10 Challenges and Uncertainty

The five-year cycle of adopting regional and state water plans allows the state to respond to challenges and uncertainties in water supply planning. To reduce risks associated with planning for and providing sufficient water supplies, every five years TWDB and regional water planning groups evaluate changes in population, demand, and supply projections; new climate information; improvements in technologies; and policy and statutory changes.

Regional water planning groups must develop plans to meet needs for water during a drought within the context of an uncertain future, both near and far. Water planning would be simpler if it were known when the next drought is going to happen and how severe it will be. But in reality, water planning has to be conducted in the context of uncertainty. The cyclical design of water planning in Texas, with regional water plans and the state water plan developed every five years, helps planning groups and the state monitor and respond to uncertainties. This chapter discusses some of the sources of uncertainty relevant to state and regional water planning, the challenges presented by uncertainty, and some strategies that planning groups use to deal with these challenges.

10.1 RISK AND UNCERTAINTY

The two related concepts of risk and uncertainty are fundamental to water planning. A risk is any negative outcome that might occur. In Texas, there is a risk that some demands for water may exceed availability under some conditions. The purpose of state and regional water planning is to minimize the negative effects of drought by planning to meet the needs for water during a repeat of the drought of record that occurred during the 1950s. Uncertainty is the unavoidable fact of not knowing what the future will bring, such as when the next drought may occur. The number of people that will live in Texas in the next 50 years, the amount of water that they will require, and the amount of water supplies that will be available are all future uncertainties. Good planning means being prepared for risks in spite of uncertainty.

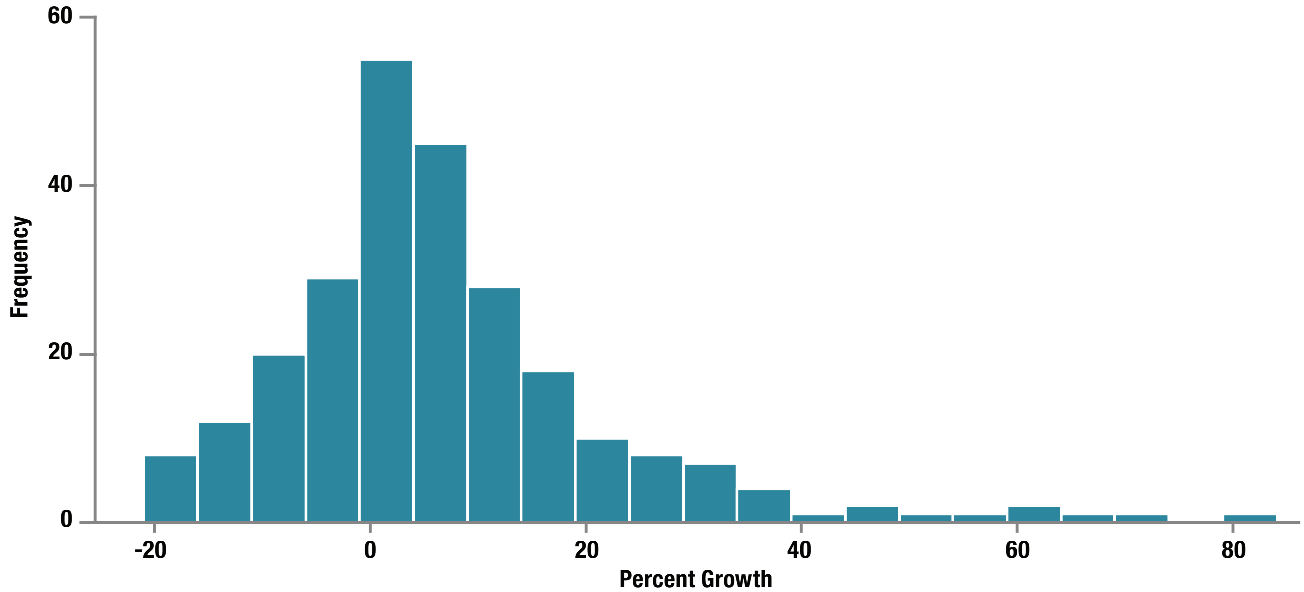
The National Research Council (a nonprofit institution that provides science, technology, and health policy advice to improve government decision making) recommends responding to risk with a cycle of analysis and deliberation, where analysis is the gathering and assessment of technical facts and deliberation is the dialogue that leads to a plan of action (NRC, 1996). The council advocates that stakeholder participation in the deliberation stage is critical because stakeholders have unique knowledge and perspectives, because they have a right to contribute to plans that will involve them, and because plan execution depends on everyone working together. A coordinated plan is more important than perfect foresight, so the most important planning strategy for reducing risk is stakeholder participation. The regional water planning process is fundamentally based on stakeholder participation by the inclusion of stakeholder interests groups as required by Texas statute.

The risk analysis stage is necessary because it is much more effective to plan for risks that are clearly understood. Measurements, readings, reports, and surveys are all used to get a clearer picture of present conditions so that more certain future projections can be made. TWDB considers state and national data sources, as well as local information from each region, in making these projections. Nevertheless, unforeseeable events occasionally happen, with distant future conditions more difficult to predict than immediate future conditions. One solution to future uncertainty is updating, which is why the state and regional water plans are developed every five years. The dynamic updating built into the water planning process by Texas statute is the regional and state water plan's strongest defense against uncertainty.

Even with the latest information and the best predictive models, some uncertainty will always remain, complicating the task of planning a focused, coordinated risk response. Rather than preparing for every possible outcome, it is more efficient to focus on a benchmark risk. In Texas water planning, the benchmark is the drought of record of the 1950s. The drought of record is better understood than other projected drought risks because it actually happened. If we prepare for the drought of record, then the state will be better positioned to respond to future droughts. Using the drought of record as a benchmark also coincides with the concept of firm yield—the maximum water volume a reservoir can provide each year under a repeat of the drought of record—which engineers use to calculate reservoir yield.

While all planning groups are required to plan based on firm yield, some regions are even more cautious when addressing climate variability and other uncertainties. Several planning regions planned for a drought worse than the drought of record by making changes to the assumptions in the availability of surface water during development of their regional water plans. Regions D and G modified the water availability models that they use in their planning process to include hydrology from later, more severe droughts that occurred within their particular regions. To address the possibility of a drought that is more severe than the drought of record, Regions A, B, F, and G assumed safe yield (the annual amount of water that can be withdrawn from a reservoir for a period of time longer than the drought of record) for some reservoirs in their regions. Since the planning process is repeated every five years, planning groups have the opportunity to update their planning assumptions each cycle as needed to address risk and uncertainty.

FIGURE 10.1. VARIABILITY IN COUNTY POPULATION GROWTH, 2000–2010.



Beyond participation, updating, and benchmarking, the best response to uncertainty is simply to be aware of it. Population growth, water demands, and the weather are all naturally variable and can lead to uncertainty.

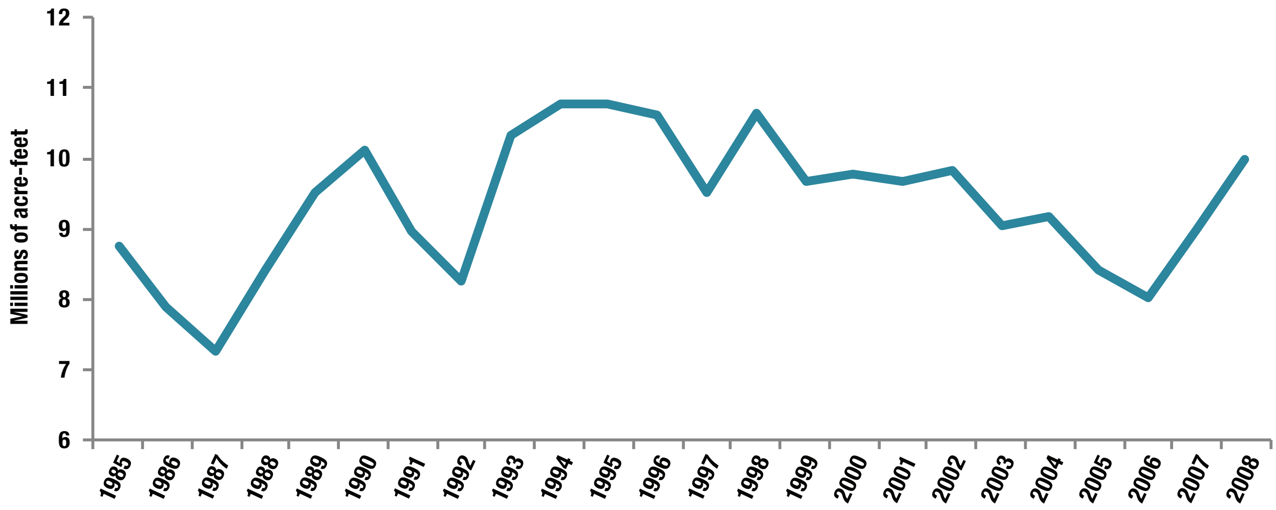
10.2 UNCERTAINTY OF DEMAND

Every category of water demand—municipal, manufacturing, irrigation, steam-electric, mining, and livestock—is naturally variable. Municipal demand depends on how many residents are using water and how much water they are using. Population growth depends on social and economic factors including individual preferences. Per capita, or per person, water use depends on preferences, habits, and water-using appliances, all of which are influenced by the economy and the weather. Irrigation and livestock demands are also strongly influenced by the economy and the weather. Manufacturing and mining demands are influenced by economic factors and government regulation but are less sensitive to the weather than other water uses. All of these underlying factors that influence water use are difficult to predict and result in uncertainty in water demand projections.

The population of Texas increased over 20 percent between 2000 and 2010; however, this growth was not distributed evenly throughout the state. The median Texas county grew by only 4.2 percent during the last decade. Some counties have less population now than they did in 2000, while others grew by as much as 82 percent. One way of representing this type of variability is in the form of a histogram, a bar chart representing a frequency distribution. Figure 10.1 is a histogram of the population growth for each county in Texas between 2000 and 2010, showing the number of counties whose growth was in each percentage range. The tallest bar in the middle of the histogram represents all of the counties whose growth was between zero and +5 percent (about 55 counties). Since the bars representing growth are taller and more numerous than the bars representing population decline, it is evident that most counties experienced positive population growth over the past decade.

Because population growth is so variable, projections have to be adjusted every decade when each new U.S. census is released. Between each census, TWDB relies on estimates from the Texas State Data Center.

FIGURE 10.2. IRRIGATION WATER DEMAND, 1985–2008 (ACRE-FEET PER YEAR).



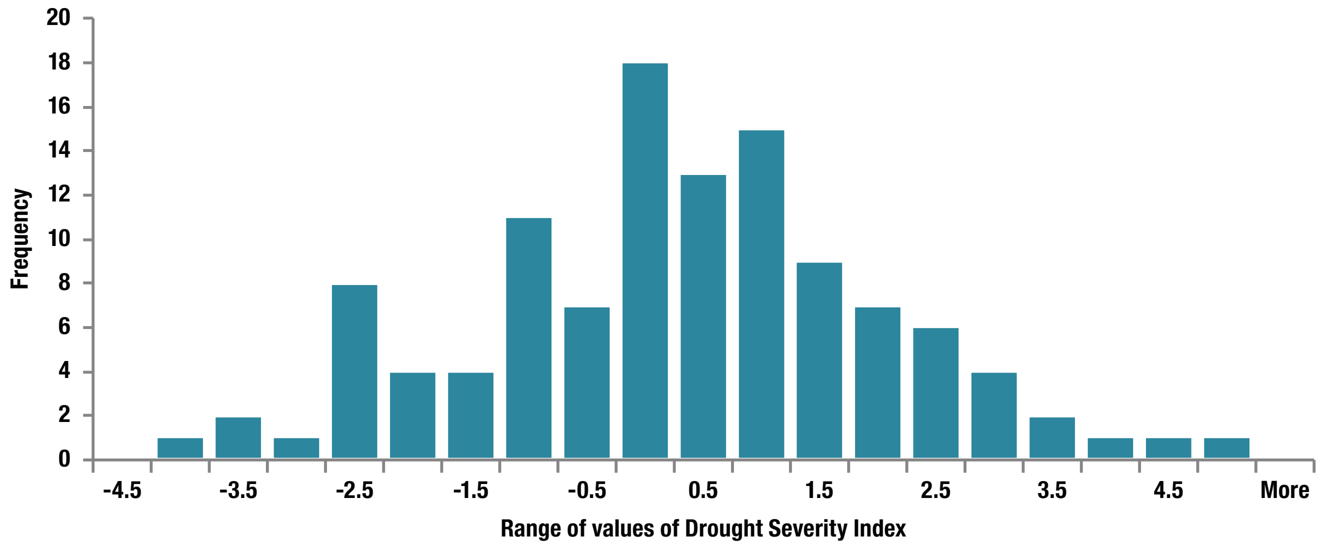
For example, population projections for some water user groups in the 2007 State Water Plan were revised upward for the next planning cycle, based on information from the State Data Center that indicated growth in excess of the original projections. The state population projected for 2010 in the 2007 State Water Plan turned out to be about 1 percent lower than the actual 2010 census. The revisions made for the 2012 State Water Plan resulted in projected Texas population about 1 percent above the census (Chapter 3, Population and Water Demand Projections). Since communities often want to plan for the highest potential growth scenario, such projections may prove to be slight overestimates. However, planning for a high-growth scenario is a way to manage risk.

Irrigation demand depends on how many acres of each crop are planted, the water needs of each crop type, and the weather. Neither an upward nor a downward overall trend is evident in irrigation demand over the years 1985 through 2008 (Figure 10.2).

Irrigation for agriculture has historically been the category of greatest water use in Texas. Variability in irrigation demand therefore translates to variability in total state water demand. Irrigation demand depends on farmers' decisions on how much acreage and what crops to plant. These decisions depend on prices of both agricultural commodities and inputs like fuel and fertilizer. Government policies can also be influential. For example, the combination of an ethanol subsidy and an ethanol import tariff has encouraged corn production.

Rather than attempt to guess at future policies and commodity prices, TWDB projects irrigation water use based on current levels. Important future developments then can be reflected through adjustments in the assumptions in future planning cycles. For example, recent crop prices have been relatively high by historical standards. If these prices decrease, projected irrigation water demand may require a downward adjustment, while the lower cost of feed might require projected demand for water for livestock to be adjusted upward. More recently, studies have explored the potential for expanded production of biofuels using "energy cane" and algae as feedstocks, which could also result in increased water demand.

FIGURE 10.3. VARIABILITY IN STATEWIDE PALMER DROUGHT SEVERITY INDEX, 1895–2010.



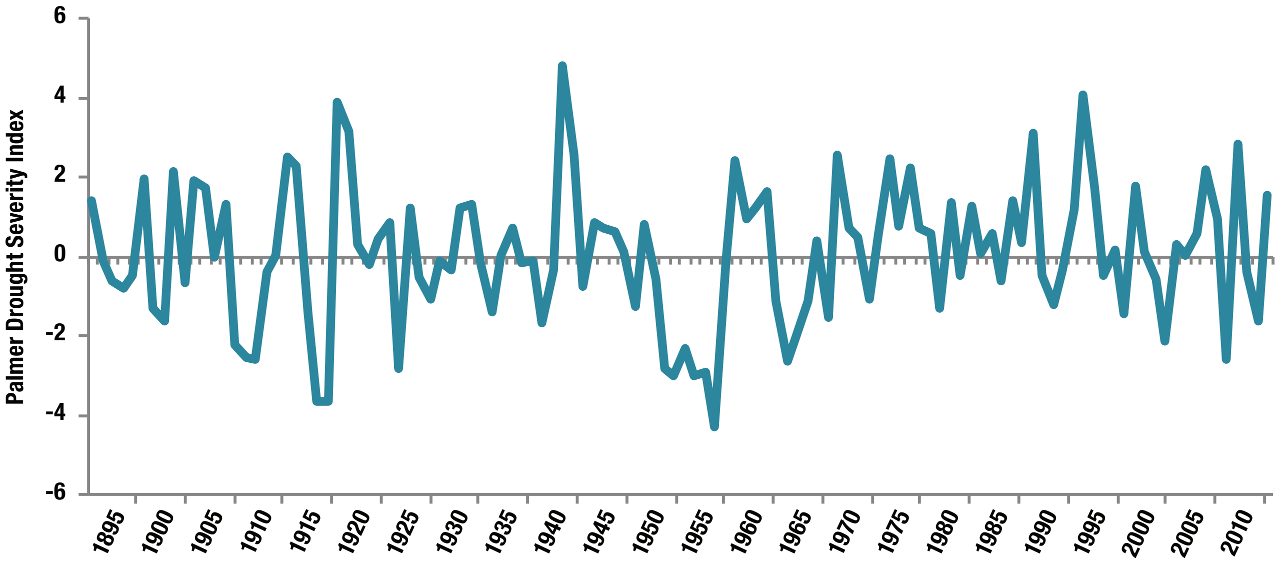
Manufacturing, mining, and power production also depend on price levels of their inputs and outputs, or the resources needed for production and the products or results of that production. Because practically all industrial processes are energy intensive, the prices of energy sources such as gasoline, natural gas, and coal are of particular importance. The hydrocarbon mining industry produces energy and uses it at the same time. Higher energy prices could shift water use away from manufacturing and toward mining and power production. The new technology of hydraulic fracturing is a method of producing hydrocarbon energy that experienced a boom during this planning cycle; thus, new developments in the hydraulic fracturing industry that could result in increased water use in the mining water use category will be monitored closely in the next regional water planning cycle.

10.3 UNCERTAINTY OF SUPPLY AND NEED

The regional water plans recommend water management strategies to increase future water supplies to meet needs during a severe drought. The actual water volume that will result from any recommended strategy is always uncertain, but it is also uncertain whether or not each strategy will be implemented, and when implementation will occur. Each water supply strategy requires some amount of funding and often political consensus to accomplish, both of which are ultimately uncertain. Projected yield of a strategy might not be realized. To avoid this possibility, regional planning groups may prioritize their recommended strategies, generally planning to execute cheaper, simpler, or more important strategies first.

Hydrology, the study of water movements in the natural environment, is also a source of uncertainty because it is so complex. Hydrologic drought is a condition of below average water content in aquifers and reservoirs, which results in reduced water supplies. It usually follows agricultural drought—an adverse impact on crop or range production—where soil and surface moisture are reduced, stressing natural ecosystems and crops. Agricultural drought increases irrigation water demands. Both hydrologic and agricultural droughts are consequences of meteorological drought, which is the occurrence of

FIGURE 10.4. STATEWIDE AVERAGE PALMER DROUGHT SEVERITY INDEX, 1895–2010.



abnormally dry weather, usually less precipitation than is seasonally normal for the region.

Levels of precipitation and evaporation are naturally variable, along with the amount of water that flows to a reservoir or recharges an aquifer. Exchanges between groundwater and surface water are not only variable but incompletely understood. Hydrologic modeling has advanced rapidly in recent years, but no model of a system so complex can completely address all uncertainty.

Hydrological drought can be measured by the Palmer Drought Index, which rates dry conditions on a scale relative to the normal conditions for each location. A Palmer Index of "zero" indicates a normal year; negative numbers indicate drought, whereas positive numbers indicate above-normal moisture. The National Oceanographic and Atmospheric Administration computes and records the Palmer Index monthly for each of the 10 climatic divisions in Texas. The Palmer Index is constructed so that the mean will be zero as long as the climate maintains its historical pattern. Figure 10.3 shows a histogram of the same series of averaged Palmer Indexes, illustrating its variability.

Figure 10.4 illustrates the 1950s as a cluster of negative values that correspond to the drought of record. Even though Palmer Index values in this period are noticeably low, no single value constitutes an outlier, or a value far apart from the rest of the data set. The most unusual feature of the drought of record is that so many dry years occurred consecutively. Annual Palmer Index values as low as they were during the drought of record occur about 10 percent of the time, but they occurred 6 years in a row during the 1950s with water supplies unable to recover from the preceding drought before the next drought started.

Agricultural drought can appear suddenly, causing almost instantaneous damage to agriculture and encouraging wildfires. Most recently, Texas experienced severe agricultural droughts in 1996, 1998, 2009, and 2011. Prolonged agricultural drought is often an indicator of impending hydrologic drought. Since 1997, public water suppliers and irrigation districts in Texas have been required to develop drought contingency plans to respond to the early warnings of hydrologic drought. Contingency plans help to manage risk by promoting preparation and coordination before a drought emergency appears.

10.4 UNCERTAIN POTENTIAL FUTURE CHALLENGES

Although the processes discussed so far all exhibit natural variability, historical distributions indicate what values they will probably take most of the time. Some risks, called ambiguous risks, are so uncertain that it is not known when they will happen, what their impacts will be, or even whether they will occur at all. The potential consequences of natural disasters, terrorism, and climate change are examples of ambiguous risks. Developments in new technology, as well as future state and federal policy decisions, can also be ambiguous, with unforeseeable implications. Awareness may be the only defense against this kind of uncertainty. This section discusses some of the challenges to water planning that may arise in the future from ambiguous risks.

10.4.1 NATURAL DISASTERS

Natural disasters include floods, hurricanes, tornados, and fires. The worst natural disaster in the history of the United States occurred in Galveston in 1900, when a hurricane killed more than 6,000 people. Hurricanes and floods generally increase water availability, so they do not usually pose a serious challenge for drought planning; however, they can degrade water infrastructure and water quality and can result in the redistribution of populations. An example is Hurricane Katrina, which forced many people to evacuate to Texas from Louisiana and Mississippi, adding to population variability. Hurricane Ike caused tremendous devastation to the Bolivar Peninsula, damaging a new water treatment plant's distribution system in addition to much of the residential housing, leaving a considerably smaller population to pay for the investment already incurred. Wildfires generally occur during drought conditions, so they may inflict additional damages on communities already suffering from drought. Fires also cause erosion that may affect streamflow positively or negatively.

Although less frequent than either flood or fire, earthquakes also occur occasionally in Texas. magnitude 5.7 earthquake hit Marathon in 1995. Earthquakes are a serious risk to dams and infrastructure in some states, but it is unlikely that Texas will experience an earthquake significant enough to damage water infrastructure. A terrorist attack, much like a natural disaster, could damage infrastructure, degrade water quality, or result in only minimal impacts.

10.4.2 CLIMATE VARIABILITY

Chapter 4 (Climate of Texas) presents information on climate variability, including that during the last 10 to 15 years, temperatures have become as warm as during earlier parts of the 20th century. Climate change or climatic variability both pose challenges to water planning because they add uncertainty. Scientists on the Intergovernmental Panel on Climate Change believe this warming trend is "unequivocal" (IPCC, 2007). While TWDB is not endorsing this panel's conclusions, additional challenges, primarily to agriculture, could arise if the climate of Texas becomes permanently warmer.

If precipitation decreases or evaporation increases as a result of climate change, farmers and ranchers will be forced to pump more groundwater, change their crop mix, or plant less. In one possible scenario, Texas could experience a 20 percent decline in cropped acreage. At the same time, cotton and grain sorghum could replace broilers, cattle, corn, rice, and wheat (McCarl, 2011). In areas of declining water availability, a change toward more cotton is plausible because cotton may be grown with deficit irrigation. On the other hand, research in the Northern High Plains has focused on producing corn with only 12 inches of supplemental irrigation, so the projected changes in production due to climate change may be overstated. Improvements in water use efficiency and adoption of new technologies or crop varieties may allow farmers the ability to grow more crops with less irrigation water applied. While technological advancements may further extend the useful life of the Ogallala Aquifer in the Panhandle and moderate changes to the climate may benefit rain-fed agriculture, future climate change impacts could increase the vulnerability of unsustainable practices in agricultural systems in the High Plains (IPCC, 2007).

Even though surface water would be the most vulnerable to projected climatic changes through increased evaporation and decreased streamflows, some groundwater sources would also be vulnerable. Aquifers with relatively fast recharge, such as those in the Edwards Aquifer in central Texas, are fed directly from the surface. For these types of aquifers, low runoff translates to low water recharge. More intense rainfall or flooding could impact recharge as well, by altering soil permeability or simply by forcing water courses away from recharge zones. Climate change resulting in higher temperatures in the Edwards Aquifer region could be especially damaging for agriculture, since increased irrigation pumping may not be legal or feasible.

TWDB has taken a number of steps to address uncertainty related to climate variability in the regional planning process. The agency monitors climate science for applicability to the planning process, consults with subject experts, and solicits research. TWDB also co-hosted the Far West Texas Climate Change Conference in 2008 (Chapter 4, Climate of Texas). TWDB will continue to monitor drought conditions to determine if a new drought of record occurs, which would change water planning assumptions.

10.5 WATER AND SOCIETY

The greatest uncertainty pertaining to water planning is the future of human society. Economic cycles can affect the use of water inputs in productive processes like agriculture and industry. In the long run, these processes adapt to water availability and the needs of society. For example, most industrial users have dramatically increased their reuse of water in recent years. These users respond to the price and reliability of water as a signal of increased water scarcity, motivating them to develop new technology, which can improve the efficiency of water use, locate new supplies, and provide new supplies more efficiently. Desalination and reuse are two examples.

Society's values change as well. Over the past 40 years, public interest in protecting natural resources has increased dramatically. Water-based recreation is also much more popular now than it was 40 years ago. These new values have translated into new behaviors, new industries, and even new laws. Predicting which new values will emerge in the future is probably futile; the only solution to changing values is to recognize them early and to adapt plans accordingly.

Whether new challenges come from the values of society, the weather, or the economy, the regional water planning groups are prepared to deal with challenges and uncertainty through the five-year regional water planning cycle. Most importantly, they meet regularly to coordinate their activities and to assimilate new information. They employ conservative measures like firm yield and safe yield and include model drought contingency plans. Although the challenge of uncertainty can never completely be overcome, it can be managed through vigilance and adaptive planning.

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UNCERTAINTY IN THE WEATHER

It is often said that Texas' weather can best be described as drought punctuated by floods. Our climate is certainly marked by extremes in temperature, precipitation, and catastrophic weather events such as droughts, floods, and hurricanes. While our daily weather is compared to precipitation and temperature "averages," these averages can obscure the sometimes impressive day-to-day, season-to-season, and year-to-year extremes that are imbedded within them (TWDB, 1967).

The variability in Texas' weather is largely due to the state's location and topography. When moisture-laden air from the Gulf of Mexico collides with cooler, drier air masses moving southeast from the interior of the continent, storms and flooding can result. The Texas Hill Country is particularly susceptible to heavy thunderstorms when moist air rises over the Balcones Escarpment of the Edwards Plateau. Central Texas holds some of the highest rainfall rates in the state and the nation. In 1921, when the remnants of a hurricane moved over Williamson County, the town of Thrall received almost 40 inches of rain in 36 hours. The storm resulted in the most deadly flooding in Texas history (Jones, 1990).

This "flashiness" of the state's precipitation is an important consideration in water supply planning, particularly when addressing uncertainty. Constant variability means that much of the time river and streamflows are an undependable source of water supply in Texas (Ward, 2011). This problem is dealt with through the construction of reservoirs, which impound rivers and capture some high flows for use during dry periods (Ward, 2011). So not only are reservoirs needed for the control of flooding, but they also help replenish surface water resources when the state receives intense rains and resulting floods.