SUPPLYING WATER FOR THE FUTURE OF TEXAS

by Larry French

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Executive Summary

Water is essential to support Texas' growing population and a $2.1 trillion economy. Yet securing needed water supplies is complicated by two simple facts: surface water—rivers, streams, and lakes—is owned by the state of Texas, while groundwater—underground aquifers—is owned by landowners and is a property right. These two ownership modes complicate Texas' capacity to balance multiple water needs to maintain secure and sustainable water resources, promote economic prosperity and growth, protect private property rights, and ensure that Texas continues to be a desirable and attractive place to live. These are tall but very achievable orders. Cities, farms, and industry need water—lots of it—and must plan and work together with state policymakers to ensure that Texas continues to succeed.

Fortunately, some actions can help meet Texas' water needs:

- Surface water transport across basin boundaries is routine in other states and should happen in Texas. River basins in East Texas have water availability that exceeds anticipated demands. Those entities with surface water rights in the source basins should be appropriately compensated according to the market value of the water. Implementing market-driven solutions to surface water allocation can reduce pressure on local groundwater resources in drier, faster-growing areas in other parts of the state.

- Trans-regional transport of groundwater and surface water will continue to be needed to ensure there is sufficient water to sustain and grow economically. As groundwater is a private property right, landowners should be fairly compensated, while those sharing common aquifers need to be protected through mitigation programs.

- Robust evaluation of groundwater sources should continue by the state's resource agencies, such as the Texas Water Development Board and the Railroad Commission.

- Brackish groundwater is abundant and a viable option for larger consumers such as water supply corporations, municipalities, and industry.

- Aquifer storage and recovery does not generate "new water" but is an attractive option for addressing drought challenges when other sources are unavailable or too costly.

Key Points

- Texas as a whole has plentiful water resources, but regional supply challenges must be addressed. Crafting sound water policy is complicated by ownership and insufficient infrastructure.
- Existing policies, particularly surface water restrictions, act to restrict statewide water development and distribution.
- Hill Country aquifer challenges reflect much of the statewide water issues.
- Promising options exist to develop additional water resources that will meet Texas' water needs.
- Market-based solutions would benefit Texas' needs for water and protect property rights.

- Local off-channel reservoirs may be a good option in some areas with available land and variable stream flows.

- The state should fund joint groundwater planning as it does the regional water planning process.

- Consolidation of some groundwater conservation districts in Central Texas would help streamline groundwater management efforts without jeopardizing local input and control.

Texas Water Conditions

Texas water conditions are as varied as the state itself: flowing rivers, crystal-clear springs, and productive aquifers—these features are to be both used and preserved. But how? And how much? Here are some facts:

- Regional water plans—for example, Region I (East Texas Regional Water Planning Group, 2020)—for river basins in East Texas show surplus surface water (meaning that availability that exceeds current supply), but this water is generally captive to those basins because of legal and regulatory constraints. Nearly all surface water supply is spoken for and unavailable to meet additional future needs.

- The 2022 State Water Plan is a compilation of 16 regional plans. It brings together regional and local strategies to meet regional needs but does not address how to solve or meet overall state water conditions, especially as Texas continues to add population at a rapid rate.

- Water is available in the east, but the deficits are in the west. Water planning is regional in perspective, with little to no incentive to distribute water between regions. It will require money and political will to solve trans-regional needs. Allowing surface water to have a value and be bought and sold can help meet these needs without additional taxpayer dollars.

- Groundwater is a private property right and operates in a freer market environment that more realistically places economic value on water.

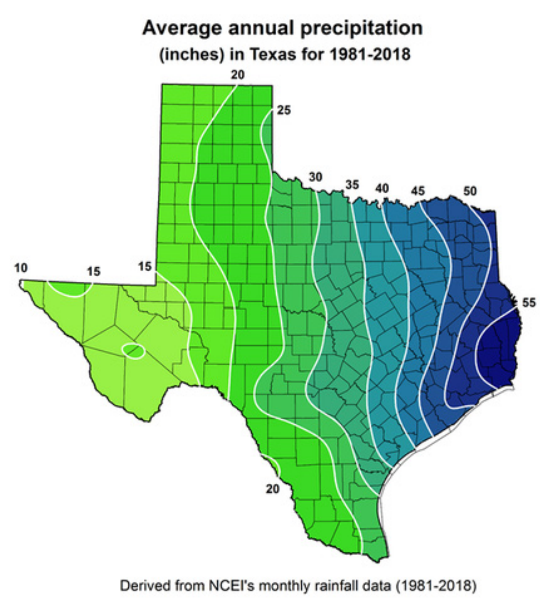
- Brackish groundwater is abundant and mostly untapped. Aquifer storage and recovery, along with off-channel storage of excess surface water, have great potential.

- Due to statutory restrictions, the Texas Water Development Board ("the Board") cannot solve water supply issues. It gathers and analyzes data and funds projects to solve problems. It is up to the local water users to apply for and use state funds. The Board's activities are dominated by funding for wastewater and water treatment, drainage systems, storage tanks and pipelines, and flood mitigation. While these projects have merit, they do not develop new water sources for the state.

Variability of Water Challenges

Texas is big. And size brings variability, complexity, and challenge. This is especially true for water. Texas has two major sources of water: surface water and groundwater. In 2022, rivers and aquifers supplied water for drinking, farming, and industry to nearly 30 million Texans. Surface water resources are unequally distributed—abundant in East Texas and scarce in West Texas. Aquifers underlie most of the state but vary considerably in their capacity to produce usable freshwater. In an average year, El Paso receives less than 10 inches of rain, and Beaumont receives nearly 60 inches (see **Figure 1**). Most Texans live in areas that do not experience these precipitation extremes but tend to alternate between drought and flood, as has been the case in Texas for centuries.

Figure 1
Average Annual Rainfall in Texas



Note. Map reproduced from *Texas is a large state whose climate and geography vary greatly. What grows well in humid East Texas may not* [Tweet], Texas Water Development Board, Twitter, 2019 (https://twitter.com/twdb/status/1122863540539416577).

Generally speaking, most of the time Texas is either in drought, going into drought, or emerging from a drought. The U.S. Drought Monitor (n.d.) defines several levels of drought, ranging from abnormally dry to exceptional drought. Drought dominates the effort to plan for and secure reliable water supply. Because drought happens gradually, it is difficult to recognize when a drought has started and when it will end.

Surface Water

Texas has about 191,000 miles of rivers and streams, 15 major river basins, 8 coastal basins, and almost 200 major reservoirs (Texas Water Development Board, 2007). The average annual discharge of water has varied throughout the years, "historically … from around 21 million acre-feet to 55 million acre-feet, depending on whether the state is in a wet or dry period" (Texas State Historical Association, 1995, para. 1). That's over twice the amount of surface water and groundwater used in 2019. Some surface water is used by municipal consumers, industry, or irrigation. Flow in the Rio Grande depends on releases of water from Mexico in accordance with 1944 Treaty Water delivery obligations (Texas Commission on Environmental Quality, n.d.). And some surface water flows are dedicated to supporting ecological systems in the coastal bays and estuaries. The 2022 State Water Plan (Texas Water Development Board, 2021) reports that total surface water availability—the maximum amount of water that could be withdrawn annually in a drought of record—is about 12.7 million acre-feet. However, surface water supply—that which today is connected to or legally available to water users—is about 7.2 million acre-feet per year. Millions of acre-feet of surface water are potentially available—that is, water that could be accessed—for use. Nearly 100% of surface water supply is legally dedicated via long-term contracts. Unless more storage capacity is added or surface water usage is decreased (via conservation), there now is no more surface water supply to satisfy future needs. In 2019, surface water accounted for nearly 42% of the 14.2 million acre-feet of water used in Texas. As of early January 2023, The Texas Water Development Board's Water Data for Texas website reported that Texas reservoirs were nearly 72% full compared with the median storage (since 1990) of about 80%.

Surface water is owned and regulated by the state via the Texas Commission on Environmental Quality (TCEQ). The overarching principle for regulating surface water use is the doctrine of "first in time, first in rights." About 70% of the surface water rights are held by public river authorities, which then sell water to municipalities, water districts, and industry. When river authorities sell water to farmers or cities, the price is usually based on the costs of moving and treating the water, not competition or market economics. When water is scarce, the authorities often restrict supply to certain groups—just as the Lower Colorado River Authority did in 2012—rather than rely on market pricing and allocation (Federal Reserve Bank of Dallas, 2013).

> Total surface water availability is about 12.7 million acre-feet per year. Existing surface water supply (connected to water users) is about 7.2 million acre-feet per year. Millions of acre-feet of surface water are potentially available for use. An acre-foot is the volume of water that covers an acre to a depth of 1 foot. It is the unit of measure in water management and represents 325,851 gallons. The average water use per single-family residential connection per day in Texas is 246 gallons or 89,790 gallons a year, a bit more than ¼ acre-foot.

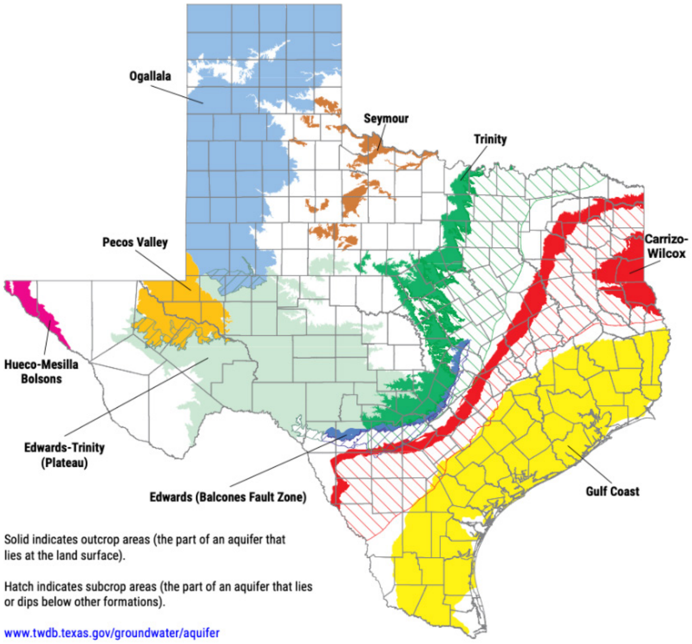
Groundwater

Texas has nine major aquifers and 22 minor aquifers (George et al., 2011). Aquifers are geologic formations such as sand, gravel, and limestone that can store and transmit economic quantities of groundwater. Major aquifers extend over large areas and can supply lots of groundwater. Minor aquifers vary in size and ability to provide water—but are important local sources of water. Together, these aquifers are the state's primary suppliers of water, producing about 60% of what Texans use in an average year. That amount varies from year to year—higher in drought times when surface water supplies are stressed and lower in periods of higher rainfall when agricultural demands are less. According to the Texas Groundwater Protection Committee, groundwater supplies over 99% of water to rural Texas. An estimated 30% of the river flows are attributable to discharge of groundwater (Texas Water Development Board, 2016).

> According to the Texas Water Development Board, an estimated 9.3 million acre-feet of groundwater flows into Texas rivers and streams, or about 30% of the total surface water flow in an average year.

Groundwater is the "go-to" source of water during drought and is generally non-interruptible and critical to cities such as San Antonio and El Paso. Much of Houston—particularly high-growth suburban areas—relies on groundwater

Figure 2
Map of the Major Aquifers of Texas



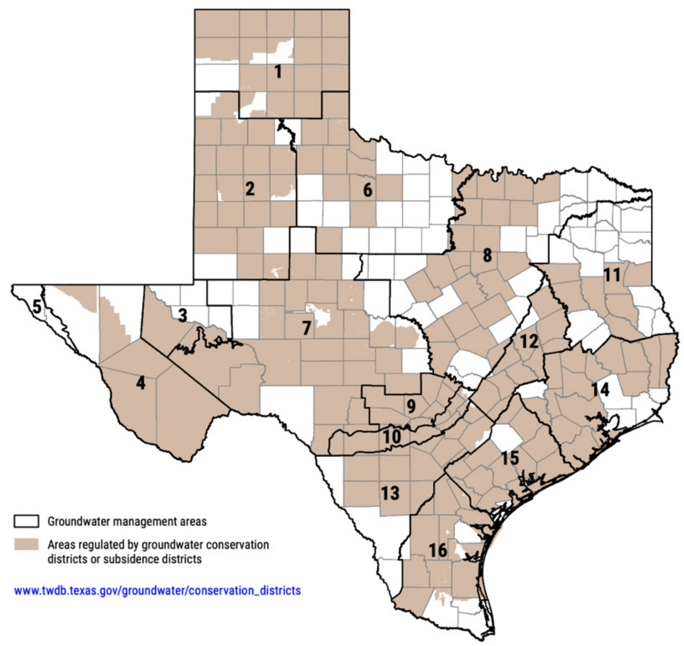
Note. Map reproduced from *Major Aquifers*, Texas Water Development Board, n.d.-f (https://www.twdb.texas.gov/groundwater/aquifer/major.asp).

from the vast Gulf Coast aquifer system. Groundwater is increasingly important to the high-growth areas with limited options for additional surface water, including Austin, San Antonio, and much of the Texas Hill Country.

Groundwater belongs to the landowner and is governed by the "rule of capture," which grants landowners the right to pump groundwater beneath their property. Texas Water Code Section 36.002 acknowledges private ownership of groundwater but within the context of groundwater conservation districts (see **Figure 3**), which were made possible by the 51st Texas Legislature that passed the Texas Groundwater District Act of 1949. These districts have the authority to create and enforce rules for conserving, protecting, recharging, and preventing waste of groundwater. They develop a groundwater management plan, adopt rules to implement it, and issue permits to pump water from the wells.

Nearly 100 groundwater conservation districts (Texas Water Development Board, n.d.-g) cover nearly 70% of the state and 72% of the state's major and minor aquifers. These districts are the state's "preferred method" of groundwater management (Texas Water Code Section 36.0015). While a foundational principle, the rule of capture can be modified by districts through rules that govern well spacing, production limits, and other features. Policies governing groundwater management can significantly change through the election of boards with differing perspectives. And neighboring districts, even those that share a common, connected aquifer, can also have significantly different policies related to groundwater development. Several neighboring districts in Central Texas had significant groundwater availability policy differences that were discussed during public meetings and documented in explanatory reports (Texas Water Development Board, n.d.-d) submitted for the most recent joint planning process.

Figure 3
Areas Regulated by Groundwater Conservation Districts and Outlines of the 16 Groundwater Management Areas



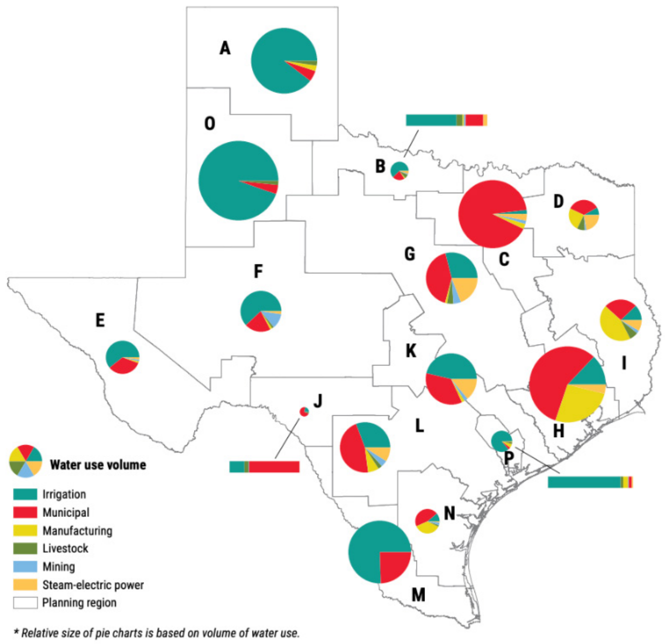
Note. Map reproduced from *Water for Texas – 2022 State Water Plan*, Texas Water Development Board, 2021 (https://www.twdb.texas.gov/waterplanning/swp/2022/index.asp).

The demands for all sources of water are also unequally distributed (see **Figure 4**). Current water demands are highest in the High Plains region—dominated by groundwater-supported agriculture—and in large urban/suburban counties in areas such as Houston and Dallas–Fort Worth. According to the 2022 State Water Plan (Texas Water Development Board, 2021), pumping from the Ogallala aquifer in the High Plains region represents about 50% of groundwater demand and about 30% of all water demands in Texas. Groundwater supply is projected to decrease by 32% by 2070, mostly through the managed depletion of the Ogallala aquifer and regulatory cutbacks of pumping in the Houston–Galveston region to mitigate land subsidence. By

2070, the greatest municipal demands for water are projected to be in high-growth urban centers. Each of these areas has specific and unique water-related challenges and is pursuing different options.

Figure 4

Surface Water and Groundwater Use Volumes in the 16 Water Planning Regions



Note. Map reproduced from *Water for Texas – 2022 State Water Plan*, Texas Water Development Board, 2021 (https://www.twdb.texas.gov/waterplanning/swp/2022/index.asp).

Water Supply Planning

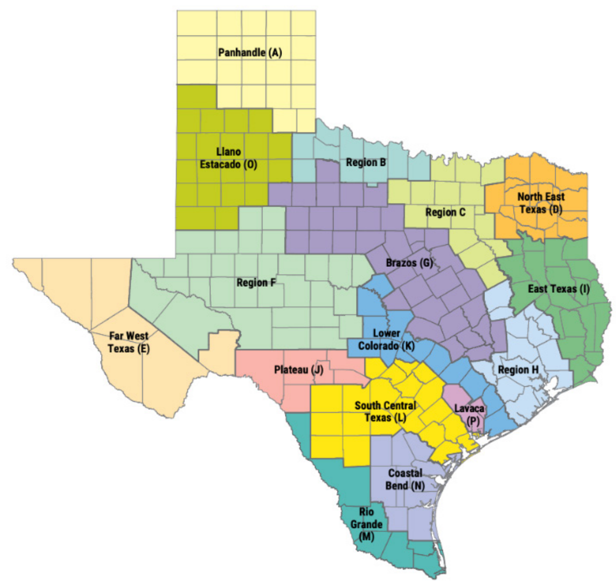
For nearly 25 years, water planning has centered on 16 regional water planning areas (see **Figure 5**) which develop custom plans that are combined by the Board into a comprehensive state water plan. Regional water planning groups work on a 5-year cycle and are composed of a cross-section of water users and interest groups. These groups evaluate supplies and demands to project needs on a 50-year planning horizon and outline water management strategies to meet those demands. Little, if any, consideration is given to coordinate those items with other regional water planning groups. The Board then compiles the plans and issues the state water plan. The Board's role is essentially passive because it is up to public entities to come to the Board for funding of specific projects that have already been incorporated into the state water plan. The Board does not propose projects or strategies that address either regional or statewide needs—those originate in the regions. Therefore, it is no surprise that, when all regional plans are "rolled up," statewide water needs continue to be identified, but there

According to the 2022 State Water Plan, demand management refers to measures that reduce the need for additional water, such as long-term conservation and short-term drought management measures. By 2070, demand management will account for about 31% of the total volume of water management strategies.

is little incentive or reason for regional water planning groups to address needs beyond their borders as those are the state's problems. Each region is basically "on its own" by design. Before passage of Senate Bill 1 (1997), the legislation that created the current system, the Board would take a more proactive development stance—at least for groundwater—by identifying areas for favorable groundwater development based on aquifer conditions. That no longer happens.

Figure 5

16 Regional Water Planning Areas

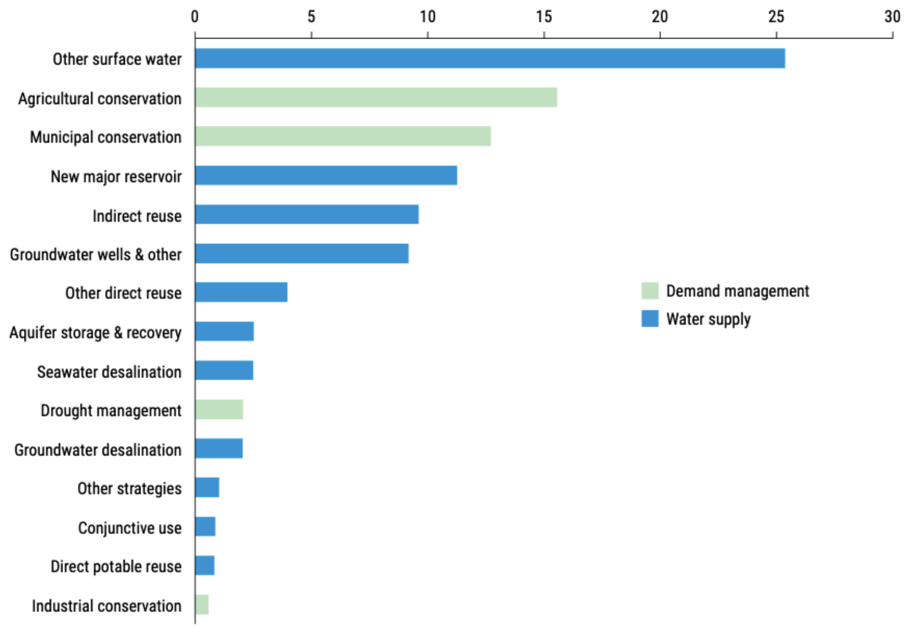


Note. Map reproduced from *Water for Texas – 2022 State Water Plan*, Texas Water Development Board, 2021 (https://www.twdb.texas.gov/waterplanning/swp/2022/index.asp).

The strategies and projects identified by these planning efforts may be moved forward and financed by the State Water Implementation Fund for Texas (SWIFT) or other financial programs at the Board. With some notable exceptions, most of the projects and associated financing over the last 20 years have been to "plug the leaks" or move water within basins over relatively short distances. For example, the author reviewed the 2022 financing decisions at the Board and most have been for projects such as wastewater treatment systems, infrastructure improvements, drainage

Figure 6

Percentage of Water Needs That Will Be Met by Strategies in the 2022 State Water Plan



Note. Figure reproduced from *Water for Texas – 2022 State Water Plan*, Texas Water Development Board, 2021 (https://www.twdb.texas.gov/waterplanning/swp/2022/index.asp).

projects, flood control and mitigation, and technical studies. While those are necessary and worthwhile projects, relatively few projects to bring new sources of water online have been brought to the Board for financing. Very little effort by the state has gone into finding or developing new sources of water. That work has largely been done by the private sector, at the direction of local governments, to meet the needs of growing cities and suburbs.

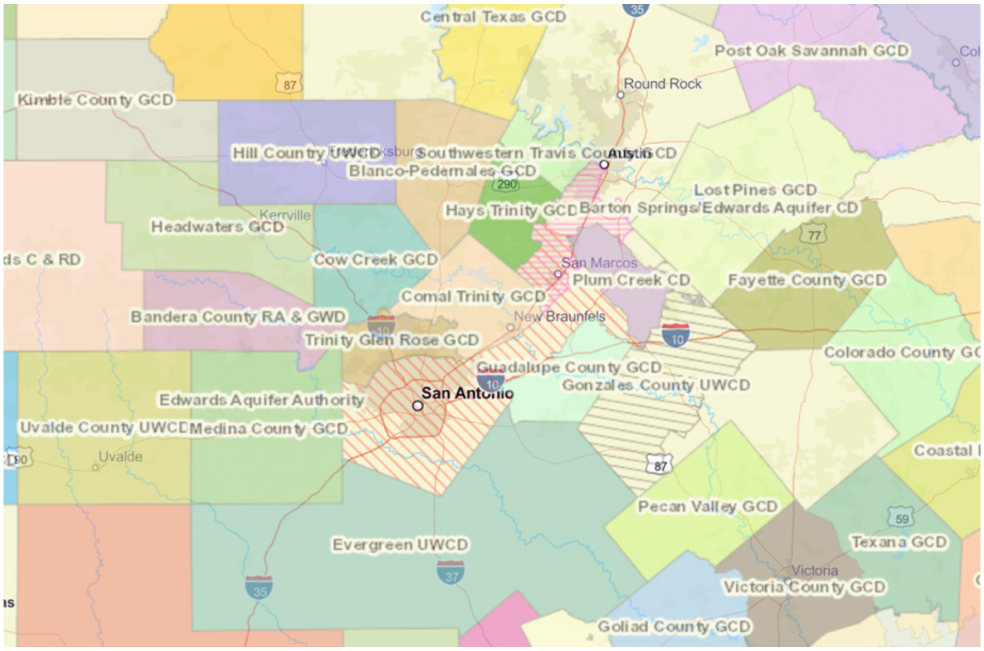
Figure 6 shows that at least two thirds of the water management strategies, such as "demand management" and "other surface water," do not generate "new water" but reallocate water or make water systems more efficient. According to the 2022 State Water Plan (Texas Water Development Board, 2021), describing "other surface water":

> These strategies generally do not require further development of surface water resources and new water right permits but simply convey previously developed and permitted surface water to users. In addition to pipelines, the types of projects associated with these strategies may include, but are not limited to, constructing pump stations, adding water treatment capacity, or lowering the elevation of a reservoir intake to allow a water provider to continue to draw water when lake levels are low. (p. 105)

Groundwater conservation districts engage in joint planning to determine groundwater availability and input those availability numbers into regional plans. The districts that share common aquifers in a groundwater management area—16 in the state—are required to work together to adopt aquifer management goals called "desired future conditions." They consider various technical factors and must balance conservation with the maximum possible groundwater production, as well as protect private property rights. A desired future condition is "the desired, quantified condition of groundwater resources (such as water levels, spring flows, or volumes) within a management area at one or more specified future times" (Texas Administrative Code Section 356.10). The desired future conditions are input into groundwater availability models, which are developed and run by the Board, to determine groundwater availability, termed modeled available groundwater. Modeled available groundwater is the annual volume of groundwater that can be pumped to achieve the desired future condition of an aquifer. Districts consider modeled available groundwater, along with other parameters, in the implementation of

Figure 7

Many Groundwater Conservation Districts Exist in Central Texas



Note. Map created at *Water Data Interactive*, Texas Water Development Board, n.d.-h (https://www3.twdb.texas.gov/apps/waterdatainteractive/groundwaterdataviewer).

management plans, permitting decisions and management strategies to achieve the desired future conditions.

Central Texas Water Supply Challenges

Perhaps no region of Texas encompasses the statewide challenges and opportunities of meeting demands for water better than Central Texas, including the Hill Country. This region has drawn many people for employment in the Austin and San Antonio areas and retirement in small towns and the countryside. But none of these people bring water. Furthermore, this region bounces between drought and flood. Interstate 35 bisects this region and has been referred to as the "gateway to the desert" as the climate gets drier to the west. Major springs that discharge along the Balcones Escarpment are the headwaters of rivers that are important sources of water for supply and recreation, and that sustain ecologically sensitive areas.

The water supply challenges that Central Texas faces include the confounding issues of natural cycles of drought and flood, pressures from ongoing and future population increases, limited opportunities for location of major reservoirs, regulatory limits on groundwater pumping from the Edwards Balcones Fault Zone (BFZ) aquifer, and groundwater management divided into many (mostly) county-based groundwater conservation districts (see **Figure** 7).

Limits to the Edwards (BFZ) aquifer. The Edwards BFZ aquifer is one of the most productive aquifers in the world and the source of the two largest springs in Texas. The aquifer is the primary water source for San Antonio and irrigated agriculture in the region. Springs discharging from the Edwards aquifer also support endangered species habitat. The Edwards Aquifer Authority was established by Senate Bill 1477 (1993), passed by the 73rd Texas Legislature, in response to the legal threat of federal takeover of the aquifer under the Endangered Species Act. The current pumping cap is 572,000 acre-feet per year, which is subject to reductions in accordance with the Critical Period Management Plan that provides for reductions based on spring flow rates from the Comal or San Marcos Springs. The TCEQ regulates activities on the aquifer surface to protect water quality.

Limited options for reservoirs or storage. Although the topography of the Hill Country is favorable for reservoir development, no major reservoir projects are envisioned except for off-channel reservoirs along the Colorado River.

Highland Lakes of the Colorado River were about 53% full in January 2023. In October 2022, inflows were at about 2.5% of the average for October, dating back 80 years (Lower Colorado River Authority, n.d.).

Possible reservoir sites are constrained by existing development and population. A further challenge is the high rate of evaporation that consumes large quantities of water. In 2012, the evaporation from the Highland Lakes—estimated at nearly 145,000 acre-feet—exceeded the amount of water used from these lakes by the city of Austin (Henry, 2013).

Declining water levels in the Trinity aquifer. Downward trends in the regional water levels of the Trinity aquifer (see **Figure 8**) continue to be a concern for rural residents and may limit further population growth in the Hill Country. Just north of Austin, an effort is underway for western Williamson County to be annexed to the Clearwater Underground Water Conservation District to implement groundwater management of the depleting Trinity aquifer (Aquifer Conservation Alliance, n.d.).

"Balkanized" groundwater management. Groundwater management in Central Texas is performed by nearly 30 groundwater conservation districts that are typically single-county (or partial-county) districts organized into 7 groundwater management areas. Some districts are restricted by enabling legislation to certain aquifers, and many of the districts are overlain by the Edwards Aquifer Authority that introduces separate groundwater policy approaches. Regional solutions to groundwater supply issues are therefore challenged by this "balkanization" of management—particularly associated with the joint planning process underway in multiple groundwater management areas. Regional water suppliers—faced with multiple jurisdictions or unsettled policies generated by different district boards of directors—may abandon projects or significantly alter project parameters. Such was the case in the decision by the San Antonio Water System to locate a major project just inside Bexar County and outside of a groundwater conservation district.

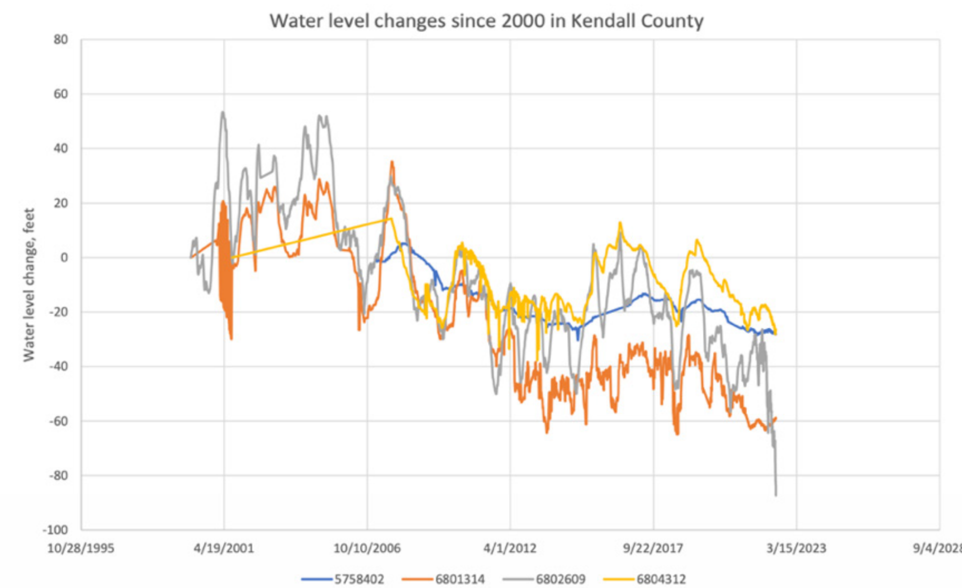
Aggregate Production Facilities. Aggregate production facilities—including quarries for building stone, crushed rock, frac sand, and raw materials for cement plants—have a long history in Central Texas. The number of such facilities has soared to serve the exploding construction industries of Central Texas. Lately, they have been encountering more organized opposition from nearby residents concerned about air quality, water supply and quality, noise, and impacts to rural roads. Regulation of these operations is limited, primarily focused on air quality permitting and on facilities located on the outcrop of the Edwards aquifer. However, during the 87th Legislature, HB 1912 (2021) was introduced to address permitting of aggregate production operations and concrete batch plants. It provided notification requirements for public hearings and meetings, mandating that the local groundwater conservation district be notified. The bill also required monitoring and reporting of noise levels and air emissions and that the facility either (1) use water from a metered source or under a permit issued by a groundwater conservation district or (2) implement an approved method of water recirculation to ensure efficient use of groundwater. Permit holders would have been required to address post-operation conditions concerning any safety or environmental problems, minimize fugitive dust emissions, and control erosion. The bill did not advance out of committee.

In the wake of Hurricane Harvey in 2017, there were concerns that aggregate operators within the San Jacinto River floodplain, flowing from the north of Houston into the Trinity Bay to the city's east, increased the severity of flooding in some residential areas due to increased flows of debris downstream. After the flooding, a new section was adopted under the Texas Administrative Code—Title 30 Environmental Quality, Part 1 Texas Commission on Environmental Quality, Chapter 311 Watershed Protection Rules, Subchapter J Best Management Practices for Sand Mining Facility Operators with the San Jacinto River Basin. The rule, §311.102, became effective January 6, 2022, and could be rolled out to other river basins to address concerns over aggregate and sand mining operations within floodplains.

It is not surprising that mining, including oil and gas production or aggregate quarrying, can generate concerns regarding water. For aggregate operations, those concerns generally fall into the categories of groundwater supply, groundwater quality, and how the sites will be closed. While some short-term water level declines may be difficult to avoid, there are also opportunities to gain long-term benefits with planning and the application of water-saving or water supply-enhancing strategies. One interesting possibility is using quarry sites as managed aquifer recharge sites. By directing excess runoff or other water sources to these sites, the shallow aquifer can be recharged, and water levels stabilized or increased to offset earlier, short-term declines. This approach has been used successfully (California Department of Water Resources, n.d.) in California, which has for decades employed managed aquifer recharge for a

Figure 8

Downward Trend of Groundwater Levels in the Trinity Aquifer in Kendall County



Note. Graph reproduced from Effects of Drought on Groundwater in Texas: Water Level and Spring Flow Data Analysis of Current and Historic Drought Conditions by R. Storms, Texas Water Development Board, 2022, p. 18 (https://tgpc.texas.gov/tgpc-sub-meetings/presentations/Final_GW_Drought_TGPC.pdf).

variety of purposes, such as increasing groundwater levels and creating barriers to coastal seawater intrusion into aquifers.

Table 1 summarizes some of the water issues related to aggregate operations in terms of their effects or impacts and possible benefits or mitigation that can be applied.

Mitigation or water supply enhancement strategies will need to be evaluated through the lens of private property rights and market-centered approaches to ensure that the interests of both operators and the neighboring landowners are protected.

Table 1

Water Issues and Aggregate Production Operations in the Texas Hill Country

Operations/Issues	Effect/Impact	Mitigation or Benefit
Groundwater pumped for dewatering pits, washing aggregates, or suppressing dust.	Possible lowering of water levels in nearby wells.	Employ efforts to reduce water use, such as recycling wash water. After closure, the site could be used for managed aquifer recharge. Local well owners with demonstrated impacts from operations could be compensated for deepening wells or drilling replacements.
Operations involving diesel fuel, chemicals in explosives to facilitate quarrying.	Concerns that blasting residues and general operations could contaminate groundwater, particularly in a karst aquifer.	For quarries subject to Edwards Aquifer Authority rules, water pollution abatement plans must be prepared. Monitoring and testing of water may be required in certain jurisdictions.
Closure of quarry sites without reclamation or repurposing for other uses.	Unsightly if abandoned; could attract unauthorized dumping if the site is not secured.	Potential use of property for managed aquifer recharge. Repurpose used quarry sites for commercial, recreational, or other land use.

With nearly 30 rock crusher operations in Williamson County, there have been growing concerns related to water use by such operations. These concerns have contributed to organized efforts by landowners (Aquifer Conservation Alliance, n.d.) to seek regulation of groundwater, in this case, by seeking annexation to the Clearwater Underground Water District just north of Williamson County. South of Austin, in Hays County, legal action has been proposed by the Trinity Edwards Springs Protection Association (TESPA) to halt the proposed rock quarry by Far South Mining LLC. The legal filings (First Amended Notice of Intent or NOI) raise issues of possible harm or "take" of endangered species, contamination of groundwater, and impacts to rural roads. In Hays County, another proposed 1,500-acre quarry on the Edwards (BFZ) aquifer recharge zone and near new subdivisions has generated concerns from the "Friends of Dry Comal Creek" about air pollution, water quality, destruction of caves, and decreased property values. The quarry owner will be required to prepare a water pollution abatement plan, which is required only when quarries are over the Edwards (BFZ) aquifer recharge zone.

Since these aggregate operations meet local needs, restrictions on them will likely result in greater strain on the regional transportation system as material not produced locally would have to be brought into the area. This, in turn, would increase emissions from the transportation sector while also driving up the cost of raw materials, construction, and other activities.

Property Rights and Property Values

Private property rights, as they relate to water, center on groundwater as it is owned by the landowner. Where there is no groundwater conservation district, the "rule of capture" is unrestricted except for prohibition against waste or malicious drainage of other property or negligently causing land subsidence. But where there is a groundwater conservation district, it has the authority to limit or prohibit the drilling of a well by a landowner, may require minimum well spacing or tract size requirements, and regulate groundwater production (Texas Water Code Section 36.113, 36.116, or 36.122). A district could also "allocate to each landowner a proportionate share of available groundwater for production from the aquifer based on the number of acres owned by the landowner." However, the districts must protect private property rights by considering the "impact [of proposed desired future conditions] on the interests and rights in private property, including ownership and the rights of management area landowners and their lessees and assigns in groundwater" (Section 36.108(d)(7)).

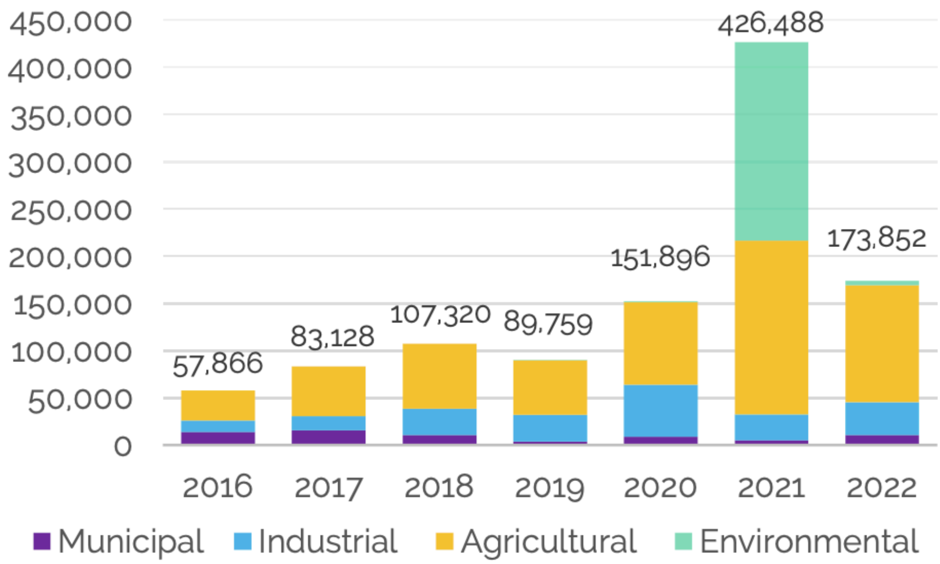
Discussions of private property rights between groundwater conservation districts are required as part of the joint groundwater planning process. In Groundwater Management Area (GMA) 14 (Groundwater Conservation Districts, 2022), discussions (Texas Water Development Board, n.d.-d) have centered around several points. Districts must protect three groups of property rights owners: (1) well owners who have been producing and continue to produce groundwater, (2) applicants who desire to produce groundwater in the future, and (3) landowners who do not own a well and do not have current plans to drill a well but nevertheless want to protect their groundwater. In addition, presenters at public meetings have pointed out that constitutionally protected rights are different than an interest in a right. While groundwater conservation districts have the right to regulate the production of groundwater, landowners have constitutionally protected rights in groundwater. In addition, groundwater conservation districts face difficulties navigating issues of private property rights with respect to managing the common regional aquifers without common rules among districts (as well as non-district areas). There is also a tension between the requirement to compensate a landowner for a groundwater taking and the obligation of the Legislature to create laws to preserve and conserve the natural resources of Texas.

Water Markets

Water markets need to be considered in any discussion of private property rights and property values. A water market is a mechanism to trade surface water or groundwater across basins or regions. Texas water markets—how they function and the ways in which they are limited—have been discussed in detail by the Foundation (White et al., 2017), the Texas Water Development Board (n.d.-a), and Votteler et al. (2006). A bill (HB 3298, 2015) introduced in the 84th Texas Legislature would have required the Board to study the development of a market and conveyance network for water in Texas. The bill was passed by the Texas House but failed to be considered by the Senate. HB 3298 stated that "improving the efficient use of water in the state may be promoted by improving the laws regarding water transfers and markets and by using an integrated network of both natural and constructed water conveyance infrastructure" (Section 1). The comprehensive study would have identified and evaluated various aspects of a statewide "water grid" with specific attention to sources of water for a market, a strategy for operating the water grid, alternative methods for ownership, construction, operation, maintenance, control, and financing of the grid, and a number of other water market issues. The study would have also included identification of the features of an "efficient market for water,

Figure 9

Annual Volume of Surface Water Leasing in Texas (Values in Acre-Feet)



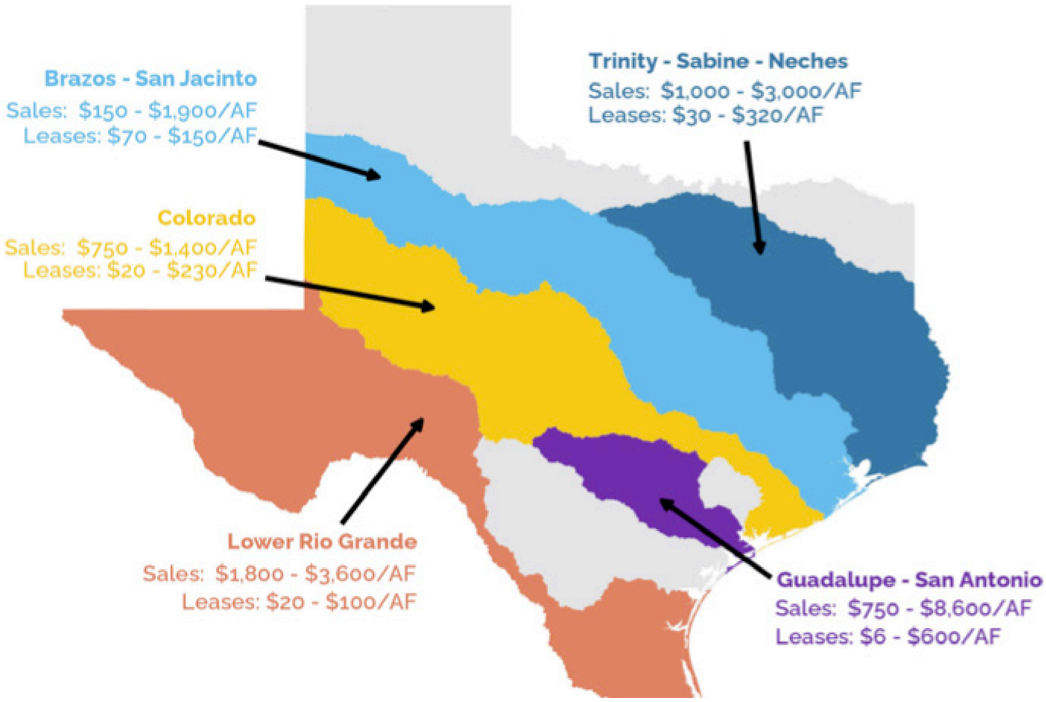
Note. Graph reproduced from *Growing Water Demand, Drought, and Increasing Water Development Costs – Why Texas Needs a More Robust Surface Water Market*, WestWater Research, Water Market Insider, 2022, p. 3 (https://static.texastribune.org/media/files/a96b41488965c98e7f424c7cb5885c21/2022-Q3-Water-Market-Insider.pdf).

including water rights, institutions, and infrastructure" (Section 3).

Surface water leasing activity (**Figure 9**)in Texas—driven primarily by agriculture with a spike of environmental transactions in 2021—has increased from about 57,000 acre-feet in 2016 to over 425,000 acre-feet in 2021 (WestWater Research, 2022, Figure B). The 2021 spike in environmental transactions was primarily a lease of 210,000 acre-feet in the Guadalupe River basin. In July 2022, transactions were about 173,000 acre-feet. Lease prices (**Figure 10**) vary considerably, from $6 per acre-foot for a nonconsumptive water right to $600 per acre-foot for the oil and gas industry. Sales of water rights generate higher prices but are much smaller in volume than leases. California, with water supply and distribution challenges not unlike those of Texas, has successfully used water markets for more than 30 years to facilitate moving water from places of surplus to places of need (Ayers et al., 2021). By comparison, trading activity in California is typically greater than 500,000 acre-feet per year, with nearly 1 million acre-feet leased in 2020 and 2021. Water markets in California have historically focused on movement of surface water, but with growing activity in the groundwater market (Ayers et al., 2021). In most situations, farms are the sellers, and cities are the buyers. These transactions have addressed both short- and long-term needs. But these transactions are subject to much regulatory oversight that may last months or years.

The water market for surface water in Texas is currently inhibited by the "junior rights" provision for interbasin transfers created by the Legislature in 1997. Surface water projects generally are restricted to moving water within basins to avoid triggering the junior rights provision. This is a significant barrier to the widespread use of interbasin transfer of surface water to meet water needs in Texas, although there are some exceptions (Rochelle & Vassar, 2016). However, with movement of groundwater, there is no limit (or penalty) associated with transfer of water. In fact, the Texas Water Code, Section 36.122, prohibits districts from establishing more restrictive conditions on transfers of groundwater than on in-district use of groundwater. Therefore, the most robust water market has been and will continue to be in groundwater transfers, unless the 1997 law is repealed or amended. Examples include the Vista Ridge project that pipes 45 million gallons of groundwater per day, 142 miles from Burleson County to San Antonio (San Antonio Water System, 2019). Across the state, Midland receives Pecos Valley aquifer groundwater 70 miles away from a well field in Winkler County (City of Midland, n.d.). And there are numerous other examples

Figure 10
Prices of Surface Water Leases and Sales



Note. Map reproduced from *Growing Water Demand, Drought, and Increasing Water Development Costs – Why Texas Needs a More Robust Surface Water Market*, WestWater Research, Water Market Insider, 2022, p. 2 (https://static.texastribune.org/media/files/a96b41488965c98e7f424c7cb5885c21/2022-Q3-Water-Market-Insider.pdf).

of groundwater projects moving water distances from the point of withdrawal.

The Texas Water Bank (Texas Water Development Board, n.d.-b) is managed by the Board and is intended to facilitate the marketing and transfer of water and water rights through the provision of information describing availability and needs for water. However, the bank is relatively inactive, with slightly more than 2,000 acre-feet deposited in late 2022 (Texas Water Development Board, n.d.-i). In contrast, water banks in California had a balance of more than 3 million acre-feet in 2020 (Escriva-Bou et al., 2021).

Options for Meeting Future Water Demands

The state water plan depends heavily on conservation and use of legal and contractual mechanisms to access available water to meet the state's water needs. While these are necessary and important, relatively few major projects have been proposed to generate new water supply. Nevertheless, there are workable options that can address water supply issues soon, for Central Texas and the state as a whole. These include:

1. **Brackish groundwater desalination.** The H2Oaks facility in southern Bexar County can produce and treat up to 11,200 acre-feet per year of brackish groundwater from the Wilcox Aquifer. In 2021, 6,000 acre-feet of desalinated water were produced from the facility (San Antonio Water System, n.d). Several technical studies have been completed revealing the potential for large volumes of brackish groundwater that could be exploited. For example, the recently completed Hill Country Trinity aquifer brackish groundwater study (Robinson et al., 2022) estimated that 979 million acre-feet of brackish groundwater are within the deeper zones of the Trinity aquifer. To the east, an evaluation (Meyer et al., 2020) of brackish groundwater in the Upper Coastal Plains suggested that 237 million acre-feet of brackish groundwater exist in several aquifers. Canyon Regional Water Authority has also identified a brackish groundwater strategy for Gonzales County, projected to be online by 2040. Although not all brackish groundwater volumes would be technologically or economically recoverable, it does represent an opportunity that could be evaluated for site-specific needs. Eight groundwater desalination projects totaling $1.2

billion in capital costs are listed in the 2021 plans for regions J, K, and L that cover Austin, San Antonio, and much of the Hill Country areas. An ongoing challenge continues to be the disposal of residual salts that are the by-product of treating the brackish groundwater.

2. **Aquifer storage and recovery (ASR).** Two ASR projects—Kerrville and San Antonio—are currently in operation in Central Texas. The cities of Buda and Austin are also considering developing ASR projects. One of the impediments to widespread use of ASR in Texas relates to ensuring the "control" of water once it is introduced to the aquifer and preventing its capture and removal by other wells in the area. The separate legal systems for surface water and groundwater are also complicating factors. The Texas Water Code allows unappropriated water, including stormwater and floodwater, to be appropriated for aquifer recharge and ASR projects (Sections 11.023, 11.157, and 11.158).

   The San Antonio Water System (SAWS) project is basically a "groundwater to groundwater" project as it pumps excess water from the Edwards (BFZ) aquifer underground into the Carrizo aquifer at the H2Oaks facility. By 2022, the ASR project had received more than 192,000 acre-feet of water. This project is also a component of the Edwards Aquifer Habitat Conservation Plan to protect endangered species at Comal and San Marcos Springs. The city of Austin is considering a yet-to-be-determined site to store about 60,000 acre-feet underground by 2040. The Board is actively evaluating aquifers for their possible use as ASR sites. For example, the Board completed a study (Croskrey et al., 2022) of the Carrizo-Wilcox aquifer in Gonzales, Caldwell, and Guadalupe counties, areas where ASR was listed as a water management strategy by seven water user groups in the 2012 State Water Plan. Fifteen ASR projects, totaling $1.16 billion in capital costs, are now listed in the 2021 water plans for regions J, K, and L (Texas Water Development Board, n.d.-e).

3. **Conservation/rainwater catchment.** Rainwater collection systems are a viable water supply option for individual rural residents or small businesses by easing pressure off the Trinity aquifer and other aquifers. In recent years, collection of rainwater has increased because of escalating environmental and economic costs of providing water by centralized water systems or by well drilling. Texas has enacted laws regulating the practice of collecting rainwater. These include:

   - Allowing a state sales tax exemption on rainwater harvesting equipment (Texas Tax Code, Section 151.355).
   - Prevention of homeowner associations from banning rainwater harvesting installations (Texas Property Code, Section 202.007).
   - Rainwater harvesting technology must be incorporated into the design of new state buildings. Financial institutions are to consider making loans for developments using rainwater as the sole source of water supply (Texas Finance Code, Section 59.012).

4. **Off-channel reservoirs**. The Lower Colorado River Authority is completing an off-channel storage reservoir (Arbuckle Reservoir) and a new irrigation regulating reservoir (Prairie Regulating Reservoir) in the lower basin of the Colorado River. A key function of this approach is to provide water supply flexibility during times of water scarcity. A similar project—the Allen's Creek Reservoir—has been proposed for the Brazos River, west of Houston. The disadvantage of these projects, like any surface reservoir, is that they need large areas of land and can be vulnerable to legal challenges.

   Similar projects in other areas of the country have been particularly effective in addressing persistent threats of drought. For example, according to the Metropolitan Water District of Southern California, the Diamond Valley Lake is Southern California's largest drinking water reservoir. It has a surface area of 4,500 acres and has a maximum depth of 250 feet. With a capacity of 810,000 acre-feet, the reservoir was designed to meet the region's emergency and drought needs for six months. Water delivered to the reservoir travels the 444 miles of the State Water Project's California Aqueduct as well as the Colorado River Aqueduct. Stored water can be routed to almost all of the metropolitan's service area if needed during a drought or an emergency. It was built and is operated by the Metropolitan Water District of Southern California, a cooperative agency with 26 member agencies (Metropolitan Water District of Southern California, n.d.).

5. **Groundwater imports.** The Carrizo-Wilcox aquifer on the eastern side of the Central Texas region offers the most likely source of groundwater that could be transported to meet water needs in the San Antonio and Austin areas. Vista Ridge, the largest groundwater transfer project in the state, pipes groundwater pumped from the Simsboro and Carrizo aquifers a distance of 142 miles from Burleson County to San Antonio. This project moves as much as 50,000 acre-feet per year of groundwater to meet about 20% of San Antonio's demand for water. Other projects include the Schertz-Seguin wellfield in Gonzales County that supplies water to suburban San Antonio. Several other groundwater transport projects, such as those anticipated to meet growing municipal and industrial water demands in Williamson and Travis counties, are being considered for the Carrizo-Wilcox aquifer. About 80 groundwater projects, both local and transport projects, are included in the 2021 plans for regions J, K, and L. Together these projects represent an estimated $1.1 billion in capital costs (Texas Water Development Board, n.d.-e).

6. **New Sources.** In 2021, the Railroad Commission of Texas identified and began to map a deep portion of the Glen Rose Formation (a possible extension of the Trinity aquifer) in several South Texas counties that could be a potential source of freshwater. The aquifer has been informally referred to as the Maverick Basin aquifer. Fresh groundwater has been reported at depths between 5,000 and 8,000 feet below land surface. Multiple organizations are working to evaluate its potential as a source of water (Texas Water Development Board, n.d.-c).

Recommendations for Implementation of Solutions

There is no one unique solution to address the water supply challenges of Central Texas—or for that matter the entire state. In Central Texas, solutions depend on the nature of the challenge.

1. Brackish groundwater is abundant and due to the cost of recovery and treatment, it may represent a good option for larger consumers such as water supply corporations, individual municipalities, and industry. Depending on the quality of the source water, the disposal of treatment residuals (either via a brine line to the deep waters of the Gulf or that and a combination of industrial uses that could derive value from the separated minerals) is likely to be the biggest impediment to large-scale implementation. Site-specific studies will be required, and the Board is working with individual groundwater conservation districts to develop a technical and regulatory framework to address future exploitation of this resource.

2. Aquifer storage and recovery does not generate "new water" but is an attractive option for addressing drought challenges when other sources are unavailable or too costly. This, too, is a site-specific option, and the Board has prepared regional ASR assessments. This is a demonstrated technology that is working well across America and is now beginning to be considered seriously due to the successful experience of the H2Oaks project. One of the challenges to be expected is finding suitable subsurface conditions as well as working within the regulatory framework of the local groundwater conservation districts.

3. Local off-channel reservoirs may be a good option in select areas with available land and variable stream flows. Like ASR, this option does not generate new water but can provide additional supply during times of water scarcity. However, off-channel reservoirs face land acquisition and evaporation concerns.

4. Transfer of groundwater and surface water will continue to be needed to ensure there is sufficient water to sustain and grow economically. Other than costs, there are few physical impediments to implementation for groundwater as groundwater transfer on a large scale is already taking place. Landowners are compensated for the sale of their groundwater while those who share common aquifers will need to be protected through mitigation programs to ensure that all have access to water. Surface water transport faces more legal and regulatory headwinds, and it will require both legislative action and political will to move water across basin boundaries. Surface water transport across basin boundaries is routine in other states and should happen in Texas. River basins in East Texas have water availability that exceeds anticipated demands, and with willing customers in other areas of Texas this should be a strategy to address future needs. Those in the source basins should be appropriately compensated according to the market value of the water.

5. Robust evaluation of underground water sources should continue from the state's resource agencies, such as the Board and the Railroad Commission. As has been recently shown, a significant amount of data is available that, when evaluated, could lead to

"It's impossible to overstate the importance of water to the economy. Prominent industries across Texas and the nation, such as agriculture, mining, manufacturing and health care depend on clean and reliable water sources to operate. Clean water for households and businesses also promotes public health, a prerequisite for economic growth." (Grubbs & Donald, 2022)

development of new sources of groundwater, such as the Maverick Basin aquifer.

6. For decades, the Board has funded regional water planning groups. However, districts in groundwater management areas have not received any funding to accomplish the legislatively mandated joint groundwater planning process. That process, which involves about 60% of the water consumed in Texas, represents an economic hardship for most of the groundwater conservation districts in the state. For a relatively small funding commitment (compared to that for current regional water planning), the state should fund joint groundwater planning.

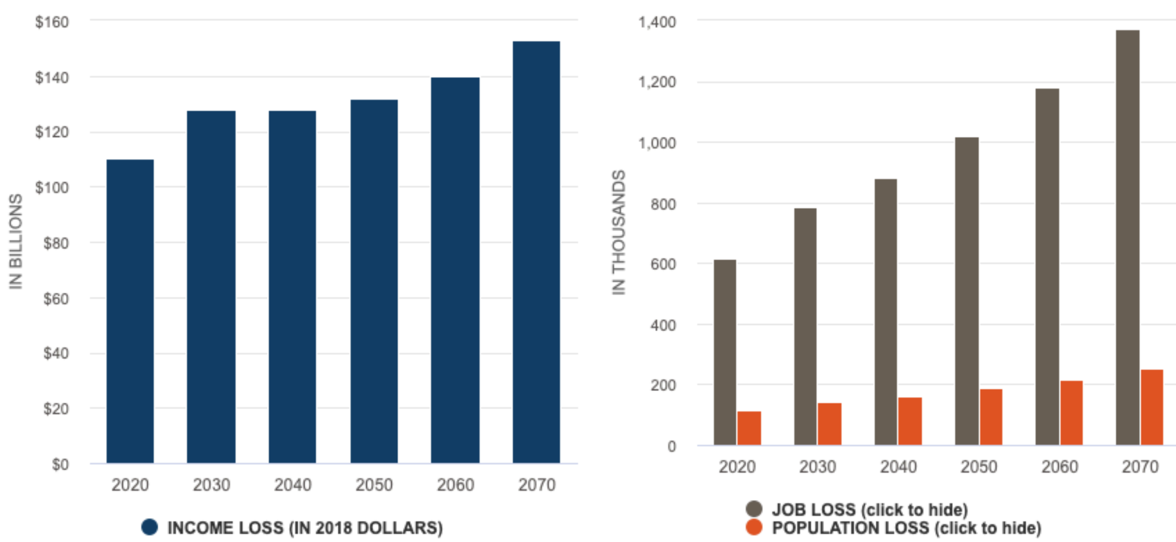
7. Groundwater management in Central Texas is heavily fragmented and runs counter to sensible decision-making concerning extensive regional aquifers. Consolidation of districts would help streamline groundwater management efforts without jeopardizing local input and control.

Impacts of Success and Failure

Quite simply, meeting the needs for water—both today and tomorrow—is essential for preserving and continuing the success of Texas. Water is the engine for agriculture, supports the growth of vital industries, ensures adequate and clean drinking water for Texas, and preserves an attractive place for recreation and enjoyment of the natural beauty. **Figure 11** illustrates the projected economic and demographic impacts of failing to implement water management strategies to ensure adequate and clean water for Texas. Failure costs billions of dollars and many thousands of jobs. Success ensures that Texas continues to lead the nation as an attractive and prosperous place to live.

Figure 11

Projected Statewide Annual Economic and Demographic Impacts If Water Needs Are Not Met, 2020–2070



Note. Graph reproduced from *2022 State Water Plan* by S. Grubbs and J. Donald, Fiscal Notes, July 2022, exhibit 3 (https://comptroller.texas.gov/economy/fiscal-notes/2022/jul/water-plan.php).

References

Aquifer Conservation Alliance. (n.d.). *Home page*. Retrieved January 3, 2023, from https://aquiferconservation.org/

Ayers, A., Hanak, E., Gray, B., Sencan, G., Bruno, E., Escriva-Bou, A., & Gartrell, G. (2021). *Improving California's water market – How water trading and banking can support groundwater management.* Public Policy Institute of California. https://www.ppic.org/publication/improving-californias-water-market/

California Department of Water Resources. (n.d.). *Flood-managed aquifer recharge (flood-MAR)*. Retrieved February 5, 2023, from https://water.ca.gov/programs/all-programs/flood-mar

City of Midland. (n.d.) *Midland's water sources*. Retrieved February 5, 2023, from https://www.midlandtexas.gov/170/Midlands-Water-Sources

Croskrey, A., Golab, J., & Collazo, D. (2022). *Aquifer storage and recovery report: Carrizo-Wilcox aquifer characterization for eastern Gonzales and parts of Caldwell and Guadalupe counties, Texas*. Texas Water Development Board. https://www.twdb.texas.gov/publications/reports/numbered_reports/doc/R387-TWDB-ASR-report-Cz-Wx-Aquifer-East-Gonzales-County.pdf

East Texas Regional Water Planning Group. (2020). *East Texas regional water planning area 2021 regional water plan.* https://www.twdb.texas.gov/waterplanning/rwp/plans/2021/index.asp#region-i

Escriva-Bou, A., Sencan, G., & Hanak, E. (2021). *Groundwater recharge fact sheet*. Public Policy Institute of California. https://www.ppic.org/publication/groundwater-recharge/

Federal Reserve Bank of Dallas. (2013). *Dallas Fed: Water scarcity could impede Texas economic growth.* https://www.dallasfed.org/news/releases/2013/nr131203

George, P.G., Mace, R. E., & Petrossian, R. (2011). *Aquifers of Texas*. Texas Water Development Board. https://www.twdb.texas.gov/publications/reports/numbered_reports/doc/R380_AquifersofTexas.pdf

Groundwater Conservation Districts in Groundwater Management Area 14. (2022). *Desired future conditions explanatory report*. https://www.twdb.texas.gov/groundwater/dfc/docs/2021/GMA14_DFCExpRep_2021.pdf

Grubbs, S., & Donald, J. (2022, July). *The 2022 state water plan*. Fiscal Notes. https://comptroller.texas.gov/economy/fiscal-notes/2022/jul/water-plan.php

Harcourt, J. (2022, January). *Identification of a deep superior quality aquifer in several transboundary counties of Texas*. Railroad Commission of Texas. https://tgpc.texas.gov/tgpc-sub-meetings/presentations/ReviewDeepMaverickAquiferPotentialTGPC.pdf

HB 1912. 87th Texas Legislature. Regular. (2021). https://capitol.texas.gov/BillLookup/History.aspx?LegSess=87R&Bill=HB1912

Henry, T. (2013, June 11). *After rice farmers cut off last year, water use cut in half in Central Texas*. NPR StateImpact. https://stateimpact.npr.org/texas/2013/06/11/after-rice-farmers-cut-off-water-use-cut-in-half-in-central-texas/

Lower Colorado River Authority. (n.d.). *The Colorado River and Highland Lakes*. Retrieved February 6, 2023, from https://www.lcra.org/water/highland-lakes-overview/

Metropolitan Water District of Southern California. (n.d.). *Diamond Valley Lake*. Retrieved February 6, 2023, from https://www.mwdh2o.com/diamond-valley-lake/

Meyer, J., Croskrey, A., Suydam, A., & van Oort, N. (2020). *Brackish groundwater in aquifers of the Upper Coastal Plains, Central Texas*. Texas Water Development Board. https://www.twdb.texas.gov/publications/reports/numbered_reports/doc/R385/R385_UCPC.pdf

Robinson, M., Suydam, A., Strickland, E., & AlKurdi, A. (2022). *Brackish groundwater in the Hill Country Trinity aquifer and Trinity Group formations, Texas*. Texas Water Development Board. https://www.twdb.texas.gov/publications/reports/numbered_reports/doc/R388-Hill-Country-Trinity-Brackish-Resources.pdf

Rochelle, M., & Vassar, N. (2016). *Water supply planning opportunities: exempt interbasin transfers*. Lloyd Gosselink Attorneys at Law. https://www.lglawfirm.com/wp-content/uploads/2016/06/Water-Supply-Planning-Opportunities-MCR-NEV.pdf .

San Antonio Water System. (2019). *Vista Ridge pipeline*. https://www.saws.org/wp-content/uploads/2019/07/SAWS_VistaRidge_PipelineFactSheet.pdf

San Antonio Water System. (n.d.). *Brackish groundwater desalination.* Retrieved February 23, 2023, from https://sawsstg.saws.org/your-water/management-sources/brackish-groundwater-desalination/

Shaffer, B. (2022, November 22). Perry: 'Texas Miracle' depends on access to water. *Plainview Herald*. https://www.myplainview.com/news/local/article/Perry-Texas-Miracle-depends-on-access-to-17604308.php

Storms, R. (2022). *Effects of drought on groundwater in Texas: Water level and spring flow data analysis of current and historic drought conditions*. Texas Water Development Board. https://tgpc.texas.gov/tgpc-sub-meetings/presentations/Final_GW_Drought_TGPC.pdf

Texas Commission on Environmental Quality. (n.d.) *Texas relies on 1944 Treaty Water*. Retrieved February 6, 2023, from https://www.tceq.texas.gov/border/water-deficit.html

Texas State Historical Association. (1995, December 1). *Surface water*. https://www.tshaonline.org/handbook/entries/surface-water

Texas Water Development Board. (n.d.-a). *A Texan's guide to water and water rights marketing*. Retrieved November 14, 2022, from https://www.twdb.texas.gov/publications/reports/infosheets/doc/WaterRightsMarketingBrochure.pdf

Texas Water Development Board. (n.d.-b). *Texas water bank*. Retrieved November 14, 2022, from http://www.twdb.texas.gov/waterplanning/waterbank/bank/index.asp

Texas Water Development Board. (n.d.-c). *Deep Glen Rose formation in South Texas (the 'Maverick Basin' aquifer)*. Retrieved November 10, 2022, from http://www.twdb.texas.gov/groundwater/special_projects/maverick/index.asp

Texas Water Development Board. (n.d.-d). *2021 joint groundwater planning*. Retrieved November 10, 2022, from http://www.twdb.texas.gov/groundwater/dfc/2021jointplanning.asp

Texas Water Development Board. (n.d.-e). *2021 regional water plans*. Retrieved December 5, 2022, from https://www.twdb.texas.gov/waterplanning/rwp/plans/2021/index.asp

Texas Water Development Board. (n.d.-f). *Major aquifers*. Retrieved February 20, 2023, from https://www.twdb.texas.gov/groundwater/aquifer/major.asp

Texas Water Development Board. (n.d.-g). *Groundwater conservation district facts*. Retrieved February 20, 2023, from https://www.twdb.texas.gov/groundwater/aquifer/major.asp

Texas Water Development Board. (n.d.-h). *Water data interactive*. Retrieved February 20, 2023, from https://www3.twdb.texas.gov/apps/waterdatainteractive/groundwaterdataviewer

Texas Water Development Board. (n.d.-i). *Current water bank deposits*. Retrieved February 20, 2023, from https://www.twdb.texas.gov/waterplanning/waterbank/bank/deposits.asp

Texas Water Development Board. (2007). *Water for Texas – 2007 state water plan*. https://www.twdb.texas.gov/waterplanning/swp/2007/index.asp

Texas Water Development Board. (2016). *Texas aquifers study – Groundwater quantity, quality, flow, and contributions to surface water*. https://www.twdb.texas.gov/groundwater/docs/studies/TexasAquifersStudy_2016.pdf

Texas Water Development Board [@twdb]. (2019, April 29).*Texas is a large state whose climate and geography vary greatly. What grows well in humid East Texas may not* [Image attached] [Tweet]. Twitter. https://twitter.com/twdb/status/1122863540539416577

Texas Water Development Board. (2021). *Water for Texas – 2022 state water plan*. https://www.twdb.texas.gov/waterplanning/swp/2022/

Votteler, T., Alexander, K., & Moore, J. (2006). The evolution of surface water interbasin transfer policy in Texas: Viable options for future water, water grabs, or just pipe dreams? *Texas Environmental Law Journal*, *36*(3), 125. https://waterdisputes.org/wp-content/uploads/2017/12/water-transfers-todd-votteler.pdf

WestWater Research. (2022). *Growing water demand, drought, and increasing water development costs – Why Texas needs a more robust surface water market*. Water Market Insider. https://static.texastribune.org/media/files/a96b41488965c98e7f424c7cb5885c21/2022-Q3-Water-Market-Insider.pdf

White, K. H., Rubinstein, C., Settemeyer, H., & Ingram, M. (2017). *The Case for a Texas Water Market*. Texas Public Policy Foundation. https://www.texaspolicy.com/the-case-for-a-texas-water-market/

Notes

Notes

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