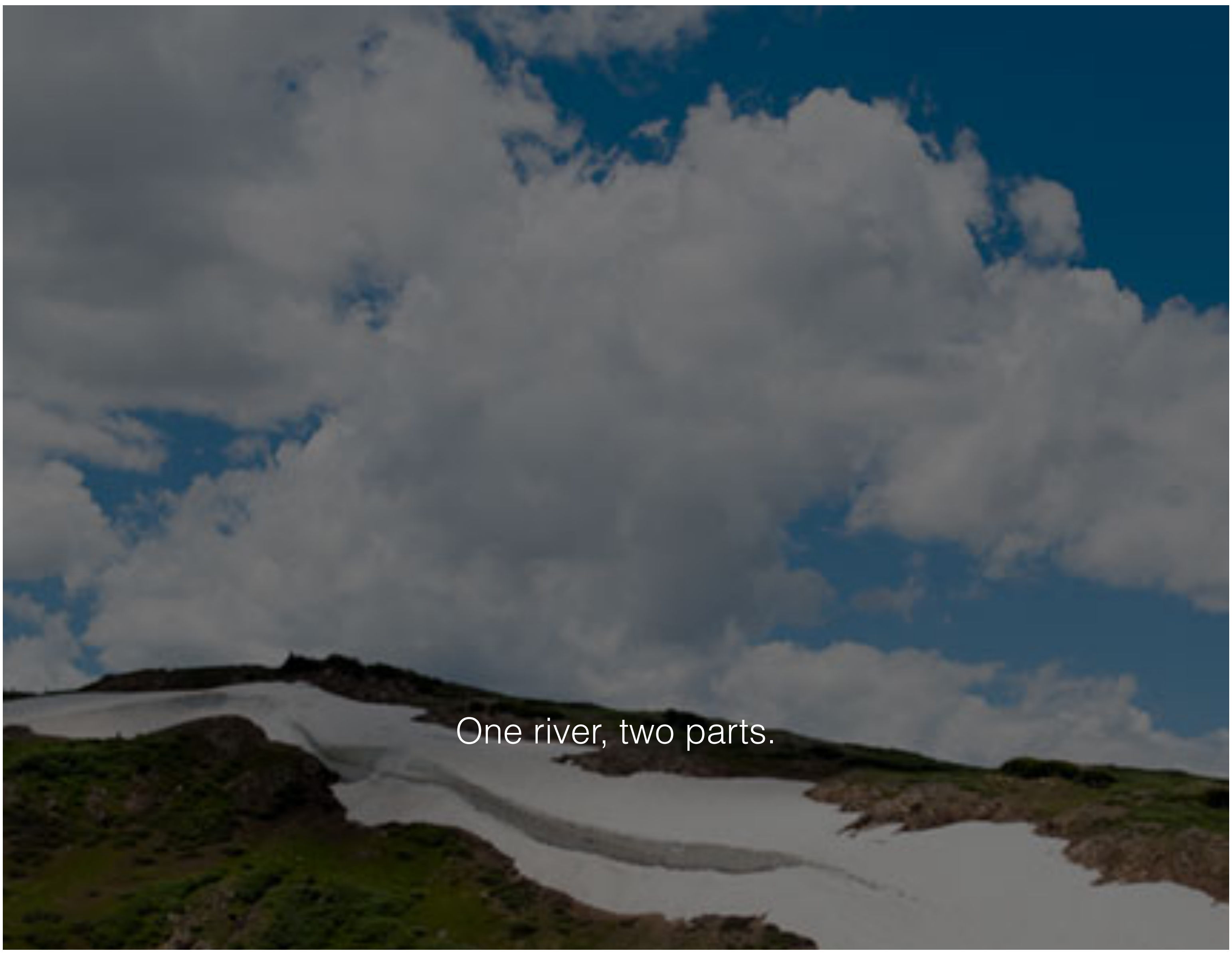
Water from the Colorado River is essential for life in parts of the southwestern United States and northwestern Mexico. According to the Colorado River Basin Water Supply and Demand Study (2012), the Colorado River and its tributaries:

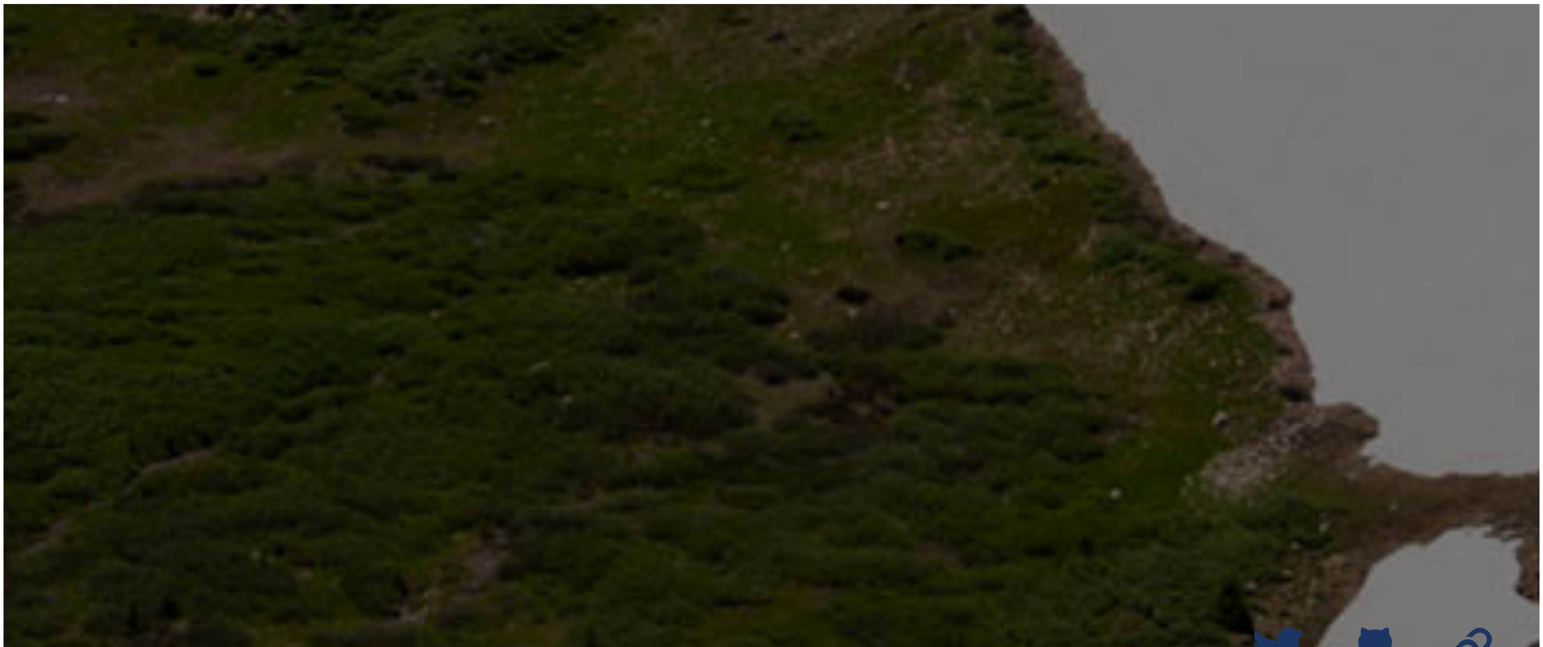
- Supply more than 1 in 10 Americans with some, if not all, of their water for municipal use, including drinking water.

- Provide irrigation water to more than 5.5 million acres (approximately 8,590 square miles) of land.
- Are essential as a physical, economic and cultural resource to at least **22 federally recognized Tribes**.
- Support 4,200 megawatts of electrical generating capacity, providing power to hundreds of local areas and millions of people.
- Are directly linked to nine **National Park Service** units and seven **National Wildlife Refuges**, supporting over $1 billion in tourism revenue associated with outdoor recreation and wildlife.
- Provide habitat for a wide range of species, including **threatened and endangered** species, as well as other species of wildlife and vegetation.

Bureau of Reclamation, 2012. **Colorado River Basin Water Supply and Demand Study**.




One river, two parts.



Approximately 1,400 miles long and flowing through seven U.S. States and into Mexico, the Colorado River drains roughly one-twelfth of the land area of the contiguous United States. The Colorado River Basin is divided into the Upper and Lower Basins at the Lee Ferry **Colorado River Compact** Point (Compact Point) located in northern Arizona. The Upper Basin spans portions of Wyoming, Colorado, New Mexico, Utah, and northern Arizona. The Lower Basin covers parts of Nevada, Arizona, California, southwestern Utah, and western New Mexico. The Colorado River also supplies water to parts of the states of Baja California and Sonora in northwestern Mexico.

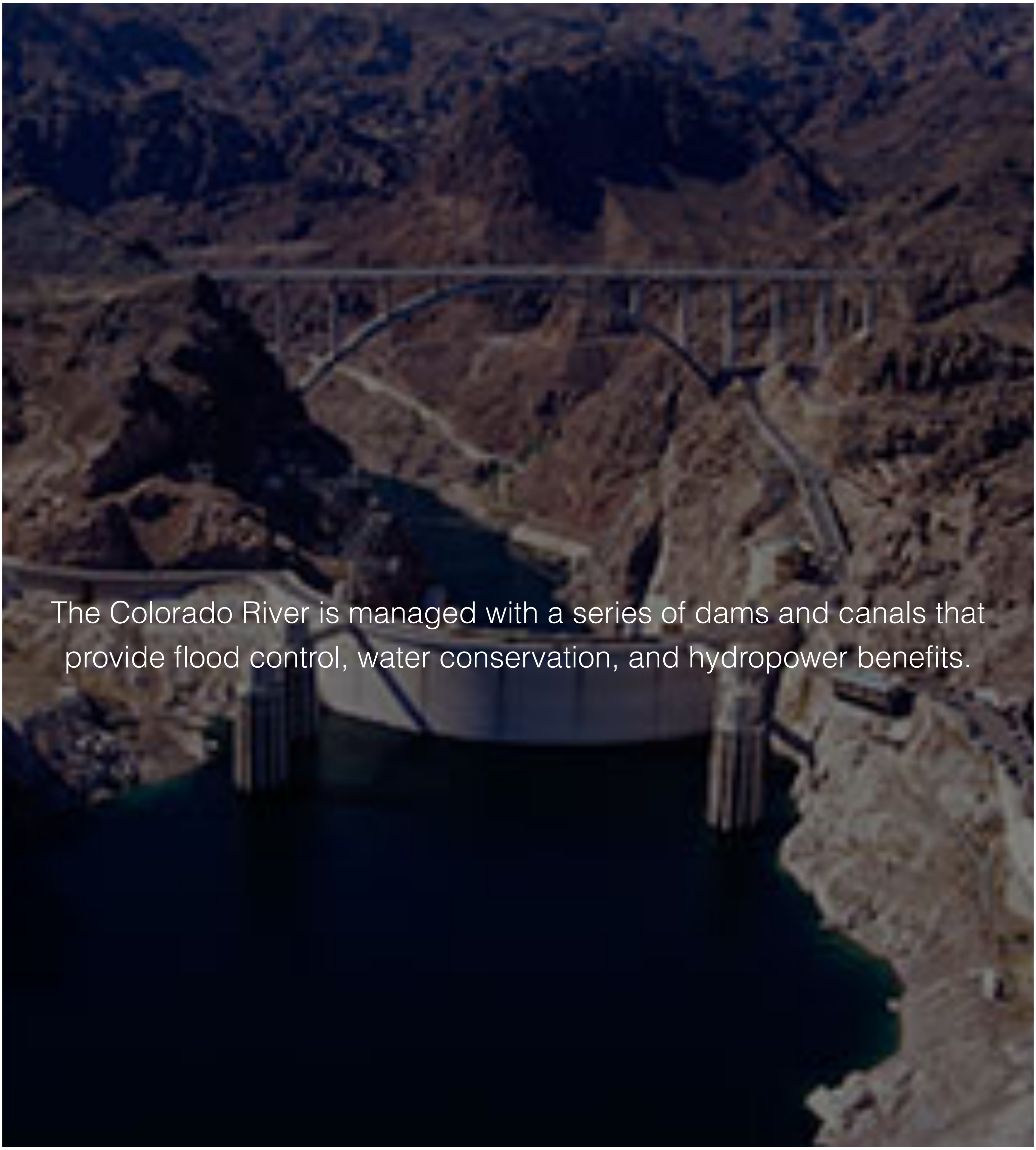
The Upper Colorado River Basin supplies approximately 90 percent of the water for the entire Basin. This water originates as precipitation and snowmelt in the Rocky and Wasatch Mountains. About 50 percent of streamflow comes from baseflow, which is surface water that percolates into groundwater aquifers and then resurfaces as streamflow (**Rumsey et al., 2015**). The Lower Basin is arid, with little tributary runoff reaching the mainstream of the Colorado River except during occasional rain events.

Read More >>

Rumsey, C.A., et al. 2015. "**Regional scale estimates of baseflow and factors influencing baseflow in the Upper Colorado River Basin**." Journal of Hydrology: Regional Studies 4: 91-107.

Learn about the Colorado River Basin's network of reservoirs, water delivery infrastructure, and water delivery service areas.

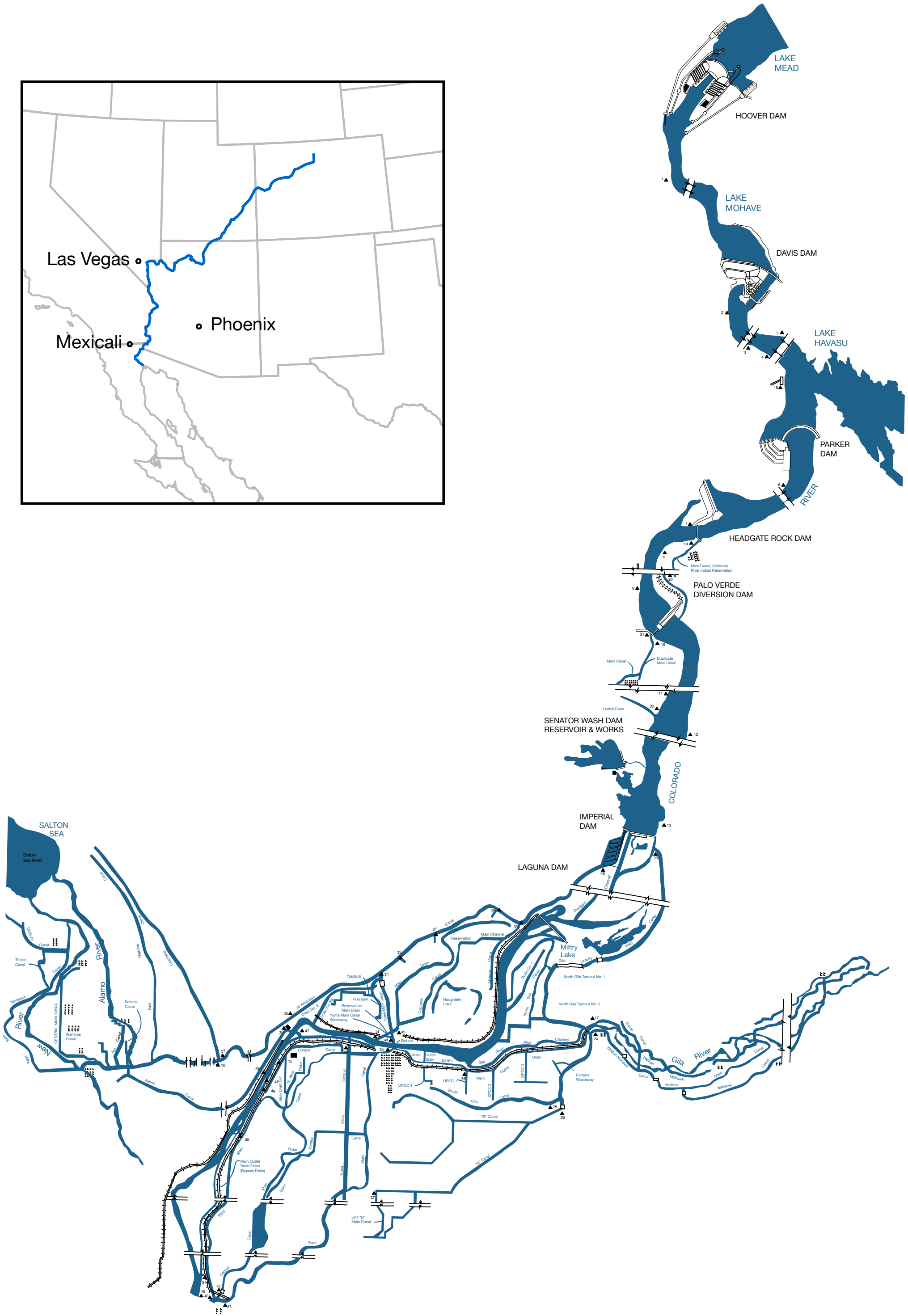
Explore


The Colorado River is managed with a series of dams and canals that provide flood control, water conservation, and hydropower benefits.

The dams and canals in the Colorado River system provide storage for regional water supply, facilitate water deliveries, provide flood control benefits, improve navigation, and generate hydroelectric power. These facilities are operated in coordination with adjacent or nearby water delivery systems that also provide a variety of other economic, cultural, and ecologic benefits.

Read More >>

Hover over sections of the diagram below to get additional information

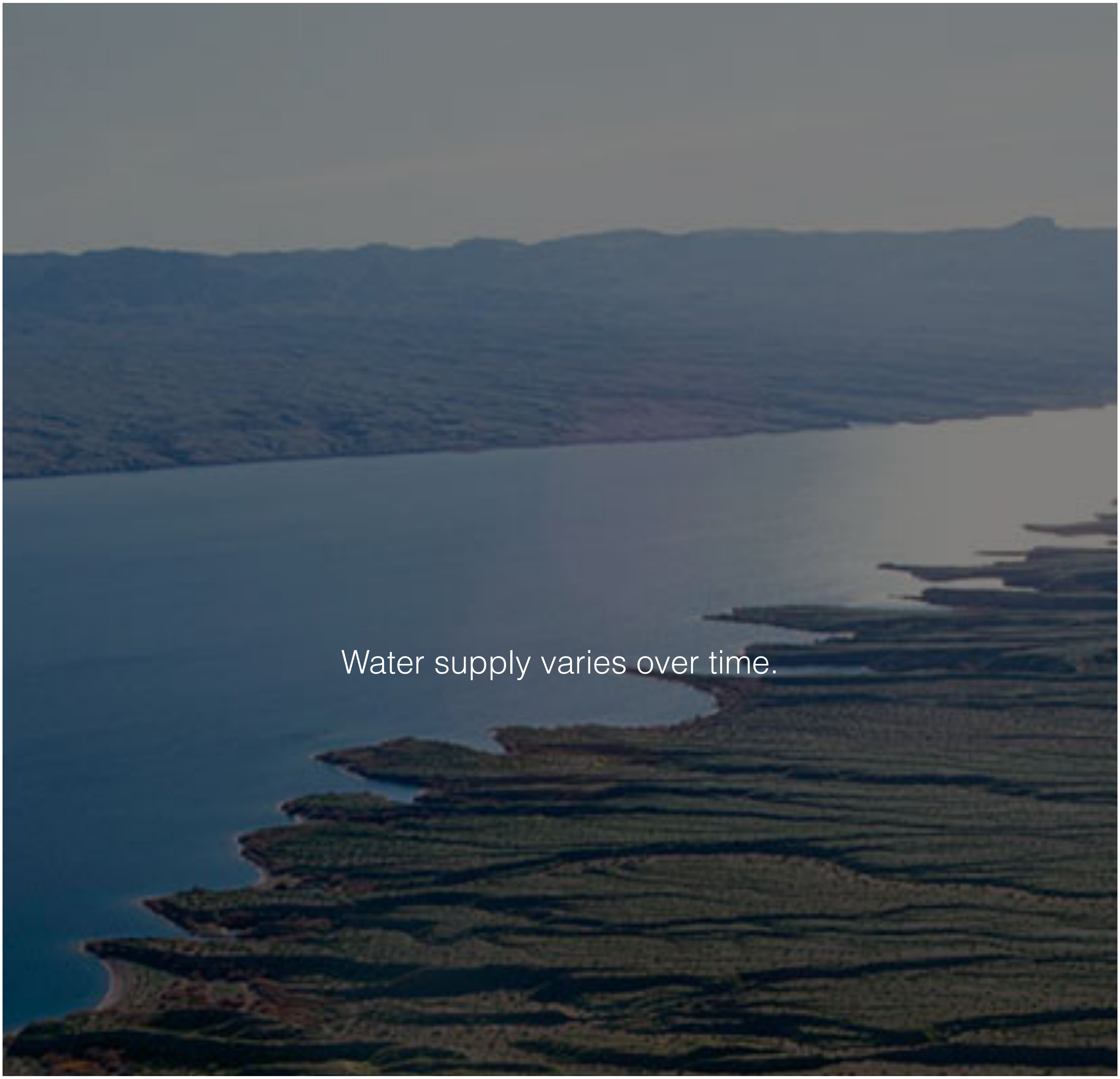


The diagram above depicts the major dams, reservoirs, and control structures of the Lower Colorado River.

Click here for a PDF version of the Operational Diagram.

View real-time data and take a journey through major dams on the Lower Colorado River.

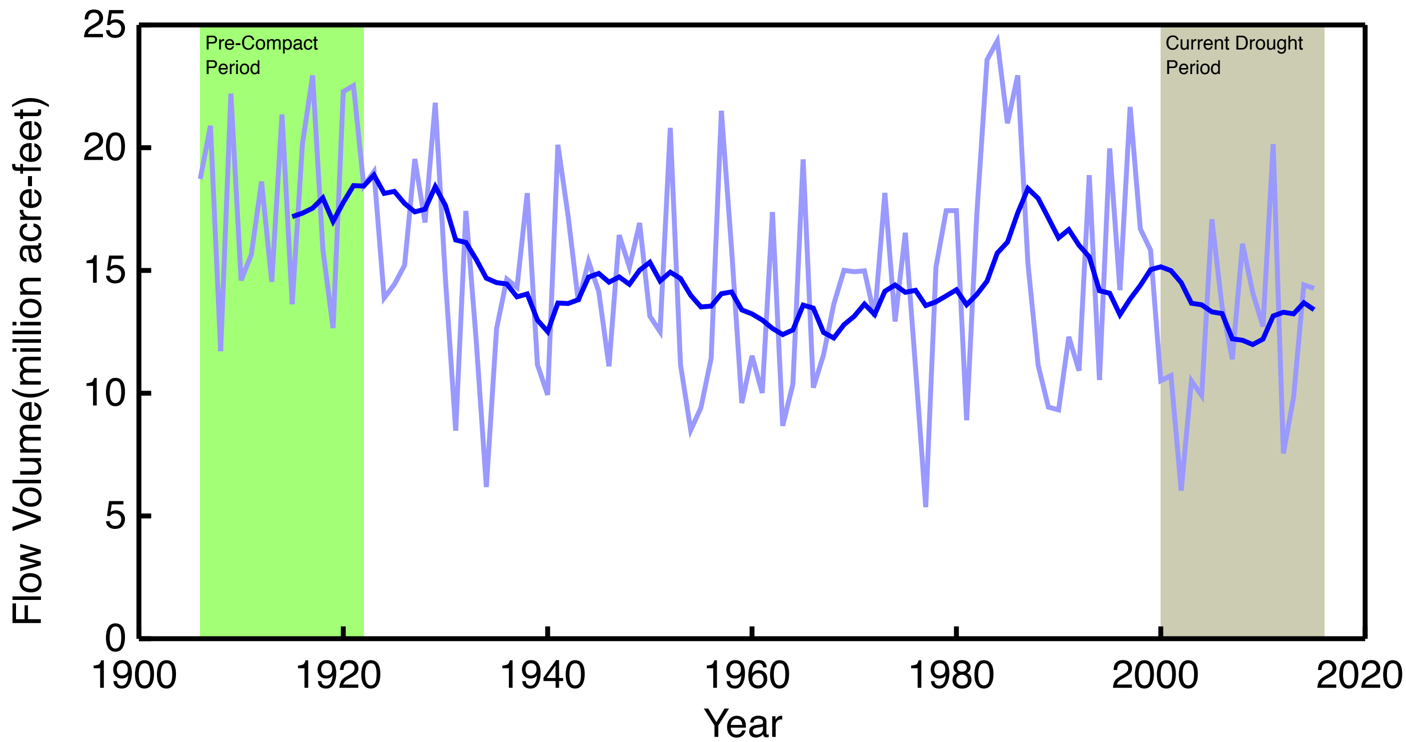
Explore



Due to year-to-year differences in precipitation and snowmelt, the natural water supply of the Basin is highly variable. Long-term drought like the Basin has experienced since 2000 reflects natural climate variability coupled with the likely impacts from **changing climate**. Since most of the Basin's water supply comes from the Upper Basin, drought conditions in the Upper Basin impact water supply and resources in both the Upper and Lower Basins of the Colorado River.

The U.S. Geological Survey (USGS) stream gage at Lees Ferry, Arizona, is the lowermost mainstream gage in the Upper Basin, located about 12 miles downstream of Glen Canyon Dam and about 1 mile upstream of the Compact Point between the Upper and Lower Basins. Natural flow at this stream gage location is used as a proxy for the hydrologic conditions in the Upper Basin and the overall hydrologic health of the Basin. Natural flow is defined as the streamflow that would have otherwise occurred without the effects of human activities such as reservoir regulation and river diversions.

Hover over sections of the graph below to take a closer look



In the graphic above, the 10-year average **natural flow** at Lees Ferry shows periods of below and above average annual flow (approximately 14.8 million acre-feet [maf]). The most recent drought for the 2000-2015 period (indicated by the brown shaded area) was the driest 16-year period in the past 100 years and one of the driest 16-year periods in the past 1,200 years. The graphic also depicts how the early part of the 1900s, which corresponds to the period of reference used to set the apportionments for the Upper and Lower Basins in the 1922 **Colorado River Compact**, was an unusually wet period (indicated by the green shaded area). At the time the 1922 Colorado River Compact was signed, the average annual inflow at Lees Ferry during the pre-Compact period (1906-1921) was approximately 18.0 maf.

USGS observations of the Colorado River at Lees Ferry (**USGS site 09380000**) have been recorded since 1895. For more information and data on this site, visit the U.S. Geological Survey **National Water Information System Lees Ferry stream gage website**. Real-time gage height, discharge, water temperature, sediment, and water-quality properties can be accessed from the U.S. Geological Survey **Grand Canyon Monitoring and Research Center website**.

The Lees Ferry gage is distinct from the Lee Ferry Compact Point: Lees Ferry refers to the **USGS-operated stream gage** located near the town of Lees Ferry, Arizona; whereas Lee Ferry refers to the Colorado River Compact Point, as referenced in the 1922 **Colorado River Compact**. The Lee Ferry Compact Point is located 1 mile downstream of the Lees Ferry gage.

Historical observations are extended by a **tree-ring reconstruction** of streamflow going back approximately 1,200 years, as estimated by Meko et al. (2007a). Because trees grow less during dry years and more during wet years, tree-ring cores can be used to estimate historical streamflow conditions going back many centuries. Tree-ring core samples were collected from locations throughout the Upper Basin to estimate historical natural flow. These estimates were validated using the observed natural flow record developed by the Bureau of Reclamation.

Explore more about reconstructed natural flow based on tree-ring data.

Explore

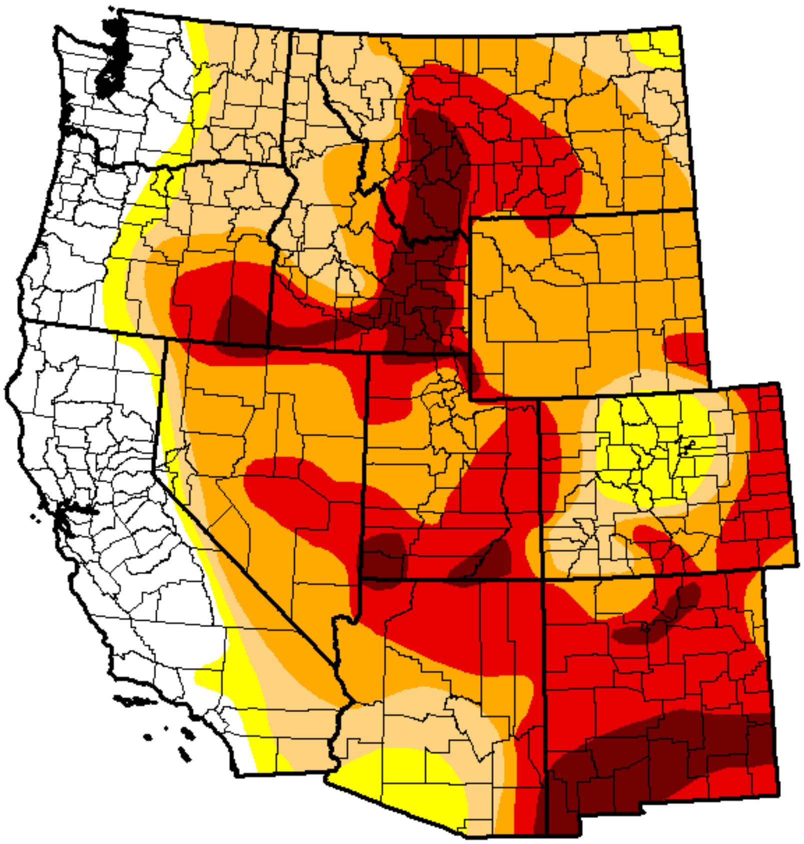
1922 Colorado River Compact.
Bureau of Reclamation. 1922. **Minutes of the 19th meeting of the Colorado River Commission**.
Bureau of Reclamation, 2015. **Natural Flow and Salt Data**.
Bureau of Reclamation, 2012. **Colorado River Basin Water Supply and Demand Study**.
Meko, D.M., C.A. Woodhouse, C.H. Baisan, T. Knight, J.J. Lukas, M.K. Hughes, and M.W. Salzer, 2007. **Medieval drought in the upper Colorado River Basin**. Geophysical Research Letters, Vol. 34, L10705.
Lab of Tree-Ring Research

Since 2000, the Colorado River Basin has experienced the driest 16-year period in over 100 years of historical natural flows (Bureau of Reclamation, 2015). This period also ranks as the fifth driest 16-year period in the last 1,200 years (Meko et al., 2007a and 2007b).

While the current drought is severe and historic, the most extreme drought in the Colorado River Basin occurred in the mid-1100s (Meko et al. 2007a). The 1100s drought was characterized by a 25-year period of flows that were 15% lower than the long-term average of 14.8 maf and no higher-flow years (greater than 125% of average) for six decades. By comparison, the current drought is characterized by flows that are 16% lower than the long-term average with one year of higher flows (135% percent of average in 2011).

U.S. Drought Monitor
West

January 6, 2004
(Released Thursday, Jan. 8, 2004)
Valid 7 a.m. EST



Drought Conditions (Percent Area)

	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	15.12	84.88	77.67	61.67	32.85	8.69
Last Week 12/30/2003	14.51	85.49	78.10	64.14	32.80	8.62
3 Months Ago 10/7/2003	9.11	90.89	84.12	66.52	38.68	5.25
Start of Calendar Year 12/30/2003	14.51	85.49	78.10	64.14	32.80	8.62
Start of Water Year 9/30/2003	9.28	90.72	82.26	64.88	39.35	5.31
One Year Ago 1/7/2003	38.64	61.36	29.93	9.12	2.22	0.00

Intensity:

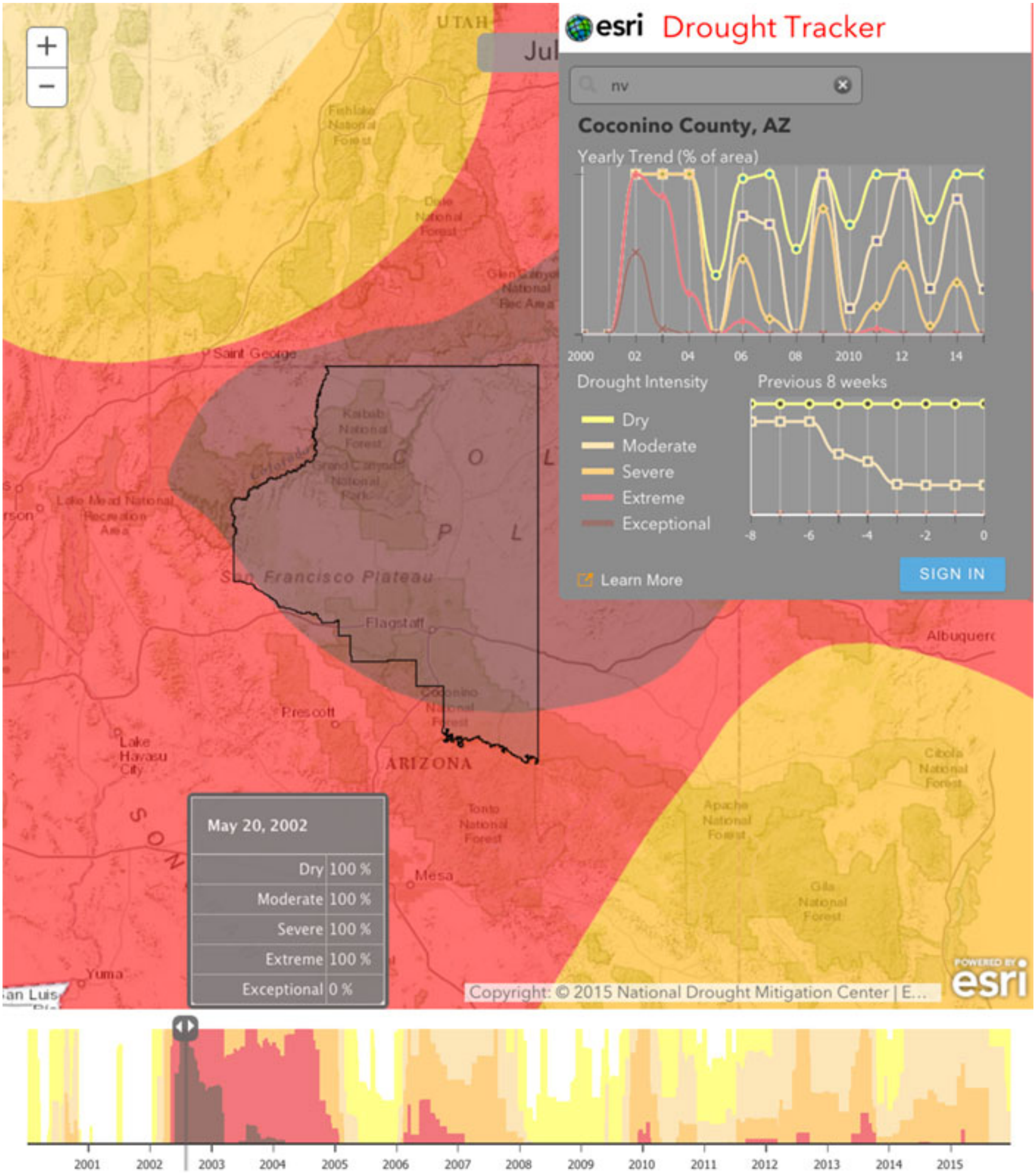
- D0 Abnormally Dry
- D1 Moderate Drought
- D2 Severe Drought
- D3 Extreme Drought
- D4 Exceptional Drought

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

Author:
Richard Tinker
CPC/NOAA/NWS/NCEP

http://droughtmonitor.unl.edu/

The **U.S. Drought Monitor** shows the extent and intensity of drought conditions in the Western U.S. from 2000 to 2015. The **Esri Drought Tracker** provides a means to view drought conditions in the U.S. over time, using data from the U.S. Drought Monitor.



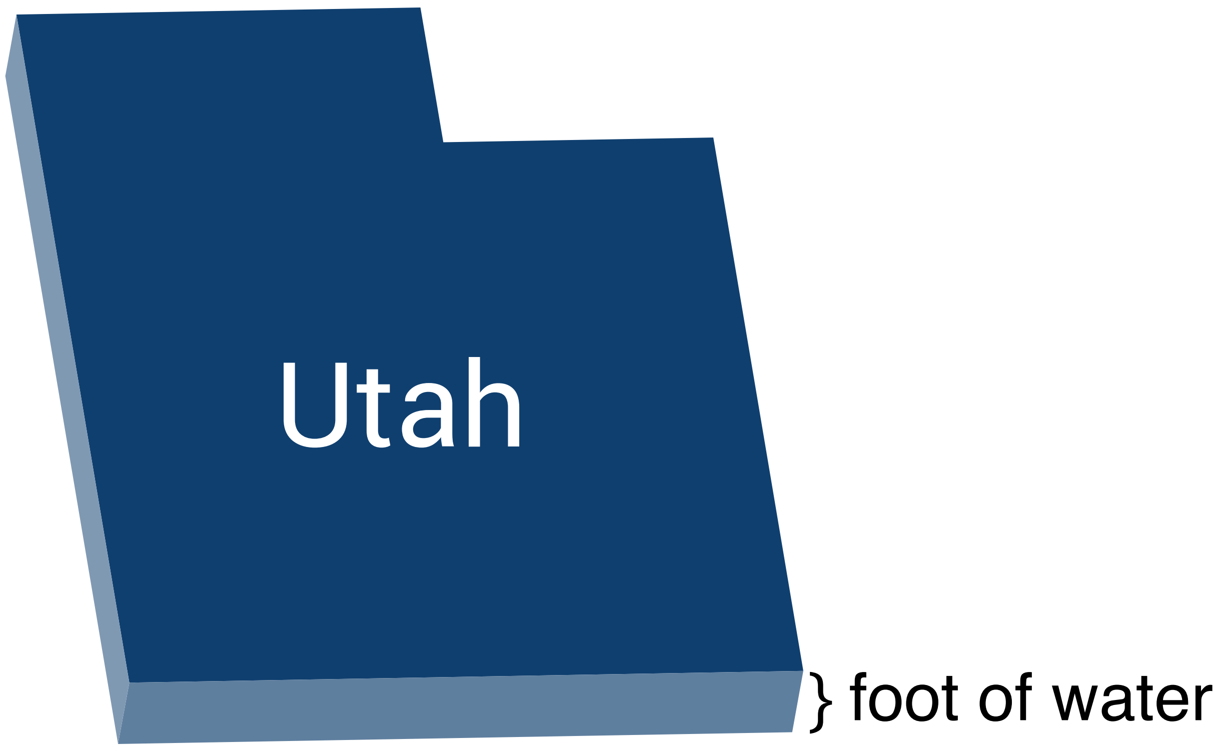
View more information about drought in the U.S. and Colorado River Basin.

Explore

Bureau of Reclamation, 2015. **Colorado River Basin Natural Flow and Salt Data website**.
Meko, D.M., et al. 2007a. **Upper Colorado River Flow Reconstruction**. IGBP PAGES/World Data Center for Paleoclimatology. Data Contribution Series # 2007-052. NOAA/NCDC Paleoclimatology Program, Boulder CO, USA.
Meko, D.M., C.A. Woodhouse, C.H. Baisan, T. Knight, J.J. Lukas, M.K. Hughes, and M.W. Salzer. 2007b. **Medieval drought in the upper Colorado River Basin**. Geophysical Research Letters, Vol. 34, L10705.

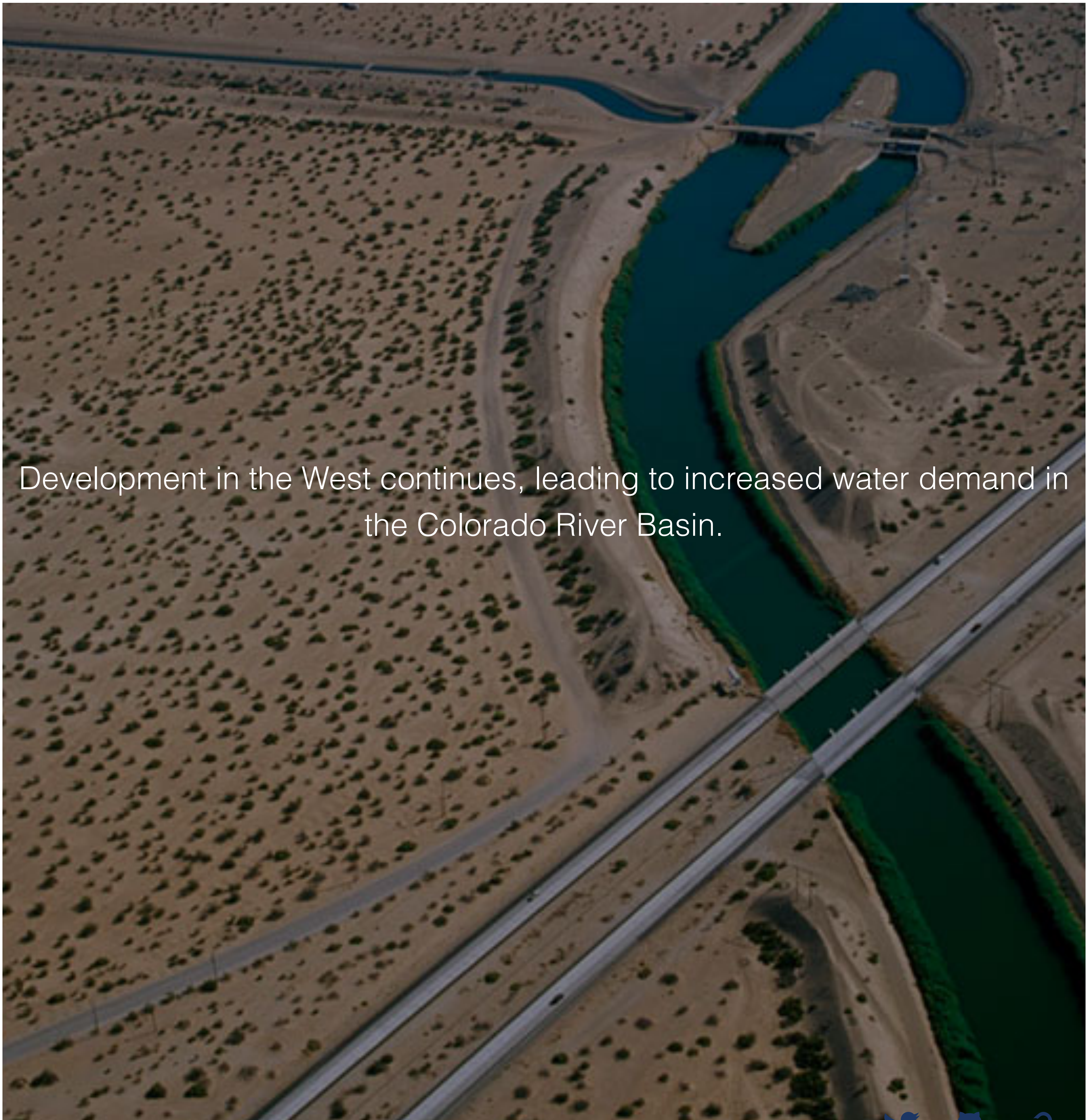
The basin-wide storage capacity of the Colorado River totals about 60 million acre-feet (maf), approximately four times the average annual inflow in the Upper Basin (14.8 maf). The Basin's two largest reservoirs, Lake Powell and Lake Mead hold about 50 maf combined, which is approximately 83 percent of the total system storage capacity. This large storage capacity creates a buffer against year-to-year hydrologic variability and longer-term drought periods by allowing excess water to be stored during wet years and used during dry years.

It is this large amount of basin-wide storage capacity that has allowed the Bureau of Reclamation to continue to meet water delivery requirements during the current drought period. It should be noted, however, that headwater reaches in the Upper Basin can experience localized shortages due to insufficient in-stream flows during dry years.



The volume of water that can be stored in the Colorado River system reservoirs (60 million acre-feet) is enough to cover the State of Utah in about 1 foot of water. Dimensions shown above are not to scale.

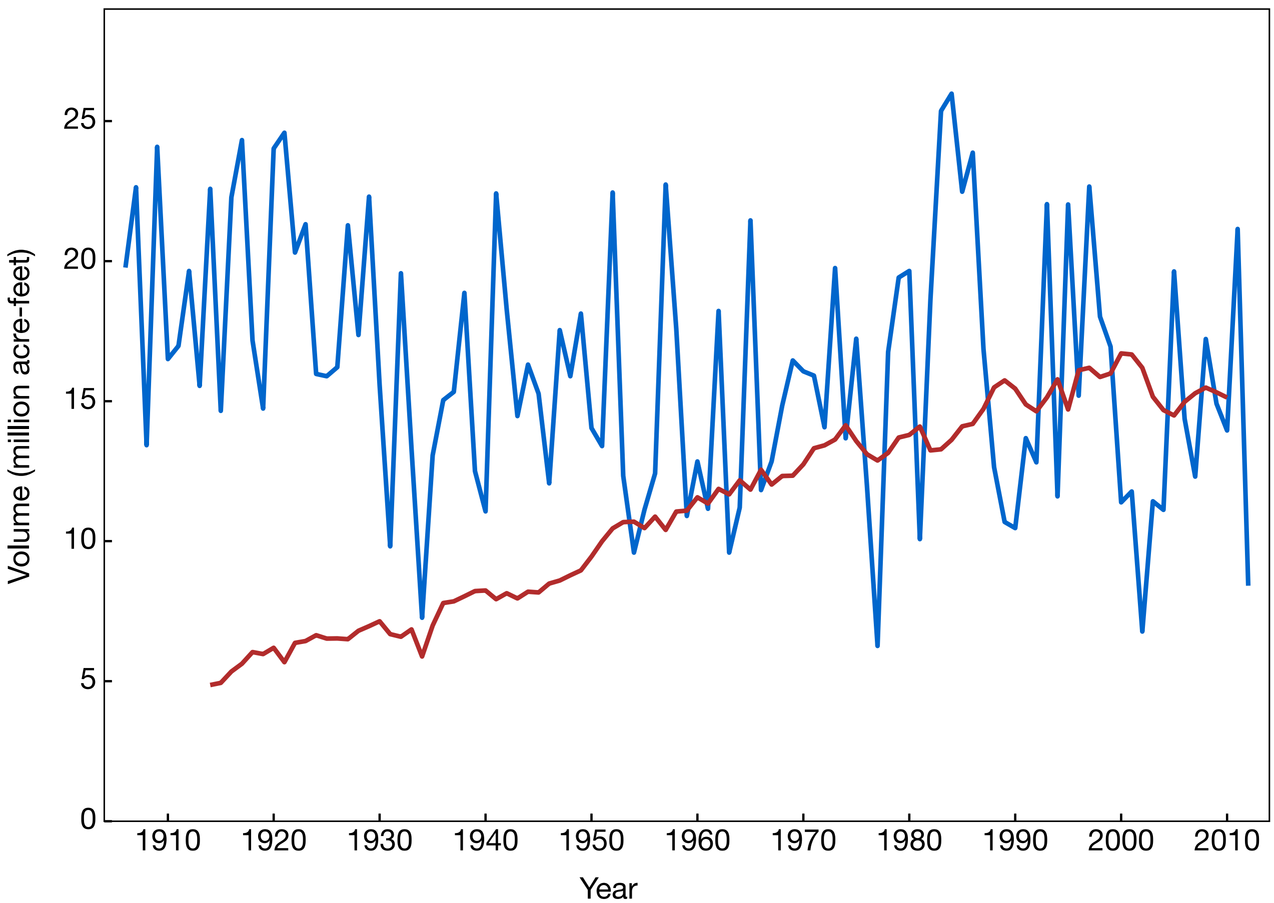
Bureau of Reclamation. Colorado River Basin Supply and Demand Study, 2012.



Since the early 1900s, water demand in the Colorado River Basin has increased while water supply has, on average, decreased. For the 16-year period preceding the signing of the 1922 **Colorado River Compact**, when the beneficial consumptive use of 7.5 million acre-feet (maf) per year was apportioned to both the Upper and Lower Basins, the average annual natural flow in the Upper Basin was about 18.0 maf (1906-1921). When the 1944 U.S.-Mexico Water Treaty was executed, the average annual natural flow in the Upper Basin was about 16.3 maf (1906-1944). The current average annual natural flow in the Upper Basin is about 14.8 maf (1906-2015).

Read More >>

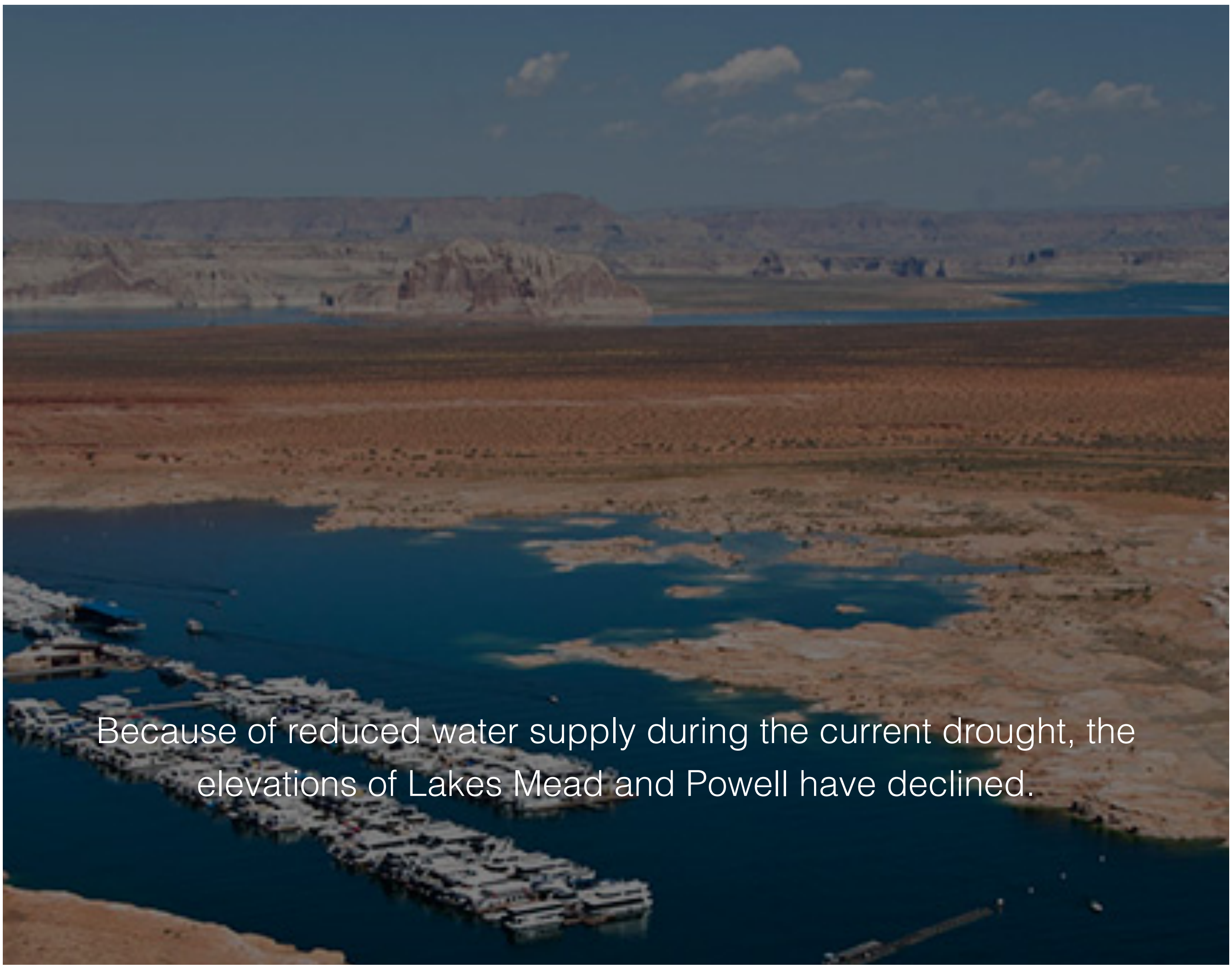
Hover over sections of the graph below to take a closer look



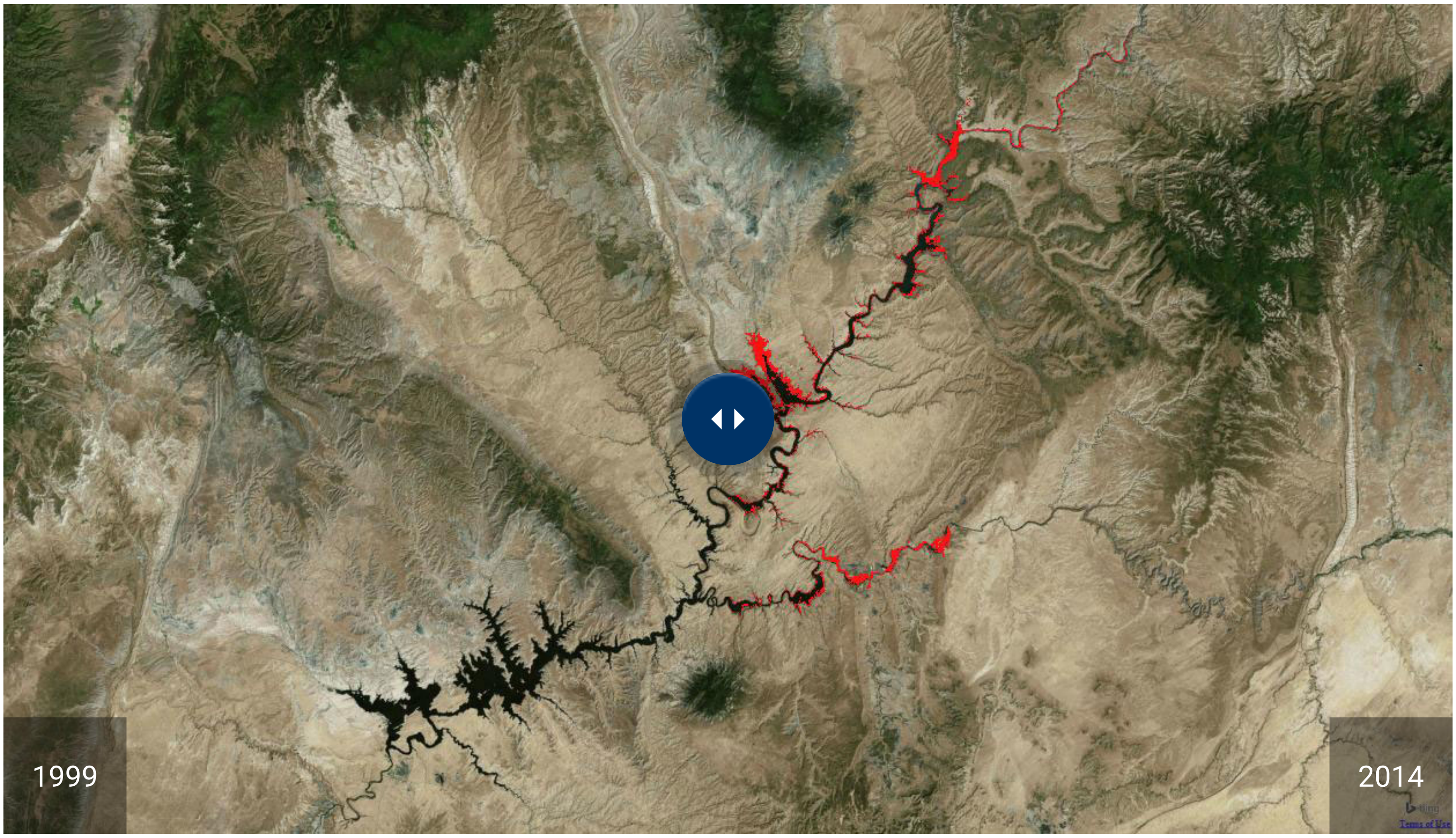
Trends in water supply and water use in the Colorado River Basin are shown above. When water use (red line) exceeds water supply (blue line) in a given year, the amount of water stored is reduced. During the past 20 years, average water supply and average water use have been about equal. Under these conditions, reservoirs are replenished more slowly. Water-supply and water-use data shown in the graphic above are estimated by the Bureau of Reclamation using water accounting information, U.S. Geological Survey **stream gage data**, and other sources.

In this graphic, water use is shown as “consumptive use” (surface-water diversions and groundwater pumping minus measured and unmeasured return flows) as estimated by the Bureau of Reclamation in its **annual water accounting reports**. Other estimates of water use that account for withdrawals of surface and groundwater and incorporate water that is used and returned to the stream, are made by the USGS.

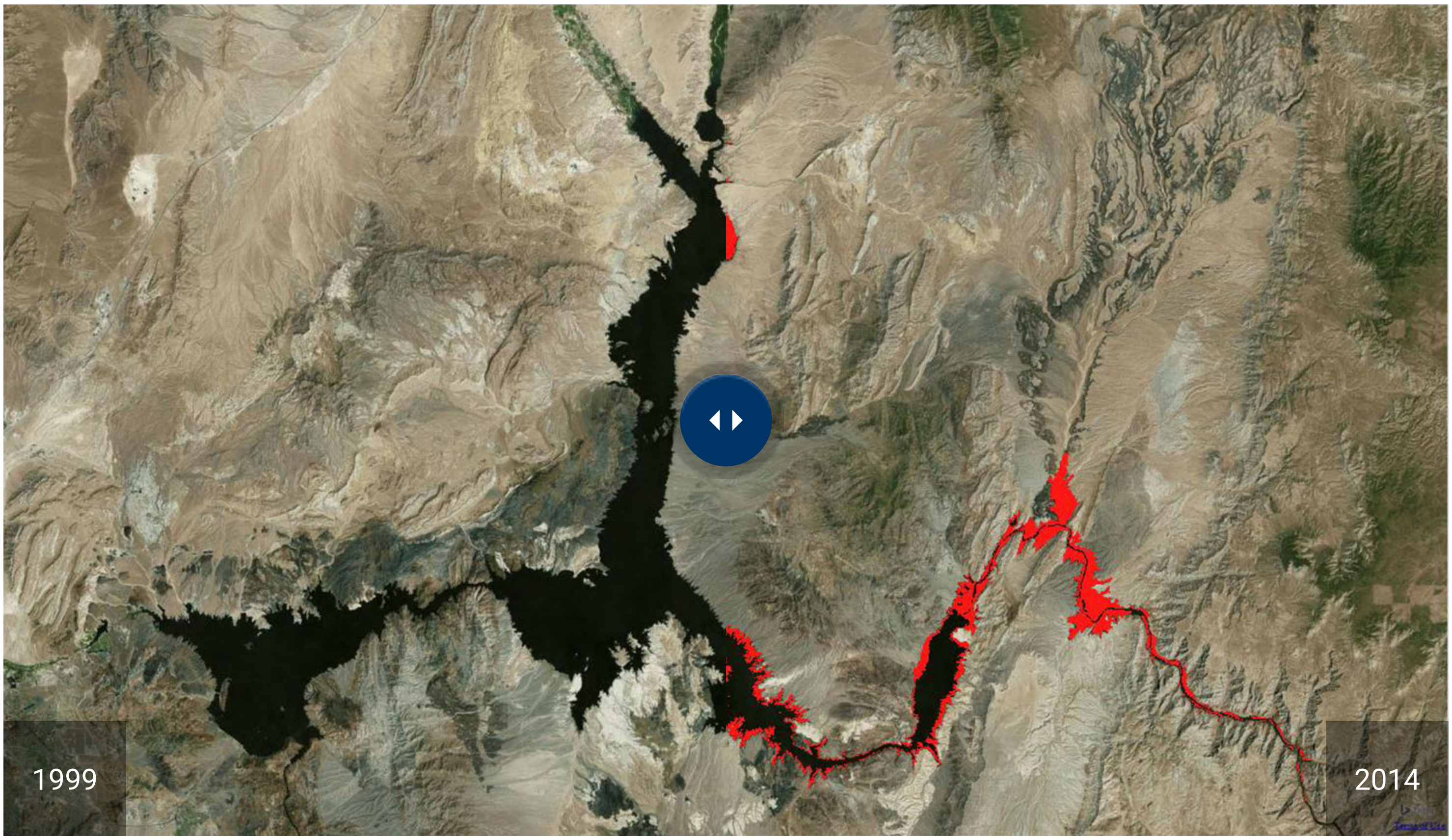
Bureau of Reclamation. 2012. **Colorado River Basin Water Supply and Demand Study**. Access current reservoir conditions in the **Upper Basin** and **Lower Basin**.



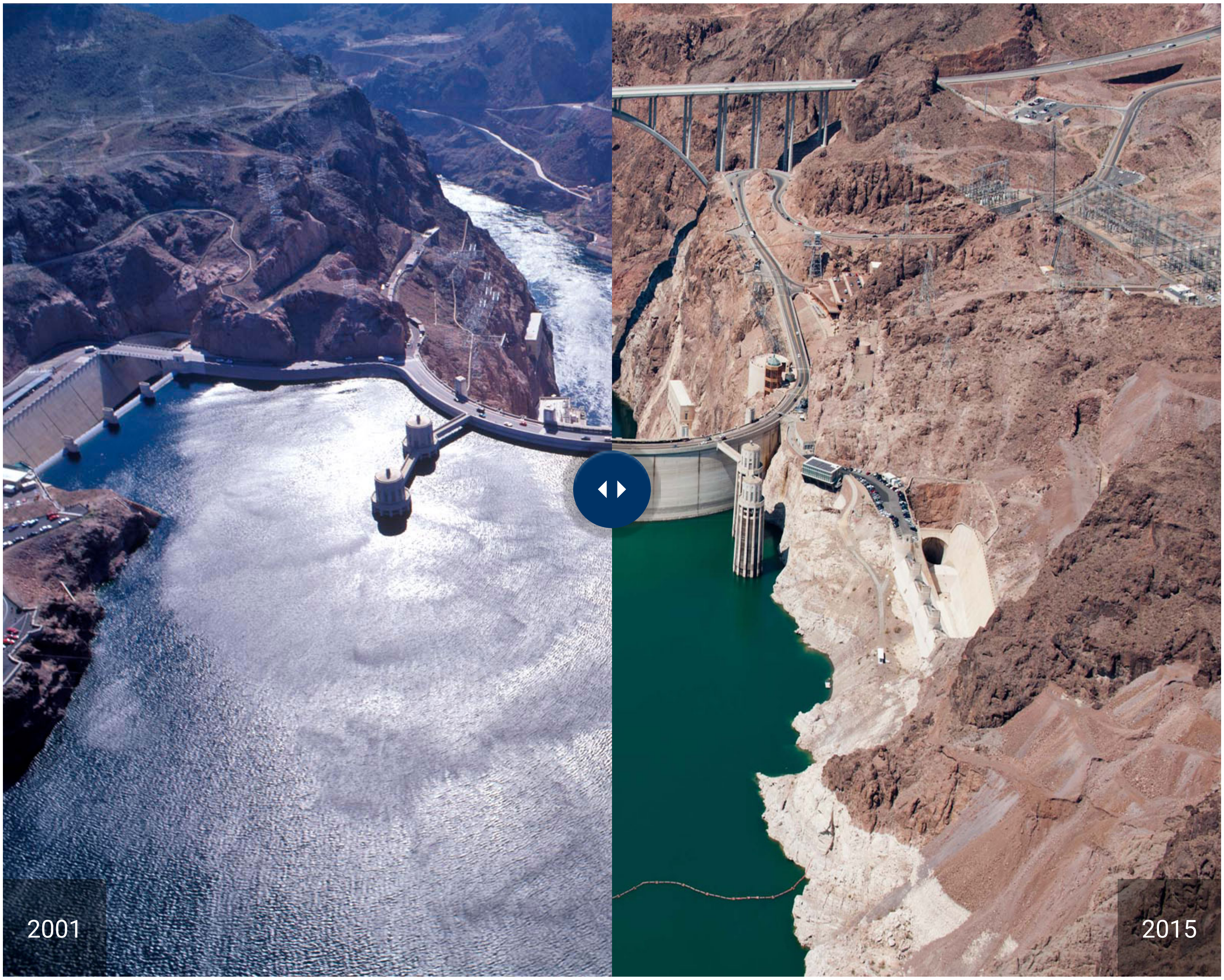
As the reservoir levels of Lake Mead and Lake Powell decline, other resources, such as hydropower, recreation, and water quality, are also affected.

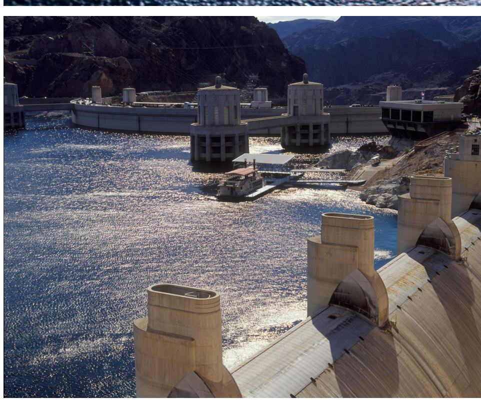


In the photo slider above, the change in the surface area of Lake Powell can be seen from the pre-drought conditions in 1999 to the current drought conditions as of 2014. The red area that emerges represents the loss in the reservoir's surface area as lake elevations have declined. These maps are based on U.S. Geological Survey **Landsat satellite** surface reflectance-corrected images acquired in the month of June in 1999 and 2014. Landsat images acquired within 16 days of each other have been merged together to generate cloud-free composite satellite images suitable for measurement and change comparison.



In the photo slider above, the change in the surface area of Lake Mead can be seen from the pre-drought conditions in 1999 to the current drought conditions as of 2014. The red area that emerges represents the loss in the reservoir's surface area as lake elevations have declined. These maps were prepared using the U.S. Geological Survey **Landsat satellite** data as described in the Lake Powell caption above.





Between 2001 and 2015, Lake Mead's elevation dropped from 1,196 to 1,075 feet, a decline of 121 feet. Move the slider on the upper photo to see the decline in the reservoir elevation during this time. The decline in water elevation has exposed a white band of mineralized rock around the shoreline. The declining reservoir level has also exposed portions of Hoover Dam's four intake towers, two on the right side and two on the left side. These intake towers channel water from Lake Mead into penstocks that serve Hoover Dam's 17 hydroelectric generators. Water moves through the generators, creating electricity on the way, and is released back into the Colorado River below the dam.

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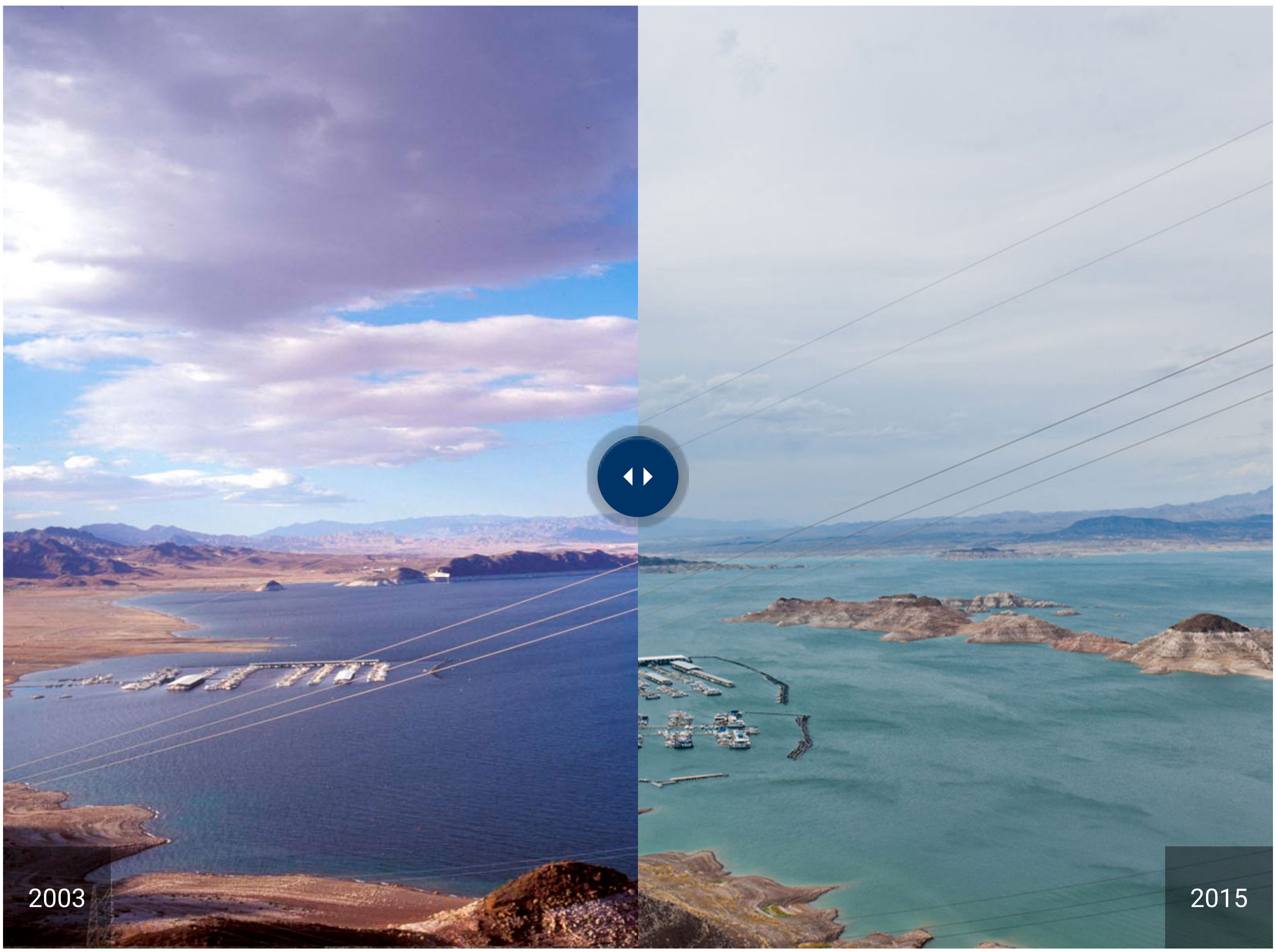

The photo slider above shows Hemenway Harbor, located in the southwestern portion of Lake Mead, and the location of Las Vegas Marina at an elevation of 1,152 feet in January 2003, and the new location of Las Vegas Marina at an elevation of 1,078 feet in May 2015. The photos also depict the increased exposure of Lake Mead's shoreline and the emergence of the Boulder Islands, located on the right side of the photo, as the reservoir elevation has declined.

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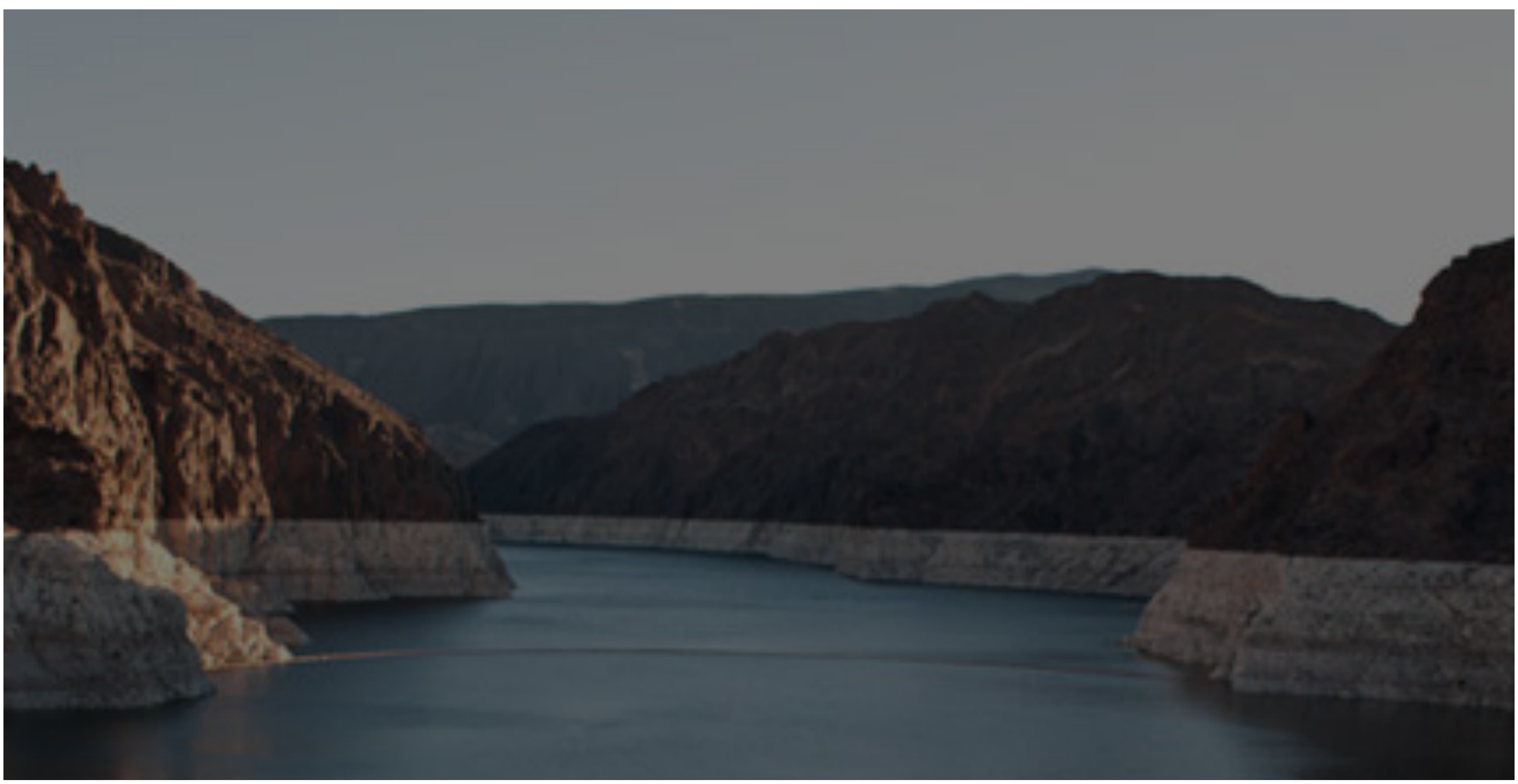
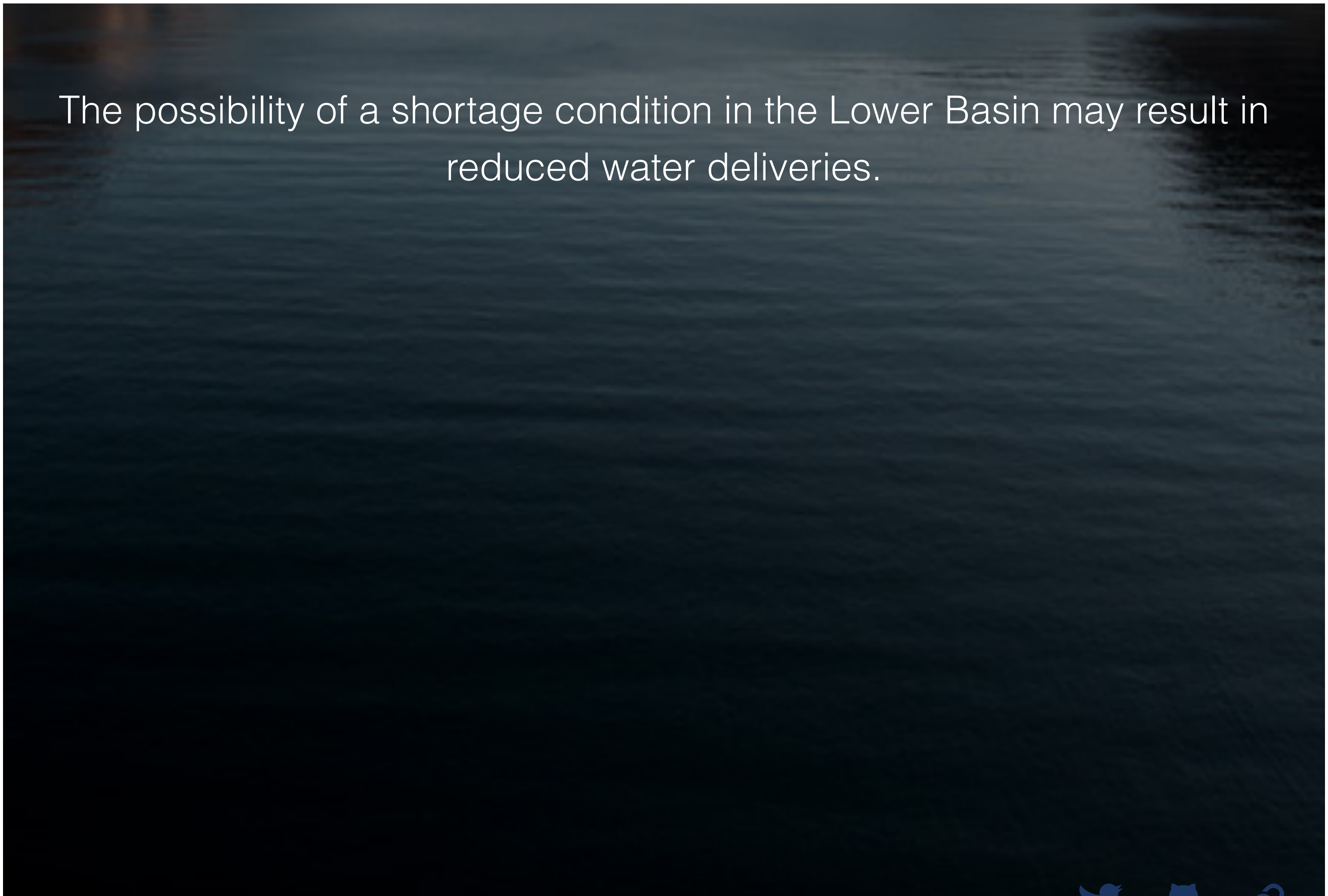
Illia, T. 2010. **Big Drop in Lake Mead Level Curbs Hoover Water, Power**. ENR Southwest website.
Kuckro, R., 2014. **Receding Lake Mead poses challenges to Hoover Dam's power output**. E&E Publishing EnergyWire website.
Rosen, M.R., Turner, K., Goodbred, S.L., and Miller, J.M., eds., 2012, **A Synthesis of Aquatic Science for Management of Lakes Mead and Mojave**: U.S. Geological Survey Circular 1381, 162 p.

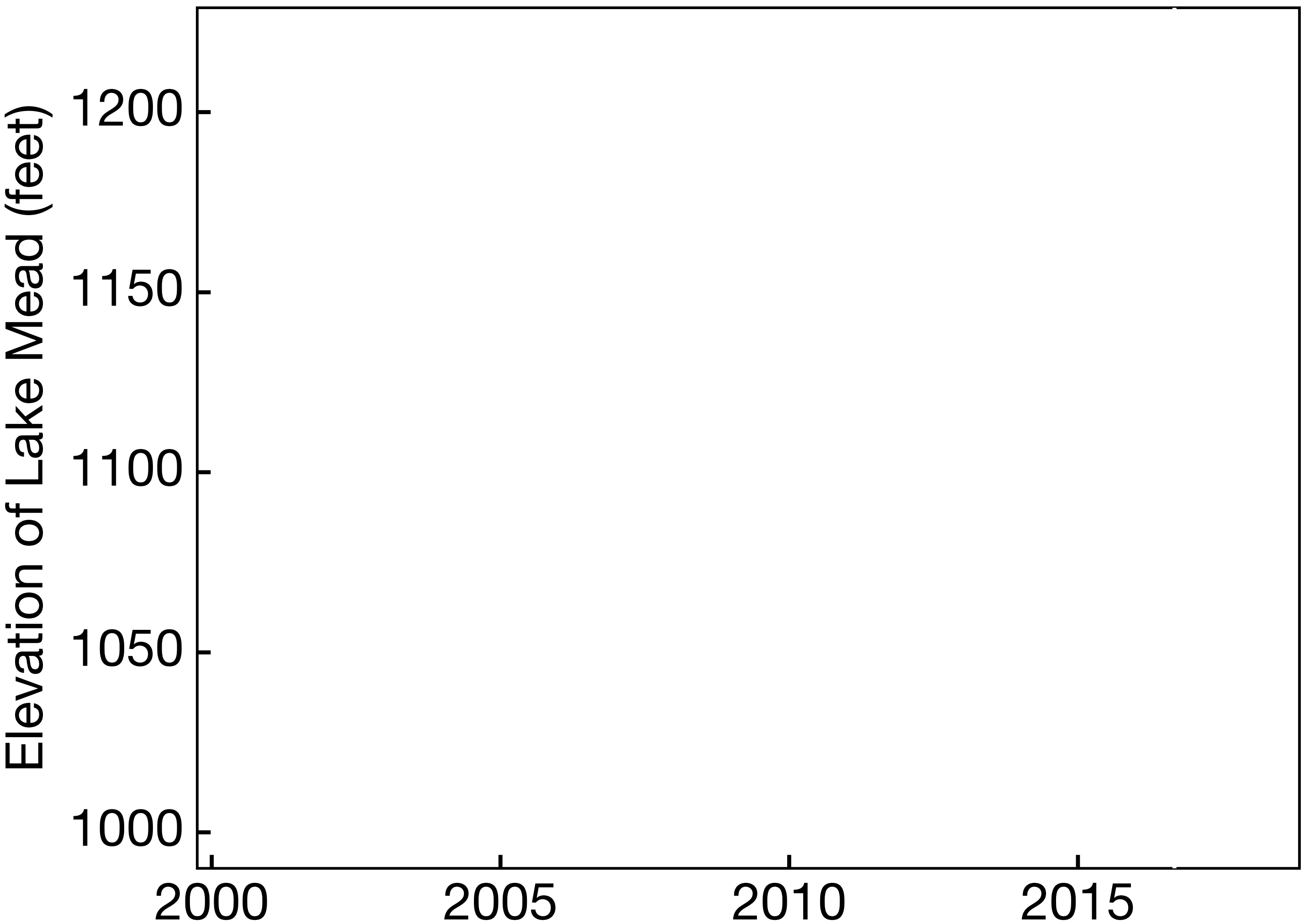




In keeping with the Bureau of Reclamation **2007 Interim Guidelines**, if Lake Mead's January 1 elevation is projected to be 1,075 feet or lower based on an August projection, a Lower Basin shortage condition would be determined. Monthly projections made by the Bureau of Reclamation through an operational model called the "24-Month Study" are used to set the operational conditions for Lake Mead and Lake Powell.

Continue with the visualization to learn more about Lake Mead's operational conditions, how operational conditions are determined, and the potential impacts of drought on water deliveries in the Lower Basin.

Hover over sections of the graph below to take a closer look



The graphic above shows Lake Mead's historical elevations (on a monthly basis) since 2000, projected elevations for 2016 and 2017, and annual operating conditions.

As Lake Mead's elevation declines, the Lower Basin comes closer to its first-ever shortage condition. Since the drought began in 2000, Lake Mead's elevation has dropped by nearly 140 feet, declining every year except in 2005 and 2011. The Bureau of Reclamation makes projections of Lake Mead elevations and summarizes them in the **Colorado River Basin 24-Month Study reports**. The 24-Month Study model simulates operations of 12 major reservoirs in the Colorado River Basin. The projections are used to support annual and monthly decisions about how to operate the system looking out 1 to 2 years. The annual operating conditions for Lake Mead and Lake Powell in the upcoming year are based on projected January 1 reservoir elevations from the August 24-Month Study consistent with the 2007 Record of Decision on Colorado River Interim Guidelines for Lower Basin Shortages and the Coordinated Operations for Lake Powell and Lake Mead (**2007 Interim Guidelines**).

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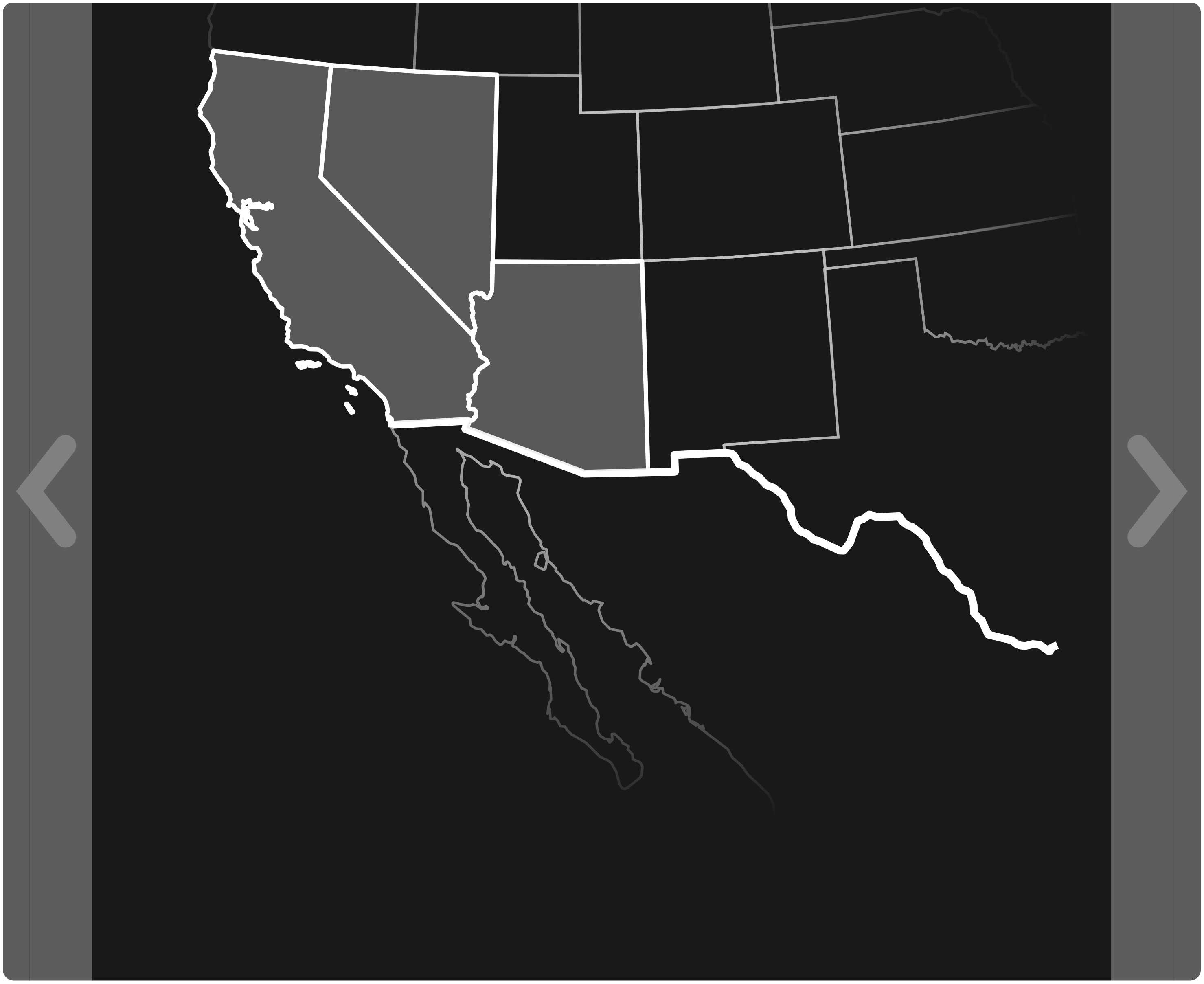


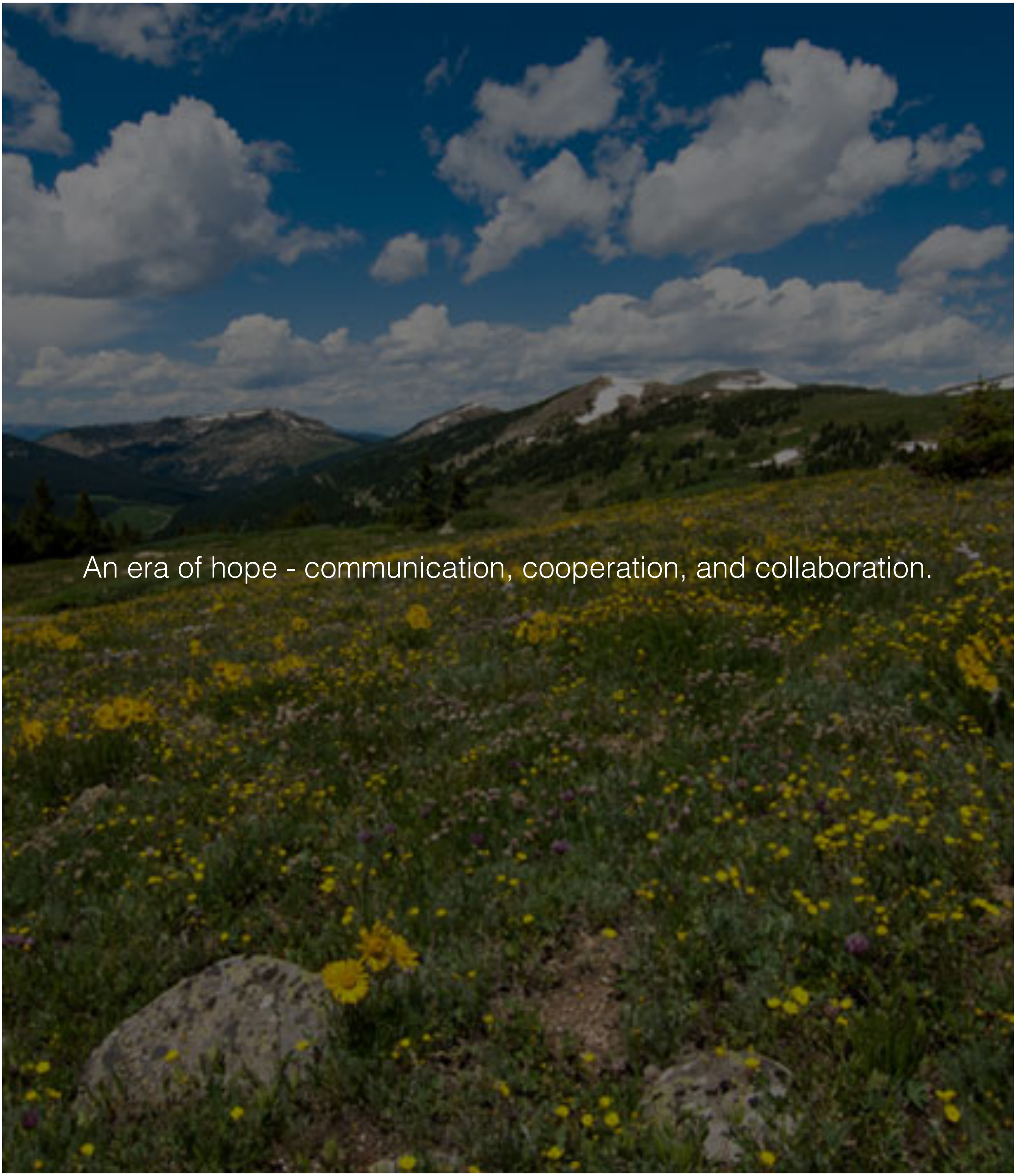
The Colorado River is one of the primary sources of water for irrigation and domestic use in Arizona, southern California, southern Nevada, and portions of northwestern Mexico.

National Oceanic and Atmospheric Administration Colorado River Basin River Forecast Center
U.S. Geological Survey Stream Gage Information
Bureau of Reclamation Reclamation's Colorado River Basin 24-Month Study reports
Upper Colorado Region Water Operations website

Lower Colorado Region Water Operations
2007 Record of Decision on Colorado River Interim Guidelines for Lower Basin Shortages and the Coordinated Operations for Lake Powell and Lake Mead (2007 Interim Guidelines)

To learn more about Lower Colorado River water entitlement holders and consumptive use data from the Bureau of Reclamation, click button below.

Explore


An era of hope - communication, cooperation, and collaboration.

In the Colorado River Basin, stakeholders, States, and Federal and local agencies are collaborating to develop creative strategies to reduce the impacts of drought and increase reservoir storage at Lake Powell and Lake Mead. Activities related to drought response include a system conservation program and drought contingency planning efforts in both the Upper and Lower Basins. Additional ongoing activities are being conducted with stakeholders through the Basin Study Moving Forward process and with Native American Tribes through the Ten Tribes Partnership Tribal Water Study. Lastly, the implementation of Minute 319 and related binational discussions also underscore the importance of the partnership and continued collaboration between the United States and Mexico.

Read More >>

Bureau of Reclamation System Conservation Pilot Program. **October, 8, 2014 press release**.
2014 Pilot System Conservation Program Agreement.
2014 Memorandum of Understanding for Lower Basin Pilot Drought Response Actions.
Colorado River Basin Moving Forward Activities.
Minute 319: Interior Secretary Salazar and Reclamation Commissioner Connor Join U.S. and Mexico Delegations for Historic Colorado River Water Agreement Ceremony.**November 20, 2012 press release**.

This product is an activity of the Advisory Committee on Water Information Open Water Data Initiative **(OWDI)**, and was developed collaboratively by the Department of Interior, U.S. Geological Survey, and U.S. Bureau of Reclamation, and with contributions from the U.S. Environmental Protection Agency, Oregon State University, and the Western States Water Council. The OWDI seeks to integrate currently fragmented water information into a connected, national water data framework and leverage existing systems, infrastructure and tools to underpin innovation, modeling, data sharing, and solution development. Application design was inspired by the **2014 National Climate Assessment**. Any use of trade, firm, or product names is for descriptive purposes only and does not imply endorsement by the U.S. Government.

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Climate Change

Native American Issues

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Deepwater Horizon

Hurricane Sandy

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New Energy Frontier

Native American Issues

Open Government Initiative

Water Challenges

Youth

Businesses

Pathways Program

Veterans Employment Program

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