3

Drought and drought response in Texas

QUICK FACTS

Though the drought of the 1950s remains the most significant statewide drought observed in Texas' history, new droughts of record have since been confirmed on sub-basin scales in six river basins.

Since the 2010–2014 drought, during which 100 percent of the state was affected by drought for many weeks, most of the state has experienced milder drought conditions:

- As of January 2021, the area of the state impacted by drought had not risen above 84 percent (NDMC, 2020).
- On average, drought impacted approximately 20 percent of the area of the state, considerably less than the average of 70 percent that occurred during the 2010–2014 drought (NDMC, 2020).

Texas has recorded periods of drought dating to the 1800s (TBWE, 1959), and persistent drought conditions have driven the evolution of the state's water laws and financial programs, as well as conservation and drought management programs administered at local levels. Texas uses the 1950s drought, known as the *drought of record*, as a fundamental benchmark for statewide water planning, with the intention that preparing for severe drought conditions that have already occurred will help the state better respond to future droughts. That said, more severe, regional, or basin-specific droughts of record are also considered by regional water planning groups as updated hydrologic and water use information is incorporated into both the relevant datasets and surface water availability models.

3.1 Measuring drought status and severity

Measuring drought is complex. Not only is it difficult to identify the beginning and end of a drought, the impacts vary greatly by location and type. Droughts are described as meteorological, agricultural, hydrologic, and socioeconomic[6]—all of which address the multitude of impacts. Likewise, severity is assessed via multiple drought indices,[7] each based on different parameters. Hydrologic drought is the focus of regional water planning since it impacts water supplies.

The U.S. Drought Monitor assesses weekly drought conditions and is commonly relied upon to determine drought status in the state. Established in 1999, it is jointly produced by the National Oceanic and Atmospheric Administration, the U.S. Department of Agriculture, and the National Drought Mitigation Center. The U.S. Drought Monitor uses a composite index incorporating measurements of climatic, hydrologic, and soil conditions, as well as reported impacts

[6] During the 2011 drought, agricultural losses reached a record $7.62 billion, making 2011 the costliest drought year in history (Fannin, 2012).

[7] In addition to the U.S. Drought Monitor, other indices used by the Texas Drought Preparedness Council to assess drought severity in Texas include the Crop Moisture Index, Keetch-Byram Drought Index, Palmer Drought Severity Index, Reservoir Storage Index, Streamflow Index, and Standardized Precipitation Index (TDEM, 2016).

and observations from contributors throughout the country.

3.2 Historical and potential new droughts of record

3.2.1 Historical droughts

History demonstrates that extended droughts are natural phenomena in Texas, often punctuated by times of flood. The drought of the 1950s is the most significant drought recorded in Texas' history (dating back to 1895) in terms of geographic extent, duration, and intensity. As measured by the Palmer Drought Severity Index, the drought of record lasted 77 months, from October 1950 to February 1957 (NOAA, 2020). Based on the same index, the 2010–2014 drought ranks as the second worst and the second-longest statewide drought, lasting 51 months, from August 2010 to October 2014.

3.2.2 Confirmed and potential new droughts of record

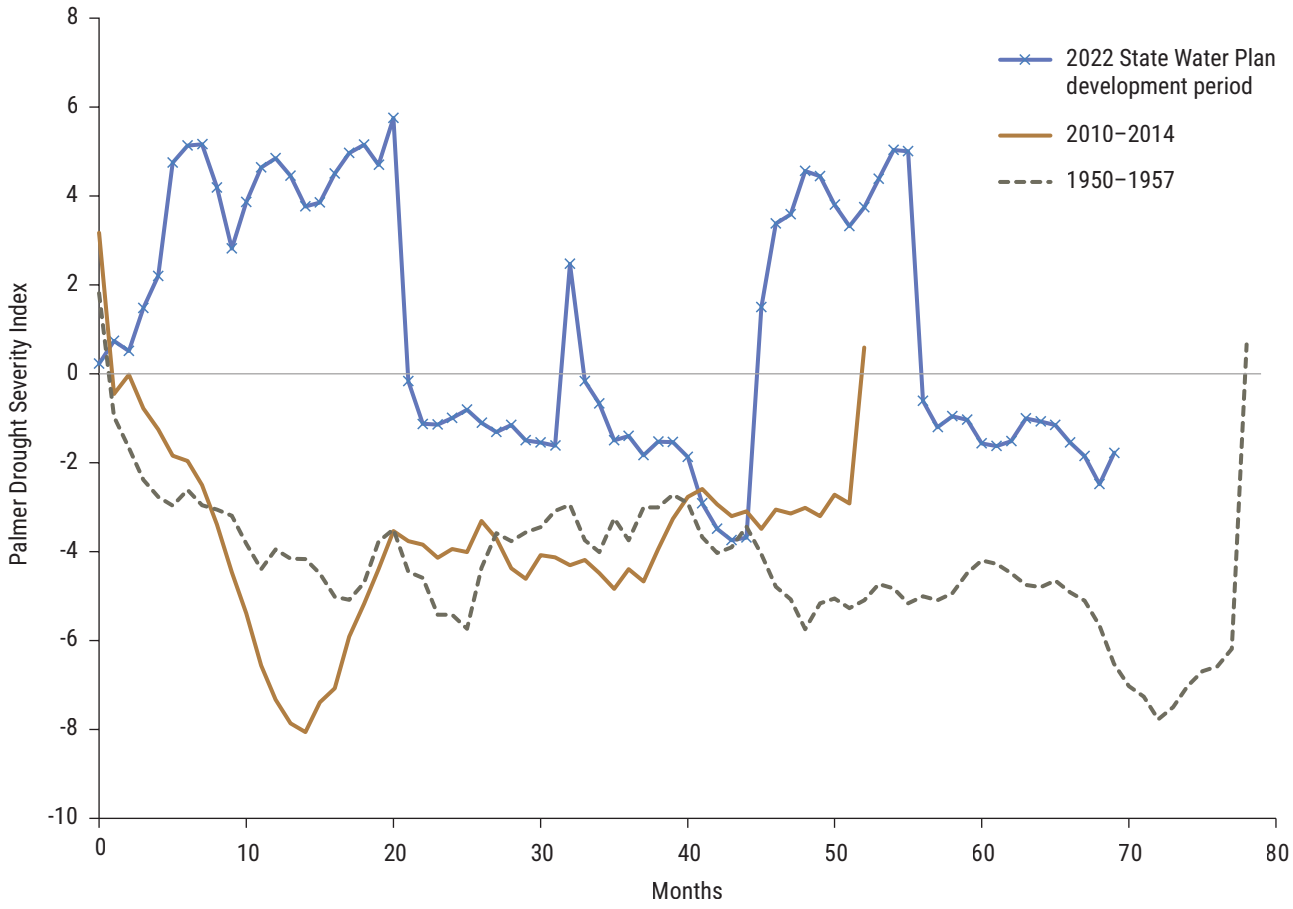
Occurring within the 2010–2014 drought, 2011 ranks as the worst one-year drought on record. A record low measurement of the Palmer Drought Severity Index occurred in September 2011, having followed the driest 12-month period of statewide precipitation on record. Conditions in that year were so severe that they continued to be utilized in this state water plan as the representative "dry-year" for the majority of the water demand projections discussed in Chapter 4.

Since 2014, above-normal moisture conditions have generally prevailed statewide, but drought disaster declarations continue to be issued at a local scale. The Palmer Drought Severity Index has alternated between extended periods of above-normal moisture and periods of drought. The highest index (wet conditions) occurred in August 2016 and the lowest (dry conditions) in July 2018 (Figure 3-1). This pattern represents the volatility in hydrologic conditions that should be anticipated and, most importantly, prepared for. Such fluctuations between drought and flood stress communities, water providers, and emergency responders in the near term (less than 10 years). Planning for the near-term timescale will allow a measure of flexibility in how water supply sources are managed (for example, variable flood pools in surface water reservoirs). Near-term planning could allow Texans to harness some of the supply side benefits of excess water during periods of higher precipitation for use later in drier times.

While the statewide drought of the 1950s is considered the benchmark drought for state water planning, regional droughts of record may occur by sub-basin or water source. For planning purposes, a drought of record for an individual reservoir is generally determined by the water availability models developed by the Texas Commission on Environmental Quality. These models are based on historical naturalized flows—flows without human influence—for time periods, varying by river basin, between the 1930s or 1940s to the 1980s or 1990s for most of the models they maintain. Recent drought years such as 2006, 2009, and 2011, therefore, are not included in the naturalized flow record of most water availability models. However, House Bill 723 (86th Texas Legislature, 2019) provides for official updates to the Brazos, Neches, Red, and Rio Grande water availability models by December 1, 2022. As these models are updated to reflect recent hydrologic conditions, either officially by the Texas Commission on Environmental Quality or via TWDB-approved hydrologic variances for the planning groups, potential new droughts of record can be confirmed.

In the 2017 State Water Plan, several planning groups (Regions A, B, C, F, G, and K) identified potential new droughts of record for some reservoirs or sub-basins that occurred after the historical period covered by the water availability models. These and other new droughts of record

*Figure 3-1. Statewide average Palmer Drought Severity Index (NOAA, 2020)**



** An index value of zero indicates normal conditions, while negative numbers indicate drought, and positive numbers indicate above normal moisture.*

in Regions L and N have since been confirmed through updated modeling results for the following river basins and planning regions:

- Canadian River Basin (Region A)
- Colorado River Basin (Regions F and K)
- Nueces River Basin (Regions L and N)
- Red River Basin (Regions A and B)
- Sulphur River Basin (Region C)
- Upper portions of the Brazos River Basin (Region G)

In its 2021 Regional Water Plan, Region M reported a potential new drought of record for the Rio Grande Basin. This potential new drought of record is based on the Palmer Drought Severity Index and has not been confirmed through updated water availability modeling.

The 2017 State Water Plan also reported the 2011 drought as a new drought of record for run-of-river supplies in Regions A and F (with the exception of the Llano River), based on minimum annual streamflow data. For the 2022 State Water Plan, Region G reported a new drought of record for run-of-river supplies, based on cumulative and annual streamflow data and an evaluation of low- and zero-flow months during periods of drought. These observations are supported by recent studies on future trends and drought projections in the state by the Texas state climatologist (Harwell and others, 2020; Nielsen-Gammon and others, 2019 and 2020).

Regions A and F reported drought of record information for groundwater resources based on assessments of annual precipitation and Palmer

Pedernales Falls State Park, Johnson City, Texas

Drought Severity Index data. Both regions determined that the 2011 drought was comparable to that of the 1950s based upon precipitation data, and the 1950s remains the drought of record for groundwater sources in Region F.

3.3 Drought planning and response

Drought planning and response in Texas is a multi-faceted realm. Planning and preparations occur at the local level via drought contingency plans required of utilities of a certain size; the regional level via regional water plans; and the state level through the state water plan and the state emergency management plan (which includes the state drought preparedness plan).

3.3.1. Statewide drought planning and response

Texas Water Code lays the foundation for the state's drought response plan. It designates the chief of the Texas Division of Emergency Management as the state drought manager, responsible for managing and coordinating the drought response component of the state water plan. The chief is also the designated chair of the Drought Preparedness Council, which is composed of at least 14 representatives from state entities as well as governor-appointed members. The information compiled in the regional water plans and summarized in this chapter serves as the drought response component of the state water plan.

Section 16.055 of the Texas Water Code assigns the Drought Preparedness Council the following responsibilities:

- Assessing and reporting on drought monitoring and water supply conditions
- Advising the governor on significant drought conditions
- Recommending that specific provisions for state response to drought-related disasters be included in the state emergency management plan and state water plan
- Advising regional water planning groups on drought-related issues in the regional water plans

- Ensuring effective coordination among state, local, and federal agencies in drought response planning
- Reporting biennially to the Texas Legislature on significant drought conditions in the state

The TWDB, a member of the Drought Preparedness Council and the Emergency Drinking Water Task Force, also chairs two Council sub-committees: 1) Drought Monitoring and Water Supply and 2) Drought Technical Assistance and Technology. In these roles, the TWDB provides a variety of resources to assist Texans with drought response and preparedness:

- Interactive Drought Dashboard – provides weekly drought data and monthly rainfall and temperature data at the county and Hydrologic Unit Code 08 watershed level on waterdatafortexas.org/drought
- Water Weekly – summarizes drought conditions across the state
- Drought Conditions report to the Drought Preparedness Council – monthly or quarterly (depending on the intensity and extent of drought) updates
- Texas Water Conditions report – monthly report documenting storage in state reservoirs and groundwater levels in aquifers
- Outreach – technical assistance, educational materials, and literature

Using data from the U.S. Drought Monitor, the chair of the Drought Preparedness Council makes a recommendation to the governor as to which counties should be included in a drought disaster proclamation. Counties for which any portion of the county is identified as drought stage D3 (extreme drought) or D4 (exceptional drought) per the U.S. Drought Monitor, and any county that has at least 50 percent of the county identified as drought stage D2 (severe drought) or higher for five weeks, inform the recommendation. In making the recommendation, the chair of the Drought Preparedness Council consults with the TWDB, Texas Commission on Environmental Quality, river authorities, groundwater conservation districts, and when necessary, local officials to gain further information. The chair may then develop a recommendation based upon specific required criteria.

The state also provides financial assistance with special consideration to entities experiencing drought. The Texas Department of Agriculture administers disaster relief grants related to drought. To be eligible, communities must have declared that their water supplies have less than 180 days left, in addition to other program requirements. The TWDB funds urgent need projects through the Drinking Water State Revolving Fund. These projects address unforeseen situations that require immediate attention to protect public health and safety and may be eligible for loan forgiveness up to $500,000. Urgent need situations include prolonged drought-related water supply reductions resulting in a loss of supply within 180 days, catastrophic events resulting in a 20 percent loss in connections or water provided, or other situations as established by the TWDB.

3.3.2 Regional drought planning and response

Regional water planning groups compile information about current drought planning and planned response activities and develop recommendations for their respective regions. Recommendations may include water management strategies for drought management, which are measures for temporarily reducing water use during drought conditions.

All drought-related content is consolidated into a single chapter in each regional water plan and includes

- details on current drought response triggers,
- plans for water supplier responses to drought,
- identification of potential alternative sources of municipal supply for small entities with only a single source of supply,

- development of region-specific model drought contingency plans, and
- recommendations to the Drought Preparedness Council.

New to these plans is a requirement to assess variations in drought response strategies within the region that may impede drought response efforts overall.

Response to potential loss of supply for small entities

In accordance with planning rules, all planning groups evaluated potential emergency responses to local drought conditions or loss of existing supply for two groups: 1) entities with a population of 7,500 or less that rely on a sole source of water supply (for example, a single reservoir or aquifer) and 2) all county-other (small, rural water systems) water user groups. The evaluation assumed that each entity had only 180 days or less of supply remaining and alternative sources had to be found. This high-level screening served as a guide for identifying potentially vulnerable water user groups and suitable emergency response options.

The most common response options deemed feasible among the planning groups for providing emergency supply include

- trucked in water;
- local groundwater wells;
- existing or potential emergency interconnects;
- brackish groundwater development (limited treatment or desalination);
- releases from upstream reservoirs;
- curtailment of water rights, which may or may not be feasible; and
- voluntary redistributions from other entities, including irrigation users.

This exercise also provided an opportunity for planning groups to evaluate and update their drought contingency plans. Some added triggers and responses to their plans, while others identified new or potential water system interconnects.

Existing and potential emergency interconnects

Planning groups assessed water infrastructure facilities within the region to identify existing emergency interconnects between water systems and potential new emergency interconnects. The number of existing emergency connections and potential new emergency connections reported by planning groups has increased since the previous state water plan. The 2021 regional water plans identified approximately 1,060 existing emergency connections and 610 potential new emergency connections. The 2016 regional water plans reported 570 existing emergency connections and 430 potential new emergency connections. Detailed information on existing and potential emergency interconnects was collected and submitted confidentially to the TWDB as required by statute and via review of publicly available information from the Texas Commission on Environmental Quality.

Variations in drought response strategies that may impede drought response efforts

House Bill 807 (86th Texas Legislature, 2019) required planning groups to identify "unnecessary or counterproductive variations in specific drought response strategies, including outdoor watering restrictions, among user groups in the regional water planning area that may confuse the public or otherwise impede drought response efforts."

Five planning groups (Regions B, C, G, I, and M) identified that confusion among the public occurs as a result of variation in water supply sources within the same region, requiring different drought responses and timing. Additionally, variations in drought stage definitions, the variety of drought triggers in use, and the variety of responses implemented across the region are contributing factors. Not only can these factors create confusion among the public, they represent challenges to consider when crafting solutions. Although local entities are best suited to develop responses tailored to manage local

conditions, they must ensure that awareness and coordination occur among water providers and that corresponding communications match local drought contingency plans. Public outreach targeted at educating customers on their source of water supply can be an important method for utilities in preventing confusion.

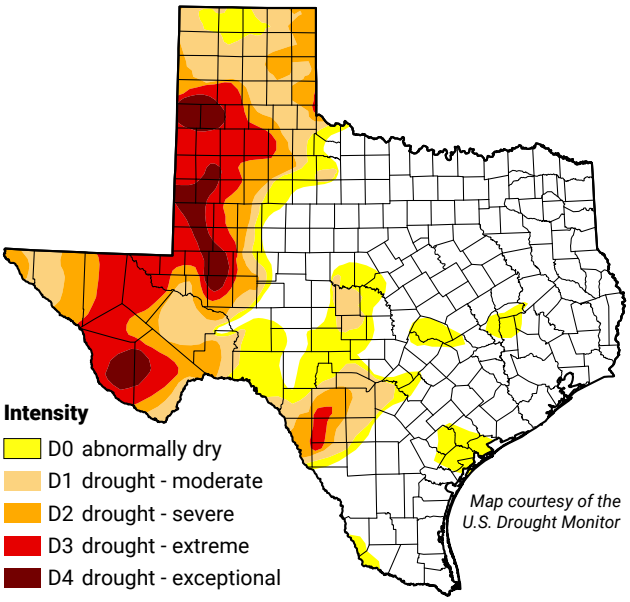
Drought management recommendations by planning groups

Drought management strategies are temporary measures that reduce water use by restricting normal economic or domestic activities, such as car washing and lawn watering. Planning groups, as in past planning cycles, generally deferred to local water providers to implement drought management strategies as part of local drought contingency plans. However, planning groups J, K, L, M, and P recommended specific, quantified municipal drought management strategies:

- Region J – included demand reductions of 20 percent for specific wells within the Bandera County-Other water user group
- Region K – included demand reductions ranging from 5 to 30 percent for most municipal water user groups, regardless of needs. Reductions depend on a water user group's gallons per capita per day consumption, drought contingency plan triggers, and presence of severe water restrictions during 2011
- Region L – included a water management strategy whereby all municipal water user groups with identified water needs in 2020 reduce the equivalent of their 2020 demands by 5 percent during drought. The San Antonio Water System requested a demand reduction strategy with varying demand reductions from 2020 to 2070
- Region M – included demand reductions of 5 percent for all municipal water user groups with water needs
- Region P – included varying demand reductions for all municipal water user groups in the region, even though no water needs exist for these entities. Reductions were based on drought contingency plan triggers and responses and the frequency at which a trigger might be reached

O.C. Fisher Reservoir in Tom Green County, Texas

During a drought of record, these collective recommended demand management strategies could temporarily reduce water use by approximately 87,000 acre-feet per year in 2020 and 158,000 acre-feet per year in 2070 (see Chapter 7).



The TWDB's Water Weekly update includes the latest Drought Monitor map

In some cases, drought management was recommended only as a near-term, stop-gap strategy to be displaced in later planning decades by projects that actually provide additional water supply to avoid drought restrictions on water use. Planning groups did not, in general, consider it prudent, sustainable, reliable, and/or economically feasible to adopt a regional plan that would intentionally require restrictions on normal economic and domestic activities, especially when there were feasible alternatives. Most planning groups chose to leave aside the potential volume of water savings from drought management measures as a back-up or last resort response to address uncertainty, such as in the event of a drought worse than the benchmark drought of record (BBC Research & Consulting, 2009).

The effectiveness and sustainability of drought measures vary between utilities and sometimes were not considered predictable or reliable enough to quantify for inclusion as a recommended water management strategy. The TWDB has evaluated reported water use for systems under restrictions and noted that results were variable due to the lack of consistent reporting, which made it difficult to determine the duration of the water restriction and its resulting impact to water use. The TWDB will continue this annual analysis and provide it to the planning groups for their consideration in future regional plan development.

Region-specific model drought contingency plans

As recommended by the Drought Preparedness Council, most planning groups developed region-specific model drought contingency plans for all water use categories that account for more than 10 percent of water demands in any decade over the 50-year planning horizon. These include wholesale water providers, retail public water suppliers, municipal providers, irrigation users, manufacturing users, and steam-electric water users. Most of these contingency plans are based upon model plans provided by the Texas Commission on Environmental Quality, modified to specific regional conditions. These plans address requirements including drought stages, triggers and responses, conservation, and emergency response stages. They are intended to assist water users seeking guidance in developing plans with meaningful, applicable triggers and responses for water sources within the region. In some instances, regions did not prepare such plans and provided the following reasoning:

- Drought conditions vary significantly across the region, and a region-specific model drought contingency plan cannot provide recommended actions that are applicable across the planning area.
- The water user group in question is a private industry and not subject to enforcement by the Texas Commission on Environmental Quality.

3.3.3 Local drought planning and response

Drought contingency plans are implemented at the local level and focus on potential issues related to retail distribution system capacity rather than the total supply volume to which the

entity has access. The plans contain triggers, which are typically based on supply or demand levels to initiate and terminate each stage, and responses associated with the triggers. They also include descriptions of drought indicators and notification and enforcement procedures. Within five days of implementing any mandatory drought contingency measures, wholesale and retail public water suppliers must notify the Texas Commission on Environmental Quality.

If a state of disaster proclamation is issued due to drought conditions, counties included in the disaster proclamation must provide general notice, including to the chair of each planning group in which the county is located and to each entity in the county required to develop a water conservation plan or drought contingency plan. After receiving such notice, the entities are required to implement their water conservation and drought contingency plans. Additionally, retail public utilities and entities from which those utilities obtain wholesale water service are required to report to the Texas Commission on Environmental Quality when they are reasonably certain their water supply will be available for less than 180 days.

3.4 Regional drought recommendations

To support the development and implementation of meaningful drought contingency plans and drought management strategies, various planning groups developed the following drought recommendations:

- Regularly monitor state and local drought conditions through the TWDB, Texas Commission on Environmental Quality, Drought Preparedness Council, or the U.S. Drought Monitor.
- Actively maintain or monitor infrastructure to minimize catastrophic failures.
- Regularly review and update management strategies and drought contingency plans.
- Effectively coordinate with wholesale providers and communicate with customers, especially during times of decreased supply.
- Develop uniformly consistent drought stage definitions among users of the same source of water.

Various planning groups made general recommendations regarding implementation of drought contingency plans, coordination among local providers during drought, and protection of supply for municipal users. Planning groups also made recommendations to the Drought Preparedness Council

- to increase coordination with local providers regarding drought conditions and potential implementation of drought stages, particularly during times of limited precipitation;
- to provide the Council's recommendations to planning groups early in the planning process; and
- to attend planning group meetings in future planning cycles.

3.5 Uncertainty of drought

Warmer temperatures, increased evaporation, and increasingly variable precipitation, as experienced in recent years, enhance the risk of extreme drought in Texas (Nielsen-Gammon and others, 2019). Tree ring records extending back to 1500 indicate the occurrence of droughts longer and more severe than the benchmark drought of record presently used in planning (Cleaveland and others, 2011). Given this context, it is clear that climate will remain a notable factor affecting the availability and reliability of the state's water resources.

Although the state's planning process does not prevent regions from planning for conditions worse than the drought of record, there is no established state framework by which to do so. Scenario planning has been suggested in the

literature (Banner and others, 2010; Nielsen-Gammon and others, 2020), and the Interregional Planning Council, established by House Bill 807 (86th Texas Legislature, 2019), developed recommendations for the TWDB to consider regarding potential enhancements to the regional and state planning framework. One of those suggestions is to conduct additional, high-level planning for a drought event that is worse than the drought of record. However, implementing a formal change to how the TWDB considers drought risks will likely require additional financial resources and development of a coherent and accepted approach.

Certain planning groups address drought uncertainty within the existing planning framework by utilizing conservative water source yields or a *management supply factor* to assess project needs. Some of the larger water providers across the state have conducted scenario planning for their individual long-range plans, but smaller entities do not have the resources or technical expertise to develop similar analyses for managing their systems. The TWDB anticipates that further research and ongoing stakeholder input during the next planning cycle will inform future enhancements to the regional and state planning process, which, for now, will remain benchmarked to a recurrence of the 1950s drought of record.

Meanwhile, the TWDB continues to develop datasets, analytical tools, and information to monitor and prepare for future drought conditions and impacts to water resources. These include the following:

- Improving and expanding estimates of reservoir evaporation monitoring (currently available through waterdatafortexas.org/lake-evaporation-rainfall)
- Monitoring soil moisture through the TexMesonet network (www.Texmesonet.org)
- Assessing temperature effects on reservoir evaporation
- Exploring the application of forecast-informed reservoir operations (www.twdb.texas.gov/publications/reports/other_reports/doc/TWDB_UTA_NIDIS_forecasts_workshop_report.pdf)
- Providing May–July rainfall forecasts (waterdatafortexas.org/drought/rainfall-forecasts) to inform the implementation of drought contingency triggers in surface water reservoirs
- Providing drought monitoring data products such as fine resolution (4 km x 4 km) drought indices (such as the Keetch-Byram Drought Index, QuickDRI, Standardized Precipitation Index, and Palmer Drought Severity Index)
- Providing fine resolution (4 km x 4 km) monthly rainfall anomalies and historical data from 1981 to the present aggregated by counties and Hydrologic Unit Code (HUC) 08 watersheds and monthly streamflow condition data by HUC08 watersheds.

The TWDB has also begun exploring ways to quantify the drought risk to water supplies that already exist. Regardless of long-term change in hydrologic or climatological trends, the natural variation in rainfall under current conditions is enough to create more severe drought events than anticipated. The TWDB seeks to better understand this fact and create tools for assessing the reliability of reservoir yields currently used to plan for existing and future water supplies.

The 2010–2014 drought, which became the new, worst drought of record for several parts of the state, demonstrated the need for water planning efforts to better account for the potential magnitude, likelihood, and impact of droughts more severe than the current drought of record. The known but unquantified uncertainty associated with hydrologic variability and persistence should be considered in the water planning process. The TWDB is actively exploring ways to better prepare the state to respond to the next drought, including identifying both the likelihood and associated severity of potential future supply shortages.

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