Water
— *for* —
Texas

2017 State Water Plan

Texas Water Development Board

2017 State Water Plan

Water
— *for* —
Texas

(Includes amendment #1)

Texas Water Development Board

www.twdb.texas.gov
texasstatewaterplan.org

Our Mission

To provide leadership, information, education, and support for planning, financial assistance, and outreach for the conservation and responsible development of water for Texas.

Texas Water Development Board

1700 North Congress Avenue,
P.O. Box 13231, Austin, Texas 78711-3231
Phone: 512-463-7847 | Fax: 512-475-2053
www.twdb.texas.gov

Dear Fellow Texans:

On behalf of my fellow Board members, Kathleen Jackson and Peter Lake, and the dedicated men and women of the Texas Water Development Board (TWDB), it is my privilege to present to you the 2017 State Water Plan. This is the 10th plan created since the agency's inception in 1957 and the fourth since the current "bottom up" regional water planning approach began in 1997. Now, decades of water planning experience and a renewed appreciation of the impacts of drought have resulted in the most comprehensive state water plan ever created.

This state water plan was produced on the heels of the worst one-year drought in our recorded history, in 2011. Over the course of one year, Texas transitioned from virtually drought free to exceptional statewide drought. The 2011 drought taught us entirely new lessons about how fast drought can strike and how severe it can be. Simply put, 2011 provided a wake-up call for water providers across our state.

Fortunately, the five-year planning cycle allows our state water plan to adapt to and account for conditions worse than the previous drought of record. In the 2017 plan, six of the 16 regional planning groups indicated potential new droughts of record for their regions, resulting in reduced estimates of existing surface water supplies. These weather assumptions, coupled with the fact that our state's population continues to boom, made this planning cycle the most challenging yet.

Our state's 16 regional water planning groups rose to the challenge. The 2017 State Water Plan includes 5,500 water management strategies—an increase from roughly 3,700 strategies listed in the previous plan—whose diversification speaks to lessons learned from the drought. Conservation and reuse strategies increased from 34 percent to 45 percent of total future water volume. Innovative water technologies such as desalination and aquifer storage and recovery (ASR) will also play a significant role in Texas' water supply future.

To assist entities with translating their water planning efforts into water projects, the TWDB remains committed to providing low-cost financing options. For state water plan projects in particular, we are proud to offer the recently created State Water Implementation Fund for Texas (SWIFT) program, through which billions of dollars in financial assistance have already been committed.

The true measure of this plan's success, however, is represented by the dedication and hard work of more than 450 regional water planning group members who have volunteered countless hours to ensure Texas will have the water it needs for decades to come. Additionally, the Board would like to extend our sincerest appreciation and thanks to TWDB staff, without whom the state water plan would not be possible. As Board members we are truly privileged to represent an agency full of public servants dedicated to fulfilling the mission of conserving and securing Texas water for future generations.

God Bless Texas,

Bech K. Bruun, Chairman

This page left intentionally blank.

Acknowledgments

The 2017 State Water Plan would not have been possible without the time and expertise of numerous people and organizations throughout Texas. The Texas Water Development Board (TWDB) would like to express its sincere appreciation to all who participated in the development of the 16 regional water plans and this state water plan: the more than 450 regional water planning group voting members (listed below), their consultants, and their administrative agents (listed below); staff of the TWDB; Texas Parks and Wildlife Department, Texas Department of Agriculture, Texas Commission on Environmental Quality, and other state and federal agencies; and the individuals and organizations that provided public input throughout the planning process.

Finally, we would like to thank the leadership of the State of Texas for their consistent support and recognition of the importance of water planning.

Regional Water Planning Group Voting Members

*(Region – member) *planning group chairs at the time the 2016 regional water plans were adopted*

A - Autrey, Emmett
A - Bailiff, Tom
A - Baumgardner, Joe
A - Clark, Nolan
A - Cook, Vernon
A - Cooke, Charles
A - Cooke, Dean
A - Crowell, Amy
A - Derington, Jim
A - Gibson, Rick
A - Gilmore, Rusty
A - Green, Glen
A - Guthrie, Janet
A - Hallerberg, Bill
A - Keys, Sandy
A - Kidd, Bobby
A - Kleuskens, Tonya
A - Krienke, Danny
A - Landis, David
A - Meyer, Robert
A - Satterwhite, Kent
A - Skaggs, Grady
A - Smith, Lynn
A - Stephens, Beverly
A - Sweeten, John M.
A - Tregellas, Janet
A - Walthour, Steve
A - Weber, Jay
A - Weinheimer, Ben
*A - Williams, C.E.**
A - Williams, John C.
B - Armstrong, Tamela
B - Banks, Jimmy
B - Bell, Charlie
B - Brite, J.K. Rooter
*B - Campbell, Curtis**
B - Campsey, Jack
B - Christopher, Mark
B - Deweber, N.E.
B - Dodge, Rebecca L.
B - Garnett, Ed
B - Grant, Mitch
B - Hughes, Dale
B - Kidd, Bobby
B - Liggett, Kenneth
B - McGuire, Mike
B - McMahon, Monte
B - Mesler, Tracy
B - Myers, Dean
B - Payne, Jerry
B - Scaling, Wilson
B - Schreiber, Russell
B - Simpson, Gayle
B - Stephens, Pamela
B - Stephens, Tom
B - Watts, Jeff
C - Bailey, David
C - Berry, Steve
C - Carman, John
C - Ceverha, Bill
C - Chapman, Jerry W.
C - Crumb, Frank
C - Douglas, Gary
C - Hotopp, James
C - Kula, Tom
C - La Point, Thomas
C - Latham, Harold
C - Laughlin, Russell
C - Lewis, Bill
C - Lingenfelder, John
C - Maenius, G.K.
C - Martin, Howard
C - McCarter, Jim
C - Mundt, Steve
C - Parks, Jim
C - Phillips, Paul
*C - Puckett, Jo "Jody"**
C - Riley, Bob
C - Satterwhite, Drew
C - Scott, Bob
C - Spicer, Gary
C - Standridge, Connie
C - Stevens, Jack
C - Vance, Danny
C - Vogelson, Mary E.
C - Ward, Kevin
C - Woodward, Tom
D - Bradley, Adam
D - Bradley, Johnny Mack
D - Brown, Michael K.
D - Calvin, Larry
D - Carter, Greg
D - Clements, Nancy
D - Conner, Doug
D - Crews, Mark
D - Douthit, Darwin
D - Duman, JoAnn
D - DuMond, Jeremy
D - Dunn, Mike
D - Eidson, Jim
D - Evans, Danny
D - Frost, George
D - Gaskill, Jerry
D - Gillis, Charles
D - Glidewell, Brice
D - Grubbs, Darrell
D - Henry, Troy
D - Hightower, Don
D - Hilliard, Dennis
D - Holt, Robert
D - Kirby, Bill
D - Long, Sam
D - McCoy, Bret
D - McCoy, Mike
D - Nabors, David
D - Nabors, Sharron
D - Nicholson, Tim
D - Nickerson, Jim
D - Patterson, Don
*D - Price, Linda**
D - Roberts, Drew
D - Shaw, Kenneth
D - Shumake, Shirley
D - Slater, Tommy
D - Speight, Robert, Jr.
D - Spence, Kevin
D - Staton, Bob
D - Stuart, Cheri
D - Wadley, Doug
D - Williams, Mark
E - Adams, Janet
E - Allen, Ann
E - Archuleta, Ed
E - Barker, Randy
*E - Beard, Tom**
E - Bennett, Jeff
E - Borunda Firth, Sylvia
E - Brewster, Rebecca L.
E - Butcher, Sterry
E - Chacon, Roger
E - Davidson, Michael
E - Etzold, David
E - Gandara, Willie
E - Hall, Dave

E - Livingston, Mike
E - Miller, Albert
E - Miller, Jim Ed
E - Mitchell, Scott
E - Norris, Kenn
E - Palacios, Arlina
E - Perez, Vincent
E - Reinert, Scott
E - Reyes, Jesus "Chuy"
E - Tate, Rick
E - Todd, Teresa
E - Waggoner, Paige
E - Webb, Summer
F - Anderson, Woody
F - Barr, Mark
F - Bearden, Jerry
F - Brown, Stephen
F - Dickson, Ricky
F - Dierschke, Kenneth
F - Gist, Richard
F - Grant, John*
F - Hagood, Charles
F - Holland, Scott
F - Moody, Wendell
F - Moore, Robert
F - Runge, Caroline
F - Scott, Terry
F - Shepard, John
F - Shepperd, Ben
F - Straub, Raymond, Jr.
F - Taylor, Merle
F - Turnbough, Larry
F - Van Deventer, Gilbert
F - Warren, Tim
F - Weatherby, Paul
F - Wilde, Will
F - Wilson, Len
G - Adams, Dale
G - Beseda, Charles
G - Blackburn, David
G - Briggs, Jim
G - Brown, Tim
G - Clark, Tom
G - Cooper, Joe
G - Cox, Alva
G - Floyd, Travis
G - Ford, Phil
G - Groth, Larry
G - Hodson, James
G - Holland, Zach
G - Kinard, Kelly
G - McGuire, Mike
G - Newman, Gary
G - O'Brien, Tommy
G - Parker, Judy
G - Patrick, Brian
G - Peek, Gail
G - Smith, Sheril
G - Spicer, Gary
G - Spurgin, Dale
G - Sutherland, Mike
G - Waclawczyk, Randy
G - Wagner, Kevin
G - Webster, Kathleen J.
G - Weldon, Kenny
G - Westbrook, Gary
G - Wilson, Wayne*
H - Bailey, David
H - Bartos, John R.
H - Blount, John
H - Bruner, Robert
H - Chang, Jun
H - Collinsworth, David
H - Comin, James
H - Eichelberger, Reed
H - Evans, Mark*
H - Fisseler, Gene
H - Hebert, Robert
H - Henson, Art
H - Hofmann, John
H - Houston, Jace
H - Howard, John
H - Istre, Robert
H - Jones, Kathy Turner
H - Leathers, Gená
H - Leiper, Glynna
H - Long, Ted
H - Lord, Glenn
H - Marcell, Marvin
H - Masterson, Carl
H - Morrison, James
H - Neighbors, Ron J.
H - Schindewolf, Jimmie
H - Teer, William, P.E.
H - Tyler, Steve
H - Vance, Danny
H - Wallace, C. Harold
H - Ward, Kevin
H - Willcox, George "Pudge"
I - Adams, Leah
I - Alders, David
I - Branick, Jeff
I - Brock, David
I - Campbell, George P.
I - Clark, Jerry
I - David, Josh Wilson
I - Davis, Chris
I - Dunn, Mark
I - Hall, Scott
I - Harbordt, Dr. C. Michael
I - Heugel, William
I - Holcomb, Joe
I - Holcomb, Kelley*
I - Kimbrough, Bill
I - Kindle, Glenda
I - Lyons, Duke
I - Martin, John
I - Montagne, David
I - Morgan, Gregory
I - Peddy, Dale
I - Reed, Hermon E., Jr.
I - Shank, Monty
I - Smith, Darla
I - Whitehead, Worth
I - Young, J. Leon, Ph.D.
J - Barron, Stuart
J - Buck, Ray
J - Bushong, Perry
J - Carver, Ken
J - Davis, Zack
J - Gonzalez, Otila
J - Heffley, Jerry
J - Hobbs, Genell
J - Jackson, Howard
J - Jeffery, David
J - Letz, Jonathan*
J - Lomas, Mitch
J - Lowery, Kent
J - Mauk, David
J - Pace, Ronnie
J - Pigg, Joel
J - Postell, Peggy Sue
J - Qualia, Thomas M.
J - Shahan, Tully
J - Simpton, Jerry
J - Stevens, Homer T., Jr.
J - Sweeten, Lee
J - Talamantes, Melony
J - Trees, Roland
J - Villareal, Rene
J - Wiedenfeld, Charles (Charlie)
J - Williams, Gene
J - Wilson, William F. (Feather)
K - Barho, Jim
K - Brasher, Jim
K - Burke, John E..*
K - Dupnik, John T., P.G.
K - Fieseler, Ronald G.
K - Gertson, Ronald
K - Gillam, Lauri
K - Haschke, Karen
K - Hoffman, John
K - Johnson, Barbara
K - King, Joseph
K - Klaeger, Donna
K - Lewis, Brenton
K - Luedecke, Bill
K - Lutes, Teresa
K - Neve, Bill
K - Powell, Doug
K - Reagor, Mike
K - Roeder, W.A. (Billy)
K - Ruggiero, Rob
K - Shell, Charlie
K - Simon, Haskell
K - Sultemeier, James
K - Theodosis, Byron
K - Totten, Jim
K - Tybor, Paul
K - Van Dresar, David
K - Wade, Brandon
K - Walker, Jennifer
K - Wheelock, David
L - Ammerman, Jason
L - Andruss, Tim
L - Balin, Donna
L - Brownlow, Darrell
L - Camargo, Gene
L - Chavez, Rey
L - Cockerell, Alan
L - Conley, Will
L - Dietzmann, Don
L - Dohmann, Art
L - Fitzsimons, Blair
L - Hilderbran, Vic
L - Janak, Kevin
L - Kight, John
L - Labus, Russell
L - Leathers, Gena
L - Lord, Glenn
L - Mahoney, Mike
L - McGookey, Doug
L - Meyer, Daniel
L - Middleton, Gary
L - Mims, Con*
L - Pena, Illiana
L - Puente, Robert
L - Ramsey, Steve
L - Roberts, David
L - Ruiz, Roland
L - Savage, Diane
L - Scott, Suzanne B.
L - Sengelmann, Greg
L - Stolte, Milton
L - Taggart, Tom
L - Wassenich, Diane
L - West, Bill
L - Yablonski, Adam
M - Barrera, Jorge
M - Benavides, Nick
M - Bruciak, John
M - Campbell, Mary Lou
M - Darling, James (Jim)
M - de la Rosa, Ella
M - Flores, Jaime
M - Fulbright, Robert E.
M - Garza, Carlos
M - Goldsberry, Dennis
M - Gonzalez, Humberto
M - Hinojosa, Sonny
M - Jarvis, Glenn*
M - Lambert, Sonia

M- McGhee, Donald K.
M- Pena, Robert, Jr.
M- Prewett, Ray
M- Quintanilla, Joel
M- Rathmell, Joe
M- Rodriguez, Tomas, Jr.
M- Schuster, Frank
M- Vela, Armando
N - Almaraz, Joe
N - Ballou, Tom
*N - Bledsoe, Scott, III**
N - Burns, Chuck
N - Carillo, Teresa
N - Dick, Billy
N - Dove, Bill
N - Durham, Lavoyger
N - Eddins, Gary
N - Garza, Andy
N - Hennings, Bill
N - Hubert, Pancho
N - Knolle, Pearson
N - Koenig, Lindsey
N - Krebs, David
N - Kunkel, Robert
N - Ornelas, Martin
N - Paulson, Bernard
N - Reding, Thomas, Jr.
N - Ring, Charles
N - Scott, Mark
*N - Serrato, Carola**
N - Stewart, Lonnie
N - Stockseth, Kimberly
N - Stockton, William
N - Sugarek, Mark
N - Tunnell, Jace
O - Barnes, Melanie
O - Baucum, Delaine
O - Blalack, Bruce
*O - Brown, Harold P. "Bo"**
O - Campsey, Jack
O - Coleman, Jason
O - Conkwright, Jim
O - DeLoach, Mike
O - Ellison, Delmon, Jr.
O - Everheart, Harvey
O - Fulton, Tom
O - Gillespie, Richard
O - Harbin, Bill
O - Hopper, Ronnie
O - Hutcheson, Doug
O - Josserand, Bob
O - Kirkpatrick, Mark
O - Leonard, Richard
O - McClendon, Mike
O - McElroy, Don
O - Montgomery, E.W. (Gene)
O - Morris, Charles
O - Rainwater, Ken
O - Satterwhite, Kent
O - Simons, Tom
O - Spear, Aubrey
O - Steiert, Jim
O - Taylor, John
O - Wedel, Jimmy
P - Bonzer, Calvin
P - Brandenberger, Tommy
P - Brzozowski, Patrick
P - Butschek, John
P - Clark, Gerald
P - Griffin, Roy
P - Hudgins, Neal
P - Jahn, Rodney
P - Little, Lester
P - Maloney, Jack
P - Martin, Robert
P - Miller, Phillip
P - Ottis, Richard
P - Pustka, Edward
P - Raun, L.G.
P - Shoemate, Robert
P - Skalicky, Michael
P - Spenrath, Philip
*P - Stafford, Harrison, II**
P - Wagner, David
P - Weinheimer, Ed

Administrative Agents

A – Panhandle Regional Planning Commission
B – Red River Authority of Texas
C – Trinity River Authority
C – North Texas Municipal Water District
D – Northeast Texas Municipal Water District
E – Rio Grande Council of Governments
F – Colorado River Municipal Water District
F – City of San Angelo
G – Brazos River Authority
H – San Jacinto River Authority
I – City of Nacogdoches
J – Upper Guadalupe River Authority
K – Lower Colorado River Authority
L – San Antonio River Authority
M – Lower Rio Grande Valley Development Council
N – Nueces River Authority
O – High Plains UWCD No. 1
P – Lavaca-Navidad River Authority

Table of contents

Contents

List of Figures

List of Tables

2017 State Water Plan

Water *for* Texas

Executive summary

Water for Texas
2017 State Water Plan
Texas Water Development Board

Quick facts

Texas' state water plans are based on future conditions that would exist in the event of a recurrence of the worst recorded drought in Texas' history—known as the "drought of record"—a time when, generally, water supplies are lowest and water demands are highest.

Texas' population is expected to increase more than 70 percent between 2020 and 2070, from 29.5 million to 51 million, with over half of this growth occurring in Regions C and H. Water demands are projected to increase less significantly, by approximately 17 percent between 2020 and 2070, from 18.4 million to 21.6 million acre-feet per year.

Texas' existing water supplies—those that can already be relied on in the event of drought—are expected to decline by approximately 11 percent between 2020 and 2070, from 15.2 million to 13.6 million acre-feet per year.

Water user groups face a potential water shortage of 4.8 million acre-feet per year in 2020 and 8.9 million acre-feet per year in 2070 in drought of record conditions.

Approximately 5,500 water management strategies recommended in this plan would provide 3.4 million acre-feet per year in additional water supplies to water user groups in 2020 and 8.5 million acre-feet per year in 2070.

The estimated capital cost to design, construct, and implement the approximately 2,500 recommended water management strategy projects by 2070 is $63 billion.

If strategies are not implemented, approximately one-third of Texas' population would have less than half the municipal water supplies they will require during a drought of record in 2070.

If Texas does not implement the state water plan, estimated annual economic losses resulting from water shortages would range from approximately $73 billion in 2020 to $151 billion in 2070.

Through SWIFT and other financial assistance programs, the TWDB has provided $1.9 billion in financial assistance to approximately 60 state water plan projects recommended in the 2012 State Water Plan.

Why do we plan?

Texas is home to a thriving, diverse, and innovative economy. To ensure the ongoing vitality of our economy, Texas' citizens, water experts, and government agencies collaborate in a comprehensive water planning process. We plan so that Texans will have enough water in the future to sustain our cities and rural communities, our farms and ranches, and our homes and businesses while also preserving the agricultural and natural resources that have defined Texas for generations.

Texas also has one of the fastest growing populations in the country. In 1950, only 8 million people lived in Texas. In 2010, approximately 25 million people called Texas home. By 2070, 51 million people are expected to live in the Lone Star State, all of whom will need water to work and live.

The goal of the water planning process is to ensure that we have adequate water supplies in times of drought. Water is Texas' most precious natural resource and is routinely threatened during our state's recurring periods of drought. Texas has a long history of drought, and there is no sign of that pattern changing; in fact, recent droughts remind us that more severe drought conditions could occur in the future. The drought of the 1950s is considered the "drought of record" for Texas and remains the benchmark for the water planning process.

Ensuring that we have adequate and affordable water supplies for all Texans requires advance planning. The Texas Water Development Board (TWDB) is the state's lead water planning and infrastructure financing agency and is statutorily responsible for administering the regional water planning process and preparing and adopting the state water plan every five years. Each new state water plan, which considers a 50-year horizon, must reflect and respond to changes in population, water supplies, technological improvements, economic shifts, project viability, and state policy.

Figure ES.1 - Regional water planning areas

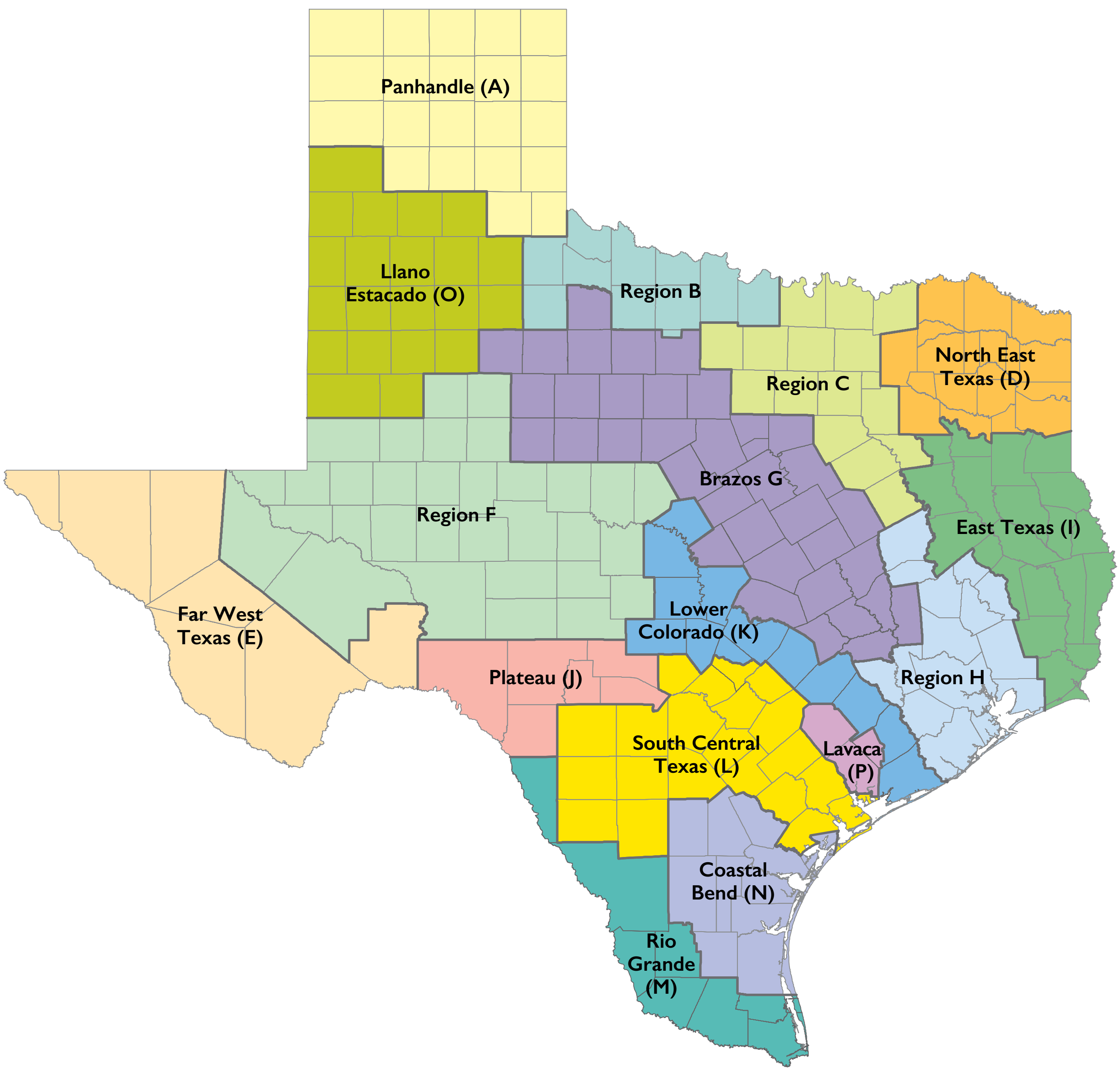
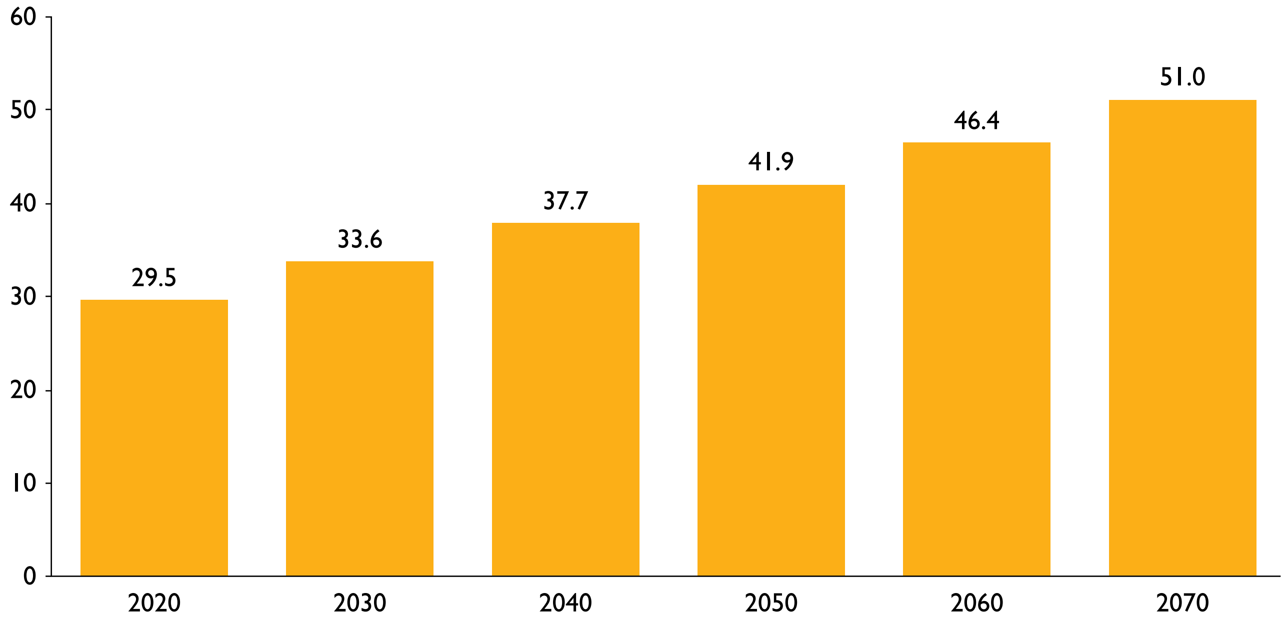


Figure ES.2 - Projected population in Texas (millions)



Water is critical to the future of Texas, and responsible planning ensures that we are addressing both the short- and long-term water needs of the state. Providing sufficient water supplies at reasonable costs presents new challenges with each planning cycle. Among those challenges are the increased costs of developing water supply projects that often require many years to implement.

How do we plan?

Since 1997, water planning in Texas has been based on a "bottom-up" approach focused at the regional level. The state is divided into 16 regional water planning areas (Figure ES.1). Each planning area is represented by a planning group that, on average, consists of about 23 members representing at least 12 statutorily required interests: the public, counties, municipalities, industries, agriculture, environment, small businesses, electric-generating utilities, river authorities, water districts, water utilities, and groundwater management areas where applicable.

During each five-year planning cycle, regional water planning groups evaluate population projections, water demand projections, and existing water supplies. Each planning group then identifies water shortages under drought of record conditions and recommends water management strategies (with cost estimates) to address those potential shortages. The bottom-up approach allows the planning groups to assess specific risks and uncertainties in their own regions and evaluate potential impacts of water management strategies on their region as well as on the state's water, agricultural, and natural resources.

Once the planning groups adopt their regional water plans, the plans are sent to the TWDB for approval. The TWDB then prepares the state water plan based on the regional water plans.

The state water plan also serves as a guide for state water policy and includes the TWDB's policy recommendations to the Texas Legislature. Each step of the water planning process is open to the public and provides numerous opportunities for public input.

How many Texans will there be?

The population in Texas is expected to increase 73 percent between 2020 and 2070, from 29.5 million[1]

[1] *Planning numbers presented throughout this plan have been rounded.*

to 51 million people (Figure ES.2). Growth rates vary considerably throughout the state. For example, 30 counties are projected to at least double their population by 2070; the rest are expected to remain the same, decline, or grow only slightly. Over half of all the statewide population growth between 2020 and 2070 is expected to occur within Regions C (which includes the Dallas-Fort Worth metropolitan area) and H (which includes the Houston metropolitan area).

How much water will we require?

While the population is projected to increase 73 percent over the next 50 years, water demand in Texas is projected to increase by only 17 percent, from about 18.4 million acre-feet per year in 2020 to about 21.6 million in 2070 (Figure ES.3). Steam-electric (power generation) demand is expected to increase in greater proportion than any other water use category, from 953,000 acre-feet per year in 2020 to 1.7 million in 2070. Municipal demands are anticipated to grow by the greatest total amount, from 5.2 million acre-feet per year in 2020 to 8.4 million in 2070. Agricultural irrigation demand is expected to decrease, from 9.4 million acre-feet per year in 2020 to about 7.8 million in 2070, due to more efficient irrigation systems, reduced groundwater supplies, and the transfer of water rights from agricultural to municipal users. Manufacturing and livestock demands are expected to increase, while mining demand is expected to decline over the next 50 years.

How much water do we have now?

The existing water supply—categorized as surface water, groundwater, and reuse water—is projected to decrease approximately 11 percent, from 15.2 million acre-feet per year in 2020 to about 13.6 million in 2070 (Figure ES.3). For planning purposes, the existing supply represents water supplies that are physically and legally available to be produced and delivered with current permits, current contracts, and existing infrastructure during drought of record conditions.

Figure ES.3 - Projected annual water demand and existing water supply in Texas (millions of acre-feet)

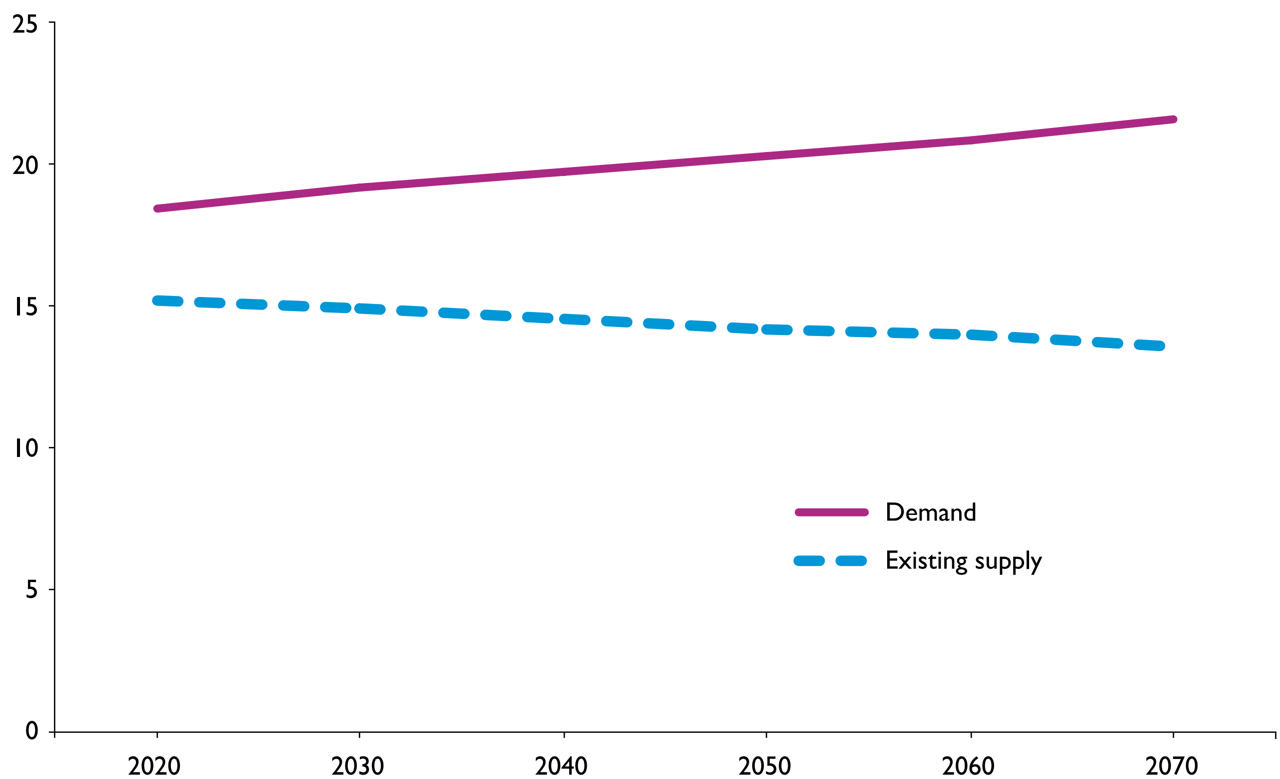
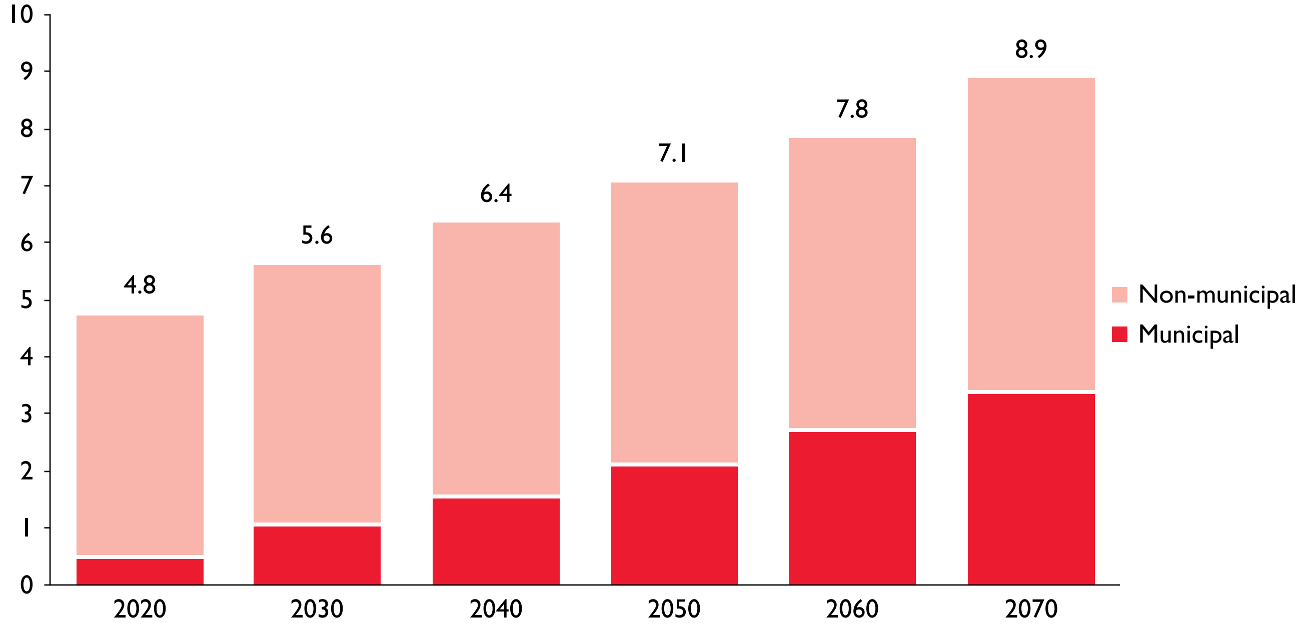


Figure ES.4 - Projected annual water needs in Texas (millions of acre-feet)



Existing surface water supplies are projected to decrease by about 1 percent, from 7.5 million acre-feet per year in 2020 to 7.4 million in 2070 due to sedimentation and changes in water contracts.

Groundwater supplies are projected to decrease 24 percent, from 7.2 million acre-feet per year in 2020 to 5.4 million in 2070. This decrease is primarily due to reduced supply from the Ogallala Aquifer (as a result of its depletion over time) and the Gulf Coast Aquifer (due to mandatory reductions in pumping to prevent land surface subsidence). Policy decisions made by groundwater conservation districts through the groundwater management area joint planning process also resulted in numerous changes to groundwater availability.

Do we have enough water for the future?

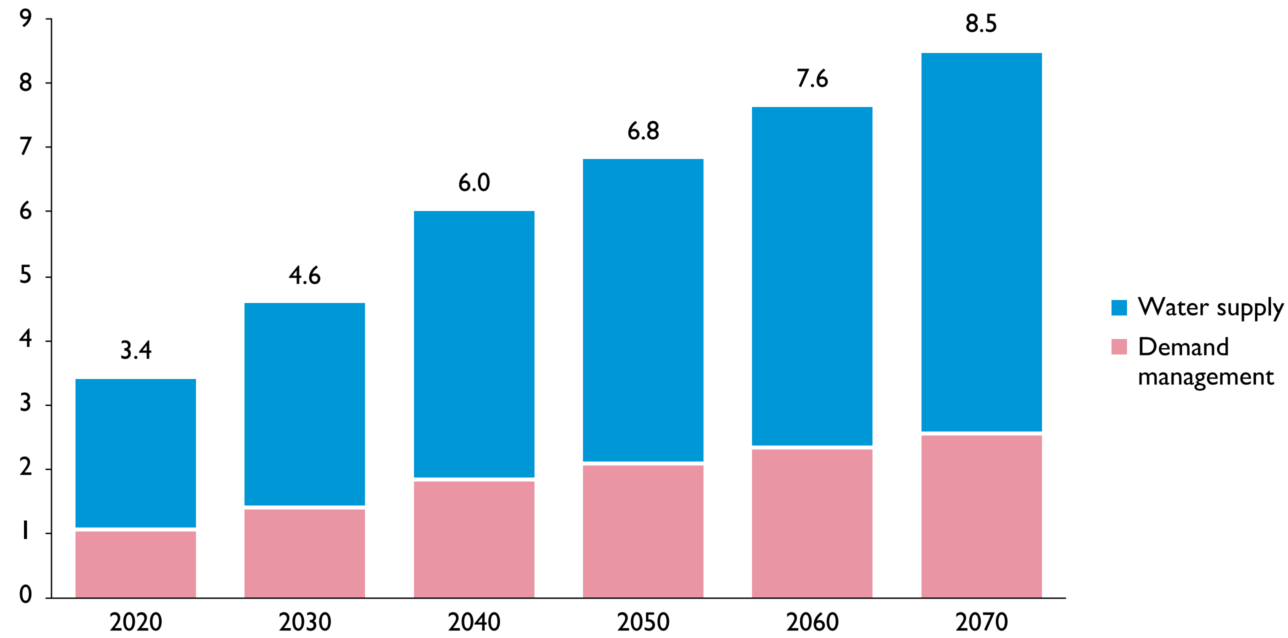
Because our existing water supply is not enough to meet our future demand for water during times of drought, Texas would need to provide 8.9 million acre-feet of *additional* water supplies, including in the form of water savings through conservation, to meet its demand for water in 2070. In the event of a recurrence of the drought of record in 2020, the state would face an immediate need for 4.8 million acre-feet per year in additional water supplies (Figure ES.4). Of that, 11 percent, (511,000 acre-feet) would be required for municipal water users, who face the largest water demand increase over the next 50 years. Total needs are projected to increase by 87 percent between 2020 and 2070, from 4.8 million to 8.9 million acre-feet per year. In 2070, 3.4 million acre-feet per year, or 38 percent of the total needs, is associated with municipal users.

What can we do to get more water?

When the projected demand for water exceeds the existing supply, the planning groups recommend water management strategies—specific plans and associated projects—to either provide additional water supply or reduce water demand. Water management strategies include conservation, new reservoirs, groundwater wells, water reuse, seawater and groundwater desalination, and more.

In the 2017 State Water Plan, planning groups recommended approximately 5,500 water management strategies and approximately 2,500 specific

Figure ES.5 - Annual volume of recommended water management strategies (millions of acre-feet)



water management strategy projects to increase the water supply. Strategies may or may not require new water infrastructure—referred to as water management strategy projects—to be developed. If implemented, these strategies would provide 8.5 million acre-feet per year in additional water supplies to water user groups by 2070 (Figure ES.5).

The full capacities of all recommended projects and strategies that are included in the approved regional water plans, including any of their associated capacities or volumes of water that may not be assigned to specific water user groups, are also considered to be part of the state water plan.

By 2070, about 30 percent of the total volume of these strategies would be in the form of demand management. Demand management refers to measures that reduce the need for additional water, such as conservation and drought management. Drought management includes activities that temporarily restrict water use for certain types of activities and businesses.

Surface water resources, including new reservoirs, compose the greatest portion of the recommended water management strategy supplies in 2070 at approximately 45 percent. Reuse is expected to provide approximately 14 percent, groundwater resources approximately 10 percent, and seawater desalination about 1 percent of additional supplies to water user groups (Figure ES.6).

Planning groups recommended a wide variety of water management strategies, each of which relies on a specific combination of water source(s), infrastructure, and technology (Figure ES.7). The types of recommended strategies depended on the region, available water resources, and water needs.

Some planning groups recommended strategies that, if implemented, would provide more water than may be required to meet their region's water needs under drought of record conditions. This additional supply addresses risks and uncertainties that are inherent to the planning process and the operation and management of water systems, including

- higher population growth and/or water demands than projected;
- unanticipated reduction in existing water supplies;
- the occurrence of a drought worse than the drought of record;

Figure ES.6 - Share of recommended water management strategies by water resource in 2070

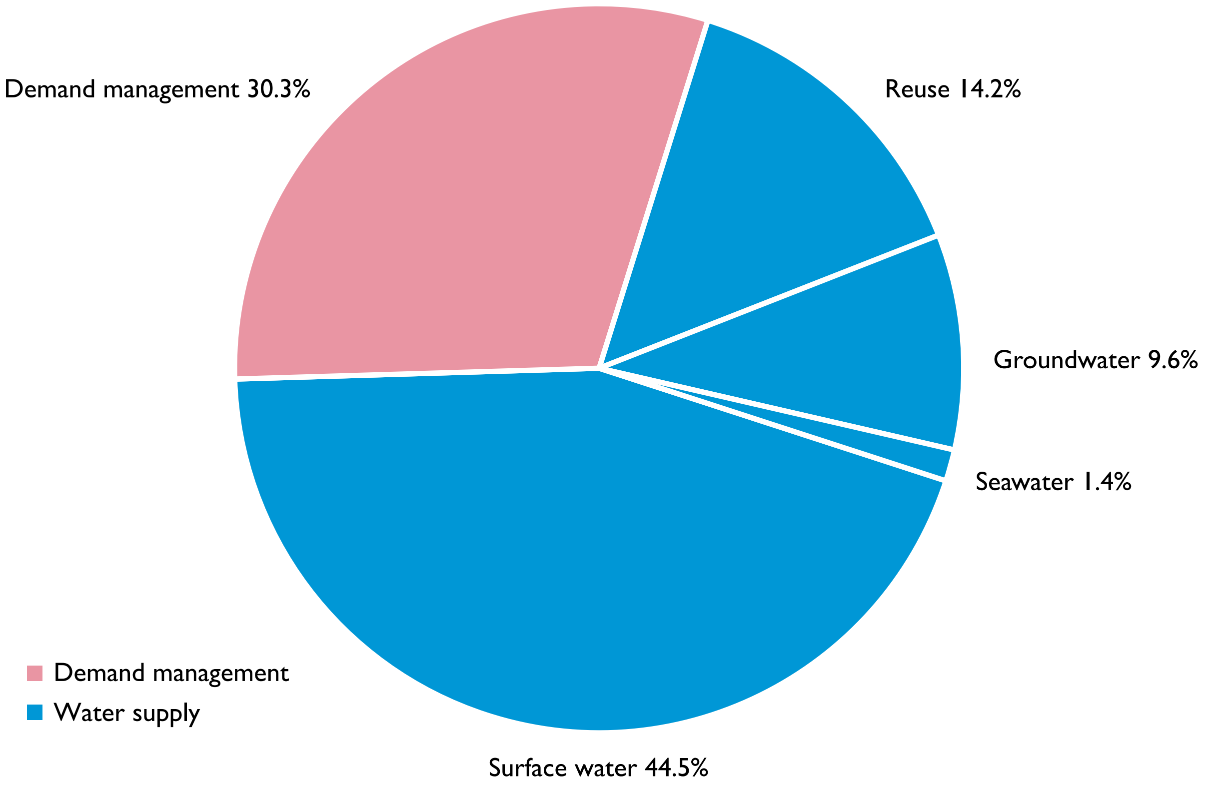


Figure ES.7 - Share of recommended water management strategies by strategy type in 2070

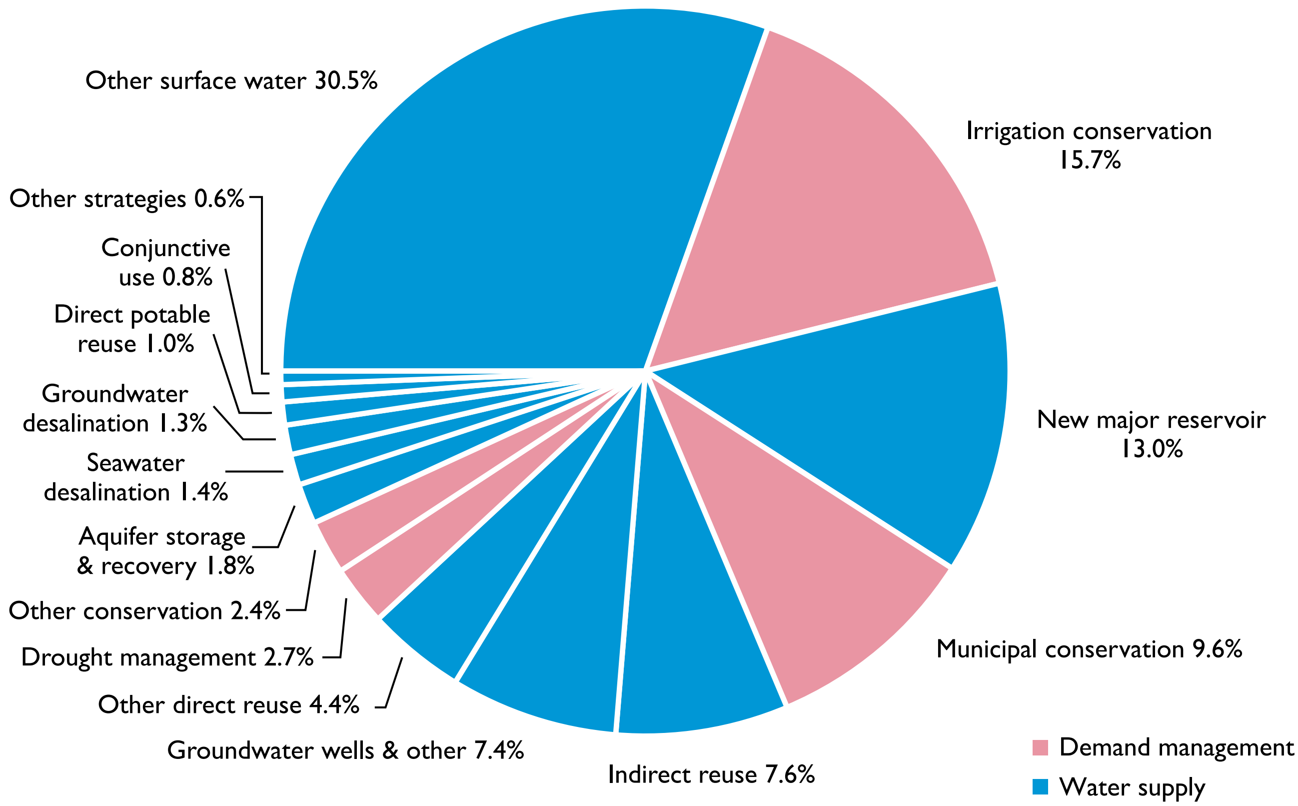


Figure ES.8 - Annual water supply needs and needs met by the plan by region in 2070 (acre-feet)

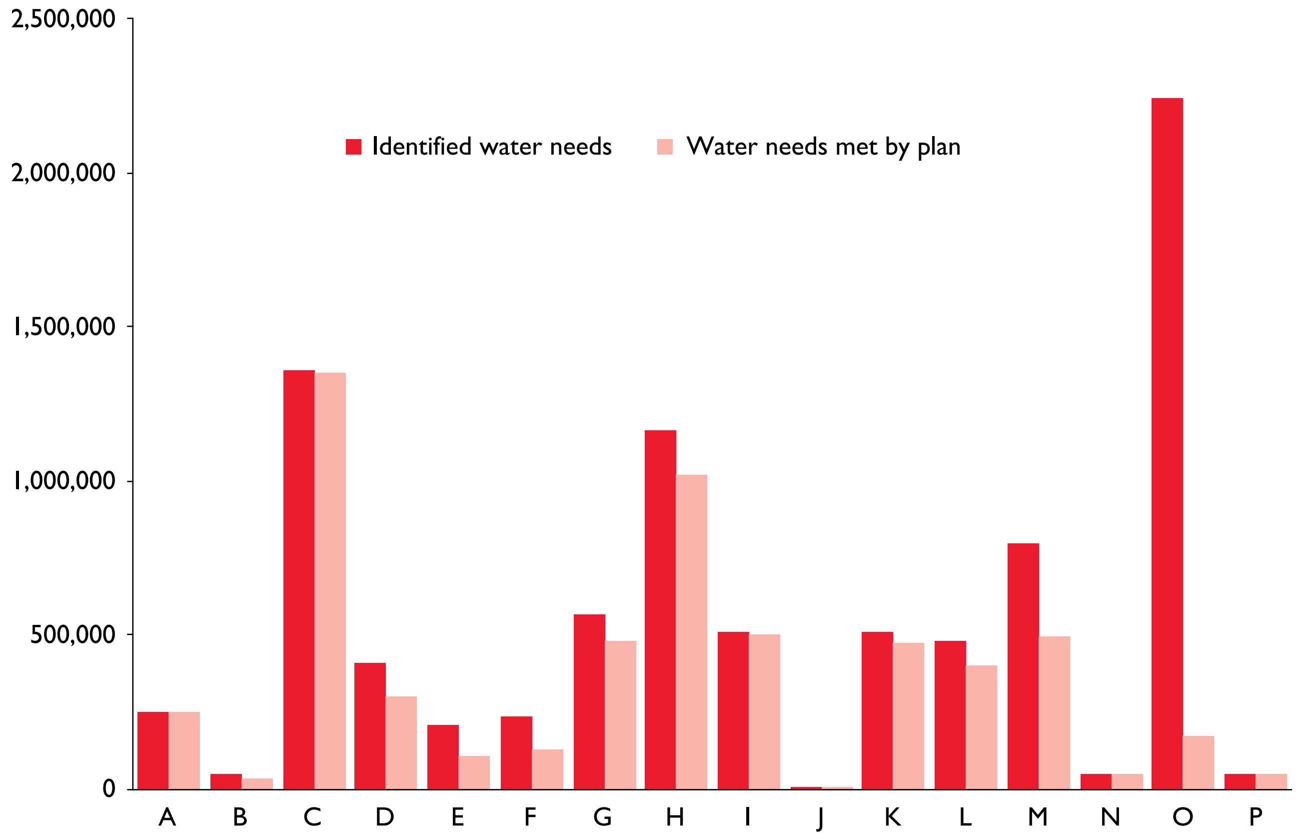
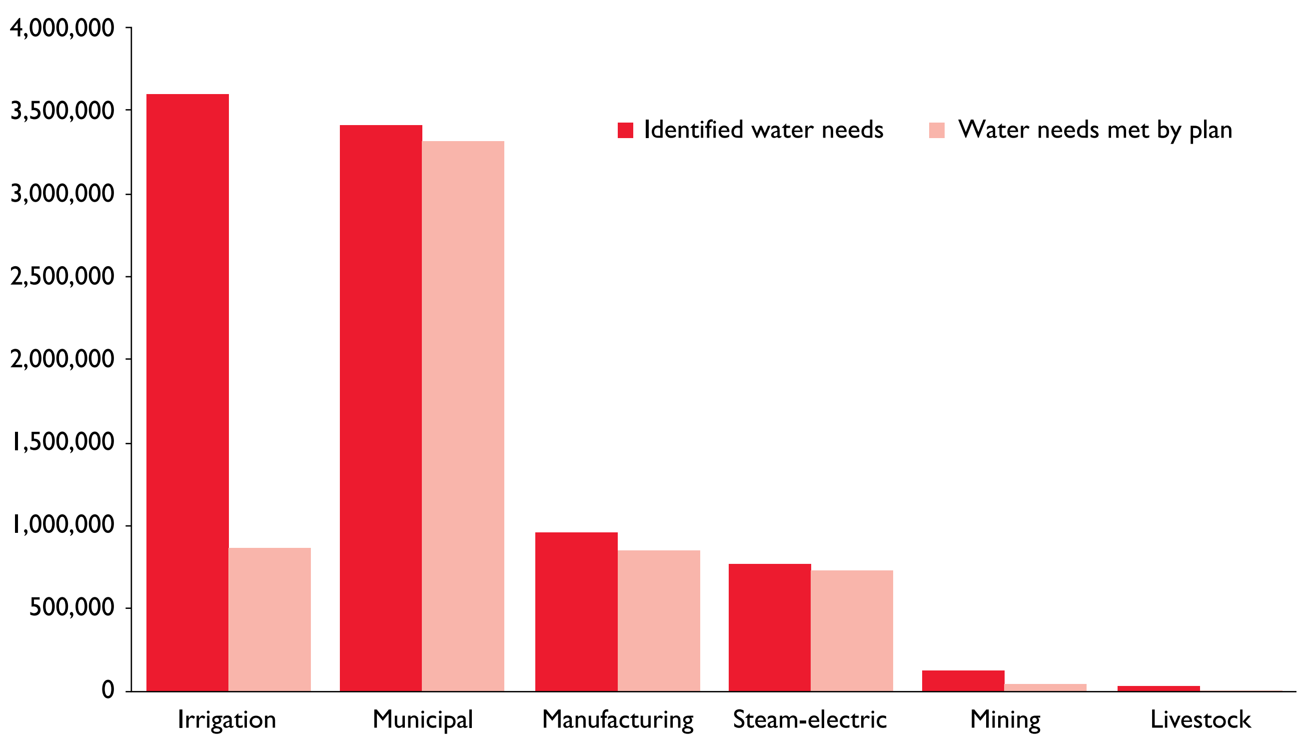


Figure ES.9 - Annual water supply needs and needs met by the plan by water use category in 2070 (acre-feet)



- water system operation, treatment losses, and operational safety factors; and
- potential difficulties in financing and implementing water supply projects.

Are all the water supply needs met?

Only one planning group (Region P) was able to recommend water management strategies capable of meeting the needs for all water user groups. The remaining 15 planning groups were unable to identify feasible strategies that met Texas' planning requirements and that would meet all of the needs in their regions (Figure ES.8).

Statewide, the majority of water needs associated with municipal, manufacturing, and steam-electric water user groups are met by the plan in 2070 (Figure ES.9). However, approximately 2.9 million acre-feet of water supply needs remain unmet by this plan in 2020, increasing to approximately 3.1 million acre-feet in 2070 (Figure ES.10). Irrigation represents the vast majority (ranging from 90 percent to 96 percent) of unmet needs in all decades. At least some unmet water supply needs occur for all categories of water user groups in the plan. The inability to meet a water user group's need in the plan is usually due to the lack of an economically feasible water management strategy, but this does not prevent an entity from pursuing additional water supplies.

How much will it cost?

The estimated total capital cost of the 2017 State Water Plan, which represents the capital costs of all recommended water management strategies and projects in the 2016 regional water plans, is $63 billion. These costs include the funds needed to permit, design, acquire water rights and land, and construct projects necessary to implement the recommended strategies. The vast majority of the cost, approximately $59.5 billion, is associated with projects sponsored by municipal water user groups and wholesale water providers that also provide water to municipal water users.

What if we do nothing?

Texas would suffer significant economic losses should recommended water management strategies not be implemented and another drought of record, or worse, occur. Economic modeling indicates that Texas businesses and workers could lose approximately $73 billion in income

Figure ES.10 - Statewide annual water supply needs that are unmet by the plan (acre-feet)

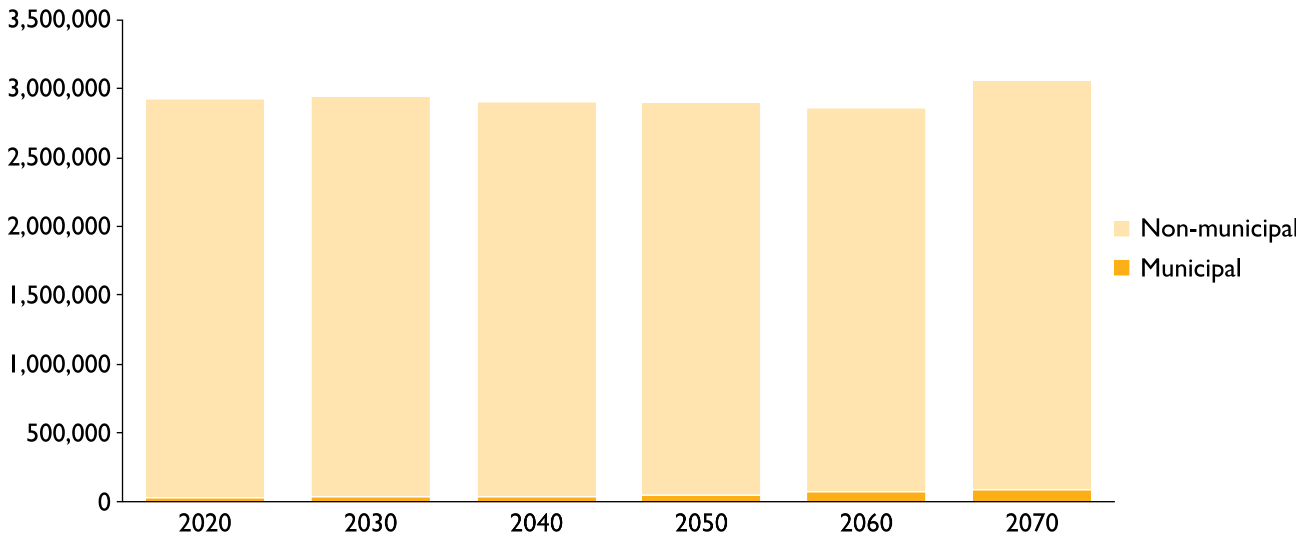
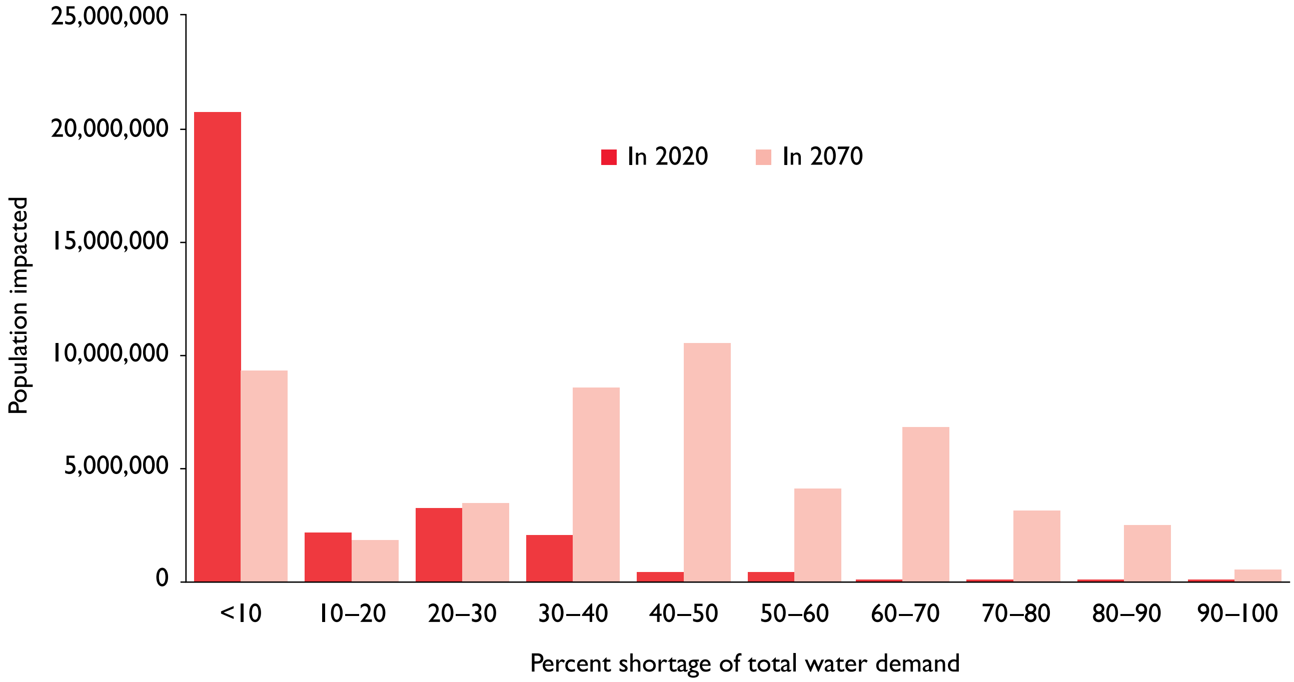


Figure ES.11 - Municipal water needs for statewide population in 2020 and 2070



annually in 2020 and $151 billion annually in 2070. Job losses could total approximately 424,000 in 2020 and 1.3 million in 2070. This estimate does not include additional drought impacts such as those to dry land farming and other activities not associated directly with water needs identified by the plan, nor does it include the potential for greater impacts due to a drought worse than the drought of record.

If we do nothing, approximately 82 percent of Texans would face at least a 10 percent water shortage in their cities and residences in 2070, and approximately one-third of Texas' municipal water users would have less than half of the water supplies that they require to live and work by 2070 (Figure ES.11).

How are strategies in the state water plan funded?

Sponsors of strategies, such as cities or wholesale water providers, must take action to develop water projects and conservation measures, many of which will require financial assistance. Water providers surveyed during the planning process reported an anticipated need of $36.2 billion in state financial assistance to implement strategies in their regions. Of this amount, approximately $35 billion is for strategies associated with municipal water suppliers or wholesale water providers. Cities, communities, and individuals can ask their water providers to apply for state financing for water projects.

In 2013, the Texas Legislature created the State Water Implementation Fund for Texas (SWIFT) and State Water Implementation Revenue Fund for Texas (SWIRFT) to provide affordable, ongoing state financial assistance for projects in the state water plan. Passed by the legislature and approved by Texas voters through a constitutional amendment, the SWIFT[2] program assists communities in developing and optimizing water supply projects at cost-effective rates. The program provides low-interest loans, extended repayment terms, deferral of loan repayments, and incremental repurchase

[2] The SWIFT program includes two funds, the State Water Implementation Fund for Texas (SWIFT) and the State Water Implementation Revenue Fund for Texas (SWIRFT). Revenue bonds for the program are issued through SWIRFT.

terms for projects with state ownership aspects. To be eligible for the SWIFT program, a project and its associated capital costs must be included in the state water plan. In addition to SWIFT, the TWDB has several state and federally funded financial assistance programs that may be utilized to fund projects in the state water plan.

What have we done already to implement water management strategies in the previous plan?

Since adoption of the 2012 State Water Plan, the TWDB has provided more than $1.9 billion in financial assistance to help implement approximately 60 state water plan projects that are associated with approximately 1 million acre-feet per year of additional water supply. Many water management strategy projects are currently in various stages of being implemented across the state, including groundwater wells, conservation, and reservoir projects.

What more can we do?

Planning groups made a number of regulatory, administrative, and legislative recommendations that they believe are needed to better manage Texas' water resources and to prepare for and respond to droughts. Based on their recommendations and other policy considerations, the TWDB recommends the following to improve water resources management in the state and facilitate the implementation of the 2017 State Water Plan:

Issue 1: Unique stream segment designation

The legislature should designate the five river or stream segments of unique ecological value recommended by the 2016 regional water plans (Alamito Creek, Black Cypress Bayou, Black Cypress Creek, Pecan Bayou, and Terlingua Creek) for protection under Texas Water Code §16.051(f).

Issue 2: Unique reservoir site designation

The legislature should designate for protection under Texas Water Code §16.051(g) three sites of unique value for the construction of reservoirs as recommended in the 2016 regional water plans: Coryell County Off-Channel Reservoir, Millers Creek Off-Channel Reservoir, and Parkhouse II (North).

Issue 3: Timing of the adoption of desired future conditions with respect to the state and regional water planning cycles

The legislature should require that the next set of desired future conditions be adopted collectively by the district representatives of each groundwater management area by January 5, 2022, and every five years thereafter and require that the regional water plans under development as of that same date be consistent with those adopted desired future conditions in effect on that date.

Approximately 5,500 recommended water management strategies, including conservation, would provide approximately 8.5 million acre-feet per year in additional water supplies to water user groups in 2070

1

Introduction

Quick facts

Texas' state water plans are based on future conditions that would exist in the event of a recurrence of the worst recorded drought in Texas' history—known as the "drought of record"— a time when, generally, water supplies are lowest and water demands are highest.

This is the first state water plan that reflects the results of legislative changes made in 2013 to the water planning and financing process.

Since 1997, water planning in Texas has been a regional, bottom-up process. Sixteen regional water plans are developed by regional water planning groups every five years and are the basis for the state water plan.

More than 450 planning group voting members participated in the development of the 2016 regional water plans.

Details from the regional and state water plans, including summaries by region, county, and water user group, can be explored through the interactive state water plan at texasstatewaterplan.org.

The 2017 State Water Plan is the first of the next generation of state water plans produced in accordance with sweeping legislative changes made by the 83rd Texas Legislature in 2013. The 83rd session marked the beginning of Texas' new approach to turning water plans into water supplies by creating the State Water Implementation Fund for Texas (SWIFT) program to fund projects in the state water plan. With assistance from the SWIFT program, Texas now has the means to help meet the state's water needs far into the future.

In addition to the changes made in conjunction with the SWIFT legislation, this state water plan also incorporates numerous other "firsts" that illustrate Texas' visionary, transparent, and science-based approach to planning and funding water projects.

Water planning is not new to Texas; we have been producing state water plans since 1961. This is our tenth plan and the fourth to be produced under the regional water planning process established in 1997. Our experience and our commitment to water planning continue to keep Texas at the forefront of state water planning in the United States.

The evolution of the regional and state water planning process has led the TWDB to change how it collects planning information and how it delivers that information to the public. One of the most significant additions to the state water plan has been the launch of the TWDB's interactive state water plan website. The site relies on the data provided by the regional water planning groups and provides users easy access to the large amount of data on which the state water plan is based.

1.1 New in the 2017 State Water Plan

Recent droughts influenced this state water plan. Although the 1950s remain Texas' worst recorded drought, this fourth planning cycle coincided with the end of Texas' second-worst recorded drought in history—from 2010 to 2014. The importance of water planning was further punctuated by the 2011 drought, which was the worst single-year drought in Texas' history. In response to these recent droughts, the TWDB revised the planning rules to require additional drought response information that is now included as a separate chapter in each regional water plan.

This state water plan incorporates several "firsts," including

- the first state water plan to include a drought response chapter;
- the first state water planning cycle in which planning groups submitted a prioritized list of their recommended projects simultaneously with the submittal of their final adopted regional water plans;
- the first plan that includes information reported by planning groups on the implementation of water management strategies contained in the previous state water plan;
- the first state water plan that includes a significant share of capital costs that are directly associated with municipal water conservation strategies;
- the first planning cycle in which modeled available groundwater volumes are the primary basis for groundwater availability statewide;
- the first planning cycle in which environmental flow standards adopted by the Texas Commission on Environmental Quality have been incorporated into water management strategy evaluations;
- the first planning cycle in which planning groups were required to directly incorporate information from the TWDB's state water planning database into their regional water plans;
- the first time that a state water plan incorporates, by adoption, an online, interactive state water plan as an integral component of the plan. The interactive state water plan website increases transparency and provides detailed planning information accessible to the public through customized views of planning data at the local, regional, or statewide level; and,
- the earliest adoption, within a five-year planning cycle, of a state water plan since 1997, well ahead of the statutory deadline of January 5, 2017, to facilitate funding projects through SWIFT. The accelerated timeline saves planning groups the time and expense of amending previous regional water plans and the 2012 State Water Plan in order to qualify new projects for SWIFT funding.

1.2 Regional water planning

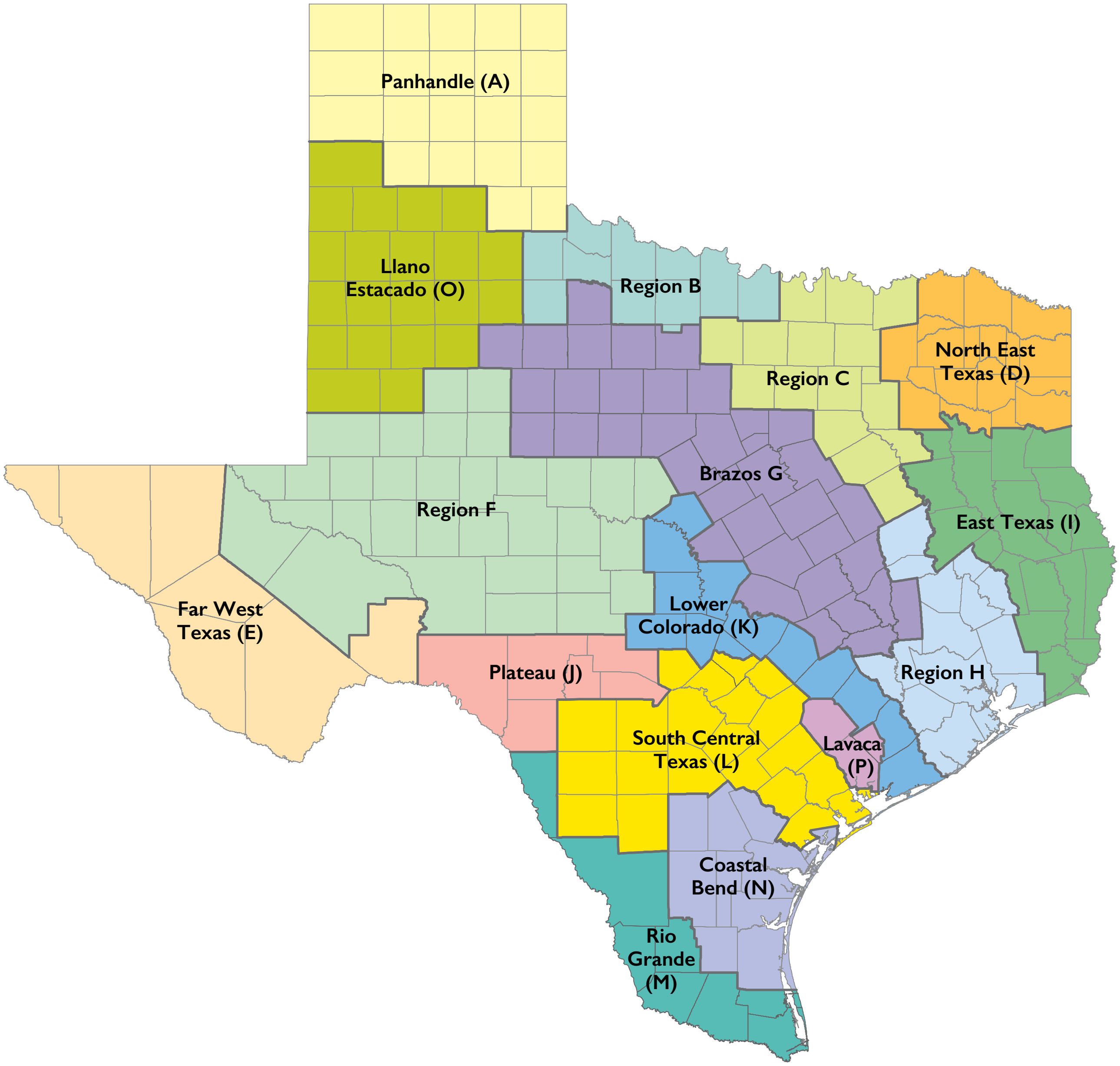
The foundation of the state water plan is the regional water planning process. Every five years planning groups involve local and regional stakeholders to develop regional plans for how to meet water needs during drought. Based on those regional water plans, the TWDB then develops a comprehensive state water plan every five years.

1.2.1 Legislative requirements

One of the most important requirements of the 1997 legislation creating the regional water planning process was that the TWDB could only provide financial assistance for water supply projects if the needs to be addressed by the project were consistent with the relevant regional water plan and the state water plan. This same consistency provision also applied to the granting of surface water right permits by the Texas Commission on Environmental Quality and thereby serves as a significant incentive for water providers and other stakeholders alike to actively participate in the planning process. Additionally, to be eligible for financial assistance from the recently created SWIFT, a project and its associated capital costs must be included in the state water plan.

Following the 1997 legislation, the TWDB introduced administrative rules to guide the new regional water planning process. The TWDB designated 16 regional water planning areas (A through P) (Figure 1.1), taking into consideration river basin and aquifer delineations, water utility development patterns, socioeconomic characteristics, existing planning areas, state political subdivision boundaries, public comments, and other factors. The TWDB is required to review and update the planning area boundaries at least once every five years, and no changes have been made to date.

Figure 1.1 - Regional water planning areas



1.2.2 Regional water planning groups

Each of the 16 regional water planning areas has its own planning group. Every five years, the planning groups are responsible for developing regional water plans that are funded primarily through legislative appropriations, administered by the TWDB, and guided by statute, rules, contracts, members of the planning groups, and the general public. In accordance with the Texas Open Meetings Act, all planning groups conduct their business in meetings that are open to the public and that give the public advance notice of the time, date, location, and subject matter of the meetings.

Each planning group is required to maintain at least one representative of each of the following 12 interests:

1. The general public
2. Counties
3. Municipalities
4. Industry
5. Agriculture
6. Environment
7. Small business

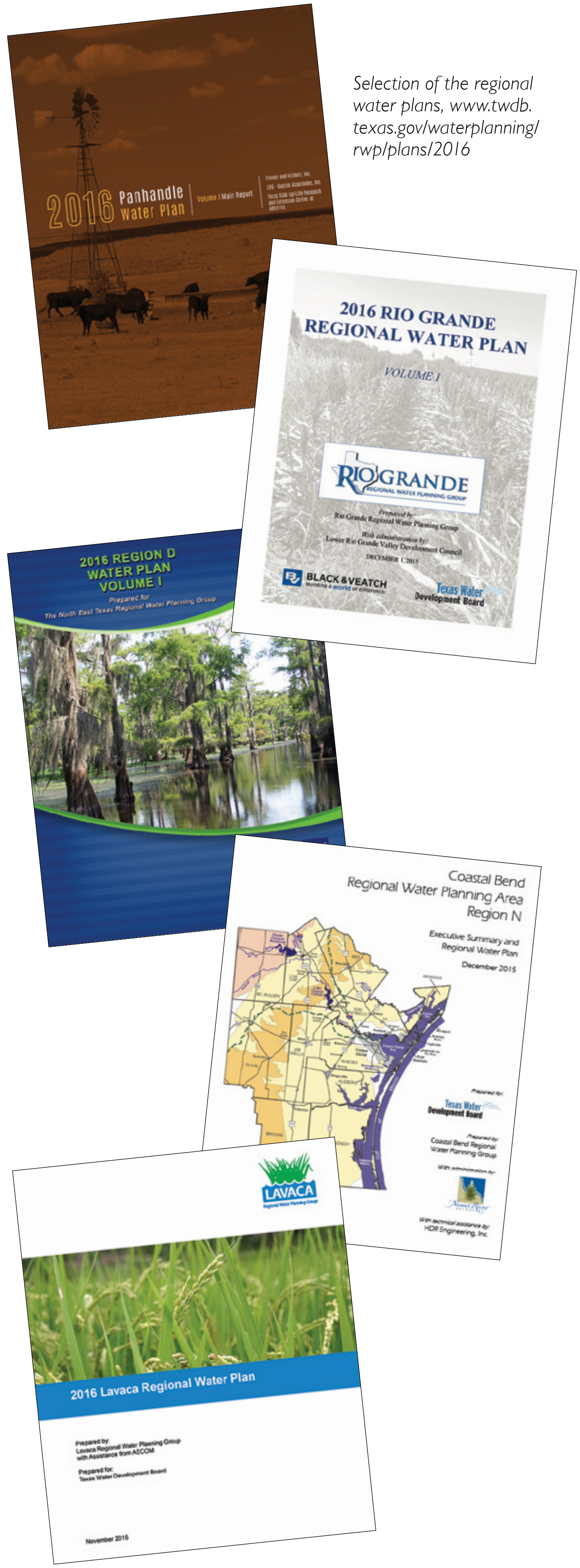
8. Electric-generating utilities
9. River authorities
10. Water districts
11. Water utilities
12. Groundwater management areas that fall within the planning area (where applicable)

Planning groups must have at least one voting representative from each required interest and may designate representatives for additional interests that are important to the planning area. Currently, each planning group has more than the minimum 12 voting members, with the largest having 30 voting members. More than 450 voting members participated in the development of the 2016 regional water plans (see plan acknowledgments). Planning group members serve in a volunteer capacity and are not compensated by the planning groups for their time.

Planning groups also include non-voting members from the TWDB, the Texas Department of Agriculture, the Texas Commission on Environmental Quality, and the Texas Parks and Wildlife Department, as well as liaisons from adjacent planning groups.

A regional water plan must meet all statutory, administrative rule, and contract requirements. In the course of each five-year planning cycle, each planning group must

- maintain its membership and governing bylaws;
- designate a political subdivision of the state, such as a river authority or council of governments, to serve as its administrator for the purpose of arranging meetings, managing grant-funded contracts, and providing public notices (the political subdivision provides staff resources, at the region's expense, to perform these administrative services);
- apply to the TWDB for regional water planning grant funding through their political subdivision;
- select a technical consultant(s) to serve at the direction of the planning group and to collect information, perform analyses, and prepare the regional water plan document;



Selection of the regional water plans, www.twdb.texas.gov/waterplanning/rwp/plans/2016

- direct the development of its water plan, including making decisions about which water management strategies will be recommended;
- solicit and consider public input, conduct open meetings, and, together with its political subdivision, provide required public notices, including for public hearings on the initially prepared (draft) regional water plan;
- submit its initially prepared plan and standardized data to the TWDB for review; and
- adopt a final regional water plan and submit it to the TWDB for approval.

To facilitate the development of the regional water plans, each planning group is supported by a TWDB project manager. The project manager serves as a non-voting planning group member, attends every planning group meeting, and manages the associated grant contract. The project managers also provide technical and administrative assistance during planning group meetings and throughout the development of the regional water plans to help ensure the planning groups meet their deadlines and all planning requirements.

1.2.3 Development of the regional water plan

Regional water planning is based on several fundamental parameters that guide the entire process, including

- planning for drought of record conditions when, generally, water supplies are lowest and water demands are highest;
- conducting evaluations of future water demands, existing supplies, potential shortages and feasible water management strategies for all wholesale water providers and for approximately 2,600 water user groups in six categories (municipal, manufacturing, steam-electric, mining, irrigation, and livestock); and
- reporting the associated data (by decade and broken down geographically) over a 50-year planning period (in this case from 2020–2070) by water user group, county, river basin, and regional water planning area.

Planning groups must also separately submit a prioritization of all the recommended water management strategy projects for funding consideration from the SWIFT program. The prioritization is based on the uniform standards approved by the TWDB. These standards, required in statute, were developed by the chairs of the planning groups through a stakeholder committee process facilitated by the TWDB.

The 16 plans are the product of hundreds of meetings; the effort and many hours of hard work of the planning groups, consultants, and stakeholders; and the large amount of information that the planning groups develop along the way. Each regional plan presents information in 11 chapters with much of the information also entered directly into the TWDB's state water planning database.

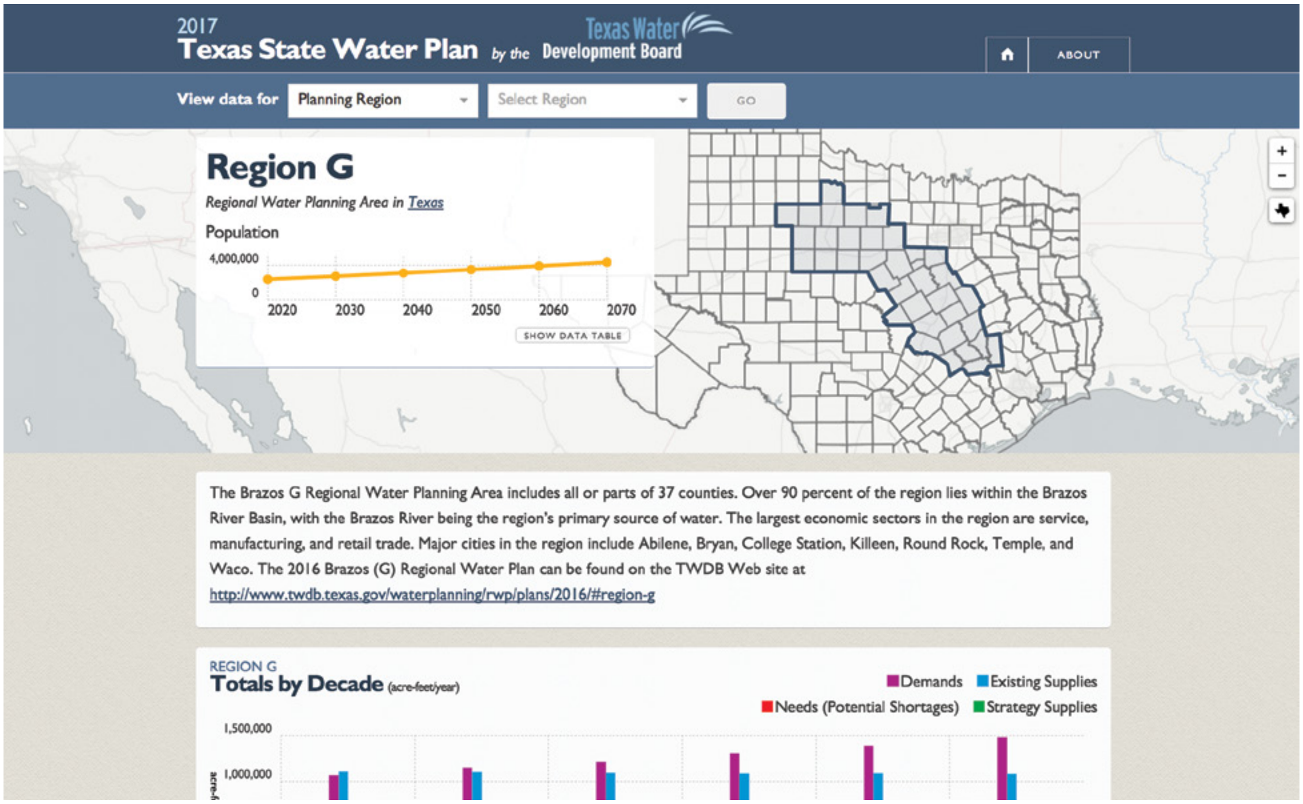
1.2.4 Development of the state water plan

After planning groups adopt their regional water plans, they are submitted to the TWDB for approval. As required by statute, the TWDB develops the state water plan based on those plans. The state water plan compiles key information from the regional water plans and also serves as a guide to state water policy. It explains planning methodology, presents data for the state as a whole, identifies statewide trends, and provides recommendations to the Texas Legislature. Prior to adopting the final state water plan, the TWDB releases a draft for public comment, publishes in the Texas Register its intent to adopt the state water plan, notifies the planning groups, and holds, at a minimum, one public hearing.

1.3 An interactive state water plan

The 2017 State Water Plan contains and makes available more in-depth information about water planning than ever before. While previous state water plans have been limited by the amount of information that would fit in a single published document, this state water plan provides information through both the actual state water plan publication and an interactive state water plan website (texasstatewaterplan.org). The publication and website together make up the state water plan approved and adopted by the TWDB. The interactive state water plan makes it easy to find

Figure 1.2 - View of interactive state water plan site



specific information on a community's potential water shortages and strategies recommended to address them. Additionally, the interactive website increases transparency, promotes awareness about water issues to the general public, and makes this critical information more accessible to a new generation of water users.

The interactive state water plan allows the public to explore the planning information in ways that cannot be accomplished through a static document. Data are presented simultaneously in different dimensions, at varying geographic levels, and through maps, tables, and additional graphics. Users can customize what they see, for example, by selecting data associated with a specific water use category or from a specific planning decade (Figure 1.2).

This new approach to the delivery of water planning data to the public provides an up-close view of local information or a big-picture view of the entire state. Once fully developed, the site will allow users to view, geographically, water sources that a particular water user group relies on today for its existing water supplies and find out what recommended strategies and water sources it will depend on in the future.

The interactive state water plan is facilitated by the state water planning database, which is populated through the internet directly by the planning groups. Planning groups rely on this dataset to produce portions of their regional water plans, including calculating water needs for each water user group. Some of the planning data, such as water demand projections and modeled available groundwater volumes, are developed and entered directly by the TWDB.

Through the interactive state water plan, information can be viewed in numerous ways:

- **Different geographic levels**—community, county, region, or state
- **Different types of planning information**—projected water demands, existing water supplies, water needs (potential shortages), and recommended water management strategies

- **Water use categories**—municipal, manufacturing, mining, steam-electric, irrigation, or livestock
- **Specific planning decades**—in multiple decades spanning the 50-year planning cycle (currently 2020–2070)

The interactive state water plan is also viewable on most mobile devices, and the website can also be embedded in other websites. All data can be downloaded into a spreadsheet for further use.

Overall, the expansion of the 2017 State Water Plan to include an interactive format will give Texans the opportunity to access more information and put that information into greater context based on their own specific needs.

1.4 Organization of the plan

The next chapter lists the TWDB's policy recommendations to the Texas Legislature, and Chapter 3 provides drought response information.

Chapter 4 presents the funding needs required to implement this new plan, which were identified by planning groups. Chapter 9 provides more information on the types of projects that have already been funded through SWIFT as well as on the implementation of the previous state water plan.

The remaining chapters, 5–8, summarize the steps that go into developing water plans and summarize the population and water demand projections, water supplies, needs, and recommended water management strategies and projects that are the fundamental building blocks of each state water plan. A variety of summaries of the information contained in these chapters can be viewed through the interactive state water plan website at texasstatewaterplan.org.

To better understand the context in which planning groups plan for water needs during a drought, it can be helpful to have more knowledge of how water is managed in the state in general. Each regional water plan must be consistent with all laws, rules, and regulations applicable to water use in the planning area. Appendix A.1 provides additional information on how surface water and groundwater are managed and on water quality, drinking water, and interstate waters, all of which are important considerations when planning for drought conditions. This appendix also includes a brief history of water planning in Texas.

Bluebonnets in the Texas Hill Country

2

Policy recommendations

Chapter 2 ♦ Water for Texas
2017 State Water Plan
Texas Water Development Board

The state water plan, as formally adopted by the Board, serves as a guide to state water policy and includes legislative recommendations on various issues related to water planning and implementation.

By statute, the Board must consider making recommendations that it believes are needed and desirable to facilitate voluntary water transfers and to identify river and stream segments of unique ecological value and sites of unique value for the construction of reservoirs. Previous state water plans also have recommendations regarding such issues as financing the state water plan, requiring retail utilities to conduct water loss audits, and encouraging water conservation.

The TWDB based the recommendations for this plan largely on recommendations contained in the 2016 regional water plans.

Regional water planning groups made a number of regulatory, administrative, and legislative recommendations[3] in the adopted regional water plans to

- facilitate the orderly development, management, and conservation of water resources;
- facilitate preparation for and response to drought conditions so that sufficient water will be available at a reasonable cost to ensure public health, safety, and welfare;
- further economic development; and
- protect the agricultural and natural resources of the state and regional water planning areas.

Along with general policy and statutory recommendations, planning groups also made recommendations in the 2016 regional plans for designating river and stream segments of unique ecological value and unique sites for reservoir construction; however, the Texas Legislature is responsible for making the official designations of these sites.

Planning groups may recommend the designation of all or parts of river and stream segments of unique ecological value located within their planning areas. These recommendations are based upon several criteria:

- biological function
- hydrologic function
- riparian conservation areas
- high water quality
- exceptional aquatic life
- high aesthetic value
- threatened or endangered species/unique communities

The recommendations include physical descriptions of the stream segments, maps, and other supporting documentation. The planning groups coordinate each recommendation with the Texas Parks and Wildlife Department and include, when available, the Texas Parks and Wildlife Department's evaluation of the river or stream segment in their final plans.

A planning group may also recommend a site as unique for reservoir construction based upon several criteria:

- site-specific reservoir development is recommended as a specific water management strategy or in an alternative long-term scenario in an adopted regional water plan
- location; hydrology; geology; topography; water availability; water quality; environmental, cultural, and current development characteristics; or other pertinent factors make the site uniquely suited for: (a) reservoir development to provide water supply for the current planning period; or (b) to meet needs beyond the 50-year planning period

Based on planning groups' recommendations and other policy considerations, the TWDB makes the following recommendations:

[3] *Available at www.twdb.texas.gov/waterplanning/rwp/plans/2016*

Issue 1: Unique stream segment designation

The legislature should designate the five river or stream segments of unique ecological value recommended by the 2016 regional water plans (Alamito Creek, Black Cypress Bayou, Black Cypress Creek, Pecan Bayou, and Terlingua Creek) for protection under Texas Water Code §16.051(f).

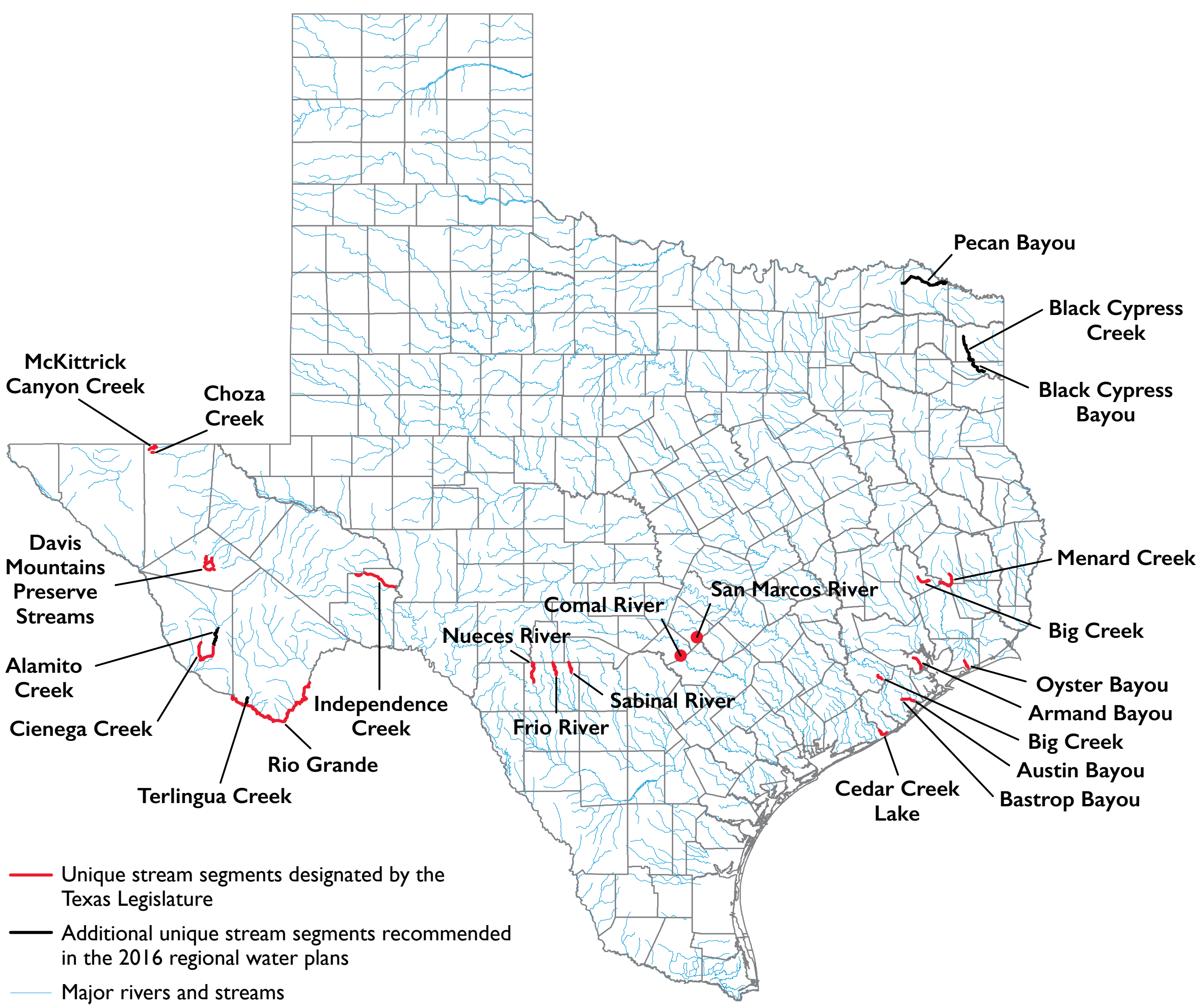
Summary of the recommendation

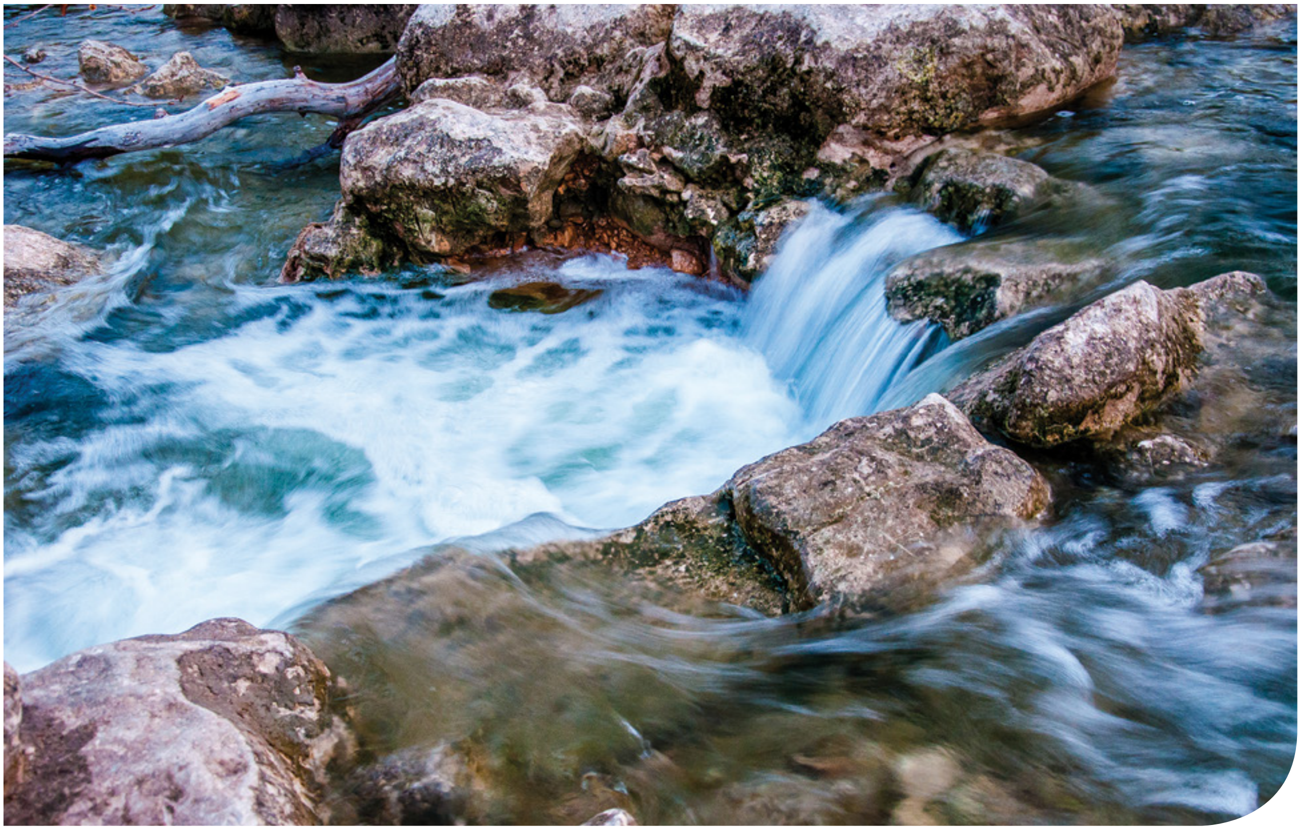
Pursuant to Texas Water Code §16.051(e) and §16.053(e)(6), state and regional water plans shall identify river and stream segments of unique ecological value that they recommend for protection. By statute, this designation solely means that a state agency or political subdivision of the state may not finance the actual construction of a reservoir in a specific river or stream segment that the legislature has designated as having unique ecological value (§16.051(f)). It is up to the legislature to make such designations.

The recommendation is for the following five stream segments:

- **Alamito Creek** in Presidio County solely within the boundary of the 1,061-acre Trans Pecos Water Trust —approximately a 3.5-mile stream segment.

Figure 2.1 - Unique stream segments previously designated by the Texas Legislature and additional recommended segments





Twin Falls on Barton Creek, Austin, Texas

- **Black Cypress Bayou** in Marion and Cass counties from the confluence with Big Cypress Bayou in south central Marion County upstream to the confluence of Black Cypress Creek east of Avinger in south Cass County.
- **Black Cypress Creek** in Cass and Morris counties from the confluence with Black Cypress Bayou east of Avinger in southern Cass County upstream to its headwaters located 4 miles northeast of Daingerfield in the eastern part of Morris County.
- **Pecan Bayou** in Red River County from 2 miles south of Woodland in northwestern Red River County east to the Red River, approximately 1 mile west of the eastern Bowie County line.
- **Terlingua Creek** in Brewster County solely within the boundary of Big Bend National Park—approximately a 5-mile stream segment. The reach of Terlingua Creek recommended as an ecologically unique stream segment is only that portion of the creek located within Big Bend National Park. This proposed unique segment is approximately 5 miles in length. Terlingua Creek transects Big Bend National Park from the confluence with the Rio Grande to the Big Bend National Park boundary located about 5 miles north of the river.

Senate Bill 3, passed by the 80th Texas Legislature, designated 19 stream segments recommended in the 2007 State Water Plan, and the 84th Texas Legislature designated an additional five segments from the 2012 State Water Plan with passage of House Bill 1016. Some of these designated stream segments included multiple, separate reaches of the same stream (Figure 2.1).

Issue 2: Unique reservoir site designation

The legislature should designate for protection under Texas Water Code §16.051(g) three sites of unique value for the construction of reservoirs as recommended in the 2016 regional water plans: Coryell County Off-Channel Reservoir, Millers Creek Off-Channel Reservoir, and Parkhouse II (North).

Summary of the recommendation

Pursuant to Texas Water Code §16.051(e) and §16.053(e)(6), the state and regional water plans shall identify sites of unique value for reservoir construction. This authority also relates to the state's general interest in reservoir development as codified in the Texas Constitution:

> "It is hereby declared to be the policy of the State of Texas to encourage the optimum development of the limited number of feasible sites available for the construction or enlargement of dams and reservoirs for conservation of the public waters of the state, which waters are held in trust for the use and benefit of the public, and to encourage the optimum regional development of systems built for the filtration, treatment, and transmission of water and wastewater." - Article 3, Section 49-d(a)

Texas Water Code §16.051(g) gives the legislature authority to designate a site of unique value for the construction of a reservoir. By statute, once a reservoir site is designated for protection, a state agency or political subdivision of the state may not obtain a fee title or an easement that would significantly prevent the construction of a reservoir. Without such designation, actions by state or local government entities could compromise the viability of these sites for future reservoir development.

Not all regions of Texas have access to the same types of water resources or in similar proportion. For many water users, development of reservoirs is an important means for providing large volumes of renewable, affordable water supply. As evidenced in the 2016 regional water plans and this state water plan, surface water resources, including the development of additional major reservoirs, will continue to play an essential role in Texas' water plans throughout and beyond the current planning horizon.

Approximately 45 percent of all recommended water management strategy supplies in this plan are associated with surface water, the majority of which is associated with existing and future reservoirs. Meeting a significant share of Texas' future water needs through the development of the most promising reservoir sites requires a stable, long-term commitment.

Designation of sites of unique value for the construction of reservoirs by the Texas Legislature provides an important measure of protection for these sites for future development. While designation of unique sites by the Texas Legislature does prevent some actions that could threaten the development of a reservoir, it does not guarantee protection of the sites, for example, against federal actions.

Prior to the 80th Texas Legislature, three unique reservoir sites had been previously designated by the legislature; the 76th Texas Legislature designated Allens Creek Reservoir with the passage of Senate Bill 1593, the 77th Texas Legislature designated Post Reservoir in 2001 with House Bill 3096, and the 78th Texas Legislature designated Lake Columbia in 2003 with the passage of Senate Bill 1362 (Figure 2.2).

With the passage of Senate Bill 3 in 2007, the 80th Texas Legislature designated an additional 19 reservoir sites (Figure 2.2) with a provision whereby the designations would expire on September 1, 2015, "unless there is an affirmative vote by a proposed project sponsor to make expenditures necessary in order to construct or file applications for permits required in connection with the construction of the reservoir under federal or state law" (Texas Water Code §16.051(g-1)). With the passage of House Bill 1042 in 2015, the 84th Texas Legislature redesignated the Lake Ringgold reservoir site as unique.

The legislature should designate for protection the three reservoir sites of Coryell County Off-Channel Reservoir, Millers Creek Off-Channel Reservoir, and Parkhouse II (North) (Figure 2.3). These three reservoir sites were recommended for designation in the 2016 regional water plans and have never been previously designated by the Texas Legislature as having unique value for the construction of reservoirs.

Issue 3: Timing of the adoption of desired future conditions with respect to the state and regional water planning cycles

The legislature should require that the next set of desired future conditions be *adopted* collectively by the district representatives of each groundwater management area by January 5, 2022, and every five years thereafter and require that the regional water plans under development as of that same date be consistent with those adopted desired future conditions in effect on that date.

Summary of the recommendation

Estimates of annual groundwater availability that are based on desired future conditions are one of the fundamental constraints in the development of regional water plans. However, under Texas Water Code §16.053(e)(2-a), the specific desired future conditions on which each regional water planning cycle is based are currently governed by a combination of an indeterminate state water plan adoption date and an indeterminate desired future conditions adoption date. This creates uncertainty for both representatives of groundwater management areas and planning group members in the form of "moving target" dates. The interrelated

Figure 2.2 - Unique reservoir sites previously designated by the Texas Legislature

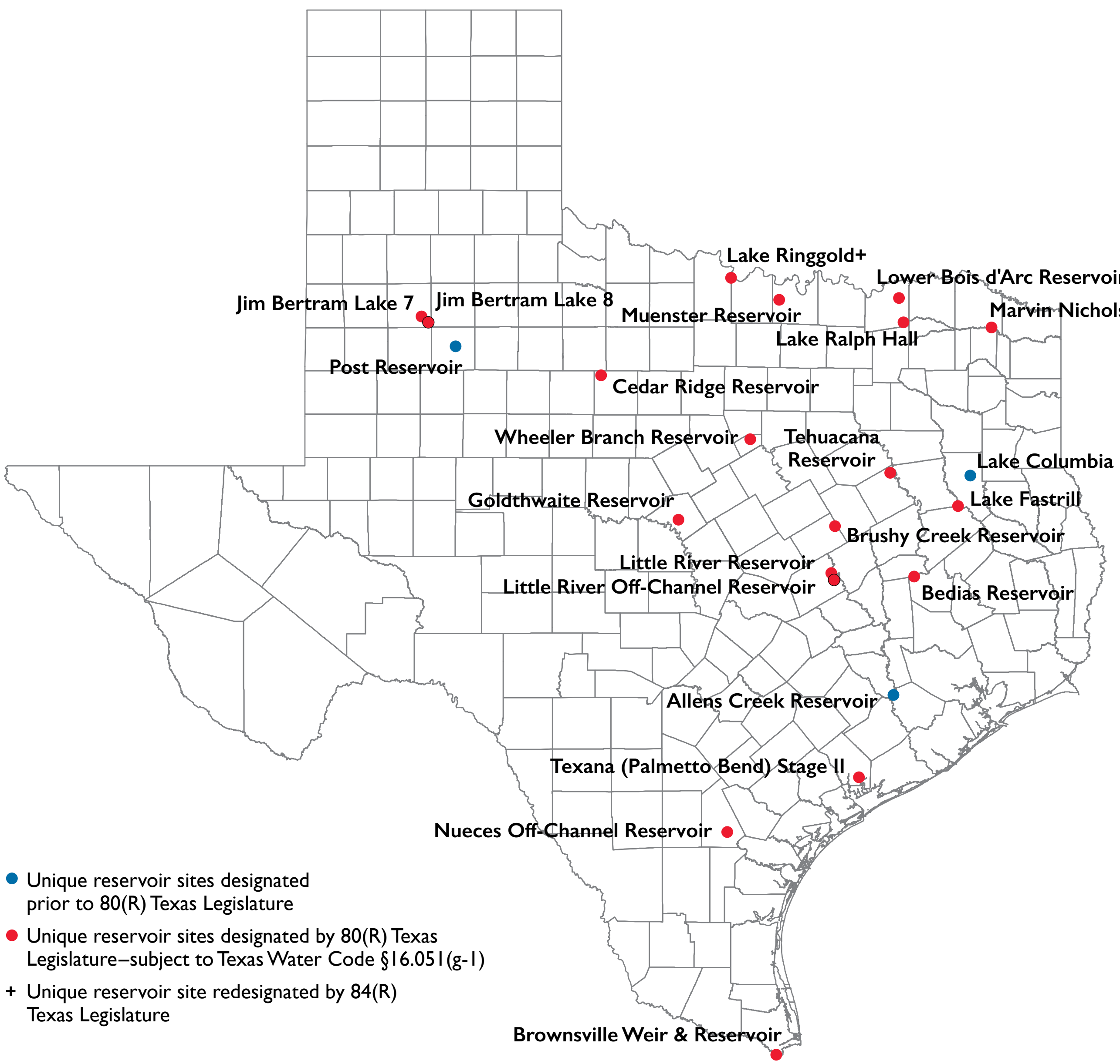
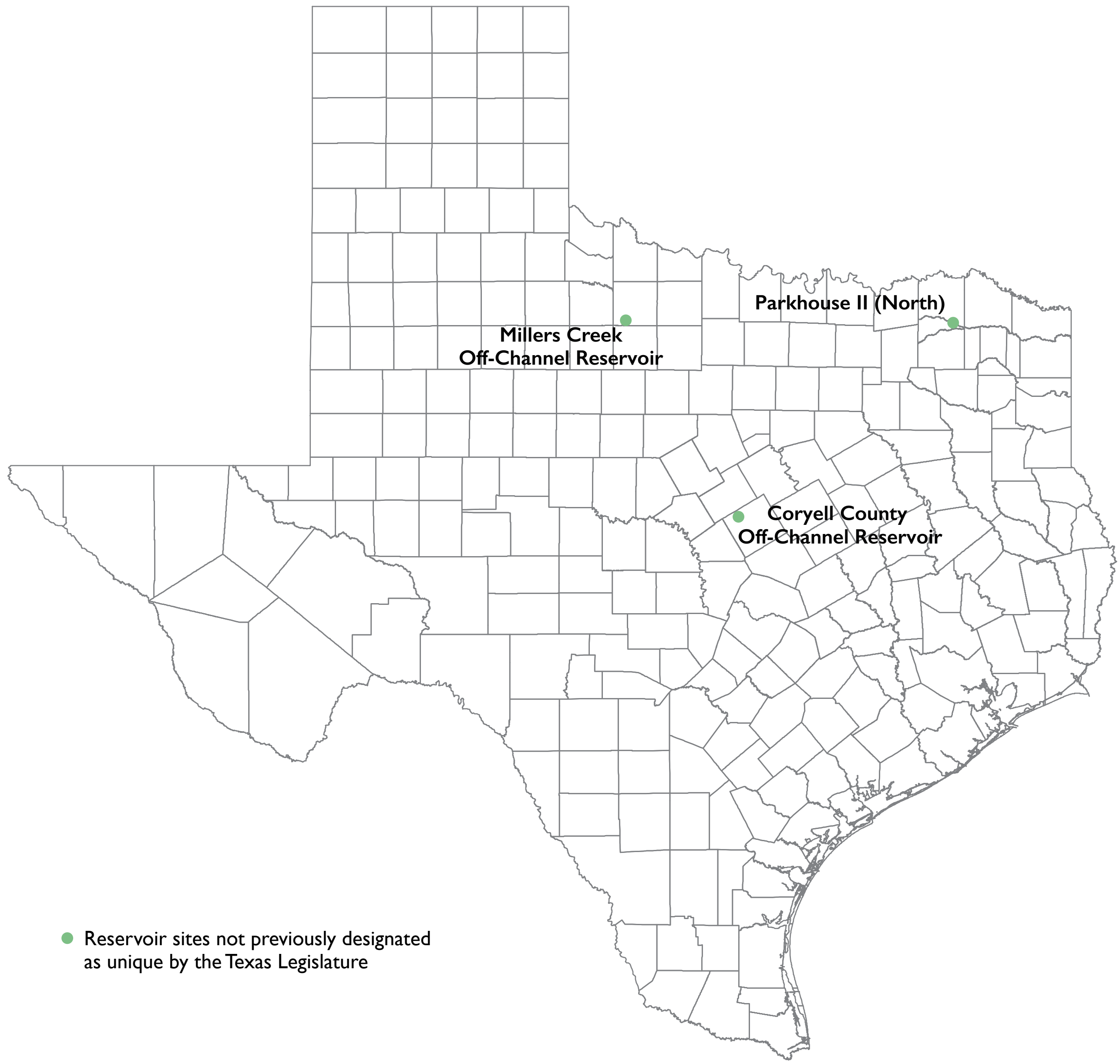


Figure 2.3 - Reservoir sites recommended for designation as unique



processes and requirements causing this situation are as follows:

- Notwithstanding the one-time, one-year extension for the current round of joint planning in groundwater management areas, the current statutory deadline for district representatives in groundwater management areas *proposing* desired future conditions is September 1, 2010, and every five years thereafter.
- Once desired future conditions are *proposed*, however, the date of actual *adoption* of desired future conditions is not date-certain. Once desired future conditions are *proposed*, it is estimated that it could require up to an additional three to nine months for their *adoption*, but that time frame is not set forth in statute. The TWDB cannot produce and deliver the resulting modeled available groundwater numbers for use by groundwater districts and planning groups until it receives the adopted desired future conditions. The estimated time required for the TWDB to develop and deliver modeled available groundwater numbers ranges from approximately six months to

one year following receipt of adopted desired future conditions.

- Statute requires that regional water plans must be consistent with the *adopted* desired future conditions as of the date the Board most recently adopted a state water plan. While the statutory deadline for adoption of the state water plan is January 5, 2002, and every five years thereafter, the specific date that the Board actually adopts each state water plan prior to that deadline is not date-certain.

Replacing the statutory deadline for *proposed* desired future conditions under Texas Water Code §36.108 with a deadline for *adoption* of desired future conditions and tying that adoption deadline to the existing statutory deadline for adoption of the state water plan will increase stakeholder certainty and better synchronize the five-year joint groundwater and regional water planning cycles. This recommendation will also provide agency staff with sufficient time to develop and deliver modeled available groundwater numbers in a timely manner for use by planning groups.

With regard to the next joint groundwater planning and 2022–2026 regional water planning cycles, the recommendation would result in an anticipated schedule as follows:

- January 5, 2022 – deadline for adopted desired future conditions
- January 5, 2022 – deadline for adoption of the 2022 State Water Plan
- January 2023 – TWDB develops and delivers modeled available groundwater numbers
- 2022–2026 regional water plans must be consistent with the desired future conditions in effect as of January 5, 2022

Benbrook Lake, a reservoir on the Clear Fork of the Trinity River in Tarrant County

3

Drought and drought response in Texas

Quick facts

Texas experienced the second-worst statewide drought on record from August 2010 to October 2014.

In response to the 2011 statewide drought, the most severe one-year drought on record, the 2016 regional water plans included additional region-specific information regarding drought preparation and response.

Texas is no stranger to drought and has experienced periods of drought in every decade of the 20th century. Although droughts typically develop slowly compared to other natural hazards, they often have far-reaching effects such as depleting water supplies, creating conditions that lead to wildfires, and decreasing agricultural production. Texas uses the 1950s drought of record as a benchmark for water planning, with the intention that preparing for severe drought conditions that have already occurred will help the state better respond to future droughts.

3.1 Measuring drought status and severity

Although drought conditions and impacts may vary locally, there are some common tools, with varying geographic scales, used to assess the status and severity of drought.

The U.S. Drought Monitor is commonly used in Texas to determine drought status. This weekly map of drought conditions 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 is a composite index and includes many indicators such as measurements of climatic, hydrological, and soil conditions, as well as reported impacts and observations from contributors throughout the country.

Multiple drought indices, each based on different parameters, are available to assess the severity of drought. Drought indices used by the Texas Drought Preparedness Council to assess the severity of drought 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, 2014). The Standardized Precipitation Index is now the accepted index for characterizing drought. The Drought Annex, a component of the state emergency management plan, shows how each severity index corresponds to stages of the U.S. Drought Monitor. The most recent U.S. Drought Monitor and drought indices are available online at waterdatafortexas.org/drought.

3.2 Types of drought

While the term drought has many definitions, there are several common types of drought, which include meteorological, agricultural, hydrological, and socioeconomic.

Meteorological drought begins with a period of abnormally dry weather resulting in less than the long-term average rainfall for that period. It does not necessarily impact water supply.

Agricultural drought often follows or coincides with meteorological drought and can appear suddenly and cause rapid impacts to agriculture. It reduces soil moisture, which decreases crop or range production, and increases irrigation demands. It often leads to drought disaster declarations and in many cases is an indicator of an impending hydrological drought.

Hydrological drought is a period of below-average streamflows and water volume in aquifers and reservoirs, resulting in reduced water supplies. It is the focus of regional water planning since it impacts water supplies.

Socioeconomic drought occurs when physical water needs affect the health, safety, and quality of life of the general public or when the drought affects the supply and demand of an economic product.

3.3 Precipitation influences

A key phenomenon influencing seasonal rainfall in Texas' fall and winter seasons is the El Niño Southern Oscillation. This phenomenon is a cyclical fluctuation of sea surface temperatures in, and associated air pressure patterns over, the tropical Pacific Ocean. It is infamous for the aberrations it induces in seasonal rainfall over many regions of the globe. Rainfall in Texas is enhanced in the fall and winter during positive phases of the El Niño Southern Oscillation and suppressed during negative phases. Thus, the onset of drought over Texas is often associated with a negative phase of the El Niño Southern Oscillation, known as La Niña. In addition to La Niña, sea surface temperature patterns in the North Pacific—particularly related to the Pacific Decadal Oscillation (Mantua and Hare, 2002)—and the North Atlantic Ocean—especially related to the Atlantic Multidecadal Oscillation (McCabe and others, 2004)—influence rainfall over Texas.

3.4 Drought of record and the 2010–2014 drought

The drought of the 1950s—the most significant drought recorded in Texas' history (dating back to 1895) in terms of both duration and intensity—is widely considered the statewide drought of record, the basis for state water planning in Texas. As measured by the Palmer Drought Severity Index, the drought of record lasted 77 months, from October 1950 to February 1957. By the same measure, the 2010–2014 drought lasted 51 months, from August 2010 to October 2014 (NOAA, 2015b).

The 2010–2014 drought ranks as the second-worst and second-longest statewide drought on record, based on the Palmer Drought Severity Index. During this period, extreme drought conditions (Palmer Drought Severity Index of less than or equal to -4) persisted 45 percent of the time and a record low statewide measurement of -8.05 was recorded after only 14 months (September 2011). By comparison, extreme drought conditions existed 62 percent of the time during the drought of record and its lowest statewide measurement of -7.7 was recorded after 72 months (Figure 3.1).

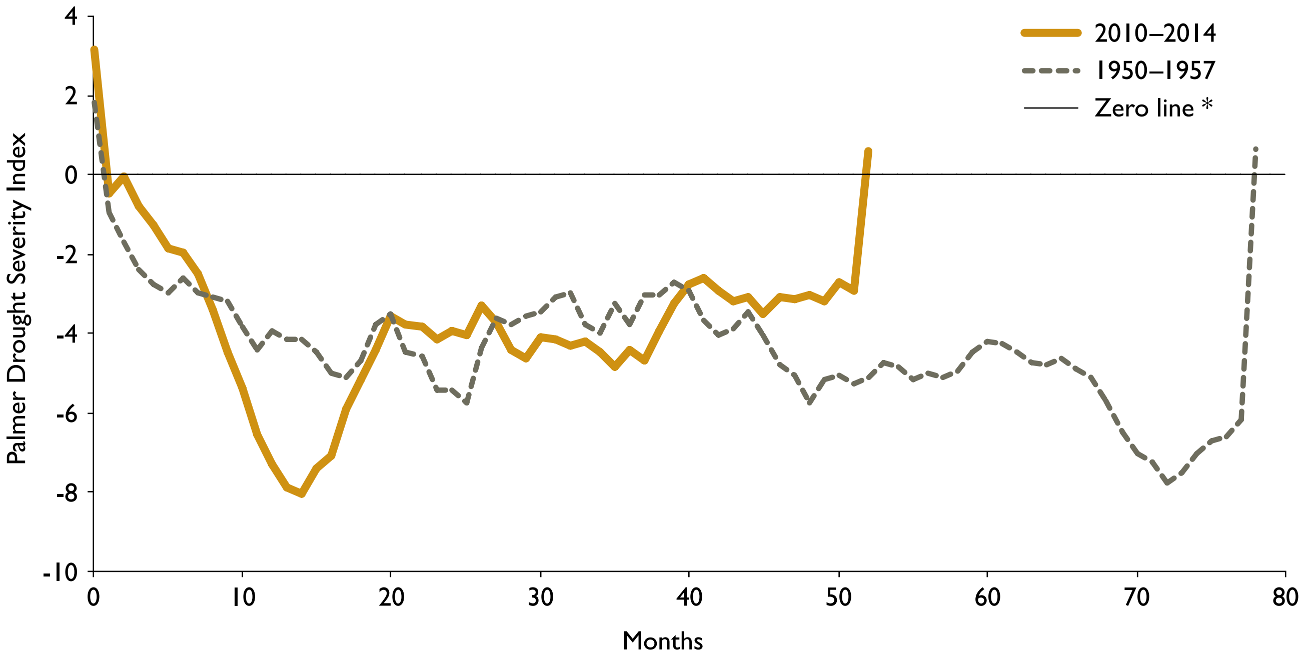
The 2011 drought is ranked as the worst one-year drought on record. The record low Palmer Drought Severity Index measurement in September 2011 followed the driest 12-month period of statewide precipitation on record. In that 12-month period from October 2010 to September 2011, the statewide average precipitation was only 10.86 inches, while the statewide average precipitation for the 12-month period between October and September using a 1981 to 2010 baseline is 27.02 inches (NOAA, 2015a). The spring intensification of the 2011 drought was likely due to interactions between dry soil moisture, elevated surface temperatures, and environmental conditions preventing heavy rainfall.

According to the U.S. Drought Monitor, July 2015 marked the first time since April 2010 that no drought conditions existed on the landscape of the state. However, this period of no drought lasted only two weeks.

3.5 The State's response to the 2010–2014 drought

During the 2011 drought, the Texas Department of Emergency Management and the Texas Commission on Environmental Quality were not always able to find relevant drought response information in the regional water plans. In response to their input, the TWDB revised a portion of the regional water planning rules to require additional

Figure 3.1 - Statewide average Palmer Drought Severity Index (NOAA, 2015b)



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

and better organization of drought information in the plans. The planning rules, amended in 2012, now require each regional water plan to include a separate chapter dedicated to drought response information, activities, and recommendations. This chapter and the drought information contained in the regional water plans serve as the drought response component of the state water plan.

Retail public utilities and entities from which the utilities obtain wholesale water service are required to report to the Texas Commission on Environmental Quality, co-chair of the Emergency Drinking Water Task Force, when they are reasonably certain that the water supply will be available for less than 180 days. This reporting was initially voluntary and later became a statutory requirement in September 2013. The entities themselves are solely responsible for identifying and reporting their projected outage dates. When entities self-report having less than 180 days of water supply remaining due to drought conditions, they will be added to the Texas Commission on Environmental Quality High Priority Water System List (called the 180-day list). As circumstances change, either through increased precipitation or the completion of a water supply project, entities may move off the list. The Emergency Drinking Water Task Force began tracking public water systems impacted by persistent drought conditions in October 2011. As of August 2015, there have been 110 public water systems on the 180-day list over the past four years. The highest number of public water systems on the 180-day list at one time was 58 (November 2014 and February 2015).

In 2012, the Texas Department of Agriculture revised an eligibility rule for 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. In September 2014, the TWDB began funding urgent need projects through the Drinking Water State Revolving Fund. Urgent need 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.

3.6 Planning and response to drought

Drought planning and response in Texas occurs with drought contingency plans at the local level, regional water plans at the regional level, and the state water plan and state emergency management plan (which includes the state drought preparedness plan) at the state level.

Drought response at the state and local levels are intertwined in Texas. Before drought conditions even exist, entities implement water conservation plans and water management strategies on an ongoing basis. When drought conditions exist, entities then implement drought contingency plans and drought management strategies as necessary. They may also seek emergency funding from the TWDB or Texas Department of Agriculture. Entities implementing water restrictions as part of their drought contingency plans are required to notify the Texas Commission on Environmental Quality. This information is reported to the Drought Preparedness Council, which coordinates the state's response to drought through the state drought preparedness plan, now known as the Drought Annex. A disaster proclamation due to drought conditions may also be issued at the state or local level.

TWDB Chairman Bech Bruun in drought-stricken Lake Arrowhead, Wichita Falls, Texas

3.6.1 Statewide drought planning and response

Texas Water Code lays the foundation for the state drought response plan. It designates the Texas Department of Emergency Management as the state drought manager, responsible for managing and coordinating the drought response component of the state water plan, and as the chair of the Drought Preparedness Council, which is composed of at least 14 representatives from state entities as well as governor-appointed members.

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

1. Assessing and reporting on drought monitoring and water supply conditions
2. Advising the governor on significant drought conditions
3. Recommending that specific provisions for state response to drought-related disasters be included in the state emergency management plan and state water plan
4. Advising regional water planning groups on drought-related information in the regional water plans
5. Ensuring effective coordination among state, local, and federal agencies in drought response planning
6. Reporting biennially to the Texas Legislature on drought conditions in the state

The Drought Preparedness Council develops the state drought preparedness plan (replaced in 2014 by the Drought Annex), which is a component of the state emergency management plan. The Drought Annex essentially lays out the state's response to drought and defines responsibilities for state agencies for drought monitoring and assessment and response and recovery. It provides triggers and potential actions that correspond to each drought stage of the U.S. Drought Monitor and includes information on drought impacts, indices and indicators, decision-making guidance, and drought coordination tools (TDEM, 2014). Coordination of the state's drought response is implemented through the Drought Preparedness Council's four committees and an Emergency Drinking Water Task Force, and there are 20 entities with specific, drought-related responsibilities listed in the Drought Annex. Annex A of the state drought preparedness plan contains the Emergency Drinking Water Contingency Annex, which develops procedures for public water systems to provide adequate water supplies and mitigate the impacts of prolonged drought.

The TWDB, a member of the Drought Preparedness Council and the Emergency Drinking Water Task Force, provides a variety of resources to assist Texans with drought response and preparedness. The TWDB maintains drought data and information on waterdatafortexas.org/drought, prepares monthly "Texas Water Conditions" reports documenting storage in the state's reservoirs and groundwater levels in aquifers, issues a weekly water report summarizing reservoir and drought conditions in the state, and provides statewide outreach on drought through educational materials and literature.

3.6.2 Regional drought planning and response

After the 2011 drought, planning groups incorporated new requirements into the 2016 regional water plans. All drought-related content is now consolidated into a single chapter in each plan to make it easy to find. An overview of current preparations and planned responses, including current triggers and how water suppliers respond to drought, is included.

New planning requirements of this fourth regional water planning cycle included

- identifying potential alternative sources for loss of municipal supply for small entities with a single source of supply,
- developing region-specific model drought contingency plans, and
- providing recommendations to the Drought Preparedness Council.

Recommendations provided in regional water plans are not mandatory or enforceable.

Regional droughts of record

While the statewide drought of the 1950s is considered the benchmark drought for state water planning, regional droughts of record may vary by sub-basin or water source. The drought of record for reservoirs for planning purposes is determined with water availability models developed by the Texas Commission on Environmental Quality and is based on historical naturalized inflows—flows without human influence. The Texas Commission on Environmental Quality models use naturalized flow at predetermined control points along river basins for all major river basins in Texas from the 1930s and 1940s to the 1980s and 1990s. Recent drought years such as 2006, 2009, and 2011 are not included in the hydrology of the water availability models.

The region A, B, C, F, G, and K planning groups reported potential new drought of record periods for some reservoirs or sub-basins that occurred after the historical period covered by the current water availability models.

Until the water availability models are updated to reflect recent hydrological conditions, it is not possible, however, to definitively confirm whether the potential new droughts of record for reservoirs or sub-basins identified by the planning groups are actually the new droughts of record. A number of regional water plans included recommendations that the Texas Commission on Environmental Quality update its water availability models to capture the more recent hydrological record.

The 2011 drought was also identified as a 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.

Some planning groups reported drought of record information for groundwater resources. A new drought of record for groundwater resources beginning in 2011 was identified in Region A based on an assessment of annual precipitation and Palmer Drought Severity Index data.

Response to potential loss of supply for small entities

Planning groups evaluated potential emergency responses to local drought conditions or loss of existing supply for 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 all county-other (rural municipal) water user groups. The high-level evaluation was based on the assumption that an entity would find itself with only 180 days or less of supply left and had to identify alternative sources. This high-level screening was intended to serve as a guidepost for potential emergency response options and to identify water user groups who may be particularly vulnerable to a loss of supply.

The most common response options deemed feasible among the planning groups for providing emergency supply to these small entitles included

- trucked in water,
- local groundwater wells,
- existing or potential water system interconnects,
- brackish groundwater development (limited treatment or desalination),
- releases from upstream reservoirs, and
- curtailment of water rights.

Less frequently cited options included voluntary transfers from irrigation, supply from nearby entities, purchase of land with existing wells, and purchase of surface water.

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 water supply connections. Detailed information on these facilities was submitted confidentially to the TWDB, as required by statute. The planning groups reported approximately 570 existing emergency connections and 430 potential new emergency connections.

Drought management recommendations by planning groups

Drought management reduces water use during times of drought by restricting certain economic and domestic activities such as car washing and lawn watering. Although the planning groups recommended many conservation strategies that don't restrict normal economic and domestic activities, they generally deferred to local water providers regarding the decision of whether to rely on drought management measures. In areas with projected high growth, temporary drought management strategies cannot be used to address overall increases to water demands that will occur even during non-drought periods. While planning groups recommended that individual water providers follow their local drought contingency plans, most planning groups chose not to incorporate drought management as recommended strategies in their plan.

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 provide additional water supplies. 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. The effectiveness and sustainability of drought measures varies between utilities and were sometimes not considered to be predictable or reliable enough to quantify for inclusion as a recommended water management strategy. Most planning groups chose instead to leave potential water savings from drought management measures as a back-up or last-resort response to address uncertainty, such as the event of a drought worse than the benchmark drought of record (BBC Research & Consulting, 2009).

The Pedernales River more than 20 feet below normal levels, leaving the boat docks unusable

However, planning groups J, K, L, and P did recommend specific, quantified municipal drought management strategies:

- Region J recommended demand reductions of 20 percent for specific wells within the Bandera County-Other water user group.
- Region K recommended demand reductions, ranging from 5 to 30 percent, for most municipal water user groups, regardless of needs. The reductions depended on the water user group's gallons per capita per day, drought contingency plan triggers, and whether they were under severe water restrictions during 2011.
- Region L recommended all municipal water user groups with a water need in 2020 reduce 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 P recommended varying demand reductions for all municipalities with a drought contingency plan, regardless of needs. The reductions were based on drought contingency plan triggers and responses, and how often the trigger might actually be reached.

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

3.6.3 Local drought planning and response

Drought contingency plans are implemented at the local level and often focus on potential issues related to the retail distribution system capacity rather than the total supply volume to which the entity has access. These plans may consist of one or more strategies for temporary supply and/or demand management and response to temporary water supply shortages and other water supply emergencies. The plans contain triggers, which are typically based on supply or demand, and responses associated with the triggers. Local entities now have the option to use the model drought contingency plans that the planning groups developed, which were intended to assist water users seeking guidance in developing plans with meaningful and applicable triggers and responses for water sources within the region.

Wholesale public water suppliers, retail public water suppliers with 3,300 or more connections, and irrigation districts must develop drought contingency plans and submit them to the Texas Commission on Environmental Quality. Retail public water suppliers with less than 3,300 connections must develop plans and make them available upon request. Investor-owned utilities are also required to develop drought contingency plans. Wholesale and retail public water suppliers must also notify the Texas Commission on Environmental Quality within five days after implementing any mandatory drought contingency plan measures.

Failed corn crop due to drought in the Lower Rio Grande Valley

At the local level, if a state of disaster proclamation is issued due to drought conditions, counties included in the disaster proclamation must provide notice of the declaration in a newspaper of general circulation in the county, 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 the water conservation and drought contingency plans.

During the 2010–2014 drought, Wichita Falls exemplified how a large city successfully endured a drought that appears to have been worse than the benchmark planning drought largely because they did not base the plan on initiating drought management measures—restriction on water use—in the event of the lesser benchmark planning drought. Instead, they retained drought restrictions as a strategy for managing a worse-than-planned drought, which provided much-needed flexibility to the city.

3.7 Uncertainty of drought

While Texas has recently emerged from its second-worst statewide drought, we do not know when the next drought will occur. Tree ring records indicate that Texas has experienced droughts longer than the drought of record extending back to 1500 (Cleaveland and others, 2011). Had the recent drought persisted for two more years, it would very likely have become the new drought of record. A combination of warmer temperatures and decreased precipitation, as experienced during the 2011 drought, enhances the risk of Texas experiencing extreme droughts.

The tree ring records, recent drought, and very wet episodes indicate that the climate of Texas is highly variable and droughts with durations and intensities exceeding the drought of record could occur in the future. Given that historical record, climate variability will always affect the availability of the state's water resources; it is therefore prudent to continue water conservation efforts, even in non-drought conditions.

References

BBC Research & Consulting, 2009, Drought management in the Texas regional and state water planning process: Prepared for the Texas Water Development Board, 96 p. www.twdb.texas.gov/publications/reports/contracted_reports/doc/0804830819_DroughtMgmt.pdf

Cleaveland, M.K., Votteler, T.H., Stahle, D.K., Casteel, R.C., and Banner, J.L., 2011, Extended chronology of drought in south central, southeastern and west Texas: Texas Water Journal, v. 2, no. 1, p. 54–96.

Mantua, N.J., and Hare, S.R., 2002, The Pacific Decadal Oscillation: Journal of Oceanography, v. 58, p. 35–44.

McCabe, G.J., Palecki, M.A., and Betancourt, J.L., 2004, Pacific and Atlantic Ocean influences on multidecadal drought frequency in the United States, Proceedings of the National Academy of Sciences, 101, p. 4136–4141.

NOAA (National Oceanic and Atmospheric Administration), 2015a, Climatological Rankings, www.ncdc.noaa.gov/temp-and-precip/climatological-rankings/index.php?periods%25255b%25255d=12&parameter=pcp&state=41&div=0&month=9&year=2011&asof=on#ranks-form, Accessed August 2015.

NOAA (National Oceanic and Atmospheric Administration), 2015b, Climatological Rankings, www.ncdc.noaa.gov/temp-and-precip/climatological-rankings/index.php?periods%25255b%25255d=1&parameter=pdsi&state=41&div=0&month=6&year=2015, Accessed August 2015.

TDEM (Texas Division of Emergency Management), 2014, Drought annex: State of Texas Emergency Management Plan, 61 p.

4

Financing needs

Quick facts

Of the $63 billion in capital costs required to implement the state water plan over the next 50 years, approximately $36.2 billion, or 57 percent, was reported as requiring state financial assistance.

The TWDB administers a variety of financial assistance programs that offer multiple financing options to aid in the planning, permitting, and construction of state water plan projects.

The State Water Implementation Fund for Texas (SWIFT) program was created in 2013 specifically to fund state water plan projects.

The reported state financial assistance need in the 2017 State Water Plan for municipal water management strategies is approximately $8.1 billion greater than the 2012 State Water Plan.

During the regional water planning process, regional water planning groups estimated the costs of water management strategies such as conservation, groundwater development, and new reservoirs that, in the event of a recurrence of a drought of record, would need to be implemented to meet the needs of their regions for the next 50 years. Implementation of many of these strategies will require financing to support water project phases such as planning, design, permitting, and construction.

The TWDB offers a variety of cost-effective financial support programs that fund state water plan projects as well as other water-related infrastructure and water quality improvement projects.

4.1 Costs of implementing the state water plan

The total capital costs of the recommended water management strategies in this plan is estimated at $63 billion, with projects anticipated to be completed at various times throughout the next 50 years (Figure 4.1). The recommended water management strategy projects include costs for developing additional sources of water, conveying water from the source to water users, treating additional volumes of delivered water supplies, and saving water through conservation and other demand management strategies. All strategies and projects also identify the decade in which they are projected to be online.

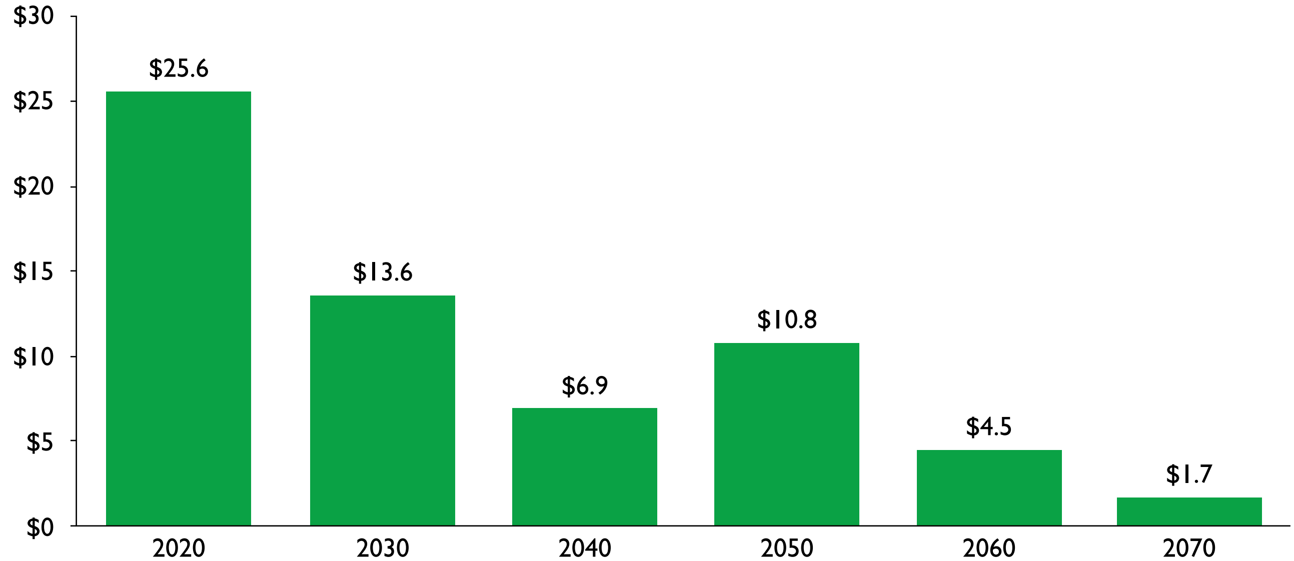
Planning groups estimated both the total capital costs of projects and the annual unit costs of water. Direct and indirect capital costs include, but are not limited to,

- engineering and feasibility studies, including those for permitting and mitigation;
- construction;
- professional services related to legal assistance and financing costs;
- land and easement acquisition; and
- purchases of water rights.

Unit costs of water supply (dollars per acre-foot supplied in each future year) are calculated based on total annual costs divided by the associated water volume and include debt service associated with the capital costs as well as operation and maintenance costs. Operation and maintenance costs, including power costs, are based on the quantity of water supplied and include all related expenses.

The estimated costs to implement the recommended water management strategies in the 16 regional water plans do not include the additional costs associated with maintaining or expanding retail water system distribution facilities or the costs of replacing aging infrastructure, with the specific exception of some conservation strategies that reduce water loss through replacement of internal distribution system lines.

Figure 4.1 - Total capital costs, by required online decade, of all recommended water management strategy projects (in billions)*



** Statewide total in this graph is slightly more than the $63 billion estimated costs due to rounding.*

The majority ($59.5 billion) of the $63 billion in anticipated capital costs is associated with recommended water management strategy projects sponsored by municipal water user groups and wholesale water providers (Figure 4.2). Region C ($23.6 billion), Region H ($10.9 billion), and Region L ($8.1 billion) have the highest estimated capital costs required to implement the strategy projects in their 2016 regional water plans (see Table 8.2). The costs associated with these three planning areas account for approximately 68 percent of the total capital costs in the 2017 State Water Plan. These regions represent approximately 61 percent of the state's projected population in 2070 (Table 5.1) and approximately two-thirds of the total projected municipal water needs for the state by 2070 (Appendix C.1).

4.2 Funding assistance required to implement the state water plan

Once the planning groups have recommended water management strategies, they administer a survey to estimate the amount of state financial assistance that local and regional water providers will require to implement the projects associated with those strategies. The planning groups' surveys attempt to collect funding needs information for any project that may qualify for any state funding programs.

As of January 2016, water providers reported an anticipated need of $36.2 billion from state financial assistance programs. Of this, $6.7 billion, or approximately 19 percent, was associated with planning, design, permitting, and acquisition activities, with the remaining $29.5 billion, or approximately 81 percent, associated directly with construction activities (Figure 4.3).

Of the total required state financial assistance

- approximately $21.3 billion is expected to be required prior to 2030,
- approximately $35 billion is required to assist in implementing recommended strategies that would be sponsored by municipal water providers or wholesale water providers, and
- approximately $3.2 billion is required by sponsors seeking state assistance through state ownership of excess capacity of their larger projects.

4.3 Financing the state water plan and other water-related projects

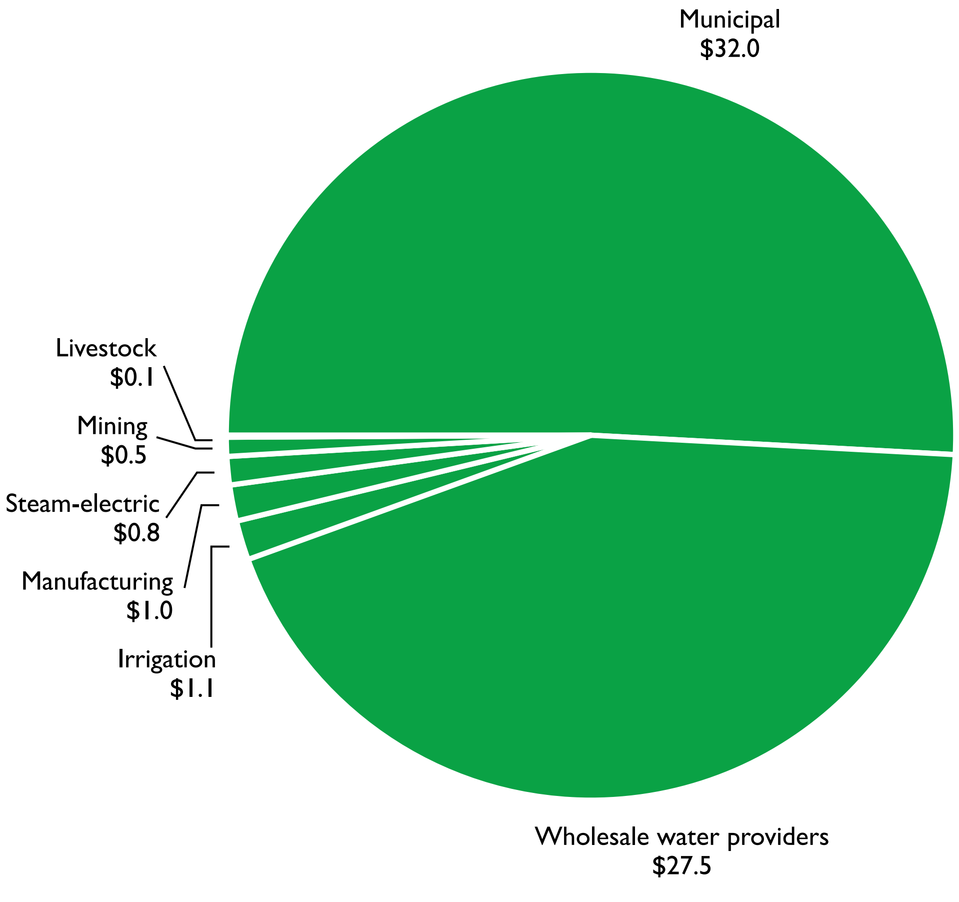
In Texas, local governments have traditionally provided the majority of the financing for water-related infrastructure projects. Water providers finance projects primarily through municipal debt on the open bond market and less frequently with cash or private equity sources such as banks.

The federal government has also historically implemented water projects, and earlier state water plans relied heavily on the federal government for financial assistance. Federal agencies such as the U.S. Natural Resources Conservation Service (formerly the Soil Conservation Service), the U.S. Bureau of Reclamation, and the U.S. Army Corps of Engineers constructed a number of surface water reservoirs in Texas. These reservoirs were built for the primary purpose of flood control but also provide a large portion of the state's current water supply.

However, the pace of federal spending on reservoir construction has declined considerably since the 1950s and 1960s, when most of the major federal reservoirs in the state were constructed. Federal policy has recognized a declining federal interest in the long-term management of water supplies and assigns the financial burden of developing water supplies to local users (USACE, 1999).

While traditional funding mechanisms will continue to assist with the financing of water projects, additional means are necessary to meet Texas' water needs. Due to the high costs of infrastructure projects, many water providers seek financial assistance from the state or federal government, which may provide attractive financing and additional subsidies to offset financial impacts.

Figure 4.2 - Total capital costs of all recommended water management strategy projects by wholesale water providers and water user group sponsor type (in billions)



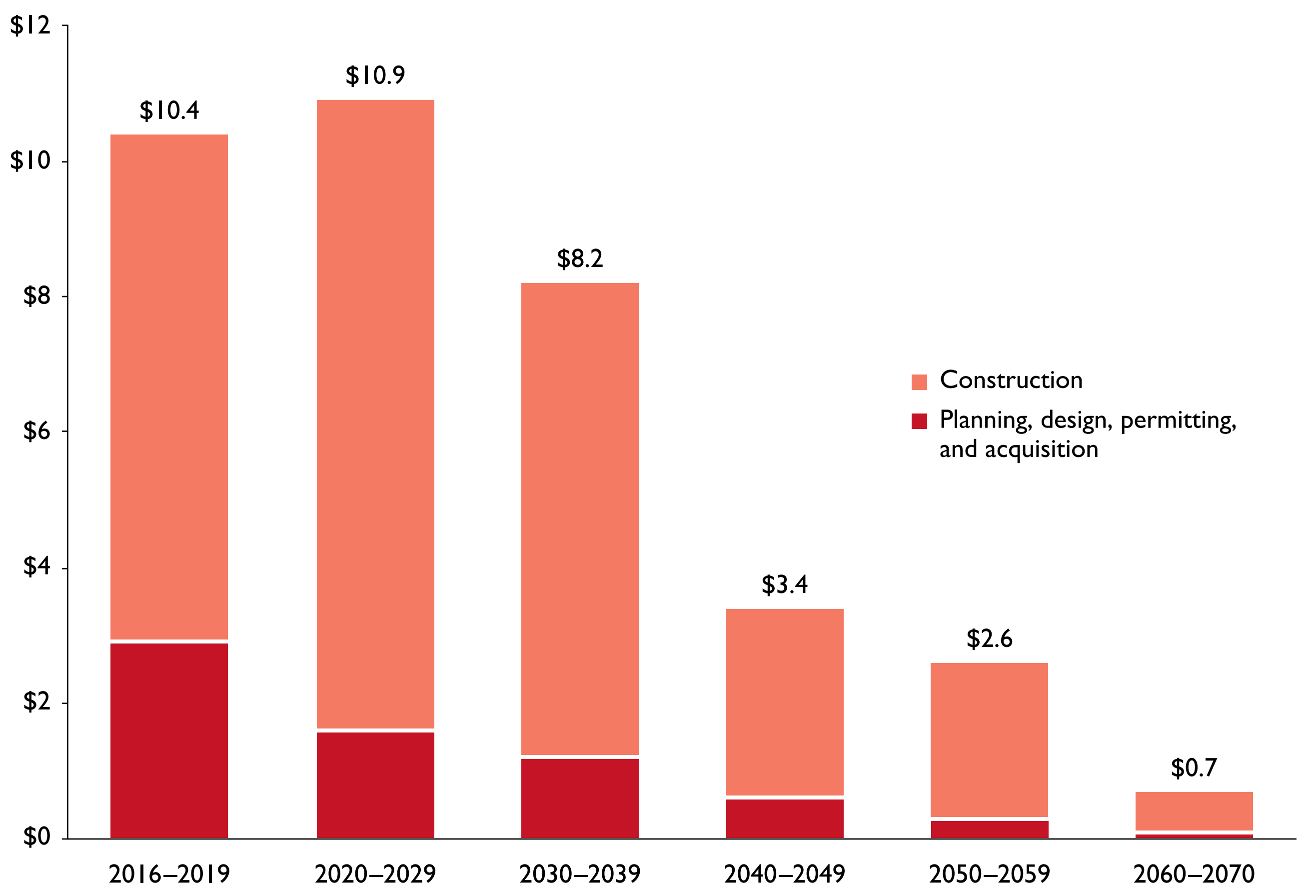
4.3.1 TWDB financial assistance

The TWDB provides financial assistance for implementation of water-related projects through several state and federally funded programs. These programs provide financing through loans and/or grants for projects that range from addressing the immediate needs of a community in meeting regulatory requirements to providing long-term water supply solutions. Not all TWDB financial assistance programs are specific to state water plan projects. However, in accordance with state statute, the TWDB can provide financial assistance for water supply projects only if the needs to be addressed by the project will be addressed in a manner that is consistent with the regional water plans and the state water plan. Through its financial assistance programs, the TWDB has funded many water management strategies that were recommended in the regional water plans and state water plan.

The TWDB's state financial assistance programs—except for SWIFT, which uses revenue bonds—are funded primarily by the sale of general obligation bonds that are secured by the full faith and credit of the State of Texas. With the state's strong credit rating, the TWDB is able to offer lower interest rates than many water providers would be able to obtain through traditional financing means. The TWDB issues bonds and utilizes the proceeds to fund loans to cities, counties, and river authorities, as well as nonprofit water supply and wastewater service corporations. The recipients in turn repay the principal along with interest, which is then used by the TWDB to pay debt service on its general obligation bonds.

The TWDB's authority to issue general obligation bonds was first approved by the Texas Legislature and voters in 1957 through a constitutional amendment. It authorized the agency to issue $200 million in general obligation bonds for financial programs for the construction of dams, reservoirs, and other water storage projects. Since then, additional bond authority has been granted, the most

Figure 4.3 - Reported state financial assistance needs (in billions)



recent in 2011 with the passage of a constitutional amendment that allows the TWDB to have up to $6 billion in bonds outstanding.

Financing previously provided by the TWDB

Since the inception of its financial assistance programs through December 2015, the TWDB has closed on more than $16 billion in funding for water and wastewater projects. The TWDB closed on approximately $3.9 billion in state financial assistance from 2011 to 2015 for all types of water and wastewater projects, including state water plan projects.

4.3.2 SWIFT as a new path to prioritizing and funding the state water plan

One of the most important outcomes of the state water planning process is a detailed list of strategies and projects that are recommended to address communities' water needs and the associated costs of the projects. The next step for communities—implementing those strategies—has been difficult in the past because in many cases the strategies rely on water infrastructure projects that require funding that may be too expensive for sponsors.

After regional water planning was established in Texas, the legislature appropriated limited funding for state water plan projects. There was not, however, a consistent, dedicated source of funds, nor was there an adequate amount to address the sizable costs of all the projects in the state water plan. The 83rd Texas Legislature decided to change that. The Texas Legislature created the **State Water Implementation Fund for Texas (SWIFT)** and **State Water Implementation Revenue Fund for Texas (SWIRFT)** to provide affordable, ongoing state financial assistance for projects in the state water plan. Passed by the legislature and approved by Texas voters through a constitutional amendment, the SWIFT program assists communities in developing and optimizing water supply projects at cost-effective rates. The program provides low-interest loans, extended repayment terms, deferral of loan repayments, and incremental repurchase terms for projects with state ownership aspects. To be eligible for the SWIFT program, a project and its associated capital costs must be included in the state water plan.

The SWIFT program was designed to provide the approximately $27 billion in reported financial assistance needs for water supply projects identified in the 2012 State Water Plan. The program will help ensure that Texas communities have adequate supplies of water during drought for many decades to come.

The goals of the SWIFT program include providing 10 percent of the funds to support projects for rural political subdivisions or agricultural water conservation and 20 percent to support projects that are designed for water conservation or reuse.

In addition to providing financial assistance for state water plan projects, the legislation creating SWIFT made other significant changes. It reshaped the regional and state water planning process by

- requiring that planning groups prioritize their recommended projects using uniform standards that are developed by the Stakeholder Committee;
- requiring the TWDB to further prioritize project proposals that are brought to the TWDB by sponsors seeking SWIFT funding;
- incorporating built-in incentives for regionalizing and right-sizing water supply projects;
- incentivizing greater cooperation between more diverse and greater numbers of water users, including rural and urban entities, in developing larger water supply projects;
- encouraging greater pursuit of conservation strategies;
- increasing both interest and participation in the regional and state water planning processes; and,
- specifically emphasizing funding for rural Texans with water needs.

The SWIFT legislation included a number of oversight, reporting, and transparency requirements, such as creation of a legislative advisory committee, requirements for a biennial report to the legislature, and regular reporting on the TWDB's website.

Project prioritization

The statutes enacted by the 83rd Legislature put in place a process for prioritizing recommended projects at both the regional and state level. At the regional level, the planning groups prioritize projects in their regional water plans using uniform standards developed by the Stakeholder Committee composed of chairs of the planning groups.

At the state level, the TWDB's administrative rules include a prioritization system for those projects applying for SWIFT funding. This system includes factors required by the SWIFT legislation and the associated weighting of criteria, such as how many people will be served by the project, whether the project will serve a diverse urban and rural population, and the ranking by the planning group. Other criteria include the local financial contribution, emergency needs for water, and the project's impact on conservation. The criteria were developed as part of an extensive and lengthy public process.

4.3.3 Other TWDB state-funded programs

The TWDB has other funding programs that, although not focused on state water plan funding, are capable of funding projects that are in the state water plan as well as projects such as replacement of facilities, which are not included in the state water plan. The funding programs include the following:

The **Texas Water Development Fund** is the oldest of the TWDB's programs. Created in 1957 with the passage of the agency's first constitutional amendment, the program provides loans for water supply and conservation, water quality enhancement, flood control, and municipal solid waste. The TWDB issues general obligation bonds to support the program.

The **State Participation Program** was created in 1962 to encourage regional water supply, wastewater, and flood control projects. The program is limited to funding the excess capacity of a regional project when the local sponsors are unable to assume debt for the optimally sized facility, thus allowing for the "right sizing" of projects to accommodate future growth. The TWDB assumes a temporary ownership interest, and the local sponsor repurchases the TWDB's interest in the project as the growth is realized and additional customers connect to the system. To support the program, the TWDB issues general obligation bonds.

Construction of a TWDB-funded ground storage tank, Amarillo, Texas

The **Rural Water Assistance Fund**, created in 2001, provides small, rural water utilities with low-cost financing for water and wastewater planning, design, and construction projects. The fund also can assist small, rural systems with participation in regional projects that benefit from economies of scale, the development of groundwater sources, desalination, and the acquisition of surface water and groundwater rights. The program is funded with general obligation bonds.

The **Agricultural Water Conservation Program** was created in 1989 to encourage conservation in irrigation water use. The program provides low-interest loans to political subdivisions to fund conservation programs or projects. The TWDB may also provide grants to state agencies and political subdivisions for agricultural water conservation programs, including demonstration projects, technology transfers, and educational programs.

The program is funded by assets in the Agricultural Water Conservation Fund as well as general obligation bonds.

The **Economically Distressed Areas Program** provides grants and loans for water and wastewater services in economically distressed areas where services do not exist or existing systems do not meet minimum state standards. Created in 1989, the program is focused on delivering water and wastewater services to meet immediate health and safety concerns and stopping the proliferation of sub-standard water and wastewater services through the development and enforcement of minimum standards. The program is funded by general obligation bonds and general revenue appropriations.

The **Water Infrastructure Fund** was created in 2001 to provide financial incentives for the implementation of strategies recommended in the state water plan. Funding for the program was first received in 2008 through general obligation bonds and general appropriations from the legislature. The program has effectively been replaced by SWIFT, which is generally based on the Water Infrastructure Fund's program structure.

4.3.4 TWDB federally funded programs

In addition to its state-funded programs, the TWDB is the primary state agency through which two federal funding programs are administered.

The **Clean Water State Revolving Fund** program was created by the federal Clean Water Act amendments of 1987 to promote water quality and to help communities meet the goals of the Clean Water Act. The fund provides low-cost loans for wastewater projects and additional subsidies for disadvantaged communities and green infrastructure projects. Currently, all 50 states and Puerto Rico operate Clean Water State Revolving Fund programs.

The program is funded by annual capitalization grants from the U.S. Congress through the U.S. Environmental Protection Agency, a required 20 percent state funding match, loan repayments, and revenue bonds.

The **Drinking Water State Revolving Fund** was created by the Safe Drinking Water Act, as amended in 1996, to finance infrastructure improvements to the nation's drinking water systems. The program provides low-cost loans for drinking water projects and additional subsidies for disadvantaged communities, green infrastructure, and small and urgent need projects.

Like the Clean Water State Revolving Fund, this program is funded by annual capitalization grants made by the U.S. Congress through the U.S. Environmental Protection Agency, a required 20 percent state funding match, loan repayments, and revenue bonds.

References

USACE (U.S. Army Corps of Engineers), 1999, Water resources policies and authorities, Digest of Water Resource Policies and Authorities: U.S. Army Corps of Engineers Publication Number 1165-2-1, 381 p. www.publications.usace.army.mil/Portals/76/Publications/EngineerPamphlets/EP_1165-2-1.pdf.

Construction of a TWDB-funded water supply project on the Colorado River

5

Future population and water demand

Quick facts

Texas' population is expected to increase more than 70 percent between 2020 and 2070, from 29.5 million to 51 million.

Over half of all the statewide population growth between 2020 and 2070 is expected to occur within Regions C and H.

Water demand is projected to increase by 17 percent, from 18.4 million acre-feet per year in 2020 to 21.6 million acre-feet per year in 2070.

The five-year water planning cycle begins with projecting the population of Texas over the next 50 years and the water supply that the population will need to live and work in both cities and rural areas. Determining projections and water demand is a lengthy process designed to develop a consensus between state agencies, regional water planning groups, and local entities. The TWDB, the Texas Commission on Environmental Quality, the Texas Department of Agriculture, the Texas Parks and Wildlife Department, representatives from the planning groups, and members of the public helped determine the final projections using initial projections developed by the Office of the State Demographer and the Texas State Data Center.

5.1 Population projections

Texas' population is the second largest in the United States and has increased more than any other state since 2000 (U.S. Census Bureau, 2011, 2014). With its population expected to increase more than 70 percent between 2020 and 2070, from 29.5 million to 51 million (Figure 5.1, Table 5.1), Texas will continue to be one of the fastest growing states in the nation. Although the state-wide population will increase over those 50 years, not all regions will grow equally.

This plan projects the population for over 1,600 population centers, including cities with more than 500 residents, utilities in unincorporated areas with annual water use in 2010 of 280 acre-feet or more, and unincorporated populations residing in sparsely populated rural areas within each county. Of the 16 regional water planning areas, 9 are expected to grow by more than 50 percent between 2020 and 2070, including those with many of the state's major metropolitan areas (Table 5.1).

Figure 5.1 - Projected population in Texas

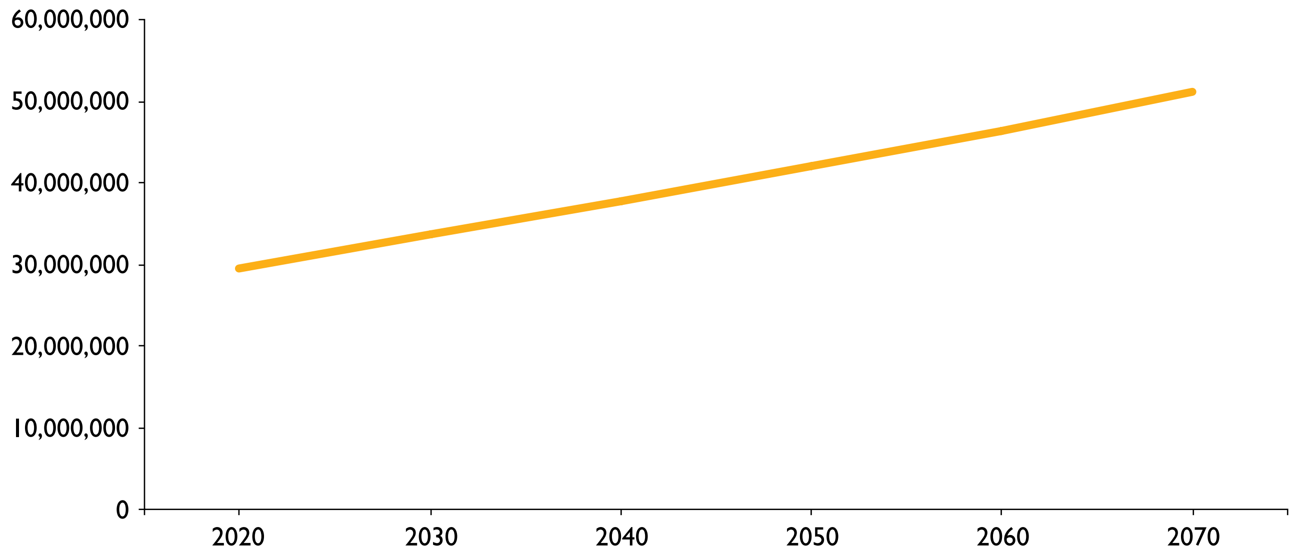


Table 5.1 - Projected population by region

Region	2020	2030	2040	2050	2060	2070	Percent growth
A	419,000	461,000	504,000	547,000	592,000	639,000	53
B	206,000	214,000	219,000	223,000	226,000	229,000	11
C	7,504,000	8,649,000	9,909,000	11,260,000	12,742,000	14,348,000	91
D	831,000	908,000	989,000	1,089,000	1,212,000	1,370,000	65
E	954,000	1,086,000	1,208,000	1,329,000	1,444,000	1,551,000	63
F	701,000	767,000	825,000	885,000	944,000	1,003,000	43
G	2,371,000	2,721,000	3,097,000	3,495,000	3,918,000	4,351,000	84
H	7,325,000	8,208,000	9,025,000	9,868,000	10,766,000	11,743,000	60
I	1,152,000	1,234,000	1,310,000	1,389,000	1,470,000	1,554,000	35
J	141,000	154,000	163,000	171,000	178,000	185,000	31
K	1,737,000	2,065,000	2,382,000	2,658,000	2,928,000	3,243,000	87
L	3,001,000	3,477,000	3,920,000	4,336,000	4,770,000	5,192,000	73
M	1,961,000	2,379,000	2,795,000	3,212,000	3,626,000	4,029,000	105
N	615,000	662,000	693,000	715,000	731,000	745,000	21
O	540,000	594,000	646,000	698,000	751,000	802,000	49
P	50,000	52,000	53,000	54,000	55,000	56,000	12
Texas	**29,508,000**	**33,631,000**	**37,738,000**	**41,929,000**	**46,353,000**	**51,040,000**	**73**

Population growth is concentrated in the eastern portion of Texas and along the Interstate Highway-35 corridor (Figure 5.2). Of Texas' 254 counties, 30 are projected to at least double in population between 2020 and 2070. The same is true for 328 population centers. Nine counties are expected to triple in population between 2020 and 2070. One, Bastrop County, is expected to quadruple in population over that time. Regions C (which includes the Dallas-Fort Worth metropolitan area) and H (which includes the Houston metropolitan area) account for more than half of the total projected statewide population growth between 2020 and 2070 (Figure 5.3). Region M, which stretches along the Rio Grande, has the highest regional growth rate and is expected to more than double its population. Conversely, 22 counties and 111 population centers in Texas are expected to lose residents or have no population growth.

5.1.1 Population methodology

Population projections for the 2017 State Water Plan were created using a standard demographic methodology known as a cohort-component model. This procedure uses separate cohorts (combinations of age, gender, and racial-ethnic groups) and components of cohort change (birth, survival, and migration rates) to estimate future county populations. The cohort-component model and demographic assumptions used as the basis for the regional population projections were developed by the State Demographer at the Texas State Data Center, which provided the TWDB with initial, 30-year projections for each county as a whole. The TWDB then extended these 30-year projections to the state water plan's 50-year planning horizon.

Of the three components of cohort change (birth, survival, and migration rates), migration rates, which calculate how many people move in and out of the counties, are the most critical. While birth and survival rates tend to closely follow historical trends, migration rates tend to be heavily influenced by the state of the economy, reflecting movement that results from economic opportunity. Migration can also be influenced by other unforeseen events, such as catastrophic weather events.

To determine the most appropriate migration projection for each region, the TWDB and the planning groups together evaluated three sets of projections based on different migration patterns:

- Zero migration
- One-half of the migration rates from 2000 to 2010
- 2000–2010 migration rates

The one-half migration scenario was used for the vast majority of counties, based on historical precedence and recommendations by the State Demographer for long-term projections.

Because detailed cohort-component data is available only for the population projections of whole counties, the TWDB had to determine subcounty level projections for cities, other utility service areas, and the remaining rural areas within each county.

The TWDB based these initial subcounty projections on the estimated share each entity had

Figure 5.2 - Projected population growth in Texas counties

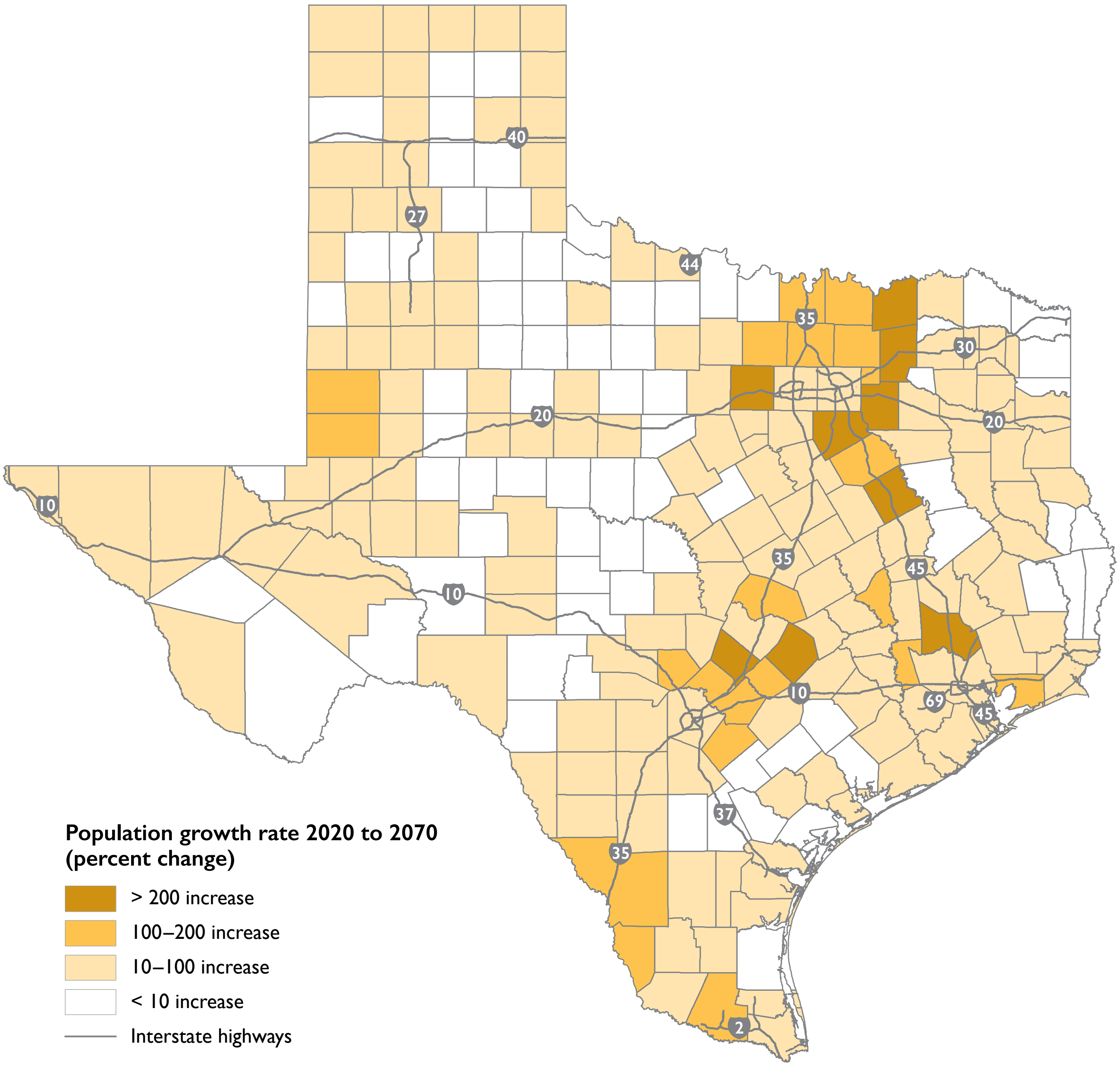
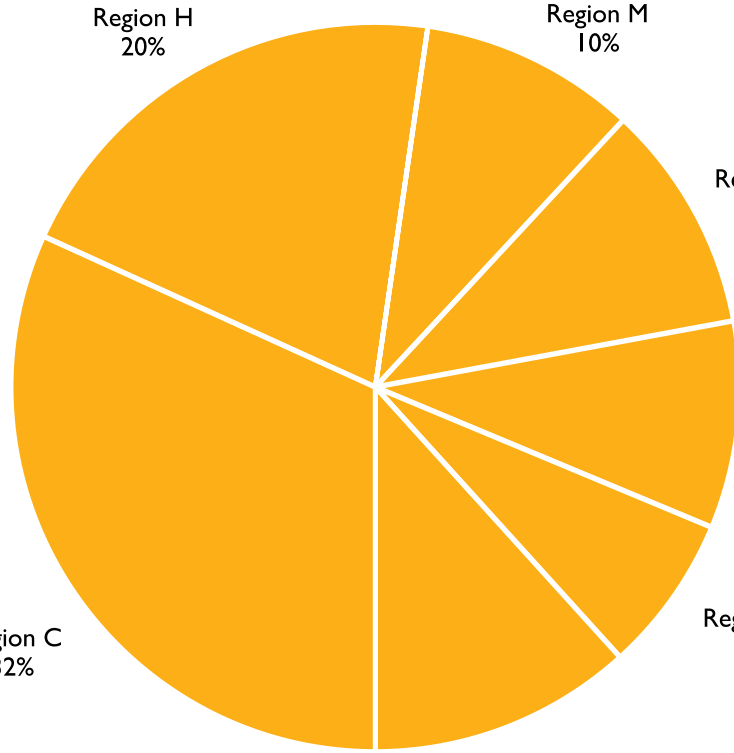


Figure 5.3 - Regional shares of statewide population growth (2020–2070)



during an entire county's growth from 2000 to 2010. The TWDB then applied that same percentage to growth projections. However, when the growth trend for a county and a city went in opposite directions, other methods of projections more specific to the situation were used. Because census populations were not available for utility service areas, the TWDB used the number of water connections and populations served that were reported in the TWDB's annual Water Use Survey to represent the baseline population figures.

These draft projections were then sent to the planning groups for review by planning group members and the public. After requests from the planning groups, the TWDB made more than 600 population projection revisions at the county and subcounty levels.

Table 5.2 - Projected annual water demand by water use category (acre-feet)

Category	2020	2030	2040	2050	2060	2070	Percent change
Irrigation	9,438,000	9,138,000	8,800,000	8,431,000	8,067,000	7,778,000	-18
Municipal	5,200,000	5,791,000	6,404,000	7,042,000	7,719,000	8,433,000	62
Manufacturing	2,177,000	2,489,000	2,644,000	2,778,000	2,900,000	3,030,000	39
Steam-electric	953,000	1,108,000	1,225,000	1,388,000	1,561,000	1,740,000	83
Livestock	296,000	305,000	309,000	315,000	320,000	325,000	10
Mining	343,000	354,000	327,000	303,000	287,000	292,000	-15
Texas[a]	**18,407,000**	**19,185,000**	**19,709,000**	**20,257,000**	**20,854,000**	**21,598,000**	**17**

[a] *Statewide totals may vary between tables due to rounding.*

5.2 Water demand projections

Projecting water demand is the second task undertaken to begin the water planning process. The TWDB projects water demand for municipal and non-municipal sectors of the Texas economy, including manufacturing, mining, steam-electric, livestock, and irrigation. Water demand in all water use categories is projected to increase by 17 percent, from 18.4 million acre-feet in 2020 to 21.6 million acre-feet in 2070 (Figure 5.4).

Steam-electric, municipal, and manufacturing categories show the greatest projected increases in water demand, ranging from approximately 83 percent to 39 percent. Mining is expected to decline, and livestock is expected to grow slightly. While irrigation is the largest water demand category for 2020, it is expected to decrease 18 percent by 2070. Municipal demand is projected to exceed irrigation demand in that decade (Table 5.2, Figure 5.5).

Water demand projections exclude water demands that are associated with purely saline supplies, much of which is associated with industrial uses located along the coast.

5.2.1 Projected water demand by region and water use category

As with population projections, total water demand varies significantly by planning area (Table 5.3). Significant increases in water demand are projected in Regions C, D, G, H, I, L, and N, each with more than 30 percent growth in projected water demand between 2020 and 2070.

Because of declining irrigation demand, four regions show a projected decrease in total water demand from 2020 to 2070: Regions A, B, O, and P. More than half of the projected water demand in 2020 is associated with irrigation use, while less than a third is associated with municipal demand (Figure 5.6). By 2070, the share of statewide water demand associated with irrigation declines to just more than one-third of the total, offset by increases in municipal, steam-electric, and manufacturing demand (Figure 5.7).

5.2.2 Water demand methodology

In a process similar to projecting future population, the TWDB, the Texas Commission on Environmental Quality, the Texas Department of Agriculture, and the Texas Parks and Wildlife Department drafted

Figure 5.4 - Projected annual water demand in Texas (acre-feet)

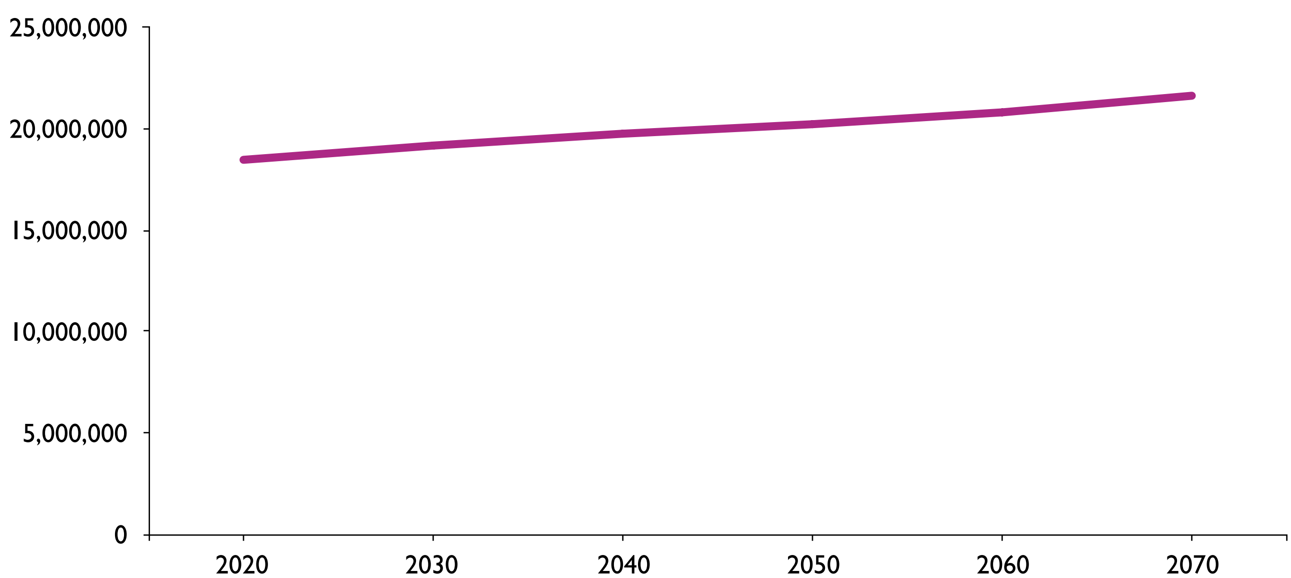
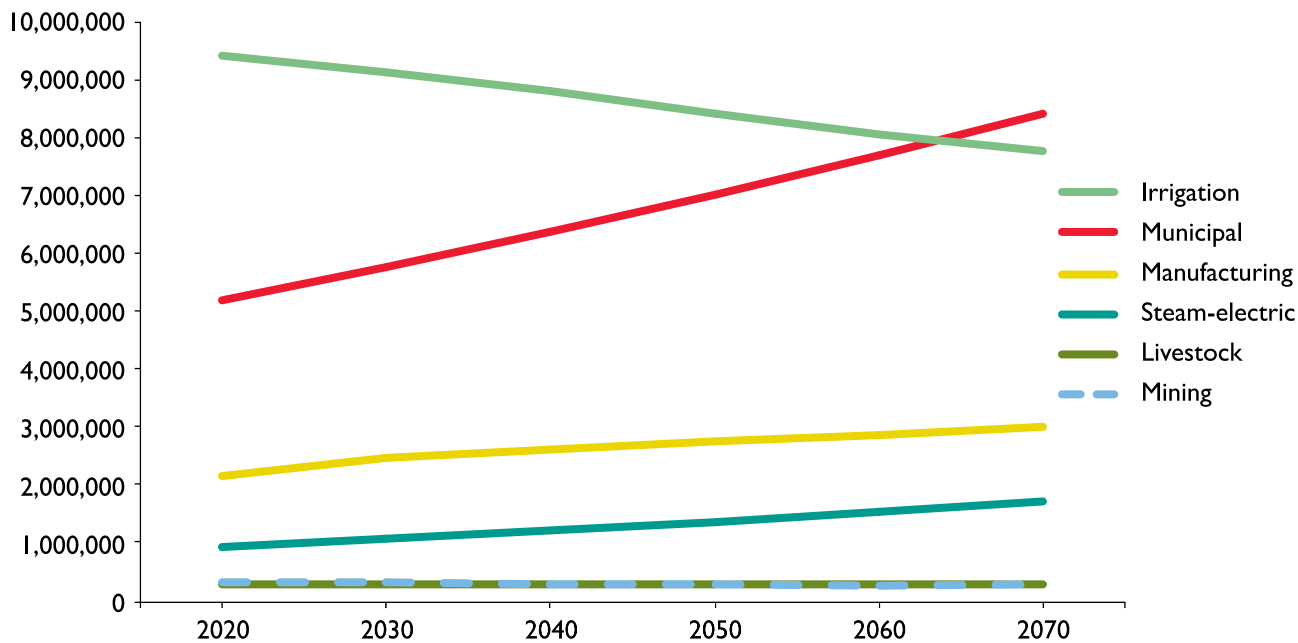


Figure 5.5 - Projected annual water demand by water use category (acre-feet)



water demand projections for the municipal, manufacturing, steam-electric, mining, livestock, and irrigation water use categories. The draft projections were provided to the planning groups for review. As a result of their review, the planning groups requested changes for more than 800 of the water user groups listed in the plan. More than 95 percent of these requested changes were recommended by the four agencies and adopted by the TWDB.

5.2.3 Municipal water demand

Municipal water demand includes water used by a variety of consumers in Texas communities, including single-family residences, multi-family residences, and nonresidential establishments (commercial, institutional, and light industrial). It includes water utilities, individual cities, and aggregated rural areas (referred to as "county-other" for planning purposes).

Residential and nonresidential consumers use water for similar purposes, such as drinking, cooking, sanitation, cooling, and landscape watering. In addition, residential and nonresidential establishments are generally intertwined in their long-term development, which supports the methodology of including both in the municipal water demand projections. Water-intensive industrial customers, such as large manufacturing plants, steam-electric power generation facilities, and mining operations, are not included in municipal water demand but instead have their own categories.

To estimate total annual water demands, the TWDB multiplied the projected per capita water use (also described as gallons per capita daily or GPCD) during a historical dry year by the projected populations. The per capita water use is based on annual Water Use Survey data for each water user group. The per capita water use values exclude wastewater reuse, sales to other water systems, and sales to large manufacturing, mining, or steam-electric power generating customers. Such exclusions in the water use calculations are made to avoid double counting water use. For the majority of municipal water user groups, the 2011 per capita water use was used in estimating demand because of the severity of the 2011 drought. In a few cases, based on local circumstances, an average of other dry years was used as the basis for estimating demand.

In all regions, the municipal water demand projections incorporated the anticipated future water savings from the installation of more efficient toilets, shower heads, dishwashers, and clothes washers that are already required by state and federal laws determining water use efficiency in fixtures and appliances. These savings are projected to be 295,000 acre-feet per year in 2020, increasing to 887,000 acre-feet per year in 2070. Water savings due to existing legal requirements are embedded in the municipal water demand projections because they require no additional action on the part of cities and water utilities. Planning groups incorporated additional future water savings from municipal conservation programs in the regional and state water plans as adopted water management strategies to be implemented by water providers (see Chapter 8).

5.2.4 Manufacturing water demand

Manufacturing water demand consists of the future water necessary for large facilities including those that process chemicals, oil and gas, food, paper, and other materials. Projections for this category were based on a combination of previous projections from the 2012 State Water Plan (Waterstone Environmental Hydrology and Engineering, Inc. and The Perryman Group, 2003). Projections in this planning cycle were also adjusted to reflect local input, information provided by the planning groups, and water use in 2011 as reported in the TWDB's annual Water Use Survey. A base water use amount for each county was projected for the future, taking into consideration economic projections for the manufacturing industry as well as incorporated efficiency improvements from new technology. Future growth in manufacturing water demand was generally predicted to be located in the same counties in which manufacturing facilities currently exist.

Table 5.3 - Projected annual water demand by region (acre-feet)

Region	2020	2030	2040	2050	2060	2070	Percent change
A	1,734,000	1,658,000	1,555,000	1,421,000	1,293,000	1,166,000	-33
B	163,000	160,000	157,000	154,000	154,000	154,000	-5
C	1,723,000	1,945,000	2,183,000	2,426,000	2,677,000	2,940,000	71
D	634,000	682,000	734,000	790,000	866,000	957,000	51
E	645,000	657,000	661,000	671,000	682,000	694,000	7
F	838,000	847,000	846,000	844,000	846,000	853,000	2
G	1,068,000	1,152,000	1,215,000	1,303,000	1,387,000	1,478,000	38
H	2,489,000	2,675,000	2,853,000	3,039,000	3,218,000	3,415,000	37
I	1,109,000	1,331,000	1,395,000	1,464,000	1,533,000	1,607,000	45
J	40,000	41,000	42,000	43,000	44,000	45,000	13
K	1,183,000	1,245,000	1,302,000	1,352,000	1,401,000	1,462,000	24
L	1,070,000	1,156,000	1,219,000	1,291,000	1,366,000	1,434,000	34
M	1,505,000	1,515,000	1,524,000	1,530,000	1,538,000	1,606,000	7
N	262,000	280,000	295,000	307,000	324,000	343,000	31
O	3,711,000	3,608,000	3,496,000	3,391,000	3,293,000	3,211,000	-13
P	234,000	233,000	233,000	232,000	232,000	232,000	-1
Texas[a]	**18,408,000**	**19,185,000**	**19,710,000**	**20,258,000**	**20,854,000**	**21,597,000**	**17**

[a] *Statewide totals may vary between tables due to rounding.*

Figure 5.6 - Water use category shares of projected annual water demand in 2020

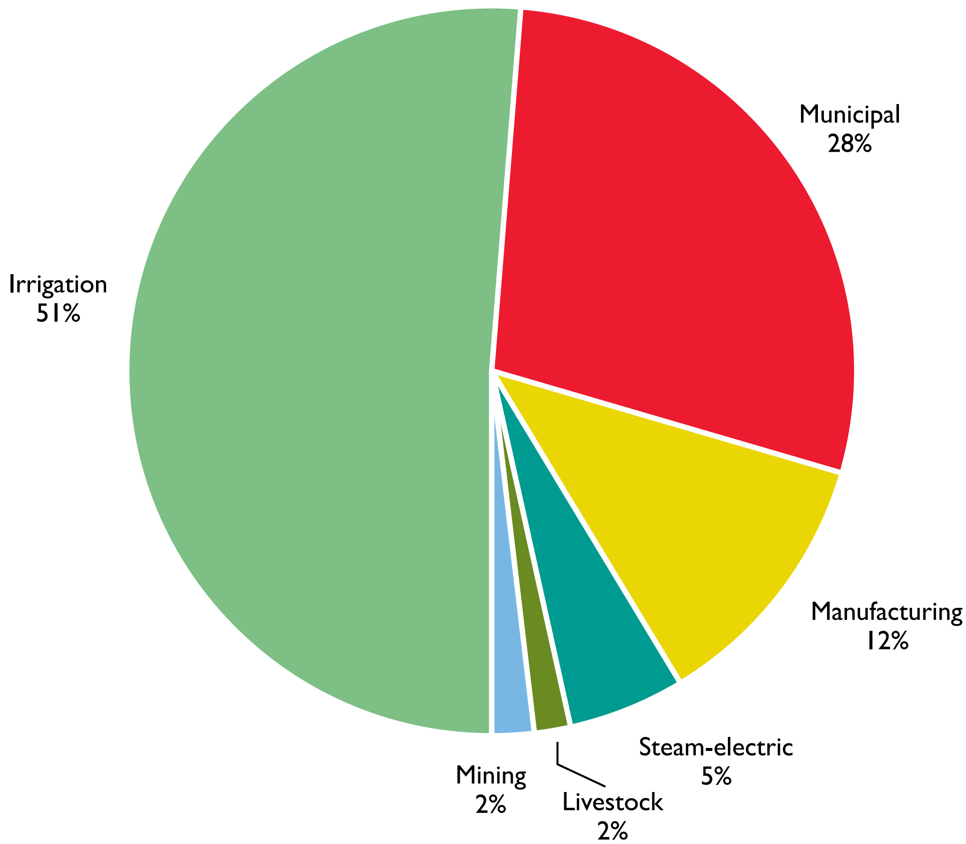
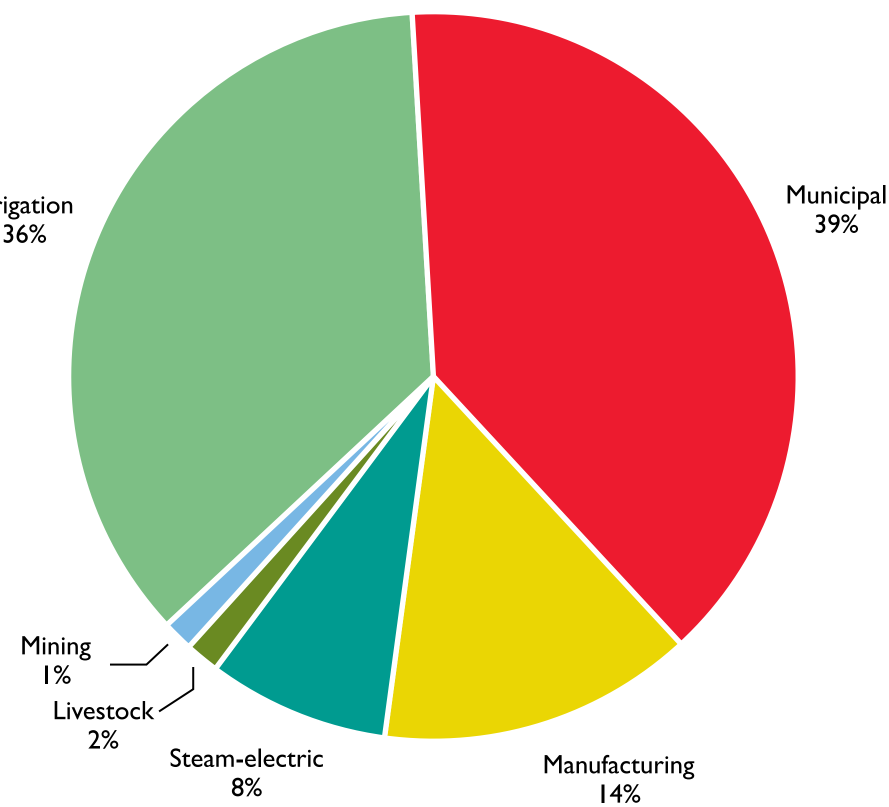


Figure 5.7 - Water use category shares of projected annual water demand in 2070



5.2.5 Mining water demand

Mining water demand consists of water used in the exploration, development, and extraction of oil, gas, coal, aggregates, and other materials. Mining demand projections were based on external research (BEG, 2011, 2012). Due to the rapidly changing hydraulic fracturing, or fracking, activity in the oil and gas industry, the TWDB contracted with the Bureau of Economic Geology in 2009 to re-evaluate the current and project the future water used in mining operations (BEG, 2011). In 2012, the Bureau of Economic Geology released an updated estimate of mining water use in response to the changes occurring in the oil and gas industry. This information was used in developing the mining water demand projections. In all planning decades except 2060, the projections of mining water use are greater than in the 2012 State Water Plan. However, mining demand is projected to decline slightly from 2020 to 2070 while remaining between 1 and 2 percent of total water use in all decades. Water use associated specifically with fracking is expected to be less than 1 percent of total water use in Texas in each decade.

5.2.6 Steam-electric water demand

Steam-electric water demand consists of water used for the purpose of generating power. A generation facility usually diverts surface water, uses it for cooling purposes, and then returns a large portion of the water to a body of water. The water use for the facility is only the volume consumed in the cooling process and not returned. Projections are based on a TWDB-funded study performed by the Bureau of Economic Geology (2008) to develop water demand projections for the steam-electric sector in Texas. Beyond the specific future steam-electric power generation facilities on file with the Public Utility Commission of Texas, most future water demand growth for steam-electric is expected to take place in the same counties in which current steam-electric facilities exist.

5.2.7 Irrigation water demand

Irrigation water demand includes water used in irrigated field crops, vineyards, orchards, and self-supplied golf courses. Projections for irrigation water demand were based on the rate of future change in demand and the previous projections used in developing the 2012 State Water Plan. Each planning cycle, the previous cycle's irrigation projections are adjusted by factors and trends including

- changes in the amount of crops under irrigation,
- increases in irrigation application efficiency,
- changes in canal losses for surface water diversions, and
- changes in cropping patterns.

Irrigation demand is expected to decline as a result of more efficient irrigation systems, reduced groundwater supplies, the economic difficulty of pumping water from increasingly greater depths, and the transfer of water rights from agricultural to municipal uses.

5.2.8 Livestock water demand

Livestock water demand includes water used in the production of various types of livestock, including cattle (beef and dairy), hogs, poultry, horses, sheep, and goats. Livestock water use for each county was based on the average livestock water use between 2005 and 2009 and on the estimated "dry year" water use per animal unit. In most cases, it was predicted that livestock use would remain fairly constant over the 50-year planning horizon.

5.3 Comparison to the 2012 State Water Plan

The overall population and water demand projections for the 2017 State Water Plan are similar to those in the 2012 State Water Plan, with a few notable exceptions. Focusing on the planning decades of 2020 and 2060 as common comparison points, some of the important similarities and differences are summarized below:

- The projected statewide population estimates are very close to those in the 2012 State Water Plan, with no more than one-half of a percent difference in any planning decade.

- The largest nominal decreases to population projections are for approximately 468,000 less people in Region C in 2020 and approximately 580,000 less people in Region H in 2060. The decrease in projected population is due to a number of factors, including a slightly slower overall growth rate during the 2007–2010 economic recession and numerous demographic shifts incorporated into the projection models that are based on 2010 census information that became available after the previous projection estimates.
- The largest relative increases in projected population from the 2012 State Water Plan were for approximately 30 and 36 percent increases in 2060 for Regions F and O, respectively. These increases are mostly associated with increased oil and gas activities in the regions.
- Statewide municipal water demand projections are projected to be approximately 8 percent lower in 2060 than the projections in the 2012 State Water Plan. This is due to lower population projections and because lower per capita water use rates (based on the drought year 2011) were used to develop the municipal water demand projections for some areas within Regions C and H. The lower per capita use may also reflect some conservation achieved since the previous state water plan.

5.4 Uncertainty of population growth and water demands

Because population growth is so variable, projections used to develop the regional and state water plans are adjusted every decade when each new U.S. Census is released. Between each census, the TWDB relies on input from planning groups to allocate the residents to population centers within each county.

As evidenced by the changes in the projections used to develop each state water plan, every category of water demand—municipal, manufacturing, irrigation, steam-electric, mining, and livestock—will vary over time. Population growth

Center-pivot irrigation near Uvalde, Texas depends on social and economic factors including individual preferences. Municipal demand depends on how many and how residents are using water and where they choose to reside. Per capita water use depends on preferences, habits, and water-using appliances, all of which are influenced by the economy and/or the weather. In addition, 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 the underlying factors that influence water use are difficult to accurately predict, especially over the long term, and result in uncertainty in water demand projections.

Historically, irrigation has been the category of greatest water use in Texas. Irrigation demand is contingent upon many variables such as the number of acres of each crop, the water needs of each crop type, and the weather. In addition, economic factors equally contribute to irrigation demand, including prices of agricultural commodities and agricultural production inputs like fuel and fertilizer. Government policies can also be influential.

Rather than attempt to predict future policies and commodity prices, the TWDB projects irrigation water demand based on current water use levels. This allows important future developments to be revised every five years through adjustments from each planning cycle.

Manufacturing, mining, and steam-electric demands also depend on numerous factors such as price levels of their inputs and outputs, the resources needed for production, and the products of that production. Because most industrial processes are energy intensive, the prices of energy sources such as gasoline, natural gas, and coal are of particular importance.

References

BEG (Bureau of Economic Geology), 2008, Water demand projections for power generation in Texas: Prepared for the Texas Water Development Board, 268 p. www.twdb.texas.gov/publications/reports/contracted_reports/doc/0704830756ThermoelectricWaterProjection.pdf

BEG (Bureau of Economic Geology), 2011, Current and projected water use in the Texas mining and oil and gas industry: Prepared for the Texas Water Development Board, 381 p. www.twdb.texas.gov/publications/reports/contracted_reports/doc/0904830939_MiningWaterUse.pdf

BEG (Bureau of Economic Geology), 2012, Oil and gas water use in Texas—Update to the 2011 mining water use report: Prepared for the Texas Water Development Board, 117 p. www.twdb.texas.gov/publications/reports/contracted_reports/doc/0904830939_2012Update_MiningWaterUse.pdf

U.S. Census Bureau, 2011, Population distribution and change—2000 to 2010: 2010 Census Briefs, www.census.gov/prod/cen2010/briefs/c2010br-01.pdf

U.S. Census Bureau, 2014, State totals: Vintage 2014, www.census.gov/popest/data/state/totals/2014

Waterstone Environmental Hydrology and Engineering, Inc. and The Perryman Group, 2003, Water demand methodology and projections for mining and manufacturing: Prepared for the Texas Water Development Board, 73 p. www.twdb.texas.gov/publications/reports/contracted_reports/doc/2001483397.pdf

6

Water supplies

Quick facts

Total surface water and groundwater availability are lower by approximately 4 percent in 2020 and 5 percent in 2060 than in the 2012 State Water Plan.

Texas' existing water supplies—those that can already be relied on in the event of drought— are expected to decline by approximately 11 percent between 2020 and 2070, from 15.2 to 13.6 million acre-feet per year.

Texas is endowed with extensive surface water and groundwater resources that are conveyed and delivered throughout the state to provide water supply. To plan for sufficient water during drought of record conditions, regional water planning groups must answer two questions: how much water do we already have and how much more do we need during a drought? To answer these questions, planning groups have to evaluate how much existing water supply each of the approximately 2,600 water user groups has access to in the event of drought.

6.1 Evaluating water resources for planning

Estimating how much water Texans will have to meet their water demands is a two-step process that examines both water availability and existing supply. Those two terms have very specific, and not necessarily intuitive, meanings in the water planning process.

Water availability refers to the maximum volume of raw water that could be withdrawn annually from each source (such as a reservoir or aquifer) during a repeat of the drought of record. Availability does not account for whether the supply is connected to or legally authorized for use by a specific water user group. Water availability is analyzed from the perspective of the source and answers the question: *How much water from this source could be delivered to water users as either an existing water supply or, in the future, as part of a water management strategy?* Determining water availability is the first step in assessing potential water supply volumes for a planning group.

Second, planning groups evaluate the subset of the water availability volume that is already connected to water user groups. This subset is defined as existing supply. Existing water supplies are based on legal access to the water as well as the infrastructure (such as pipelines and treatment plant capacity) already in place to treat and deliver the water to the "doorstep" of water user groups. Existing supply is analyzed from the perspective of water users and answers the question: *How much water supply could each water user group already rely on should there be a repeat of the drought of record?*

For example, the firm yield of a surface water reservoir may be 100,000 acre-feet per year. Of that 100,000 acre-feet per year in supplies available at the source, the current pipeline to that source could only convey 60,000 acre-feet per year to users as an existing supply. There remains, therefore, an additional 40,000 acre-feet per year in available water that could serve as the basis for a future water management strategy. Within a county, for another example, there may be a modeled available groundwater volume of 50,000 acre-feet per year, but because water users' current permits and pumping facilities are only able to pump 20,000 acre-feet per year for existing supplies, there remains 30,000 acre-feet per year in available groundwater that could support water management strategies.

Because existing supplies are a subset of the availability of water sources, existing supplies cannot exceed a source's availability without the risk of a water user running short of water in a drought of record. If existing supplies exceed availability it is called an over-allocation. To ensure that planning groups did not assign more water supply to a water source than the source could provide in a drought, the TWDB performed a detailed, statewide accounting of all assigned existing water supply volumes and notified planning groups of over-allocations. Planning groups then made adjustments to their draft plans so that supplies did not exceed the availability of any source in the final plans.

6.2 Surface water availability within river basins

Surface water in Texas comes from 188 major reservoirs and numerous river diversions, known as run-of-river supplies, Texas' 15 major river basins, and eight coastal basins (Figure 6.1).

Surface water availability is determined with the Texas Commission on Environmental Quality's surface water availability models, which are based on permitted water supplies within each river basin. These models determine the monthly and annual water volumes that could be diverted each

Figure 6.1 - Major river and coastal basins and major surface water supply reservoir locations

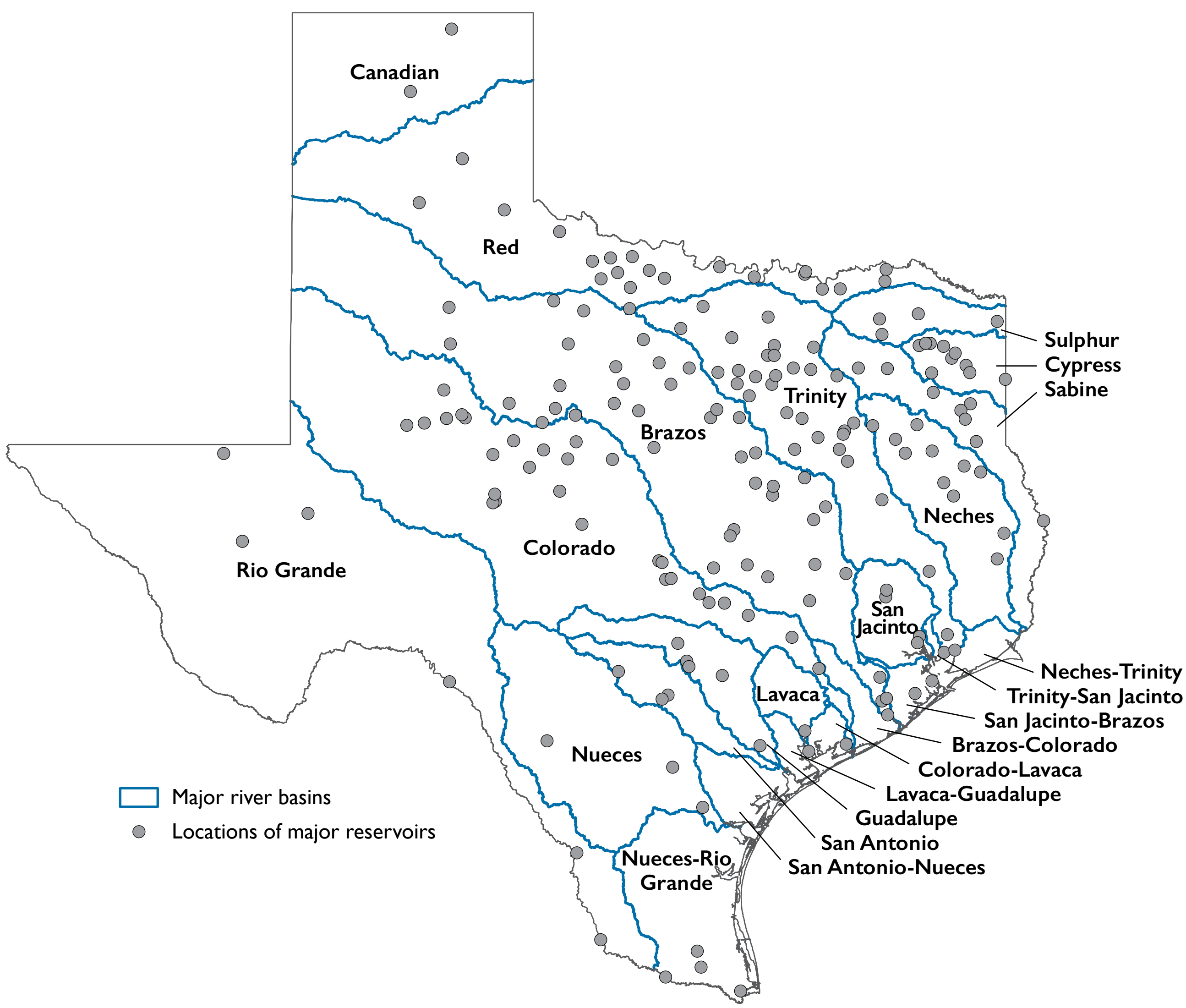
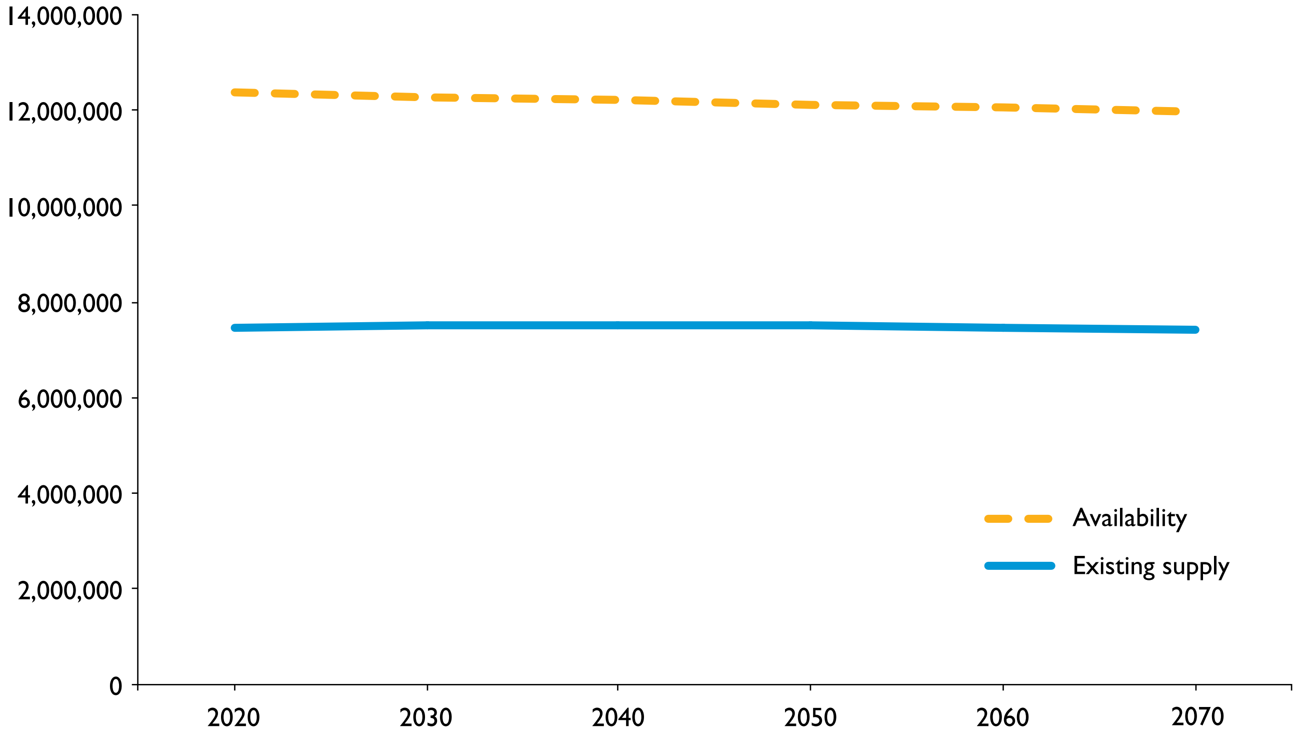


Figure 6.2 - Texas' annual surface water availability and existing surface water supply (acre-feet)



year in drought of record conditions, regardless of whether or not the water is actually connected to any water user groups. The models also incorporate all existing water rights and their relative seniority dates and apply accounting procedures to historical data, such as naturalized streamflow volumes, to estimate the availability of each water right over the historic modeling period.

The default surface water availability model assumes that all existing water right holders fully use their water rights without returning any flows to the river unless their permit requires them to do so. With approval by the executive administrator of the TWDB, planning groups are allowed to modify the default model when evaluating existing water supplies but are required to ensure that any such modifications accurately reflect the hydrologic conditions anticipated to occur under drought of record conditions.

Surface water availability in Texas is anticipated to decline by approximately 3 percent from 2020 to 2070 (Figure 6.2). The decline is due to sedimentation, which reduces reservoir storage.

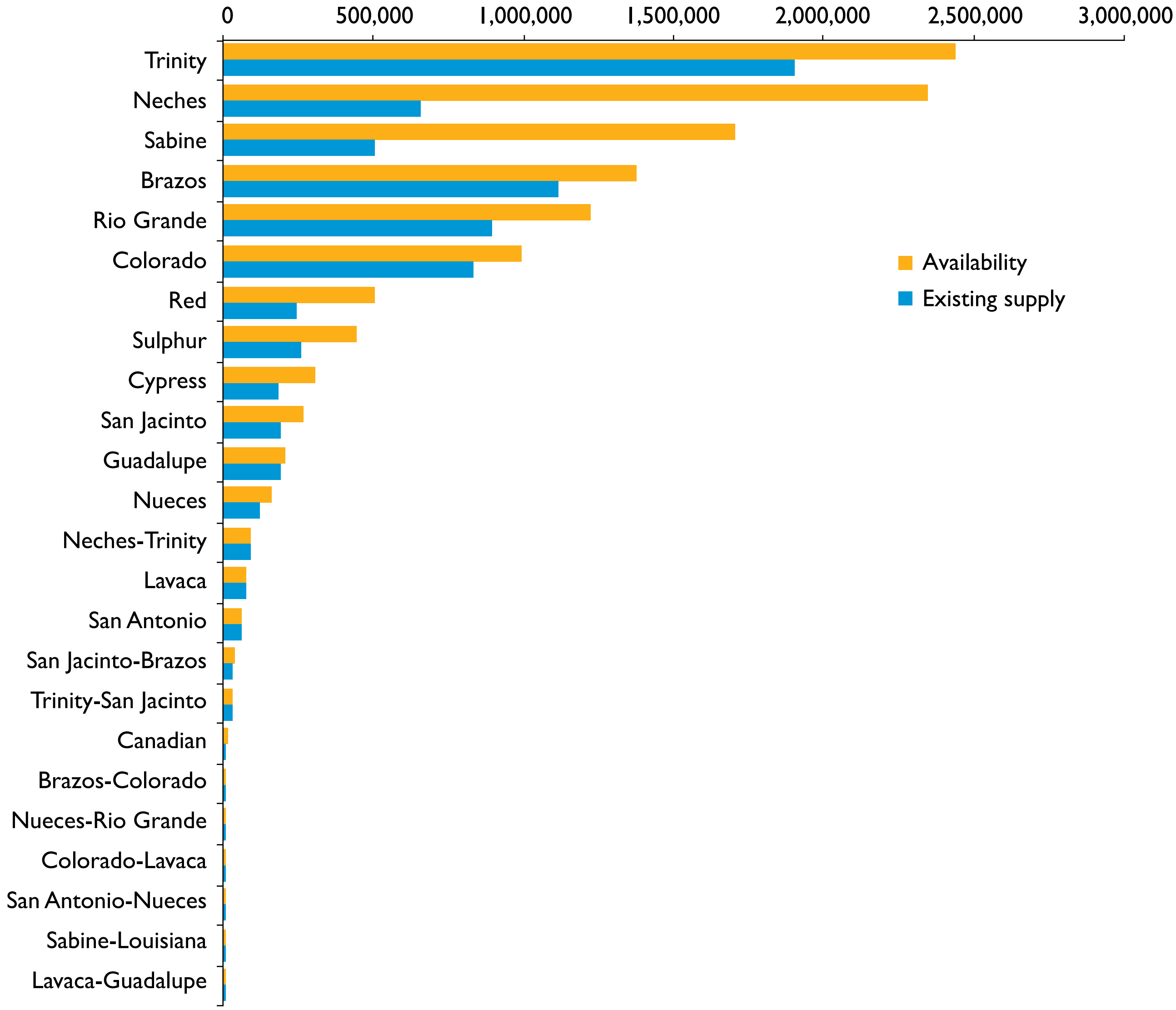
More than half of the annual statewide surface water availability of 12.4 million acre-feet in 2020 occurs within the Trinity, Neches, and Sabine river basins (Figure 6.3, Appendix B.1).

6.3 Future surface water availability

Surface water availability may be increased by implementing certain types of water management strategies. By capturing and storing streamflows, for example, the construction of a new reservoir can increase the reliable volume of permitted water available for annual diversion by water users during drought.

Future surface water availability to support projects may also be limited to account for environmental needs, such as environmental flows. Senate Bill 3, passed by the 80th Texas Legislature, led to an accelerated, science-based process with stakeholder input for addressing environmental flow needs in Texas. The result was the development and adoption of environmental flow standards.

Figure 6.3 - Annual surface water availability and existing surface water supplies by river and coastal basin in 2020 (acre-feet)



Environmental flow standards adopted by the Texas Commission on Environmental Quality balance water supply needs with environmental uses, which can reduce water availability by setting aside surface water that cannot be considered available for water projects permitted after adoption of the standards. Although previous state water plans utilized Consensus Criteria for Environmental Flow Needs or other means to balance uses, this is the first state water plan that directly incorporates recently adopted environmental flow standards into water availability models for estimating water management strategy supplies.

In cases where no environmental flow standards were adopted by the Texas Commission on Environmental Quality, planning groups were required to model diversions based on the Consensus Criteria for Environmental Flow Needs or by utilizing more detailed site-specific studies when available. Many recommended water management strategies remain subject to permitting requirements, regardless of the approach taken to estimate project yields or to consider environmental flow needs during the planning process.

6.4 Groundwater availability of aquifers

Groundwater in Texas comes from nine major and 21 minor aquifers as well as other formations around the state. Major aquifers produce large amounts of water over large areas (Figure 6.4), whereas minor aquifers produce minor amounts of water over large areas or major amounts of water over small areas (Figure 6.5). Groundwater availability is estimated through a combination of policy decisions, made primarily by groundwater conservation districts, and the ability of an aquifer to transmit water to wells.

Groundwater is generally governed by the rule of capture, which may be modified where groundwater conservation and groundwater subsidence districts exist (Figure 6.6). Districts may issue permits that regulate pumping of groundwater and spacing of wells within their jurisdictions.

In 2005, the 79th Texas Legislature passed House Bill 1763, which fundamentally changed the process of how groundwater availability is determined. Prior to House Bill 1763, planning groups determined groundwater availability with input from groundwater conservation districts. House Bill 1763 shifted that responsibility to groundwater

Figure 6.4 - Major aquifers of Texas

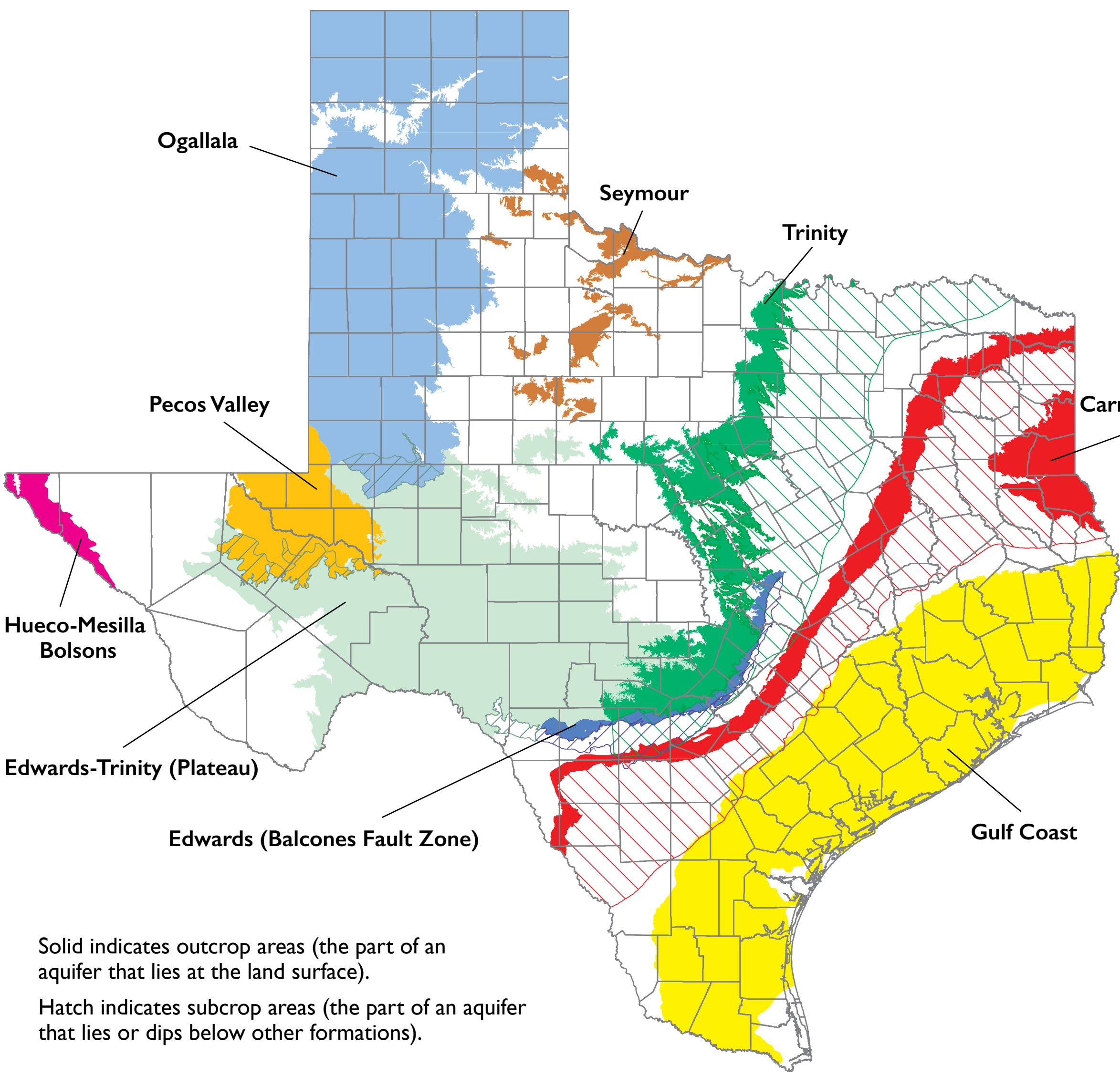
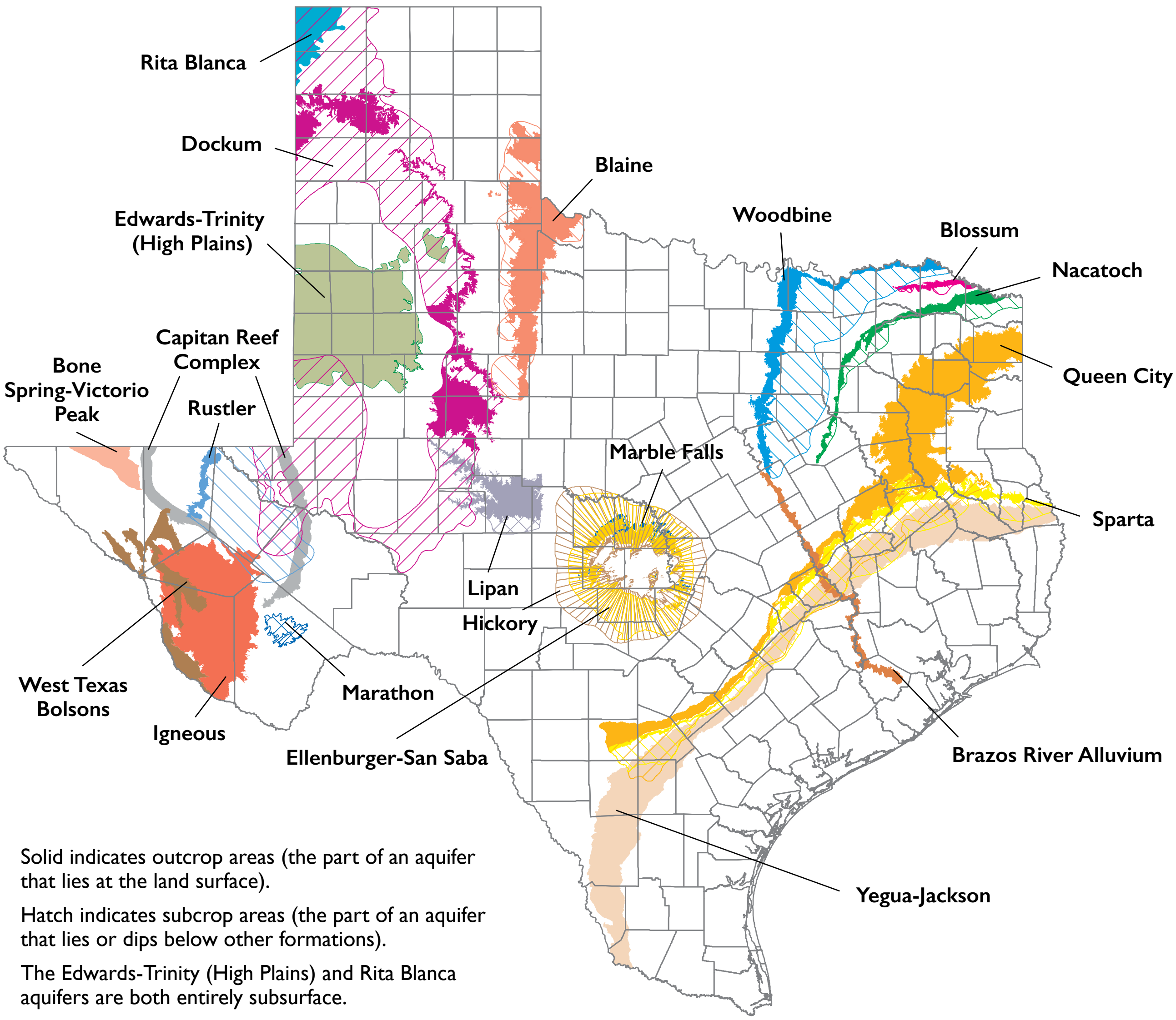


Figure 6.5 - Minor aquifers of Texas



conservation districts by requiring districts within groundwater management areas to work together to establish the desired future conditions of relevant aquifers within that area.

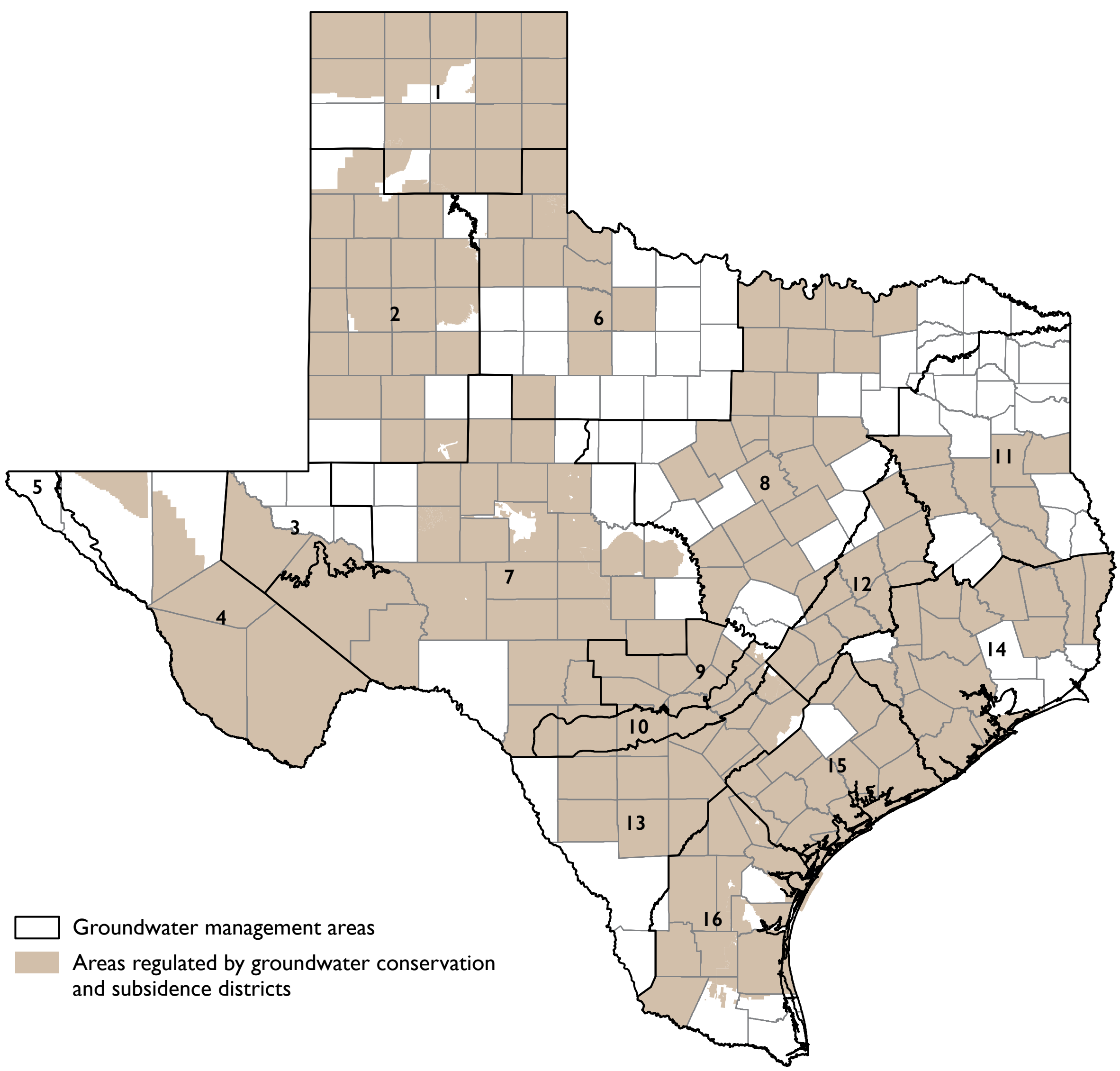
Desired future conditions are the desired, quantified conditions of groundwater resources (such as water levels, water quality, spring flows, or storage volumes) at a specified time in the future or in perpetuity. The TWDB uses desired future conditions to determine a modeled available groundwater value for an aquifer or part of an aquifer in the groundwater management area. A modeled available groundwater value is the volume of groundwater production, on an average annual basis, that will achieve the desired future condition. These values are independent of existing pumping permits and may, depending on the aquifer characteristics and how the desired future conditions are defined, include a variety of water quality types, including brackish groundwater. Depending on the aquifer and location, the inclusion of brackish groundwater in modeled available groundwater values might be subject to local and regional supply evaluations.

This is the first state water plan that is based on modeled available groundwater volumes for all relevant aquifers, statewide. Modeled available groundwater volumes account for the vast majority of groundwater availability considered in this plan. For aquifers and portions of aquifers that did not have modeled available groundwater values, planning groups determined availability with input from groundwater conservation districts. Senate Bill 1101, passed by the 84th Texas Legislature in 2015, allows a regional water planning group to define all groundwater availability as long as there are no groundwater conservation districts within the regional water planning area. This applies to Region D only.

On a statewide basis, total groundwater availability is projected to decline by approximately 20 percent from 2020 to 2070 (Figure 6.7). This decrease is primarily due to declines in the Ogallala and Gulf Coast aquifers.

Annual statewide groundwater availability in 2020 is estimated to be 12.3 million acre-feet. More than half of that comes from the Ogallala and Gulf Coast aquifers (Figure 6.8, Appendix B.2).

Figure 6.6 - Locations of groundwater conservation or subsidence districts and 16 groundwater management areas



6.5 Future groundwater availability

For planning purposes, future groundwater availability cannot be increased by implementing water management strategies other than aquifer recharge-type projects. Groundwater availability may increase or decrease in the future, typically through changes in groundwater management policy (revised desired future conditions) or improvements in technical evaluation approaches (new or updated groundwater availability models).

6.6 Availability of other sources

In addition to river basins and aquifers, which make up the vast majority of Texas' water resources, there are other types of water that are widely available for use, including seawater and treated wastewater from reuse. Seawater availability is generally limited only by the ability to legally access it along the coast. The availability of wastewater treated for reuse, on the other hand, changes over time and is limited only by the amount of wastewater generated by water users at any given time unless a source water permit or agreement states otherwise.

6.7 Existing supplies

Based on the volume of water that was determined to be available at each source, planning groups evaluated the share of those supplies that can already be relied on to meet water demands in the event of drought. The analysis considered the legal and physical limitations to supplies of each of the water user groups. For example, even if a reservoir has a large water availability volume, the existing water supplies that can actually be delivered from the reservoir to water users are limited by the current pipeline and treatment plant capacities that connect communities to the water resource.

The reliance on different water sources and combinations of sources varies greatly by water user category and location. Statewide, surface water makes up more than two-thirds (8.8 million acre-feet per year)

Figure 6.7 - Texas' annual groundwater availability and existing groundwater supplies (acre-feet)

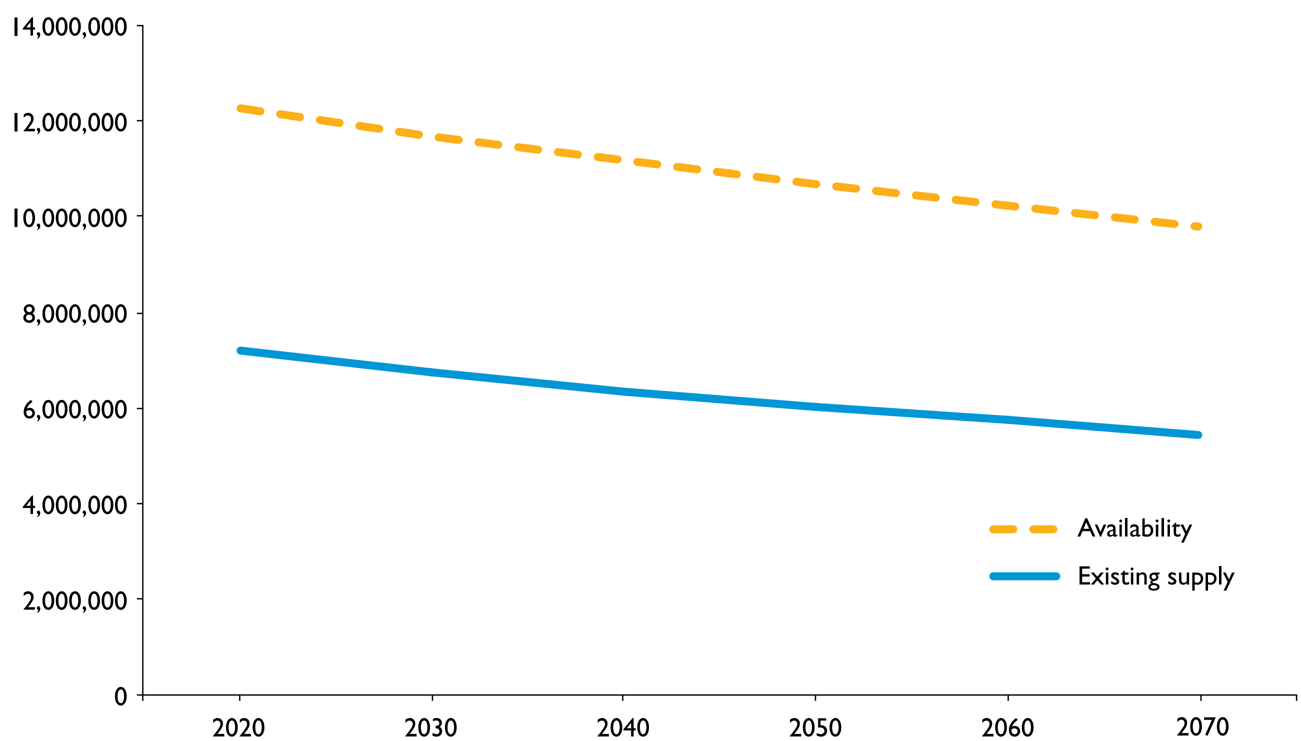
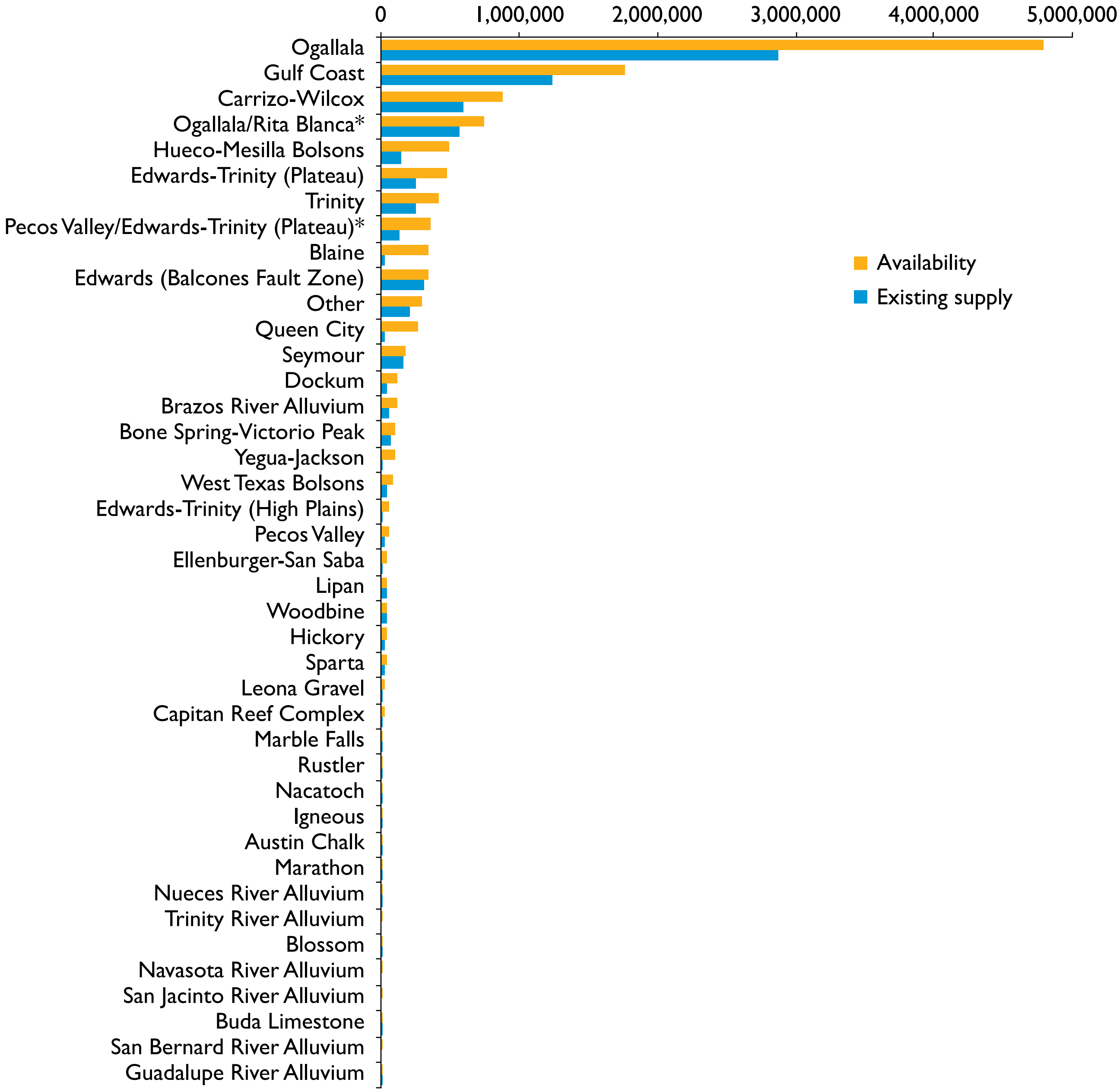
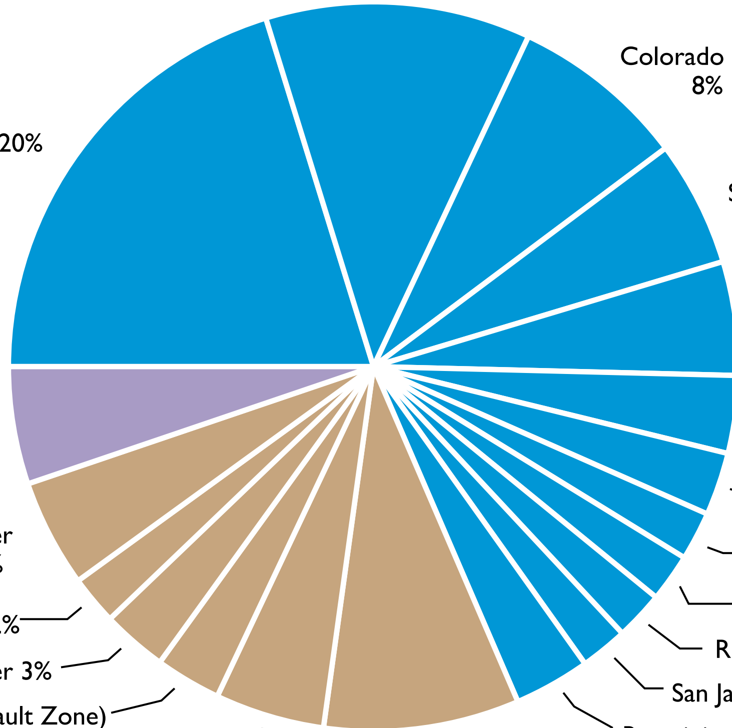


Figure 6.8 - Annual groundwater availability and existing groundwater supplies by aquifer in 2020 (acre-feet)



** The Ogallala/Rita Blanca and the Pecos Valley/Edwards-Trinity (Plateau) are aquifer combinations that reflect specific and mutual aquifer properties, undifferentiated groundwater usage, and groundwater availability model characteristics. In these cases, the modeled available groundwater and existing supply values have likewise been developed to honor these aquifer combinations.*

Figure 6.9 - Shares of existing municipal, steam-electric, manufacturing, and mining supply by water source in 2020



of the existing water supply for municipal, manufacturing, steam-electric, and mining users (Figure 6.9). However, irrigation and livestock water users rely on groundwater for more than 75 percent (6.4 million acre-feet per year) of their existing water supply (Figure 6.10).

The total annual volume of Texas' existing water supplies for all water user groups is projected to decline by approximately 11 percent from 2020 to 2070 (Figure 6.11), although changes vary significantly by location and water user.

In 2020, Texas' existing water supply of approximately 15.2 million acre-feet consists roughly of half surface water and half groundwater and is projected to decline to approximately 13.6 million acre-feet per year by 2070 (Table 6.1).

The overall reduction in water supply is due primarily to declining groundwater availability in the Ogallala and Gulf Coast aquifers and, in some areas, declining surface water availability due to reservoir sedimentation. Other factors, unrelated to water source availability but that can also reduce the existing water supply of specific water users, include declines in groundwater levels relative to current well pump intake, shallow reservoir intake levels, groundwater quality degradation, and expiring water supply contracts.

The share of surface and groundwater availability that can actually be legally produced and delivered based on existing infrastructure—the existing supply—during a repeat of the drought of record is influenced by many factors. For example, existing supply can be limited to the amount of water already being conveyed by pipeline from a reservoir to users or to the amount of water that existing well pumps are capable of delivering under current permits.

The share of availability that is considered existing supply varies by water resource. For example, more than three-fourths of the Trinity River Basin availability is committed as existing surface water supplies, but only about one-third of the Sabine and Neches basins' availability is connected to specific water user groups (Figure 6.3). Ninety percent or more of the availability of the Edwards (Balcones Fault Zone), Seymour, and some other, smaller aquifers is connected as existing supply, whereas less than 10 percent of the availability of the Blaine, Edwards-Trinity (High Plains), Marathon, and Queen City aquifers is connected as existing supply (Figure 6.8). The remaining surface water and groundwater availability in each river basin and aquifer could, in concept, be the basis for recommended water management strategies, subject to many factors including its proximity to identified water needs and costs.

Surface water supply

The total annual surface water supply remains roughly stable from 2020 to 2070, with a slight increase between 2020 and 2030 due to certain surface water delivery contracts. Over the 50-year period, sedimentation is anticipated to decrease the storage capacity of many reservoirs (Figure 6.2).

Groundwater supply

The total annual groundwater supply is anticipated to decline about 24 percent from 2020 to 2070 due primarily to reduced availability from the Ogallala Aquifer, based on its managed depletion, and the Gulf Coast Aquifer, based on regulatory limits aimed at reducing groundwater pumping in the long-term to limit land surface subsidence (Figure 6.7).

Reuse supply

The total annual reuse supply makes up less than 4 percent of total supplies in 2020, with 41 percent of this supply occurring in Region C. Reuse supplies are estimated to increase about 28 percent from

Figure 6.10 - Shares of existing irrigation and livestock supply by water source in 2020

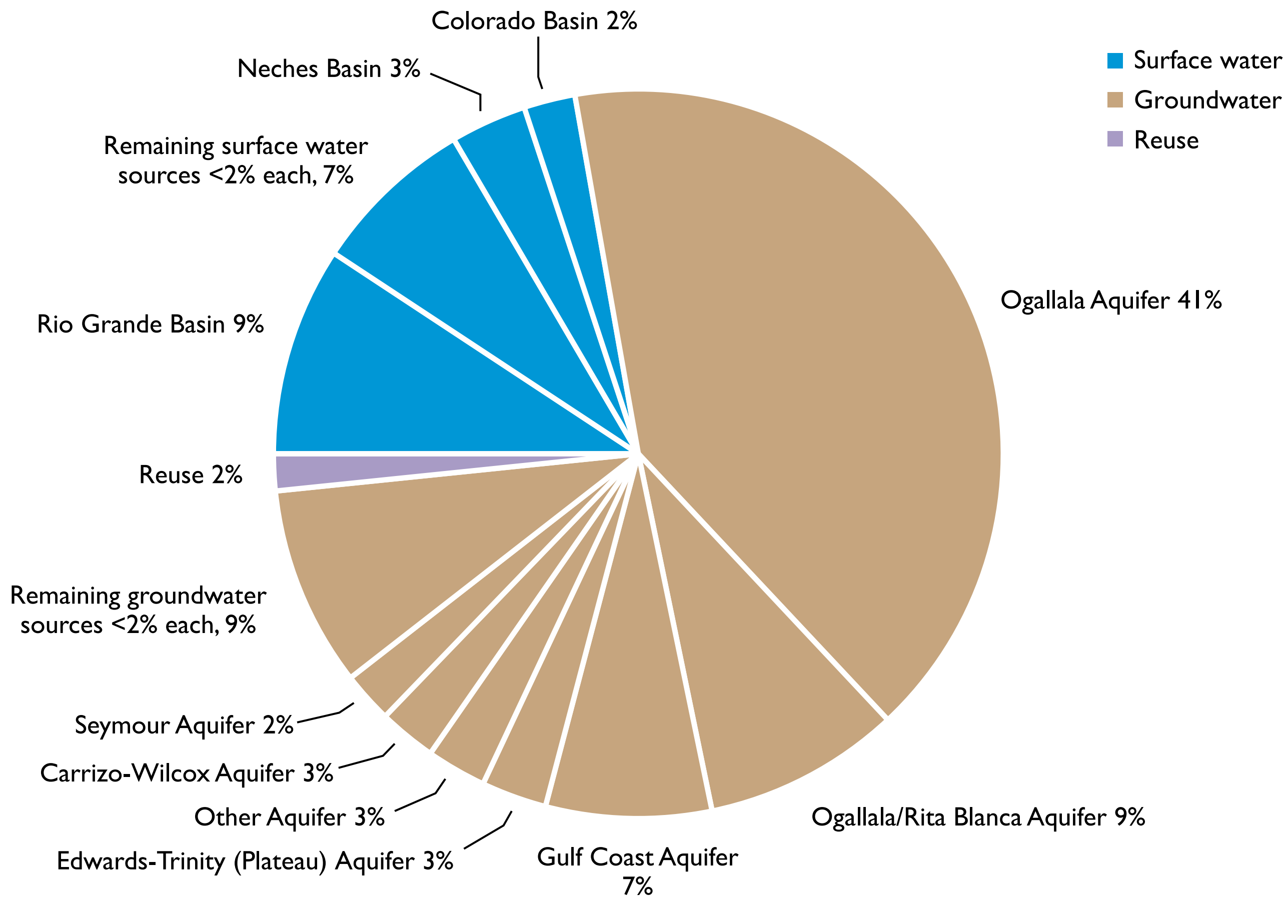
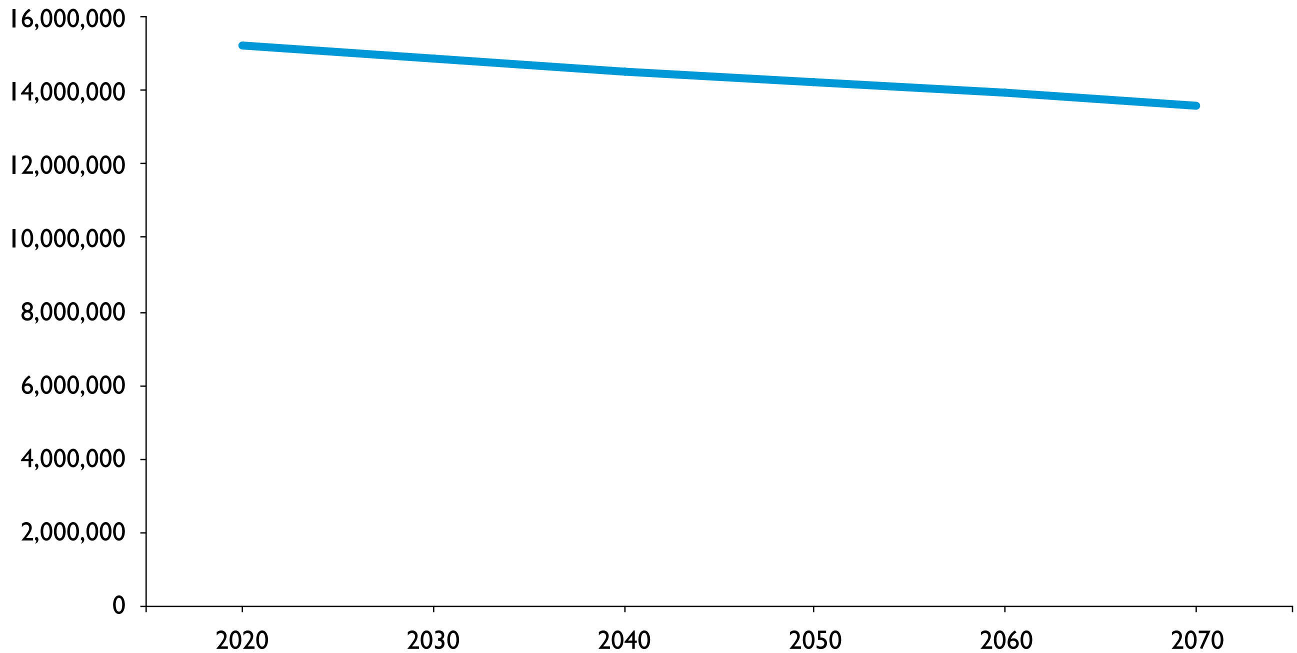


*Figure 6.11 - Texas' projected annual existing water supply (acre-feet)**



** Does not reflect some portions of existing supplies that are associated with purely saline water sources such as untreated seawater*

2020 to 2070. The increase in reuse existing supply is primarily due to an increase in wastewater flows associated with an increasing population and the capacity of existing reuse facilities.

6.8 Comparison to the 2012 State Water Plan

There are many factors that impacted estimates of water availability and the existing water supply since adoption of the 2012 State Water Plan, including policy decisions, modeling assumptions, accumulated historical streamflow data, additional information regarding physical and legal constraints to supplies, and implementation of water supply projects during the intervening years.

When comparing the planning decades of 2020 through 2060 statewide, changes range greatly by water source location and user.

Surface water

There is less surface water availability and existing surface water supply statewide, although this varies significantly by location (Figure 6.12). The greatest relative change was an approximate 17 percent

Table 6.1 - Texas' annual existing water supply (acre-feet)

Source	2020	2030	2040	2050	2060	2070	Percent change
Surface water	7,463,000	7,520,000	7,505,000	7,491,000	7,468,000	7,417,000	-1
Groundwater	7,191,000	6,770,000	6,367,000	6,048,000	5,776,000	5,432,000	-24
Reuse	564,000	602,000	631,000	671,000	710,000	723,000	28
Texas[a]	**15,218,000**	**14,892,000**	**14,503,000**	**14,210,000**	**13,954,000**	**13,572,000**	**-11**

[a] *Does not reflect some portions of existing supplies that are associated with purely saline water sources such as untreated seawater*

Tom Miller Dam, Austin, Texas

Figure 6.12 - Changes from the 2012 State Water Plan in annual surface water availability in 2020

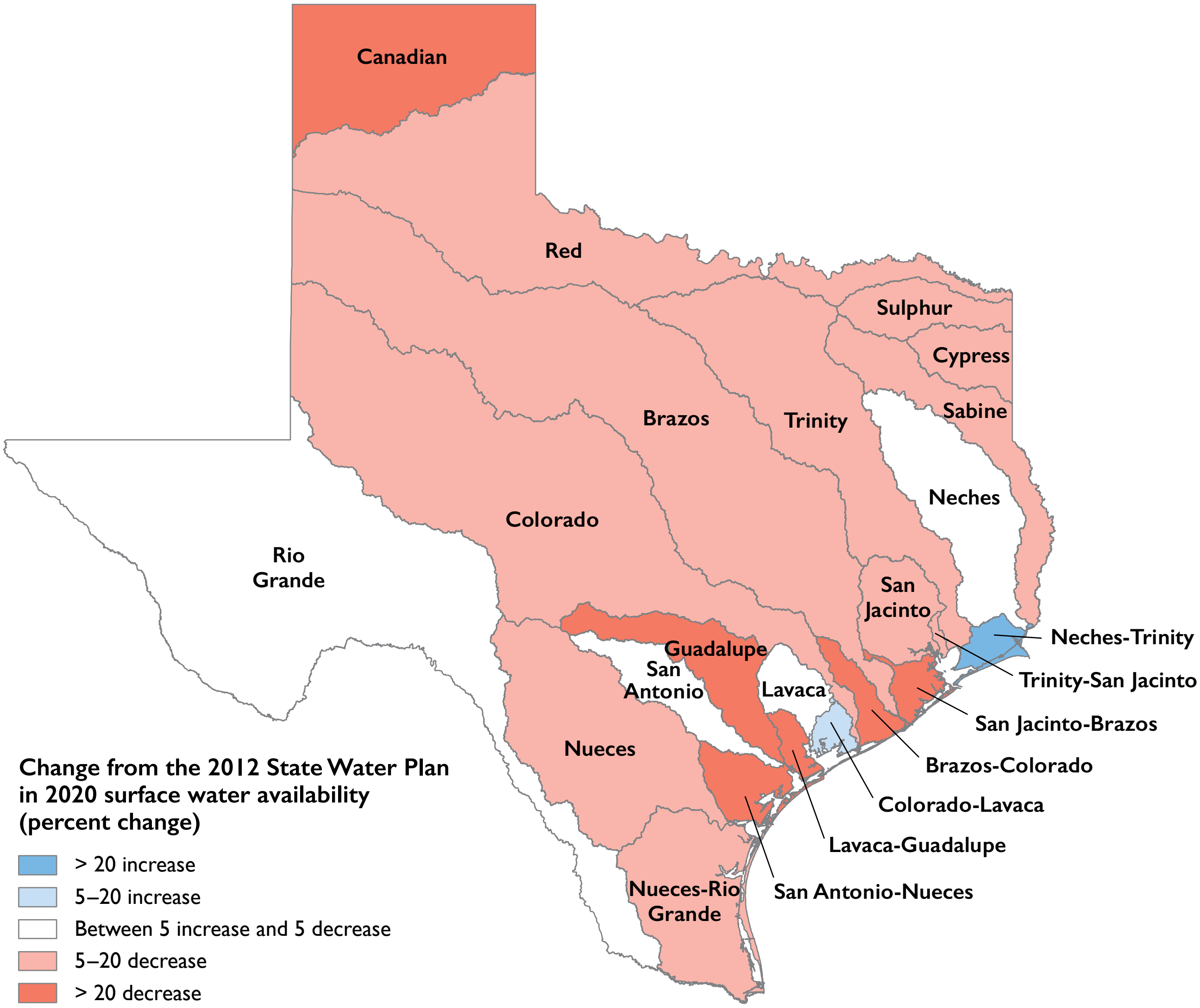
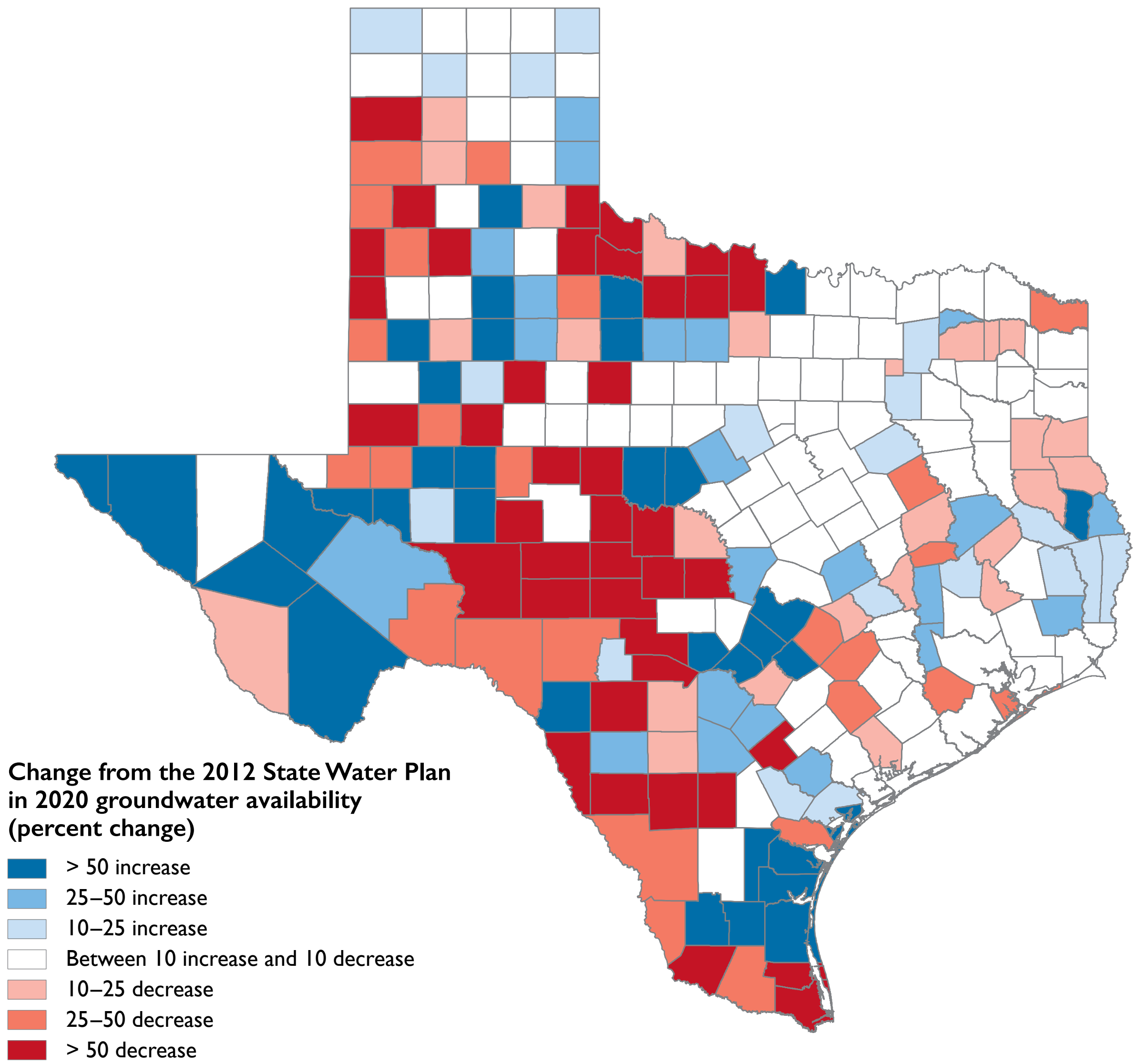


Figure 6.13 - Changes from the 2012 State Water Plan in annual groundwater availability in 2020



decrease in existing surface water supplies in 2060 due partly to reduced availability estimates based on updated historical drought conditions.

Groundwater

There is slightly less groundwater availability statewide in 2020, with considerable variations by county, including relatively more decreases in central/western and southern counties (Figure 6.13). The statewide existing groundwater supply is close to the supply in the 2012 State Water Plan, although it is somewhat higher for the decades from 2030 to 2060. The greatest relative change was an approximate 3 percent increase in statewide groundwater availability in 2040 due to policy decisions made as part of the groundwater management area joint planning process.

Reuse

The existing reuse supply is higher than the supply from the 2012 State Water Plan in each decade from 2020 to 2060.

6.9 Uncertainty of our future water supply

Because hydrology—the study of water in the natural environment—is highly complex, there will always be significant uncertainty over the future timing and quantity of available water resources. Precipitation, temperature, evaporation, wind, and soil moisture conditions all play roles in determining how much water moves in and through Texas' streams, reservoirs, and aquifers. In some cases, snowfall in southern Colorado and rainfall in northern Mexico impact our water supplies. Mexico's compliance with the 1944 water treaty also affects water supplies along the Rio Grande. Because each of these inter-related variables is difficult to quantify and predict, it is not possible to foresee exactly when hydrologic events will occur, where they will occur, and to what degree they will impact our water supply. Other abrupt events, including the introduction and spread of invasive species, can also result in unexpected restrictions on the use of certain water sources.

Texas' water plans are based on benchmark drought of record conditions using historical hydrological data. While we recognize that the full sequence of hydrologic events in our history will never be repeated exactly, the droughts that have occurred have been of such severity that it is reasonable to use them for the purpose of planning. There are currently no forecasting tools capable of providing reliable estimates of changes to future water resources in Texas at the resolution needed for water planning. In order to provide the best available, actionable science, grounded in historical data and patterns, the TWDB continues to collect data and consider potential ways to improve estimates of water supply reliability in the face of drought.

Rio Grande at dawn

7

Water supply needs

Quick facts

If no additional water supplies are developed, water users face a potential water shortage of 4.8 million acre-feet per year in 2020 and 8.9 million acre-feet per year in 2070 in the event of a repeat of the drought of record.

Without additional supplies, approximately one-third of Texas' population would have less than half of the municipal water supplies they will require in 2070.

Municipal water users may face water shortages over six times greater in 2070 (approximately 3.4 million acre-feet) than in 2020 (approximately 511,000 acre-feet).

Without additional water supplies, the annual economic losses resulting from water shortages would range from approximately $73 billion in 2020 to $151 billion in 2070.

When the existing water supply is less than the projected demand (the total water required to support regular economic and domestic activities), there is the potential for a water shortage. The TWDB refers to this potential shortage as a water need.

Water shortages pose enormous risks to the Texas economy and the public's health and safety. The perception of a lack of water can bias decision makers against expanding to or starting their businesses in Texas. Water shortages resulting from inadequate planning and implementation can also strain those state water resources that have already been developed as water supplies.

To determine if our existing water supply is adequate to support the demands of Texas' rapidly growing population, expanding economy, and vital natural resources, the regional water planning groups compared projected water demand to existing water supply. More than 15,000 comparisons revealed where and when to expect either a water supply surplus or potential shortage in a repeat of the drought of record based on existing supplies.

Once planning groups have identified water needs (potential shortages), they recommend water management strategies and associated projects, such as conservation, groundwater wells, or new reservoirs (Chapter 8), to meet the water supply needs. The discussion in this chapter, however, focuses on the total needs and does not assume that any of the water management strategies are implemented.

Planning groups also reported the economic and social impacts of not implementing water management strategies and summarized specific water needs that, unfortunately, cannot feasibly be met during drought of record conditions.

7.1 Identification of water needs

The state water plan identifies water needs for all water use categories and water user groups for each decade over the next 50 years. While the existing water supply may, in aggregate, appear sufficient to meet the water needs of an entire region, it is not distributed evenly across each region. Therefore, some areas may experience shortages while others have ample supplies. In these situations, water needs may be met by implementing water management strategies such as the transfer of surplus water supplies from one water provider to another.

In 2020, Texas faces a potential water shortage of 4.8 million acre-feet in a drought of record. In 2070, that number grows by approximately 87 percent to 8.9 million acre-feet (Table 7.1). These needs vary considerably by water use category (Figure 7.1).

Table 7.1 - Annual water needs by water use category (acre-feet)

Category	2020	2030	2040	2050	2060	2070	Percent change
Irrigation	3,522,000	3,582,000	3,655,000	3,610,000	3,530,000	3,603,000	2
Municipal	511,000	1,058,000	1,575,000	2,119,000	2,742,000	3,413,000	568
Manufacturing	394,000	550,000	637,000	733,000	825,000	953,000	142
Steam-electric	199,000	294,000	356,000	469,000	601,000	769,000	287
Mining	116,000	128,000	119,000	113,000	113,000	122,000	5
Livestock	18,000	22,000	22,000	28,000	32,000	32,000	74
Texas[a]	**4,760,000**	**5,634,000**	**6,364,000**	**7,072,000**	**7,843,000**	**8,892,000**	**87**

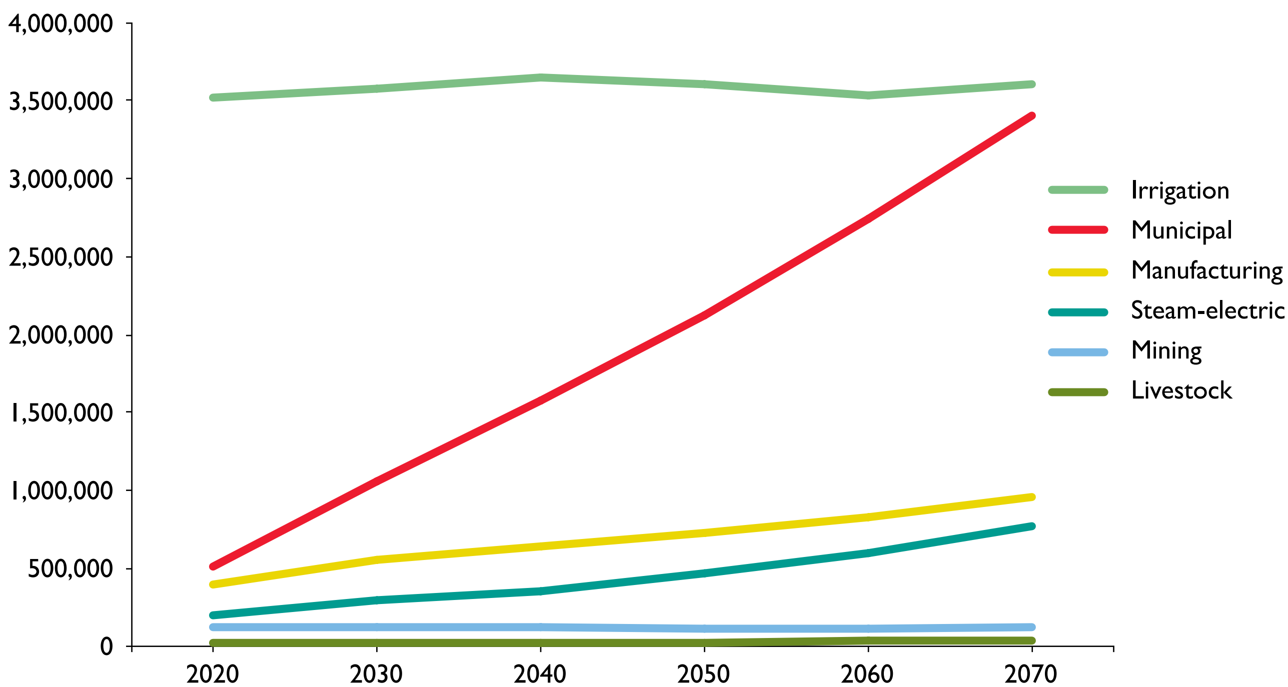
[a] *Statewide totals may vary between tables due to rounding.*

Although all 16 regions face water needs in all planning decades, the magnitude of needs varies significantly between regional water planning areas (Table 7.2). Region C faces the greatest rate of increase with nearly a 10-fold increase in needs between 2020 and 2070, whereas Region P anticipates no increase in its water needs over the planning horizon.

7.2 Municipal needs

Municipal water users face the greatest increase in water needs, from approximately 11 percent of all state water needs in 2020 to 38 percent in 2070 (Table 7.1). Except for Region P, each region faces potential municipal water shortages for the next 50 years. Municipal water needs are second only to irrigation needs in all decades.

Figure 7.1 - Annual water needs by water use category (acre-feet)



In 2020, Region H has the highest annual municipal needs (142,000 acre-feet) and in 2070, Region C has the highest (more than 1.2 million acre-feet) (Appendix C.1). In 2070, municipal needs would vary widely across the state, with 11 counties facing municipal water needs of more than 100,000 acre-feet (Figure 7.2).

Texas' population faces varying degrees of potential municipal water shortages over the next 50 years (Figure 7.3), with the severity of shortages ranging widely among individual water users. If no recommended municipal water management strategies were implemented by the onset of another drought of record,

- approximately 82 percent (41.6 million) of all Texans in 2070 would face at least a 10 percent water shortage in their cities and residences,
- approximately 34 percent (17.2 million) of all Texans in 2070 would have less than half of the municipal water supplies they require, and
- the estimated population who might have less than 10 percent of the water supplies they require grows from more than 100,000 in 2020 to more than half a million in 2070.

7.3 Non-municipal needs

From 2020 to 2070, of the non-municipal water use categories, irrigation has the most water needs statewide and livestock has the least (Appendix C.1).

Irrigation water needs remain above 3.5 million acre-feet per year, continuing to exceed all other water use categories from 2020 through 2070. The vast majority of irrigation water needs are in Region O.

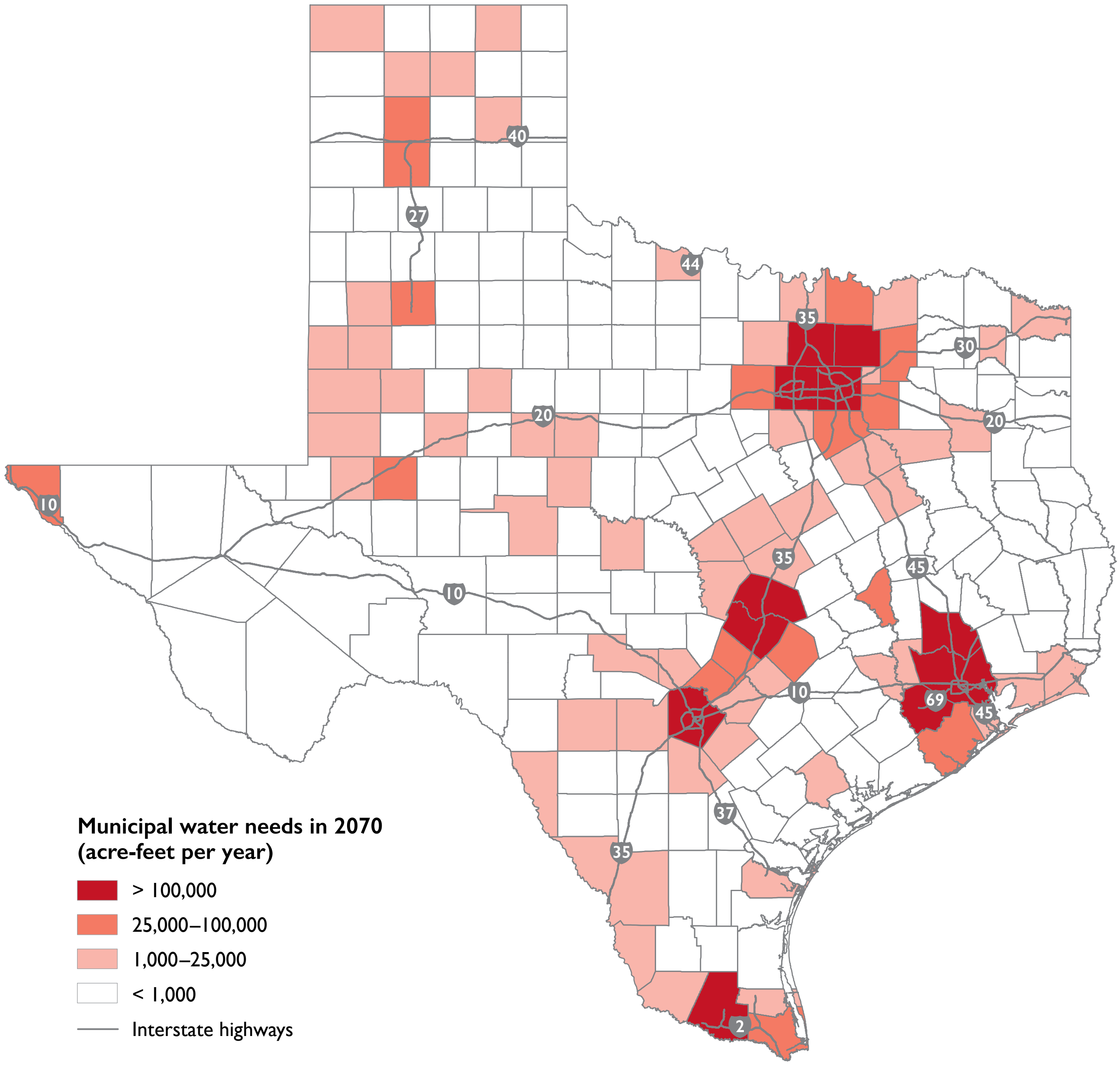
Manufacturing water needs are greatest in Region I and reach a statewide maximum of 953,000 acre-feet per year in 2070.

Table 7.2 - Annual water needs by region (acre-feet)

Region	2020	2030	2040	2050	2060	2070	Percent change
A	171,000	216,000	241,000	247,000	250,000	253,000	48
B	35,000	36,000	38,000	41,000	45,000	49,000	41
C	125,000	367,000	604,000	834,000	1,086,000	1,356,000	985
D	150,000	177,000	215,000	254,000	308,000	411,000	173
E	189,000	189,000	182,000	189,000	200,000	212,000	12
F	183,000	194,000	201,000	211,000	224,000	237,000	29
G	235,000	291,000	344,000	419,000	486,000	566,000	140
H	347,000	555,000	699,000	846,000	984,000	1,162,000	235
I	237,000	336,000	367,000	405,000	455,000	508,000	114
J	4,000	4,000	4,000	4,000	5,000	5,000	20
K	374,000	384,000	387,000	400,000	450,000	512,000	37
L	200,000	256,000	297,000	356,000	425,000	483,000	141
M	717,000	709,000	708,000	717,000	729,000	797,000	11
N	11,000	14,000	16,000	18,000	34,000	51,000	371
O	1,732,000	1,858,000	2,011,000	2,078,000	2,112,000	2,240,000	29
P	50,000	50,000	50,000	50,000	50,000	50,000	0
Texas[a]	**4,760,000**	**5,636,000**	**6,364,000**	**7,069,000**	**7,843,000**	**8,892,000**	**87**

[a] *Statewide totals may vary between tables due to rounding.*

Figure 7.2 - Projected municipal water needs by county in 2070



Steam-electric water needs are greatest in Region G and increase at a similar rate as manufacturing. Steam-electric needs will reach a statewide maximum of 769,000 acre-feet per year in 2070.

Mining needs are greatest in Region G and reach a statewide maximum of 128,000 acre-feet per year in 2030.

Livestock needs are greatest in Region O but remain no more than 32,000 acre-feet per year statewide.

7.4 Wholesale water provider needs

Some wholesale water providers—such as river authorities, municipal utility districts, and water supply corporations—deliver and sell large volumes of untreated and treated water for municipal, manufacturing, irrigation, and steam-electric use on a wholesale or retail basis. The water needs of wholesale water providers are based on aggregating the water needs of their customer water user groups and, therefore, aren't added to the overall water user group needs.

Of the wholesale water providers that serve at least some municipal entities, 132 face shortages with annual total statewide shortages of approximately 1.4 million acre-feet in 2020 increasing to 5.6 million acre-feet in 2070.

7.5 Impacts of not meeting identified water needs

Insufficient water supplies would negatively impact not only existing businesses and industry, but also ongoing economic development efforts in Texas. An unreliable water supply also disrupts activity in homes, schools, and government and endangers public health and safety. For these reasons, planning groups are required to evaluate the social and economic impacts of not meeting the identified water needs in their regional water plans.

In response to requests from the planning groups, the TWDB performed an evaluation of the socioeconomic impacts of not meeting water needs for each region. The analysis is based on a static input-output modeling approach that relies on the proprietary software known as IMPLAN™.

The analysis represents a snapshot of the temporary socioeconomic impacts that might occur during a single year in drought of record conditions if identified water needs (potential shortages) were not met.

The evaluation assumed that the structure of the economy would remain the same from 2020 to 2070 and focused primarily on direct economic impacts such as reduced economic activity and job losses. As part of the analysis, the TWDB estimated the resulting social impacts, including losses in population and school enrollment.

It is the relative magnitudes of impacts between sectors as well as the changes in these impacts over time that should be the focus rather than the absolute numbers. High-level analyses of this type are better at predicting the overall magnitude of economic impacts due to a water shortage than the precise size of the impact.

In drought of record conditions, assuming that potential water shortages are not met, Texas could suffer significant, immediate, and direct economic losses as well as losses in future economic growth

Figure 7.3 - Municipal water needs for statewide population in 2020 and 2070

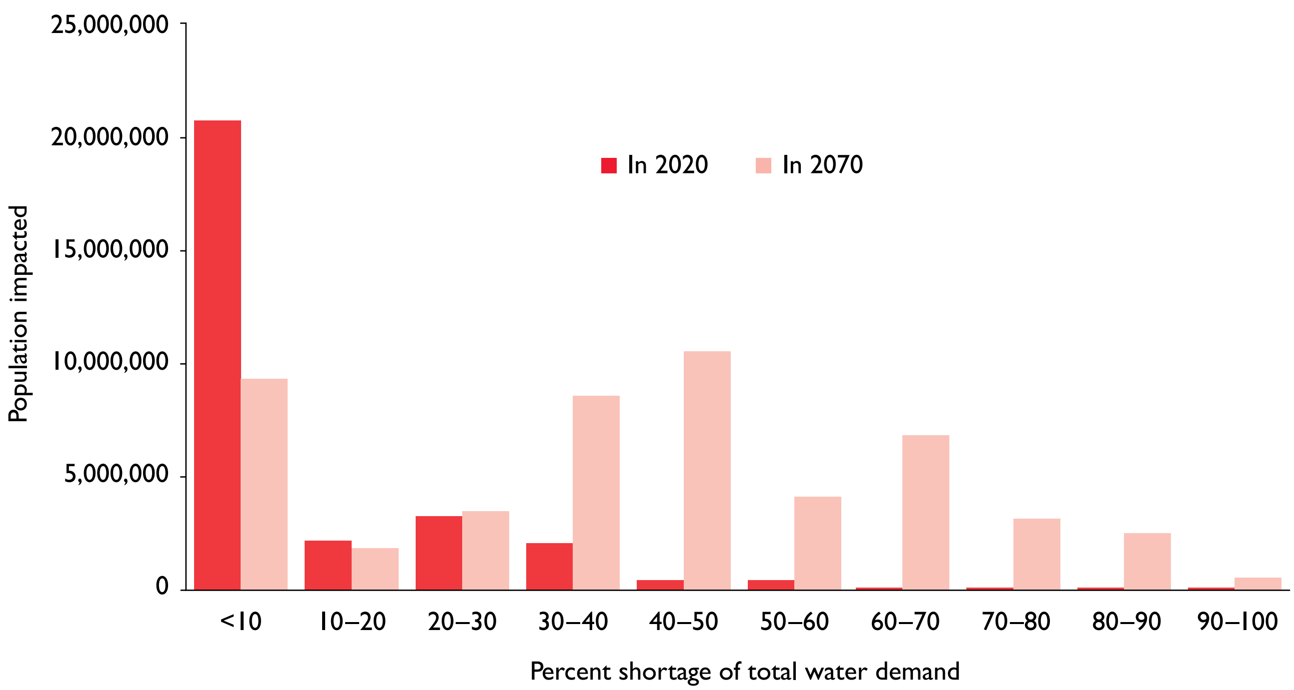


Table 7.3 - Statewide annual socioeconomic impacts from not meeting water needs

Impact	2020	2030	2040	2050	2060	2070
Income lost (billions of dollars)	$73	$91	$93	$99	$119	$151
Jobs lost	424,000	515,000	573,000	674,000	924,000	1,273,000
Population loss	78,000	95,000	105,000	124,000	170,000	234,000
School enrollment decline	14,000	17,000	19,000	23,000	31,000	43,000

(Table 7.3). Results of the TWDB analysis indicate that Texas businesses and employees could lose $73 billion in income in 2020 and more than $151 billion in 2070, with these impacts accumulating each consecutive year of a multi-year drought. The analysis also indicates that temporary job losses due to a drought of record could total approximately 424,000 in 2020 and 1.3 million in 2070. This estimate does not include additional drought impacts such as those to dry land farming and other activities not associated directly with water needs identified by the plan, nor does it include the potential for greater impacts due to a drought worse than the drought of record.

7.6 Uncertainty of future water needs

Potential water shortages during drought of record conditions are more difficult to predict than either water demand or water supply alone; the uncertainty of potential shortages is compounded by all of the uncertainties that already affect both water demand and water supply. For example, higher-than-projected per capita water demand combined with lower-than-anticipated water supply could result in a much greater water need than either factor could have caused independently.

Ultimately, future water needs will be impacted by numerous unpredictable forces including shifts in social values, legal changes, climate variability, economic trends, improvements in water use efficiency, energy costs, and advances in technology. Instead of attempting to predict the long-term positive or negative impacts of each of these changes on Texas' overall water needs, regional and state water planning incorporates the emerging impacts of these complex changes, as a whole, into the regional and state water plans during each five-year planning cycle.

7.7 Water needs not met by the plan

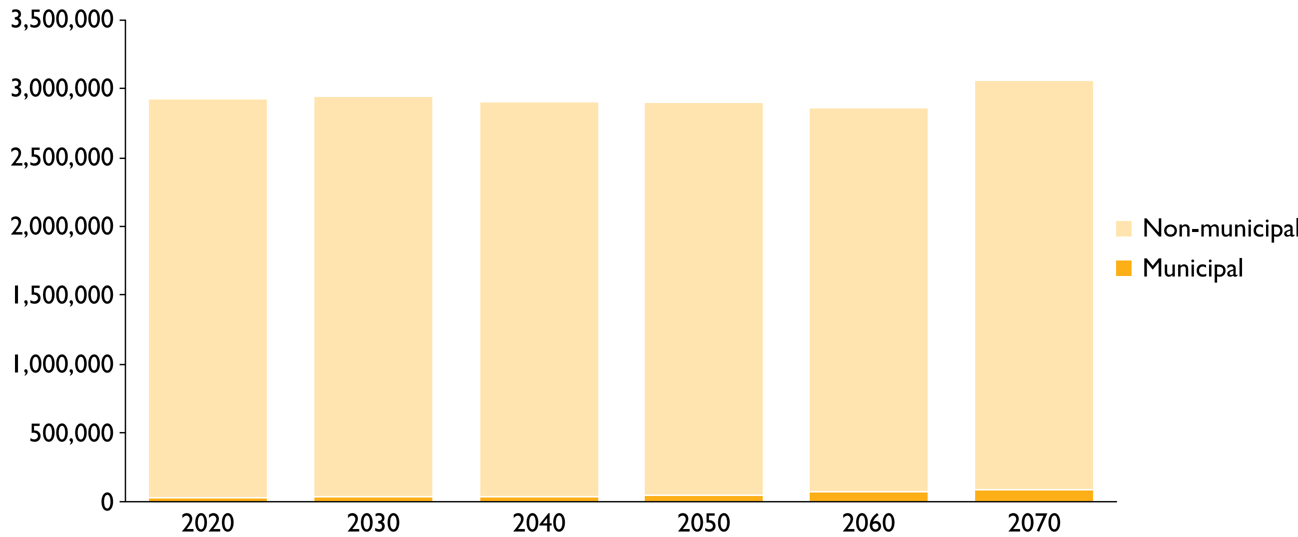
Planning groups identified some water needs that, in certain decades, could not be met because no feasible water management strategy could be identified. These are referred to as unmet needs. The vast majority of unmet needs are within the irrigation water use category (Table 7.4, Figure 7.4). For many irrigation water users, it is likely that there are insufficient returns on investment for the projects required to maintain the water supply in drought of record conditions.

Unmet municipal water needs were identified in Regions A, C, F, G, H, and I. Reasons for the planning groups not meeting certain municipal needs in the plans varied from lack of economically feasible supply alternatives to pending changes in local regulations. Statewide, unmet needs compose over 35 percent of the total projected irrigation demand and approximately 1 percent of the total municipal demand in 2070. Many of the unmet municipal needs are associated with the limits imposed by modeled available groundwater values associated with desired future conditions and, in practice, may be significantly less depending upon future regulatory decisions. An unmet need in a regional plan does not prevent an associated entity from pursuing development of additional water supplies. In some instances, portions of an underlying future increase in projected demand that is

Table 7.4 - Annual unmet water needs by region and water use category (acre-feet)

Region	Water user group	2020	2030	2040	2050	2060	2070
A	Irrigation	93,290	71,710	8,170	0	0	0
A	Municipal	0	0	0	0	0	540
B	Irrigation	1,870	1,590	1,670	3,790	6,860	9,920
B	Mining	560	210	110	60	10	10
B	Livestock	130	130	130	130	130	130
C	Municipal	0	0	0	0	0	1,860
C	Manufacturing	0	0	0	0	0	60
C	Mining	4,590	4,350	4,490	4,520	4,590	4,820
D	Irrigation	4,380	4,310	4,260	4,210	4,160	4,130
D	Manufacturing	0	0	0	0	0	86,360
D	Steam-electric	4,640	6,790	7,610	10,890	14,650	16,150
D	Mining	230	280	360	440	530	640
E	Irrigation	143,700	136,100	122,140	120,100	111,300	103,430
E	Mining	450	550	520	380	260	160
F	Irrigation	105,300	94,070	87,670	87,840	87,960	86,400
F	Municipal	1,510	2,200	4,630	9,540	14,680	19,340
F	Manufacturing	420	470	530	590	660	740
F	Mining	5,680	5,820	2,170	300	100	30
G	Irrigation	37,760	33,810	30,400	29,640	34,180	40,520
G	Municipal	10	0	0	0	0	0
G	Mining	19,140	26,180	27,720	32,170	37,830	44,830
H	Irrigation	56,480	56,000	57,970	59,520	61,080	62,560
H	Municipal	30,310	25,950	25,960	36,560	54,120	70,430
H	Manufacturing	3,150	4,510	3,370	8,200	3,910	3,950
H	Steam-electric	410	940	310	510	750	2,570
H	Mining	490	380	50	60	70	80
H	Livestock	1,980	2,250	2,500	2,650	2,780	2,910
I	Irrigation	330	330	330	330	330	330
I	Municipal	0	0	0	0	0	20
I	Manufacturing	4,720	0	0	0	0	0
I	Steam-electric	0	0	0	0	0	4,340
J	Irrigation	380	350	330	300	280	260
J	Manufacturing	0	0	0	10	10	10
J	Mining	50	50	70	70	80	80
K	Irrigation	120,820	113,480	102,190	76,540	55,300	27,920
K	Mining	620	4,360	5,010	5,730	6,510	7,380
L	Irrigation	115,470	107,350	97,960	91,280	84,820	79,610
L	Mining	11,140	10,840	9,220	5,880	2,530	1,120
M	Irrigation	500,140	453,910	408,410	359,810	311,970	294,480
M	Manufacturing	70	390	1,110	1,280	1,280	1,280
M	Mining	3,580	3,720	4,460	4,500	4,650	5,150
N	Irrigation	0	0	0	0	0	970
N	Mining	1,660	2,060	1,900	0	0	0
O	Irrigation	1,613,510	1,719,030	1,846,000	1,900,780	1,913,900	2,025,050
O	Manufacturing	5,220	4,970	4,460	4,940	6,770	7,320
O	Steam-electric	7,750	6,620	3,190	4,190	5,470	11,790
O	Mining	9,920	11,710	11,290	10,310	8,630	7,340
O	Livestock	12,130	14,510	12,890	16,270	18,790	17,630
Texas		**2,923,990**	**2,932,280**	**2,901,560**	**2,894,320**	**2,861,930**	**3,054,650**

Figure 7.4 - Statewide annual water supply needs that are unmet by the plan (acre-feet)



associated with an unmet need may actually shift geographically to a less water-scarce location, for example, when a power provider decides to shift the location of future power production.

7.8 Comparison to the 2012 State Water Plan

This water plan estimates 4.8 million acre-feet of annual statewide water needs in 2020, which is similar to the total from the 2012 State Water Plan. However, aggregation of data at the state level masks geographic and categorical changes in water needs that may be more significant at the local level. Many factors can affect water needs, making it difficult to draw broad conclusions. Notable changes to the identified water needs from the 2012 State Water Plan are summarized below:

- Statewide unmet needs are approximately 28 percent higher in 2020 and 17 percent higher

Ranch land during drought conditions in Gillespie County, Texas

Texas' population is expected to increase more than 70 percent between 2020 and 2070, from 29.5 million to 51 million

in 2060 than the 2012 plan. There was a small unmet municipal need of approximately 2,200 acre-feet per year in 2010 in the previous plan; however, unmet municipal needs in this plan range from approximately 28,000 acre-feet per year to 69,000 from 2020 to 2060. Changes to unmet needs are due to a variety of interrelated factors that vary geographically, including lower than anticipated water supplies due to more severe drought conditions, changes in demands, and changes in the process of how groundwater availability is determined.

- Statewide, annual municipal water needs in 2020 are approximately 400,000 acre-feet less than those from the previous plan, primarily due to lower water demand projections. Municipal needs in Regions A, B, and D are significantly higher in 2020 and 2060. In general, this is due to a increase in demands and a reduced amount of water supplies.
- Needs for manufacturing in 2020 doubled, largely due to the recognition of additional infrastruture limitations. Mining needs increased by approxmiately two-thirds from the 2012 plan's estimates. This is partly due to the increased water demand projections associated with hydraulic fracturing activities.
- Estimated direct economic impacts of not meeting water needs are higher than the previous plan. This is due to many factors, including inflation and changes in the economy such as increased economic activity associated with hydraulic fracturing activities (included in the mining water use category).

8

Water management strategies

Quick facts

Approximately 5,500 recommended water management strategies, including conservation, would provide approximately 8.5 million acre-feet per year in additional water supplies to water user groups in 2070.

The cost of implementing the approximately 2,500 recommended water management strategy projects by 2070 is $63 billion.

Conservation strategies were recommended for over 1,300 of the approximately 2,600 water user groups and compose approximately 28 percent, or 2.3 million acre-feet per year, of all the recommended water management strategy volumes serving water user groups in 2070.

The planning groups recommended 26 new major reservoirs that, if implemented, would provide approximately 1.1 million acre-feet per year in additional supplies to water user groups by 2070.

Approximately 45 percent of all recommended water management strategy supplies in 2070 are based on surface water resources, and just under 10 percent of new supplies will rely on groundwater resources.

After identifying water surpluses and potential water shortages in their regions, regional water planning groups identify, evaluate, and recommend water management strategies to avoid potential water shortages during a repeat of the drought of record over the next 50 years. A water management strategy is a plan to meet a water need (potential shortage) of a water user group.

Water management strategies allocate water to specific water user groups, often through an intermediate regional or wholesale water provider. In the same manner that projected water demands, existing water supplies, and water needs in this plan are associated with water user groups, recommended water management strategy water volumes are also associated directly with water user groups.

Strategies may or may not require new water infrastructure—referred to as water management strategy projects—to be developed. Construction of most new water infrastructure projects requires financing through long-term borrowing.

The TWDB may provide financial assistance to support the implementation of water supply projects only if the needs to be addressed by the project will be addressed in a manner consistent with the regional water plans and the state water plan. This same provision applies to the granting of water right permits by the Texas Commission on Environmental Quality, although the governing bodies of these agencies may grant waivers to the consistency requirement. Also, the TWDB funding programs that target the implementation of state water plan projects, such as the State Water Implementation Fund for Texas (SWIFT) program, further require that projects, including their capital costs, must be recommended water management strategy projects in the state water plan to be eligible for financial assistance.

8.1 Selecting water management strategies

Each planning group identified and evaluated feasible water management strategies and recommended a final set of strategies. The range of strategies that were considered feasible and were actually recommended varied from region to region, but, overall, the planning groups were required to consider certain factors when evaluating strategies, including

- quantity of supply provided by a strategy;
- reliability of the supply under drought of record conditions;
- cost of the supply (including borrowing costs and mitigation); and
- impacts of the strategy on water quality and on water, agricultural, and natural resources.

Water management strategy evaluations were based on drought of record conditions and honored all existing water rights, which are the same benchmark conditions used for water demand and water supply evaluations. Planning groups were also required to consider conservation and drought management strategies for all water user groups that have identified water needs.

If all the approximately 5,500 recommended strategies were implemented, they would provide approximately 3.4 million acre-feet per year, including in the form of conservation savings, to water user groups in 2020, and 8.5 million acre-feet per year in 2070 (Table 8.1). The total capital costs of all the recommended water management strategy projects is $63 billion and is associated with approximately 2,500 projects (Table 8.2). Detailed lists of the recommended water management strategies and the recommended water management strategy projects may be found on the 2017 State Water Plan website at www.twdb.texas.gov/waterplanning/swp/2017 and the interactive state water plan website at texasstatewaterplan.org.

Table 8.1 - Annual volume of recommended water management strategies by region (acre-feet)

Region	2020	2030	2040	2050	2060	2070	Number of strategies
A	178,000	310,000	490,000	554,000	595,000	637,000	140
B	53,000	53,000	71,000	72,000	72,000	73,000	128
C	192,000	427,000	670,000	900,000	1,147,000	1,436,000	2,341
D	176,000	205,000	269,000	294,000	335,000	369,000	137
E	143,000	158,000	186,000	212,000	241,000	268,000	64
F	126,000	160,000	185,000	196,000	202,000	212,000	291
G	384,000	436,000	479,000	542,000	589,000	648,000	429
H	716,000	904,000	1,468,000	1,572,000	1,648,000	1,791,000	621
I	269,000	433,000	488,000	530,000	575,000	594,000	86
J	21,000	22,000	22,000	22,000	22,000	22,000	64
K	436,000	498,000	547,000	619,000	678,000	745,000	264
L	180,000	268,000	331,000	419,000	519,000	610,000	260
M	282,000	351,000	418,000	498,000	599,000	669,000	478
N	51,000	109,000	103,000	97,000	98,000	98,000	54
O	139,000	177,000	224,000	228,000	251,000	253,000	124
P	62,000	62,000	63,000	63,000	63,000	63,000	14
Texas[a]	**3,408,000**	**4,573,000**	**6,014,000**	**6,818,000**	**7,634,000**	**8,488,000**	**5,495**

[a] *Statewide totals may vary between tables due to rounding.*

Table 8.2 - Capital costs, by required online decade, of all recommended water management strategy projects by region (in millions)

Region	2020	2030	2040	2050	2060	2070	Total capital cost	Number of projects[a]
A	$270	$348	$60	$18	$0	$170	$866	81
B	$291	$0	$339	$0	$0	$0	$630	21
C	$3,730	$5,457	$3,304	$6,728	$3,119	$1,296	$23,635	557
D	$697	$11	$17	$413	$22	$80	$1,241	120
E	$843	$42	$514	$274	$258	$0	$1,930	45
F	$917	$190	$35	$58	$0	$0	$1,201	145
G	$3,604	$579	$69	$42	$21	$6	$4,321	215
H	$2,946	$4,853	$1,612	$836	$578	$54	$10,879	717
I	$1,362	$737	$562	$77	$0	$16	$2,754	58
J	$115	$0	$29	$0	$0	$0	$144	55
K	$3,069	$506	$142	$42	$12	$3	$3,773	123
L	$5,594	$201	$7	$2,253	$2	$19	$8,076	61
M	$1,202	$123	$81	$41	$386	$33	$1,866	195
N	$178	$331	$0	$1	$0	$0	$510	18
O	$452	$192	$87	$2	$80	$1	$814	112
P	$332	$0	$0	$0	$0	$0	$332	11
Texas	**$25,601**	**$13,570**	**$6,857**	**$10,787**	**$4,478**	**$1,678**	**$62,971**	**2,534**

[a] *Some projects are associated with multiple sponsors.*

8.2 Summary of recommended strategies

Recommended water management strategies may be considered from different perspectives, including

- by the water resources on which they rely; or
- by the configurations required to implement them based on the combination of specific water source(s), projects, and/or technology.

Some water management strategies do not require projects with capital costs to implement. For example, certain types of conservation may be supported by annual program budgets, and many water purchase strategies will rely on existing infrastructure capacity to increase water supply deliveries. Many other strategies, such as new reservoirs and seawater desalination plants, will require significant investment in infrastructure with an associated capital cost. The significance of these investments is relative; for example, installation of a single new well may represent a major investment for many small communities.

The complexity of recommended strategies and projects varies greatly. Some strategies, such as a new groundwater well, may serve and be implemented by a single water provider from a single water source. Other large regional projects, such as conveyances from reservoirs, may encompass a mixture of water sources assigned to numerous water user groups, require several major pipelines, pump stations, and serve multiple water providers.

8.2.1 Water resources for recommended strategies

Recommended water management strategies serving water user groups will rely on both future demand management (reducing the requirement for additional water) and a variety of Texas' water resources (Figures 8.1 and 8.2). If implemented, all the recommended water management strategies would provide approximately 8.5 million acre-feet per year in additional water supplies to water user groups in 2070.

Demand management, mostly in the form of conservation savings, provides approximately 2.6 million acre-feet per year to water user groups, which is approximately 30 percent of the recommended strategy supplies in 2070.

Reuse provides 1.2 million acre-feet per year to water user groups, which is approximately 14 percent of the total recommended strategy supplies in 2070.

Surface water is the most significant water resource on which strategies are based, providing approximately 3.8 million acre-feet per year to water user groups, which is approximately 45 percent of the total recommended strategy supplies in 2070.

Groundwater resources provide approximately 810,000 acre-feet per year to water user groups, which is approximately 10 percent of the total recommended strategy supplies in 2070.

Seawater provides approximately 120,000 acre-feet per year to water user groups, which is approximately 1 percent of the total recommended strategy supplies in 2070.

8.2.2 Strategy types

Planning groups recommended a wide variety of water management strategies that will serve water user groups, each of which relies on a specific combination of water source(s), infrastructure, and technology (Figure 8.3, Table 8.3). The types of recommended strategies depended on the water needs, location, available water resources, impacts, and costs. Some recommended strategies require no new infrastructure, while others may require significant capital investments including various combinations of pipelines, wells, pump stations, river diversion facilities, or water treatment plants.

Figure 8.1 - Share of recommended water management strategies by water resource in 2070

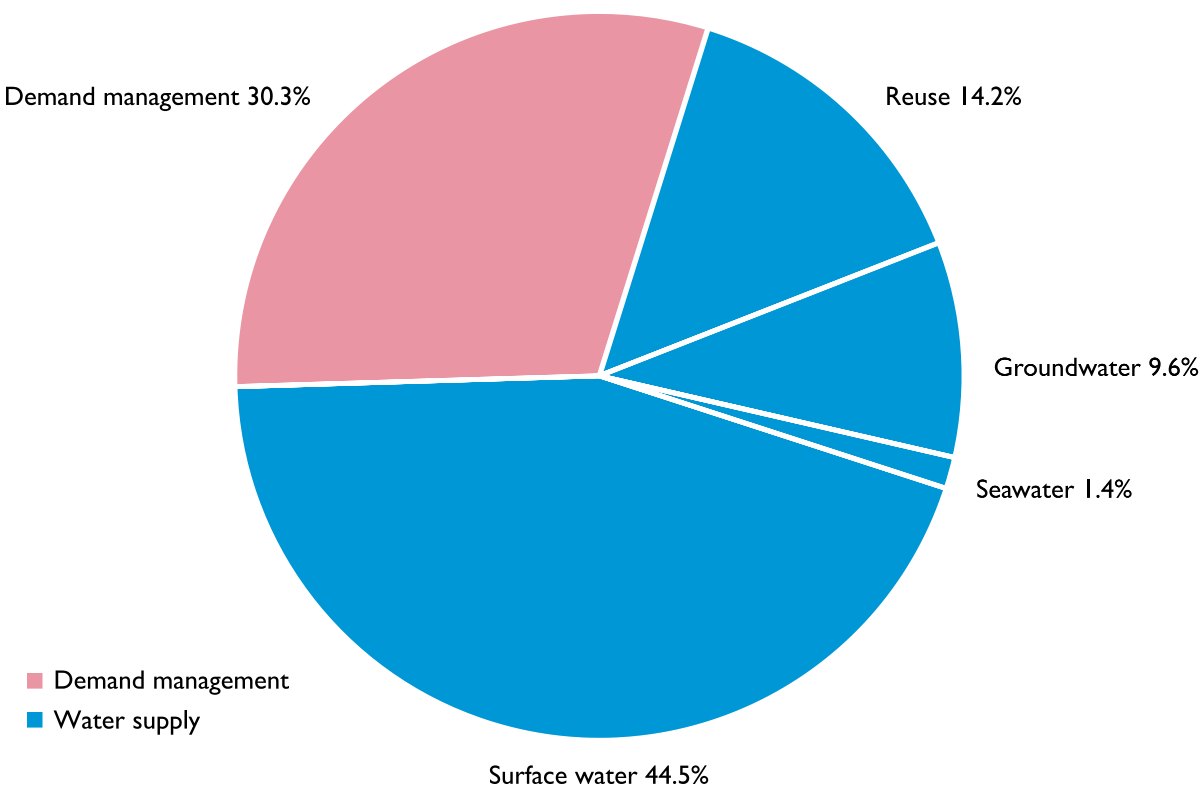


Figure 8.2 - Annual volume of recommended water management strategies by region and water resource in 2070 (thousands of acre-feet)

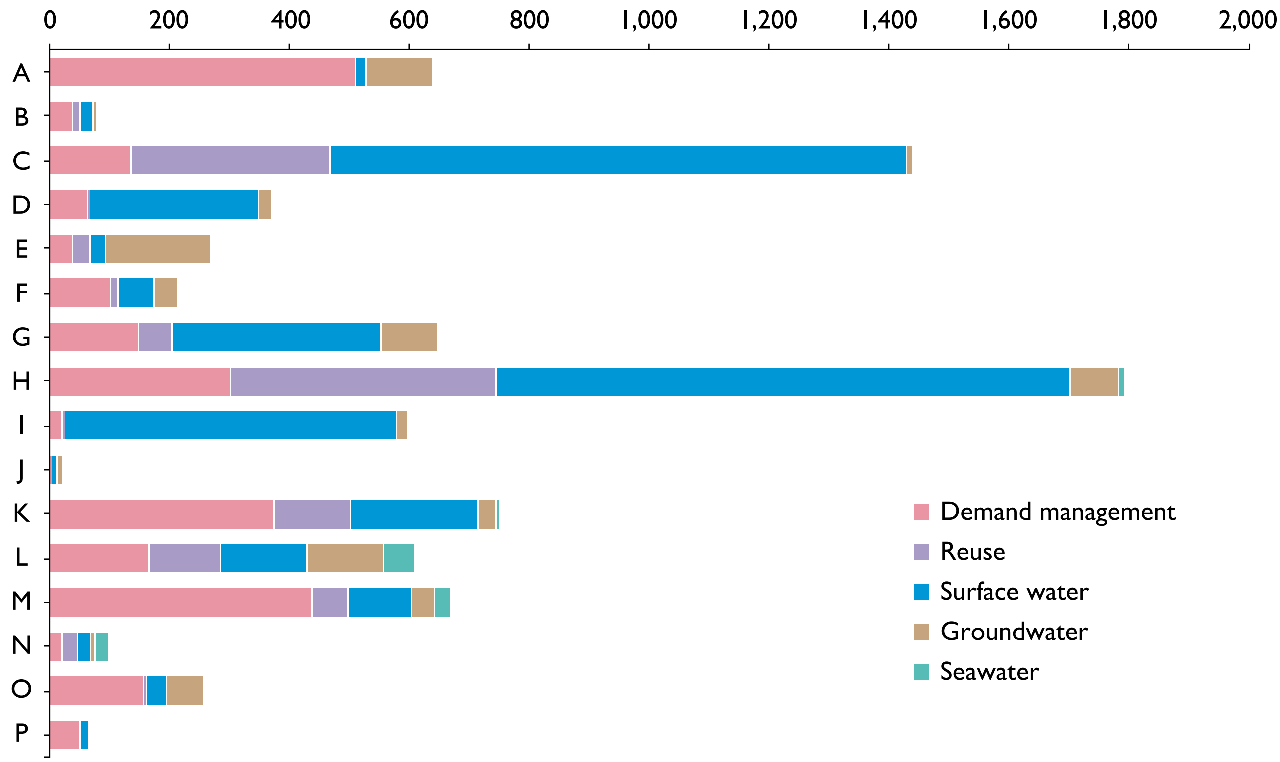


Figure 8.3 - Share of recommended water management strategies by strategy type in 2070

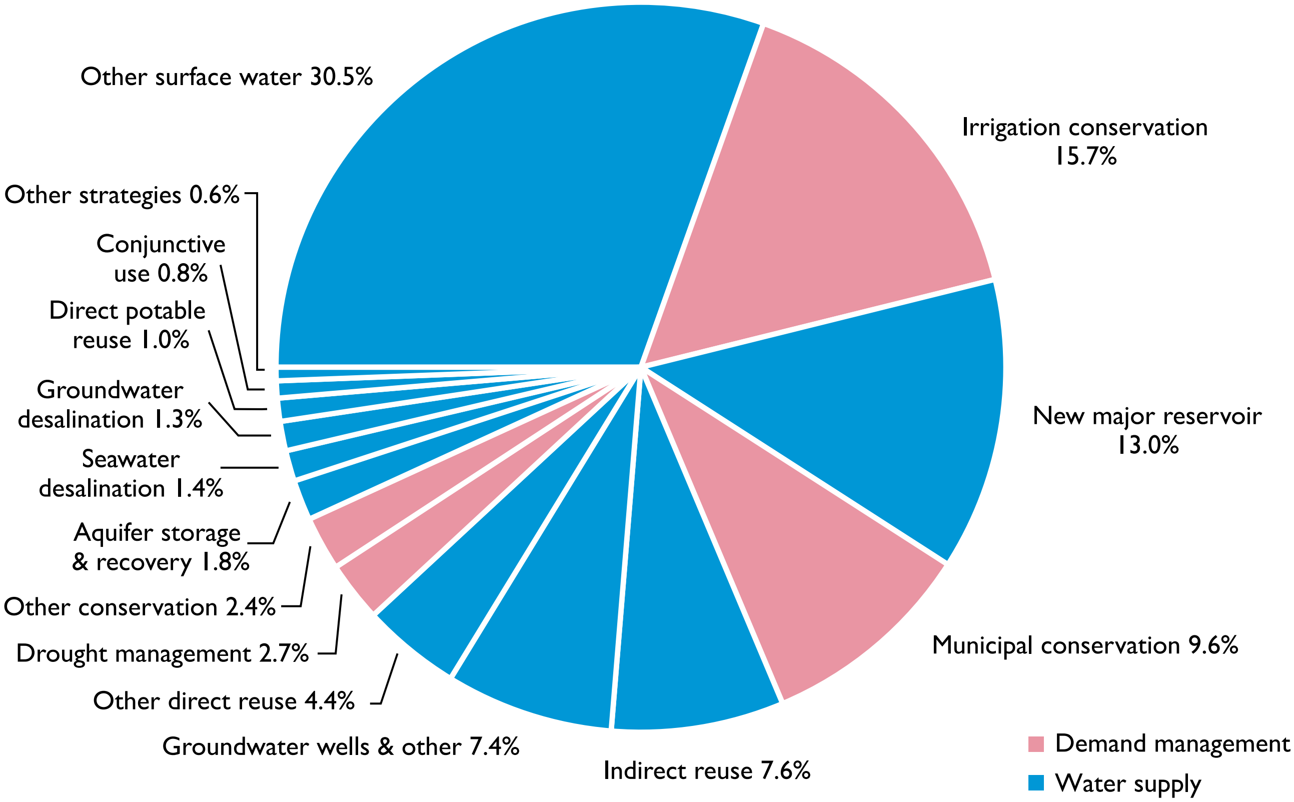


Table 8.3 - Annual volume of recommended water management strategies by strategy type (acre-feet)

Water management strategy type	2020	2030	2040	2050	2060	2070
Aquifer storage & recovery	53,000	91,000	105,000	124,000	135,000	152,000
Conjunctive use	40,000	60,000	65,000	65,000	65,000	64,000
Direct potable reuse	33,000	45,000	54,000	66,000	76,000	87,000
Drought management	152,000	178,000	199,000	208,000	217,000	226,000
Groundwater desalination	70,000	73,000	86,000	92,000	100,000	111,000
Groundwater wells & other	305,000	426,000	471,000	540,000	582,000	631,000
Indirect reuse	230,000	288,000	516,000	569,000	577,000	649,000
Irrigation conservation	639,000	809,000	1,084,000	1,175,000	1,267,000	1,330,000
Municipal conservation	204,000	333,000	435,000	562,000	686,000	811,000
New major reservoir	220,000	406,000	525,000	679,000	786,000	1,100,000
Other conservation	76,000	98,000	126,000	145,000	168,000	203,000
Other direct reuse	163,000	222,000	257,000	297,000	331,000	371,000
Other strategies	30,000	31,000	37,000	41,000	46,000	51,000
Other surface water	1,192,000	1,488,000	2,000,000	2,188,000	2,494,000	2,584,000
Seawater desalination	3,000	25,000	54,000	65,000	105,000	116,000
Texas[a]	**3,410,000**	**4,573,000**	**6,014,000**	**6,816,000**	**7,635,000**	**8,486,000**

[a] *Statewide totals may vary between tables due to rounding.*

Conservation

Conservation includes a variety of activities that either reduce everyday water consumption or increase water use efficiency, allowing more to be done with the same amount of water. Conservation occurs throughout both wet and dry weather and maintains all normal economic and domestic activities. Conservation was a recommended strategy in all regional water plans and is associated with over 1,300 water user groups (Table 8.4).

During the first cycle of regional water planning, a portion of water savings generated through non-passive conservation strategies, beyond those anticipated to be achieved due to existing state and federal plumbing standards (Section 5.6), was incorporated directly into the water demand projections developed by the TWDB. That approach could be interpreted to suggest that an additional lowering of per capita water use, for example, was inevitable. In response to subsequent criticisms of that approach, estimates of future non-passive water savings have since been shifted from the demand side of the planning equation to the supply side. This current approach better reflects the fact that a significant portion of future water savings will only be realized through the proactive implementation of conservation strategies by sponsors.

Municipal conservation includes a variety of activities such as installation of low flow plumbing fixtures, water conservation pricing structures, water system audits, or landscape irrigation restrictions. About 204,000 acre-feet per year in municipal conservation strategies is recommended in 2020, and 811,000 acre-feet per year is recommended in 2070. This is in addition to the estimated share of future passive conservation savings from plumbing codes and water efficiency standards (295,000 acre-feet per year in 2020 and 887,000 acre-feet per year in 2070), which are embedded in municipal water demand projections (Chapter 5).

The near-term conditions of no water management strategies in 2020 were compared to 2070 conditions assuming full implementation of the state water plan using a calculation method equivalent to that used by the Water Conservation Implementation Task Force for calculating gallons per capita per day, which includes

- using the baseline projected municipal gallons per capita per day projections,
- the addition of supply volumes that are provided by municipalities to manufacturing, and
- exclusion of existing municipal reuse supply volumes.

If all the recommended municipal conservation and reuse strategies were implemented in 2070, the projected statewide municipal average gallons per capita per day would decline from the currently projected 163 gallons per capita per day in 2020 (without recommended conservation or reuse strategies) to approximately 124 gallons per capita per day in 2070 (with recommended conservation and reuse strategies). This calculated 2070 water use is well below the comparable statewide municipal total water use goal of 140 gallons per capita per day recommended by the Water Conservation Implementation Task Force created by the 78th Texas Legislature through Senate Bill 1094 (TWDB, 2004). This is the first state water plan to report meeting the Task Force's recommended statewide water conservation goal within the planning horizon.

Table 8.4 - Number of water user groups relying on different types of water management strategies by region

Water management strategy type	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Texas
Aquifer storage & recovery	0	0	0	0	1	9	9	0	0	2	7	14	0	0	1	0	43
Conjunctive use	3	0	0	1	1	0	2	59	0	0	0	0	0	0	8	0	74
Direct potable reuse	0	1	0	0	1	5	1	0	0	0	0	2	28	0	2	0	40
Drought management	0	0	0	0	0	1	5	0	0	1	81	31	0	0	0	7	126
Groundwater desalination	0	0	0	0	8	4	0	6	0	1	0	9	24	1	3	0	56
Groundwater wells & other	31	25	27	32	17	42	71	34	9	20	35	54	25	5	32	0	459
Indirect reuse	0	17	220	5	1	0	5	29	3	0	5	0	0	0	0	0	285
Irrigation conservation	20	10	10	0	2	30	18	8	0	0	3	7	8	2	21	0	139
Municipal conservation	36	22	268	9	12	57	96	244	11	11	51	104	67	22	40	5	1,055
New major reservoir	0	17	247	4	1	4	31	26	15	0	27	3	0	4	1	0	380
Other conservation	0	11	11	6	0	36	53	13	0	0	0	3	20	4	0	0	157
Other direct reuse	0	0	10	0	0	10	16	14	0	1	10	7	3	3	0	0	74
Other strategies	8	1	0	0	0	22	1	0	0	6	9	0	7	0	0	0	54
Other surface water	0	17	283	38	2	35	59	53	32	3	7	4	44	5	2	0	584
Seawater desalination	0	0	0	0	0	0	0	1	0	0	0	2	4	3	0	0	10

Irrigation conservation includes water savings associated with changes to irrigation methods and equipment. It includes, for example, conversion to Low Energy Precision Application (LEPA) systems as well as other activities associated with irrigation best management practices. About 639,000 acre-feet per year in irrigation conservation strategies is recommended in 2020, and 1.3 million acre-feet per year is recommended in 2070.

Other conservation includes water savings associated with steam-electric, manufacturing, and mining conservation activities based on best management practices appropriate for each facility, which may include evaluating cooling and process water practices, water audits, or submetering. About 76,000 acre-feet per year in other conservation strategies is recommended in 2020, and 203,000 acre-feet per year is recommended in 2070.

Drought management

Drought management reduces water use during times of drought by temporarily restricting certain economic and domestic activities such as car washing and lawn watering. Drought measures vary and are generally implemented by local water providers. Planning groups recommended drought management strategies for certain water user groups and in limited instances, for example, to address near-term shortages that will eventually be met in future decades from other water supply strategies. About 152,000 acre-feet per year in drought management strategies is recommended in 2020, and 226,000 acre-feet per year is recommended in 2070.

Reuse

Reuse takes many forms and is broadly categorized as either direct or indirect. Either type of reuse may be used for potable or non-potable purposes.

Direct potable reuse is relatively new to Texas and involves taking treated wastewater effluent, further treating it at an advanced water treatment plant, and then either introducing it upfront of the water treatment plant or directly into the potable water distribution system. About 33,000 acre-feet per year in direct potable reuse strategies is recommended in 2020, and 87,000 acre-feet per year is recommended in 2070.

Other direct reuse strategies generally convey treated wastewater directly from a treatment plant to non-potable uses such as landscaping or industrial processes. About 163,000 acre-feet per year in direct reuse (other than direct potable reuse) strategies is recommended in 2020, and 371,000 acre-feet per year is recommended in 2070.

Indirect reuse generally involves discharging wastewater into a natural water body and diverting that water for subsequent use. About 230,000 acre-feet per year in other reuse strategies is recommended in 2020, and 649,000 acre-feet per year is recommended in 2070.

Conjunctive use

Conjunctive strategies combine multiple water sources, usually surface water and groundwater, to optimize the beneficial characteristics of each source, yielding additional firm water supplies. For example, a strategy may rely intermittently on groundwater to supplement surface water supplies that may not be fully available under drought of record conditions. About 40,000 acre-feet per year in conjunctive use strategies is recommended in 2020, and 64,000 acre-feet per year is recommended in 2070.

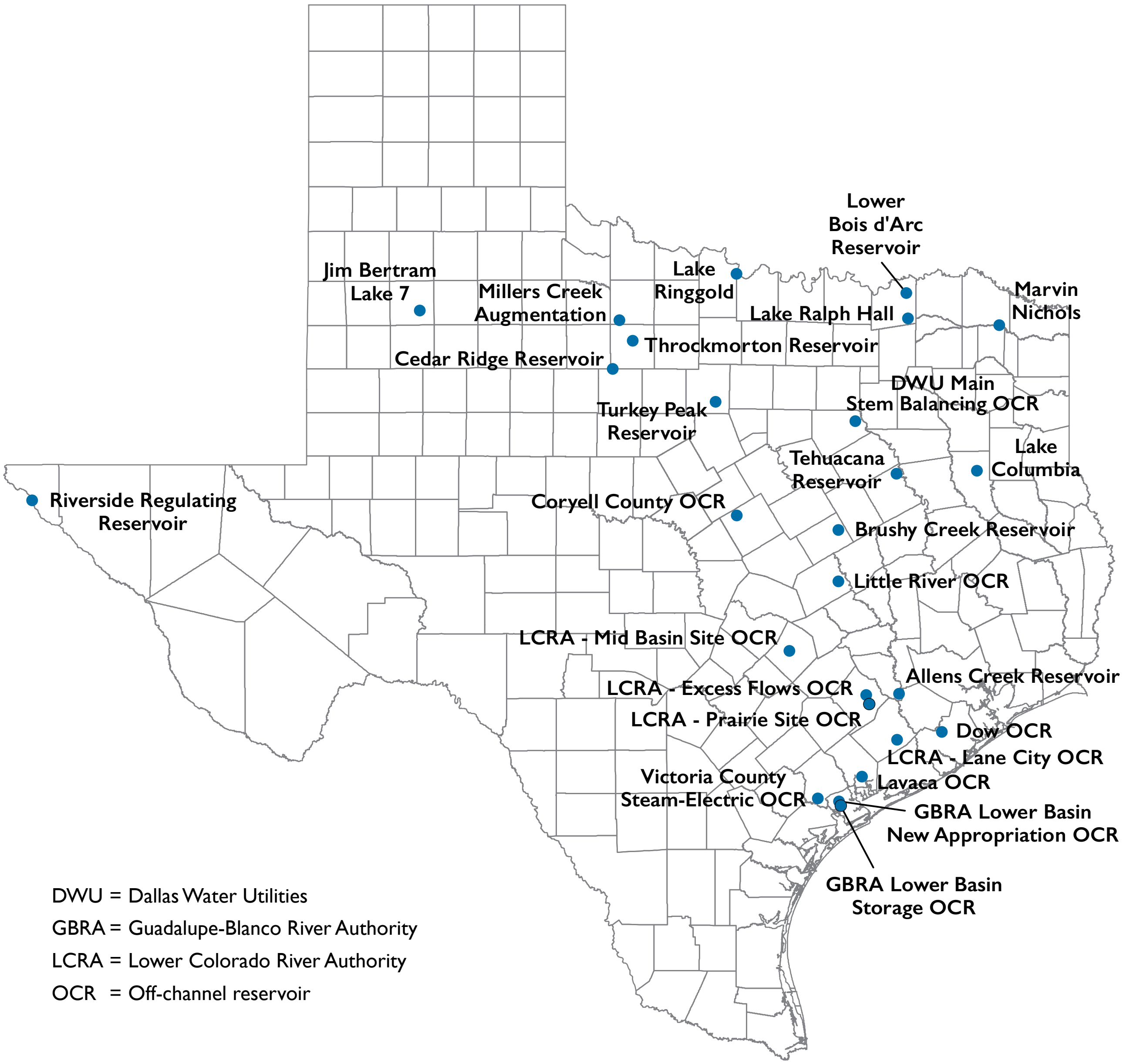
Aquifer storage and recovery

Aquifer storage and recovery refers to the practice of injecting water, when available, into an aquifer where it is stored for later use. This strategy is feasible only in certain geologic formations and in areas where only the project sponsor may retrieve the stored water. About 53,000 acre-feet per year in aquifer storage and recovery strategies is recommended in 2020, and 152,000 acre-feet per year is recommended in 2070.

New surface water reservoirs

Planning groups recommended 26 new major reservoirs (a reservoir with more than 5,000 acre-feet of storage) (Figure 8.4). About 220,000

Figure 8.4 - Recommended new major reservoirs



acre-feet per year from new major reservoir strategies, including some that rely on indirect reuse, is recommended in 2020 and 1.1 million acre-feet per year is recommended in 2070. Many of these reservoir sites are off-channel, meaning that they would not be built on the main stem of the river, although they may rely on the main stem flows.

Other surface water

Other surface water supplies include strategies relying on surface water that is not associated with new major reservoirs, surface water desalination, conjunctive use, or aquifer storage and recovery. Other surface water includes minor reservoirs (less than 5,000 acre-feet of storage) and subordination as well as a wide variety of other strategies that convey, treat, reassign, or otherwise make accessible additional surface water supplies to users with or without additional infrastructure.

Some of these strategies are based on building pipelines to convey previously developed surface water supplies over long distances to either wholesale or retail water providers, for example from an existing reservoir. These strategies generally do not require further development of surface water resources, but simply convey previously developed 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 a reservoir intake to allow a water provider to continue to draw water when lake levels are low.

Another portion of these strategies is based on reassigning existing surplus water supplies or more fully utilizing the capacity of existing infrastructure to deliver surface water to wholesale and/or retail water providers. Many of these strategies are based on transactions (such as sales, contracts, or purchases) between wholesale and/or retail water providers involving previously developed supplies. These transactions may include voluntary reallocations of existing supplies, for example, to support an emergency connection between water providers. Delivery and treatment of these additional water supplies may or may not require new or expanded water infrastructure.

The remaining other surface water strategies increase supplies simply by removing infrastructure "bottlenecks," which limit the volume of supplies that can be delivered. Expanding the capacity of a water treatment plant to better align with the larger capacity of the pipeline that already delivers water to the plant is an example of this type of infrastructure.

About 1.2 million acre-feet per year from other surface water is recommended in 2020, and 2.6 million acre-feet per year is recommended in 2070.

Groundwater wells and other

Most planning groups recommended the development of at least some additional groundwater. This includes single wells or multiple wells, which may be part of the development of new well fields or expansions of existing well fields. New wells were often the only feasible strategy to meet the water needs of rural municipal water users.

Other groundwater strategies do not involve installation of new wells but instead convey, reassign, or otherwise make accessible previously developed groundwater supplies to users with or without additional conveyance and/or treatment infrastructure. These strategies may include, for example, maximizing the use of existing facilities by increasing production from existing groundwater wells and conveying groundwater supplies from one provider to another through a purchase.

About 305,000 acre-feet per year of supply from groundwater development strategies (not associated with groundwater desalination, conjunctive use, or aquifer storage and recovery strategies) is recommended in 2020, and 631,000 acre-feet per year is recommended in 2070.

Desalination of groundwater and seawater

Desalination is the process of removing dissolved solids from seawater or brackish groundwater, often by forcing the source water through membranes under high pressure. The specific process used to desalinate water varies depending upon the total dissolved solids, the temperature, and other physical characteristics of the source water but always requires disposal of concentrate that has a higher total dissolved content than the source water. Disposal may take the form of an injection well, evaporation beds, discharge to surface water, or an ocean outfall diffuser.

About 70,000 acre-feet per year of supply from groundwater desalination strategies is recommended in 2020, and 111,000 acre-feet per year is recommended in 2070. About 3,000 acre-feet per year of supply from seawater desalination strategies is recommended in 2020, and 116,000 acre-feet per year is recommended in 2070.

Other strategies

These include strategy types that, individually, provide less than 0.5 percent of the total recommended strategy supplies in 2070.

Rainwater harvesting

Surface water desalination is the process of removing dissolved solids from brackish surface water, often by forcing the source water through membranes under high pressure. About 3,000 acre-feet per year of supply from surface water desalination strategies is recommended in 2070.

Other less common strategies that are recommended include weather modification and brush control. These strategies share a common trait: it is difficult to quantify the reliable supplies that they are capable of providing under drought of record conditions when there is less cloud cover, precipitation, runoff, and infiltration of precipitation into the soil.

Weather modification, sometimes referred to as cloud seeding, is the application of technology to enhance precipitation from clouds. About 22,000 acre-feet per year of supply from weather modification strategies is recommended in 2070.

Brush control is a land stewardship technique that involves removal of species, such as ashe juniper, that may reduce runoff to streams and rivers and recharge to aquifers. However, since it is difficult to quantify reliable water volumes that can be produced and permitted for use under drought conditions, it was not often recommended as a strategy to meet needs (Research & Planning Consultants and Espey, Padden Consultants, Inc, 2000). About 10,000 acre-feet per year of supply from brush control strategies is recommended in 2070.

Rainwater harvesting is an ancient practice involving the capture, diversion, and storage of rainwater for landscape irrigation, drinking and domestic use, aquifer recharge, and, in modern times, stormwater abatement. Rainwater harvesting can reduce municipal outdoor irrigation demand on potable systems. Building-scale type rainwater harvesting that can meet planning rules, as was generally considered by regional water planning groups, requires active management by each system owner and a way to economically develop to a scale that will ensure a significant drought of record firm yield. About 17,000 acre-feet per year of supply from rainwater harvesting strategies is recommended in 2070.

8.3 Assignment of strategy and project supply volumes

The volume of water associated with all recommended water management strategy projects may, in some cases, be greater than an identified need or what was actually assigned to specific water user groups. Differences in water volumes may occur between the yield developed by certain projects at the source and the volume that would actually be conveyed to wholesalers or water user groups, the volume assigned to wholesale water providers and retail water providers, and/or the identified water user needs and strategy volume assigned to a specific water user. Depending on the project and provider, these differences in water volumes generally represent

- anticipated water losses in conveyance and/or treatment;
- a management supply or safety factor to address uncertainties such as whether recommended projects will be implemented, unanticipated water supply reductions, or greater than anticipated water demand for wholesale and retail water system operations;
- a planning buffer against a future drought worse than the drought of record;
- water supply available to a wholesale provider that could eventually be distributed to meet the needs of its customer water user groups; and/or
- a portion of the capacity of larger, optimally sized regional projects, such as major reservoirs, that come online later in the planning decades and that may not be fully connected to or utilized by water user groups until after 2070.

In some cases, additional water may be developed at the source only, while in other instances the water may be delivered to a wholesale provider but may not have been assigned to any specific water user group in a particular decade. Future delivery of these unassigned water volumes may require additional water infrastructure that may not be included in the plan.

The full capacities of all recommended projects and strategies that are included in the approved regional water plans, including any of their associated capacities or volumes of water that may not be assigned to specific water user groups, are also considered to be part of the state water plan.

8.4 Costs of recommended strategies

Planning groups estimated the costs of their recommended water management strategy projects using common cost elements and methodologies. This is the first cycle of regional plans in which planning groups utilized a cost estimation tool that was developed under a TWDB-funded research study. Extensive use of the spreadsheet-based tool introduced greater consistency in the cost estimates and helped planning groups ensure that all required cost considerations were included in the estimates.

In accordance with planning rules and guidance, this state water plan is intended to include only those recommended projects and costs necessary to conserve, develop, deliver, or treat additional water supply volumes; it specifically excludes the cost for maintenance or replacement of existing infrastructure as well as retail distribution projects, such as an expansion of internal distribution infrastructure to serve a new subdivision, other than those directly associated with recommended conservation strategies.

The total capital cost required to implement all recommended water management strategy projects is $63 billion. This includes approximately 2,500 projects that would be built and completed during different planning decades.

The estimated unit cost of water delivered to water user groups varies greatly depending on the type of strategy, location, water source, and infrastructure required to convey and treat the water. Weight-averaged[4] on a statewide basis, the least expensive recommended water management strategy type in the year 2070 is irrigation

[4] *The weighted average is the average of values scaled by the relative volume of each strategy.*

Table 8.5 - Weight-averaged unit costs (dollars per acre-foot) of strategy water supplies by region and strategy type in 2070*

Water management strategy type	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Texas
Aquifer storage & recovery	na	na	na	na	$296	$480	$252	na	na	$205	$645	$442	na	na	$243	na	$450
Conjunctive use	$106	na	na	na	$361	na	$1,031	$928	na	na	na	na	na	na	$106	na	$753
Direct potable reuse	na	$950	na	na	$1,212	$1,041	$740	na	na	na	na	$743	$1,137	na	$2,065	na	$1,134
Groundwater desalination	na	na	na	na	$415	$718	na	$850	na	na	na	$698	$1,146	$646	$1,713	na	$713
Groundwater wells & other	$314	$635	$350	$522	$756	$226	$360	$582	$303	$236	$774	$667	$66	$120	$256	na	$493
Indirect reuse	na	$360	$111	$288	$563	na	$125	$398	na	na	$46	na	na	na	na	na	$283
Irrigation conservation	$17	$53	$310	na	$55	na	$230	$112	na	na	$163	na	$531	$230	$42	$134	$147
Municipal conservation	$446	$254	$154	$591	$226	$437	$460	$257	$182	$381	$311	$652	$464	$483	$599	$345	$373
New major reservoir	na	$482	$563	$95	$267	$710	$450	$72	$270	na	$585	$596	na	$595	$179	$33	$470
Other conservation	na	$573	$310	na	na	$794	na	na	na	na	na	na	$1,899	na	na	na	$190
Other direct reuse	na	na	$285	na	na	$267	$290	$210	na	$58	$1,157	$356	$505	$341	na	na	$423
Other strategies	$8	$280	na	na	na	$308	na	na	na	na	$2,978	na	$10	na	na	na	$1,249
Other surface water	na	$361	$571	$490	$356	$83	$320	$245	$437	$99	$176	$606	$222	$508	$427	na	$380
Seawater desalination	na	na	na	na	na	na	na	$1,461	na	na	na	$611	$3,708	$550	na	na	$1,431

** Unit costs include a mixture of projects, some of which will be beyond their debt service period by 2070.*

na = not applicable or not available.

conservation. The most expensive is seawater desalination (Table 8.5), although this can vary greatly by individual project and depends on whether the unit costs still include debt service in any given decade. There can be a substantial range in unit costs even within a single type of strategy and also between regions (Table 8.5). For example, if a seawater desalination strategy requires a 100-mile pipeline inland, the costs of that strategy will likely be substantially greater than a seawater desalination plant built to serve an entity located on the coast.

8.5 Comparison to the 2012 State Water Plan

The annual volumes and relative mix of recommended water management strategy types will change between each state water plan for a variety of reasons. Some strategies recommended in the previous plan will have been implemented by the adoption of the next water plan, at which time the new supplies are accounted for as existing water supplies (Chapter 6) and thereby reduce the estimated water needs.

Recommended water management strategy water volumes in this plan are directly associated with water user groups in the same way that the projected water demands, existing supplies, and water needs are associated with water user groups. In addition to strategy supplies that were associated with those groups, the 2012 State Water Plan also included a varying mixture of other volumes. For example, volumes associated with project facility capacities at water sources but not delivered to or otherwise directly associated with water user groups are included. This difference makes some plan comparisons difficult. The recommended water management supplies, as presented here, are those supply volumes that planning groups associated with specific water user groups. Notable changes from the 2012 State Water Plan include the following:

- The anticipated total strategy supplies directly associated with water user groups in the 2060 decade increased from 7.4 million acre-feet per year in the 2012 plan to 7.6 million acre-feet per year in this plan.
- The total capital costs of all the recommended strategies increased significantly, from $55.7 billion in the previous plan to $63 billion due to many factors, including inflation, increased engagement of water suppliers in the planning process, and a more comprehensive effort to include all projects that will conserve water or increase treated water supply volumes.
- The inclusion of many more capital-intensive conservation strategies resulted in an increase of over $3 billion in plan costs associated with conservation projects to a total of over $4 billion.
- The volume of recommended municipal conservation savings of 686,000 acre-feet per year in 2060 is greater than the 627,000 acre-feet per year recommended in the 2012 plan.
- The volume of recommended direct potable reuse strategies in 2060 increased approximately six-fold, from approximately 12,000 acre-feet per year in the 2012 plan to 76,000 acre-feet per year.
- The volume of recommended aquifer storage and recovery strategies increased more than four-fold, from approximately 30,000 acre-feet per year in the 2012 plan to 135,000 acre-feet per year in 2060.

8.6 Uncertainty of future strategies

Implementation of each particular recommended water management strategy project is not a certainty. Many of the more significant projects will require obtaining a water right permit from a regulatory entity. Some projects, such as large reservoirs, will require extensive and time-intensive studies, including additional environmental permitting from the U.S. Army Corps of Engineers and the National Environmental Policy Act process, which involves wide-ranging information collection, study, and public input.

Implementation of all water supply projects remains subject to political and financial processes associated with project sponsors and communities. Eventually, some recommended projects may become politically or financially infeasible and therefore will not provide any supply.

To account for uncertainties, including the possibility of projects being downsized or not being implemented at all, planning groups sometimes recommended a combination of water management strategies that, if implemented, would provide more water supplies than are required to meet needs. Planning groups also included alternative water management strategies, which are fully evaluated strategies that can be substituted at a future date in the event that a recommended strategy becomes infeasible. The farther we look into the 50-year planning period, the greater the uncertainty of implementing any given strategy. Regulations may change or technological advances may make a certain type of strategy more affordable. Water planning in Texas is an adaptive process in which regional and state water plans are developed every five years to reflect these and many other changes.

8.7 Impacts of recommended strategies

The process of developing regional water plans requires that planning groups describe the major impacts on key water quality parameters and how the plans are consistent with the long-term protection of water, agricultural, and natural resources.

8.7.1 Potential impacts on water quality

To assess how water management strategies could potentially affect water quality, planning groups identified key water quality parameters within their regions. These parameters were generally based on surface and groundwater quality standards, the list of impaired waters developed by the Texas Commission on Environmental Quality, and input from local and regional water management entities and the public.

Planning groups presented high-level assessments on how the implementation of strategies could potentially affect the water quality of surface water and groundwater sources. Regions used different approaches, including categorical assessments (such as low, moderate, high) or numerical impact classifications (such as 1, 2, 3, 4, 5).

To evaluate the potential impacts of the recommended water management strategies on surface water quality, the planning groups most commonly used the Texas Surface Water Quality Standards, which include these considerations:

- **Total dissolved solids (salinity):** For most purposes, total dissolved solids is a direct measure of salinity. Salinity concentration determines whether water is acceptable for drinking water, livestock, or irrigation.
- **Nutrients:** A nutrient is classified as a chemical constituent, most commonly a form of nitrogen or phosphorus, that can contribute to the overgrowth of aquatic vegetation and impact water uses in high concentrations.
- **Dissolved oxygen:** Dissolved oxygen concentrations must be sufficient to support existing, designated, presumed, and attainable aquatic life uses in classified water body segments.
- **Bacteria:** Some bacteria, although not generally harmful themselves, are indicative of potential contamination by feces of warm-blooded animals.
- **Toxicity:** Toxicity is the occurrence of adverse effects to living organisms due to exposure to a wide range of toxic materials.

The water quality indicators that planning groups most commonly used to evaluate groundwater quality impacts of the recommended water management strategies include these considerations:

- **Total dissolved solids (salinity):** As was noted with surface water, total dissolved solids is a measure of the salinity of water and represents the amount of minerals dissolved in water.
- **Nitrates:** Although nitrates exist naturally in groundwater, elevated levels generally result from human activities, such as overuse of fertilizer and improper disposal of human and animal waste.
- **Arsenic:** Although arsenic can occur both naturally and through human contamination, most of the arsenic in Texas groundwater is naturally occurring.
- **Radionuclides:** A radionuclide is an atom with an unstable nucleus that emits radiation (this occurs naturally in several Texas aquifers).

Water management strategies for water supply are subject to the Texas Commission on Environmental Quality's Public Drinking Water and Water Quality standards, permitting, monitoring, assessment, treatment, sampling, and other requirements or methods used by that agency to address water quality problems related to water supply.

8.7.2 Protecting the state's water, agricultural, and natural resources

In developing their plans, the planning groups honored all existing water rights and contracts, adhered to the Texas Commission on Environmental Quality's existing and pass-through requirements for instream flows and estuaries, and considered conservation strategies for all water user groups with a water supply need. The regional water plans are based on environmental flow standards adopted by the Texas Commission on Environmental Quality, Consensus Criteria for Environmental Flow Needs, or when available, site-specific studies. The plans do not include any recommended strategies that are incompatible with the desired future conditions of aquifers or that divert greater-than-permitted surface water volumes.

Planning groups quantified and took into consideration the impacts of water management strategies to agricultural resources. In developing their plans, planning groups were required to consider and, when feasible, recommend water management strategies to meet the water supply needs of irrigated agriculture and livestock production. Recommended strategies that would involve conversion or transfer of water associated with existing water right permits either being used for agricultural purposes or from rural areas were based on future voluntary transactions between willing buyers and willing sellers.

Planning groups included estimated costs of mitigation and quantified the potential impacts of water management strategies related to environmental factors such as bay and estuary inflows and habitat. Some categorized assessments as "high," "moderate," and "low," based on underlying quantified impacts or quantified ranges of impacts.

Environmental factors were quantified and summarized primarily based on existing data and the potential to avoid or mitigate impacts. For example, a quantification associated with a "low" impact rating indicated that impacts could generally be avoided or mitigated relatively easily. In contrast, an impact quantified and rated as "high" generally indicated that impacts would be significant and that there would likely be substantial mitigation requirements.

Planning groups considered a variety of factors including the volume of discharges a strategy would produce, the number of acres of habitat potentially impacted, changes to streamflows, and changes to bay and estuary inflow patterns. Approaches also relied on identifying the number of endangered or threatened species or cultural sites occurring within the vicinity of the recommended projects.

The emphasis of these evaluations varied by region based on the type of project under consideration and the relevant resources impacted. Evaluations included project-by-project evaluations as well as cumulative, region-wide impact analyses. In general, most planning groups relied on existing information and data generated as part of the technical

Figure 8.5 - Annual water supply needs and needs met by the plan by region in 2070 (acre-feet)

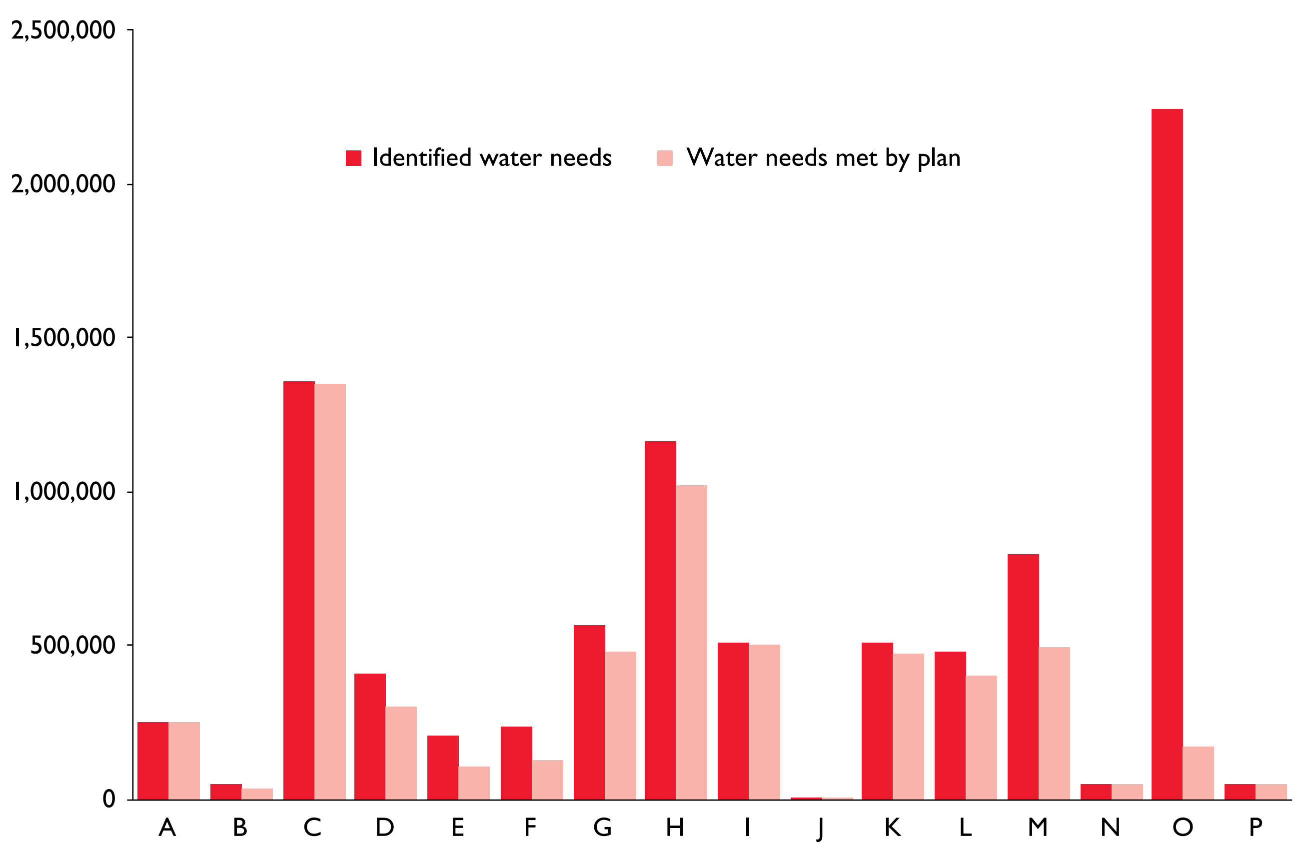
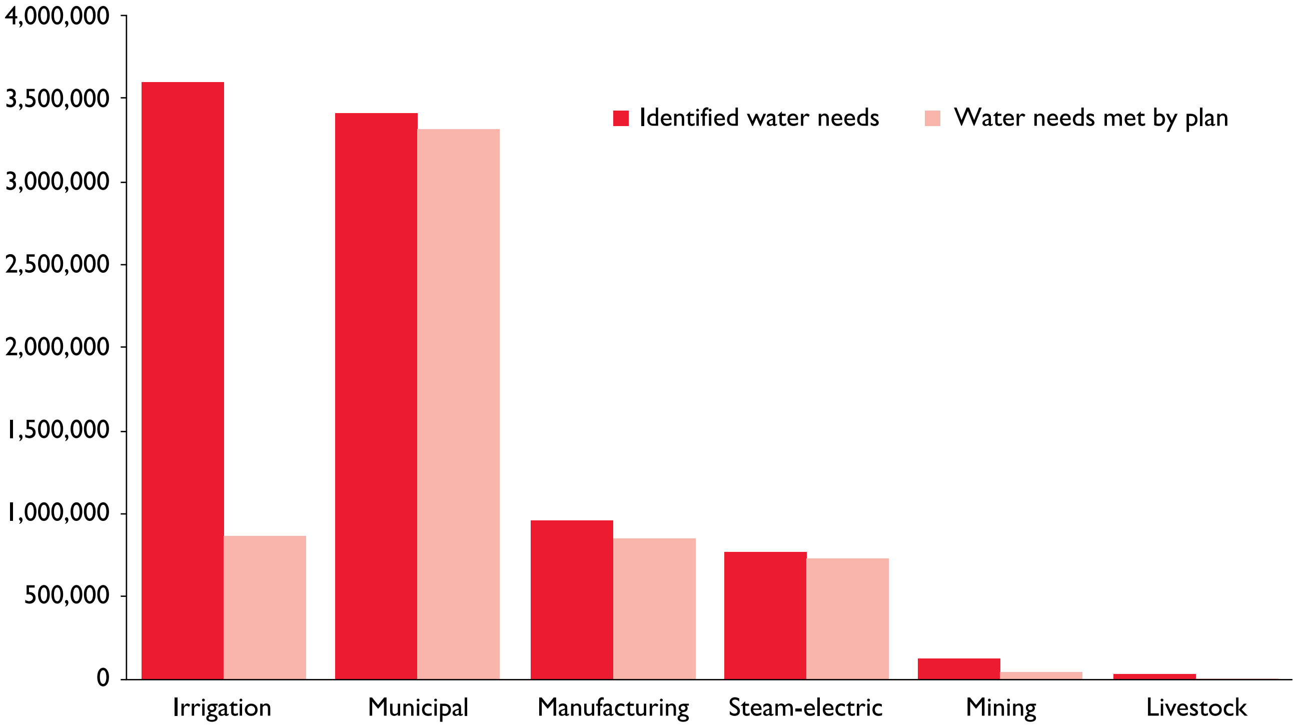


Figure 8.6 - Annual water supply needs and needs met by the plan by water use category in 2070 (acre-feet)



evaluations of strategies, such as flow frequency data, land cover, and habitat maps, to evaluate the impacts of water management strategies on agricultural and natural resources.

8.8 Needs met by recommended strategies

Planning groups were required to consider all identified water needs (potential shortages) and identify potential strategies to meet them, when feasible. Only one planning group (Region P) was able to recommend water management strategies that, if implemented, are capable of meeting the needs for all its water user groups. The remaining 15 planning groups were unable to identify feasible strategies that met Texas' planning requirements and that would meet all of the needs in their regions (Figure 8.5).

Statewide, the majority of water needs associated with municipal, manufacturing, and steam-electric water user groups are met by the plan in 2070 (Figure 8.6). However, at least some unmet water supply needs occur for all categories of water user groups in the plan. The inability to meet a water user group's need in the plan is usually due to the lack of an economically feasible water management strategy, but this does not prevent an entity from pursuing additional water supplies.

References

Research & Planning Consultants and Espey, Padden Consultants, Inc, 2000, Assessment of brush control as a water management strategy: Prepared for the Texas Water Development Board, 100 p. www.twdb.texas.gov/publications/reports/contracted_reports/doc/99483312.pdf

TWDB (Texas Water Development Board), 2004, Report to the 79th Legislature, Water Conservation Implementation Task Force: Prepared by the Texas Water Development Board, 88 p. www.twdb.texas.gov/conservation/resources/doc/WCITF_Leg_Report.pdf


Photo courtesy of Tarrant Regional Water District

9

Implementation and funding of the 2012 State Water Plan

Regional water planning groups are required to help evaluate the state's progress toward meeting future water needs by assessing the previously recommended state water plan strategies that have been implemented. In 2011, the 82nd Texas Legislature passed Senate Bill 660—the TWDB's sunset bill, requiring the planning groups and the TWDB to report on state water plan projects funded since adoption of the previous state water plan. This is the first state water plan to incorporate that information.

Quick facts

Regional water planning groups reported that approximately 440 water management strategies in the 2012 State Water Plan were either partially or fully implemented, representing approximately 14 percent of the total number (approximately 3,100) of recommended strategies.

Of the total estimated $55.7 billion in project costs in the 2012 State Water Plan, approximately $1.9 billion was funded through the TWDB's financial assistance programs and is associated with 60 projects and over 1 million acre-feet of additional annual water supply.

9.1 Implementation of the 2012 State Water Plan

Planning groups reported on the implementation of water management strategies from the 2012 State Water Plan in their 2016 regional water plans. By surveying specific project sponsors, planning groups attempted to determine the extent to which each water management strategy may have been implemented. The surveys included strategies such as conservation, which do not require significant new water infrastructure. Planning groups also attempted to gauge the degree to which sponsors had moved water infrastructure projects toward planning, design, or construction phases.

The survey focused on basic information, like whether a strategy was implemented or not, and on information regarding incremental steps that may have been taken toward initial implementation, such as permitting.

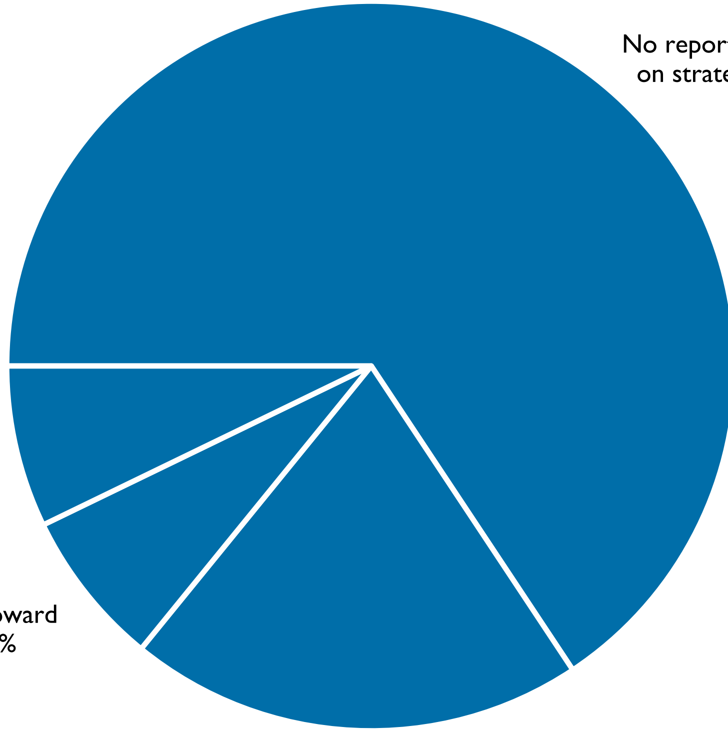
Since water management strategies, particularly those that involve infrastructure projects, can require several years or more to fully implement, strategy progress was defined in two ways:

1. **Implemented**, when a strategy is fully capable of meeting water needs in the manner planned.
2. **Progress toward implementation**, which includes any type of implementation step (including start of project construction or pre-implementation activity such as negotiating contracts, applying for and securing financing or state and federal permits, or conducting preliminary engineering studies) or achievement of a portion of the total anticipated conservation savings from a strategy.

Statewide implementation progress is represented by the relative count of strategies compared to the total number of recommended strategies (approximately 3,100) in the 2012 State Water Plan[5] (Figure 9.1). Of the approximately 1,060 strategies for which the planning groups reported information, 41 percent reported at least some form of progress on strategy implementation. Of these, half were reported as being fully implemented. Strategies reported as fully implemented represent about 7 percent of the total number of recommended water management strategies in the 2012 State Water Plan, while strategies reported as only partially implemented represent about 7 percent of the total number of strategies.

[5] *The count of water management strategies and the capital cost of projects associated with the 2012 State Water Plan include amendments to the plan.*

Figure 9.1 - Reported implementation of all recommended water management strategies from the 2012 State Water Plan by share of total number of strategies



Planning groups reported that strategies only partially implemented represent approximately 28 percent of the $55.7 billion in total capital costs associated with the 2012 State Water Plan. Strategies reported as fully implemented represent approximately 9 percent of the total capital costs associated with recommended water management strategies in the 2012 State Water Plan.

9.2 Funding of the 2012 State Water Plan

Since adoption of the 2012 State Water Plan, the TWDB has closed[6] on approximately $3.9 billion in financial assistance, of which approximately $1.9 billion was associated with state water plan projects, as of December 2015 (Table 9.1). Additionally, as of December 2015, the TWDB has committed to funding approximately $3.9 billion from the State Water Implementation Fund for Texas (SWIFT) program over the next 10 years for state water plan projects, which includes the amount closed for the 2012 State Water Plan projects funded through SWIFT. In addition to the SWIFT program, the TWDB funded the recommended water management strategies through several different funding programs, including the Water Infrastructure Fund, the State Participation Program, the Economically Distressed Areas Program, the Texas Water Development Fund, the Water Assistance Fund, the Rural Water Assistance Fund, and the Drinking Water State Revolving Fund.

A variety of types of water management strategies have been implemented with TWDB funding since adoption of the 2012 State Water Plan, including groundwater desalination; new groundwater wells; direct potable reuse; transmission and treatment facilities; and planning, design, and permitting of new reservoirs (Table 9.1).

[6] The TWDB first approves a commitment for financial assistance. After all appropriate reviews and requirements are met, funds are released at closing.

Table 9.1 - 2012 State Water Plan projects funded since November 2011 by project sponsor *(page 1 of 3)*

Map reference	Entity	Project	Financial assistance features			Closed loan amount	Associated annual water supply (acre-feet per year)[a]
			State water plan funding	State Participation	Other state and federal funding programs		
1	Airline Improvement District	Service zone 1 water and wastewater			×	$5,361,916	504
2	Baylor Water Supply Corporation	Millers Creek water supply			×	$575,000	83
3	Bedford	Conservation - water distribution system improvements	×			$30,000,000	2,716
4	Brazosport Water Authority	Brackish groundwater reverse osmosis water treatment plant and wells	×			$5,605,000	3,000
5	Bronte	Regional water service			×	$488,625	500
6	Canyon Regional Water Authority	Wells Ranch phase II - well field and transmission line	×			$42,000,000	7,800
7	Central Harris County Regional Water Authority	2nd source transmission line phase I & phase II (84" & 108"); Northeast water purification plant expansion	×			$10,805,000	5,470
8	Cleburne	Lake Whitney water supply project	×			$2,380,000	2,128
9	Coastal Water Authority	Luce Bayou interbasin transfer project	×			$66,565,000	358,447
10	Coastal Water Authority	Luce Bayou interbasin transfer		×		$28,754,000	358,447
11	D Bar B Water and Wastewater Supply Corporation	Groundwater well treatment/ replacement			×	$200,000	-
12	East Aldine Management District	Sherwood and Benton Place water and sewer			×	$10,486,094	192
13	El Paso County Tornillo Water Improvement District	Arsenic removal system			×	$45,000	-
14	El Paso Water Utilities Public Service Board	Canutillo Area water and wastewater			×	$412,730	29
15	El Paso Water Utilities Public Service Board	Land and water rights acquisition	×			$50,000,000	20,000
16	Euless	Automated metering and leak detection			×	$5,493,050	660
17	Euless	Bear Creek reclaimed water system			×	$2,755,300	368
18	Fort Bend County Water Control and Improvement District # 8	Water well and generator			×	$490,000	242
19	Fort Worth	Conservation - advanced metering infrastructure project	×			$13,000,000	9,450
20	Greater Texoma Utility Authority	Gainesville surface water treatment plant expansion	×			$1,135,000	1,120

[a] *Water volumes may also be associated with other projects.*

Table 9.1 - 2012 State Water Plan projects funded since November 2011 by project sponsor *(page 2 of 3)*

Map reference	Entity	Project	Financial assistance features			Closed loan amount	Associated annual water supply (acre-feet per year)[a]
			State water plan funding	State Participation	Other state and federal funding programs		
21	Greater Texoma Utility Authority	Sherman water treatment plant expansion and upgrade/ elevated storage tank			×	$29,825,000	11,120
22	Greater Texoma Utility Authority	Van Alstyne Colin Grayson Municipal Alliance connection			×	$3,360,000	728
23	Greater Texoma Utility Authority, City of Tom Bean	Supplemental water well and appurtenances	×			$1,210,000	325
24	Guadalupe-Blanco River Authority	Integrated water and power plant project	×			$2,000,000	28,000
25	Guadalupe-Blanco River Authority	Mid-basin project	×			$4,400,000	25,000
26	Hays Caldwell Public Utility Agency	Phase IA transmission line	×			$7,490,000	5,489
27	Hidalgo County Irrigation District #1	Agricultural irrigation conveyance improvements	×			$7,100,000	-
28	Honey Grove	Conservation - distribution line replacement			×	$2,308,700	-
29	Houston	2nd source transmission line phase I (108"); Northeast water purification plant expansion	×			$25,915,000	358,447
30	Kosse	New wells and elevated storage			×	$449,000	350
31	Lone Star Regional Water Authority	East Williamson County regional water transmission system	×			$27,640,000	11,762
32	Lower Colorado River Authority	Lower Basin Reservoir			×	$253,700,000	90,000
33	Marfa	Additional water well	×			$705,000	968
34	McAllen	Effluent reuse system			×	$7,808,511	-
35	Menard	Surface water treatment plant and well improvements			×	$1,087,000	150
36	Mission	Wastewater treatment plant expansion and reuse			×	$16,140,000	2,240
37	Montgomery County Municipal Water District #8 and #9	Walden conjunctive use water treatment plant design			×	$5,450,000	2,242
38	North Fort Bend Water Authority	Northeast water purification plant expansion; 2nd source transmission line (96")	×			$8,670,000	84,426
39	North Harris County Regional Water Authority	2nd source transmission line phase I & phase II (84" & 108"); Northeast water purification plant expansion; Internal distribution system	×			$80,435,000	126,585
40	Nueces County	Cyndie Park water improvements			×	$200,000	-

[a] *Water volumes may also be associated with other projects.*

Table 9.1 - 2012 State Water Plan projects funded since November 2011 by project sponsor (page 3 of 3)

Map reference	Entity	Project	Financial assistance features: State water plan funding	Financial assistance features: State Participation	Financial assistance features: Other state and federal funding programs	Closed loan amount	Associated annual water supply (acre-feet per year)[a]
41	Palo Pinto County Municipal Water District #1	Turkey Peak Reservoir	×			$17,100,000	6,800
42	Parker County Special Utility District	Brazos River surface water treatment plant			×	$2,000,000	1,120
43	Pharr	Purchase surface water rights			×	$3,524,500	1,500
44	Pleasant Springs Water Supply Corporation	Water plant #2			×	$1,135,000	484
45	Raymondville	Emergency well and reverse osmosis system			×	$3,800,000	2,421
46	Robert Lee	Emergency pipeline and long-term plan			×	$2,750,000	150
47	San Antonio Water System	Brackish groundwater desalination	×			$50,000,000	13,440
48	San Antonio Water System	Water resources integration pipeline			×	$75,920,000	55,982
49	San Jacinto River Authority	Water resources assessment plan			×	$447,320,000	33,627
50	Shallowater	Water and wastewater improvements			×	$4,100,000	450
51	Silverton	New water source			×	$1,825,000	126
52	Somervell County Water District	Wheeler Branch Reservoir water treatment plan			×	$1,400,000	1,680
53	Tarrant Regional Water District	Integrated transmission pipeline project with City of Dallas	×			$440,000,000	392,077
54	Upper Trinity Regional Water District	Lake Ralph Hall Reservoir	×	×		$44,680,000	33,604
55	Vista Verde Water Systems Inc.	New water well			×	$200,000	81
56	West Harris County Regional Water Authority	2nd source transmission line (96"); Northeast water purification plant expansion	×			$18,740,000	92,310
57	West Harris County Regional Water Authority	Second source project	×			$41,965,000	92,310
58	White River Municipal Water District	Regional water system upgrade			×	$2,610,000	4,000
59	Willis	Catahoula Aquifer wells			×	$3,150,000	3,874
60	Willow Park	Water line replacement			×	$685,000	100
	Total					**$1,925,349,426**	

[a] *Water volumes may also be associated with other projects.*

Funding commitments (which may be larger than closed amounts shown in Table 9.1) for projects in the state water plan were associated with many different project sponsors, including cities, water supply corporations, and regional water providers throughout Texas (Figure 9.2).

Examples of the types of projects that the TWDB has funded through SWIFT include the following:

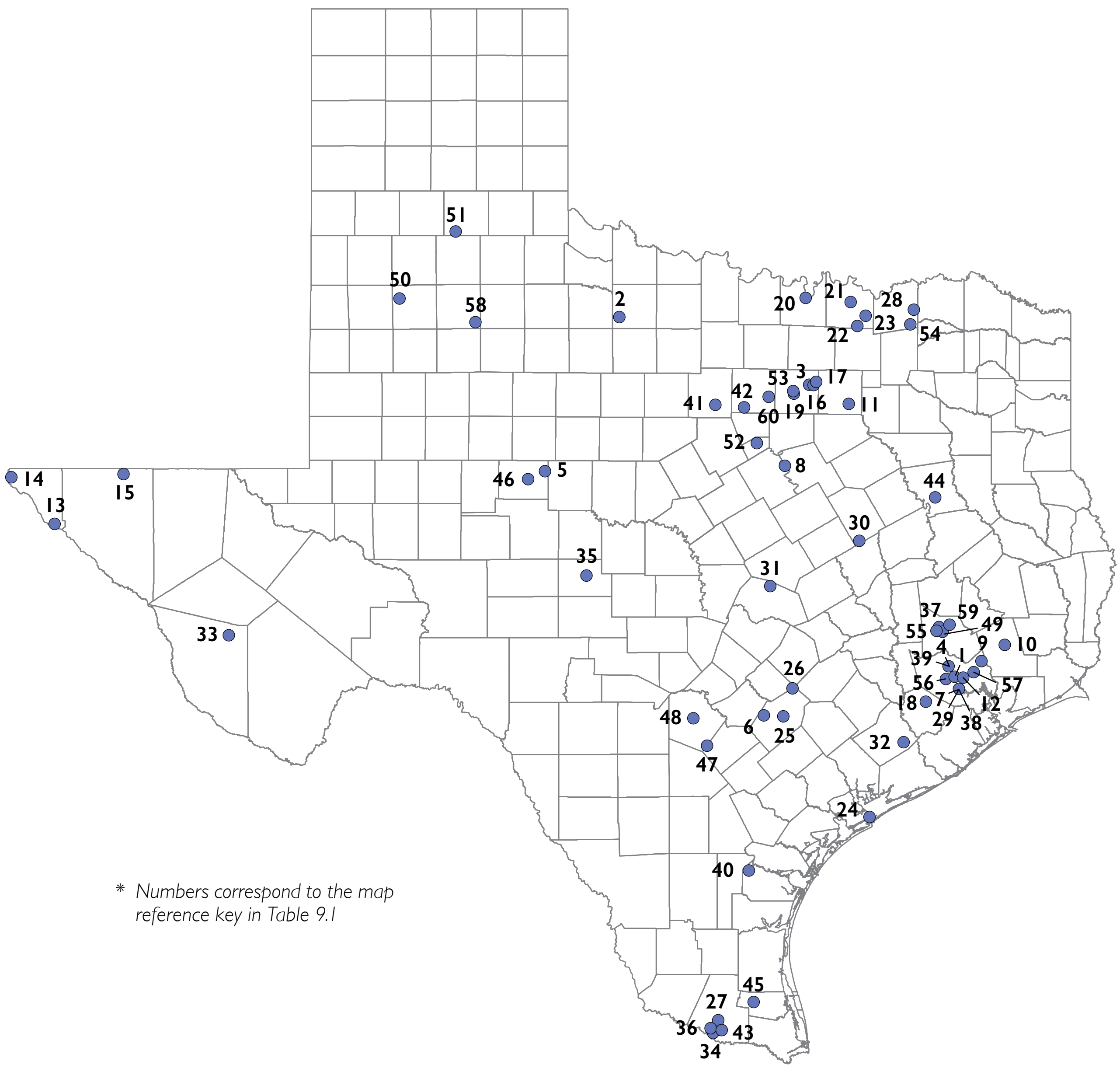
City of Fort Worth

The City obtained a $76 million loan commitment to implement a large meter replacement program that will provide the City of Fort Worth approximately 9,000 acre-feet per year in water savings.

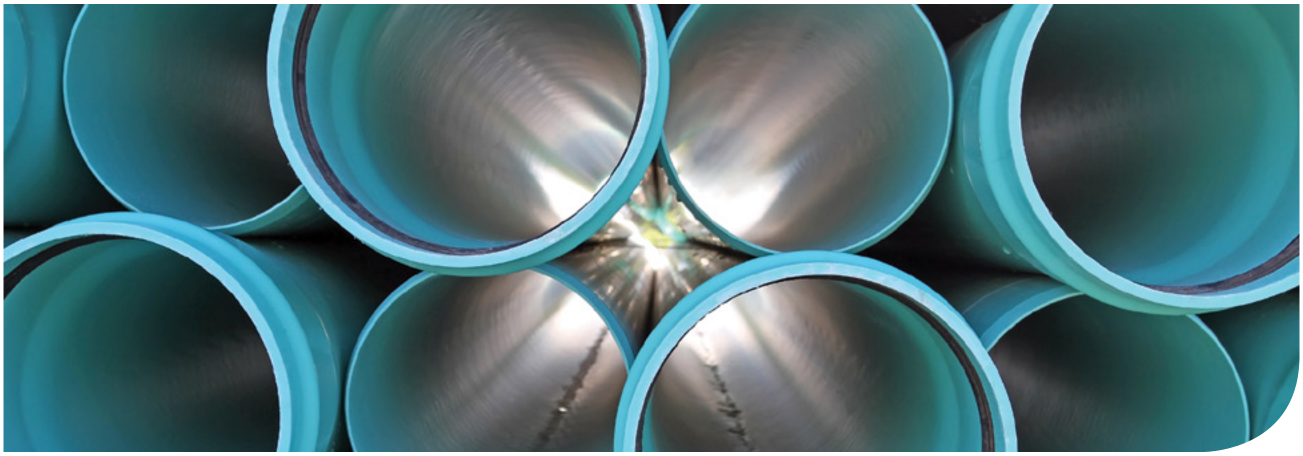
Brazosport Water Authority

The Authority obtained a $28.3 million loan commitment to implement the planning, design, and construction of a brackish groundwater reverse osmosis water treatment plant and water wells, which collectively will provide growing municipalities and industries in Brazoria County with approximately 3,000 acre-feet per year in additional water supply.

Figure 9.2 - Locations of 2012 State Water Plan projects funded by the TWDB, by project sponsor*



* *Numbers correspond to the map reference key in Table 9.1*



Blue pipes are used to transport potable water

Upper Trinity Regional Water District

The District obtained a $44.7 million loan commitment to implement the planning, land acquisition, and design for Lake Ralph Hall, which will provide growing municipalities and industry in Fannin, Collin, Cooke, Dallas, Denton, Grayson, and Wise counties with approximately 34,000 acre-feet per year in additional water supply. The project will rely on initial Board Participation in ownership of a portion of the project.

City of Marfa

The City obtained a $705,000 loan commitment to implement the planning, design, and construction of a new water well that will provide the city with approximately 1,000 acre-feet per year in additional water supply.

Houston area regional water supply projects

The City of Houston, the Coastal Water Authority, the North Harris County Regional Water Authority, the Central Harris County Regional Water Authority, the West Harris County Regional Water Authority, and the North Fort Bend Water Authority obtained a total of $2.96 billion in multi-year commitments to implement the planning, design, and construction of several interrelated, regional projects. The projects include the Luce Bayou transfer project, a massive water treatment plant expansion that will serve all the entities, as well as major shared transmission pipelines and pump stations delivering water to each of the participants. The project will provide approximately 358,000 acre-feet per year in additional water supplies to municipal and industrial water users throughout Harris and Fort Bend counties.

El Paso Water Utilities

El Paso Water Utilities obtained a $50 million loan commitment to acquire land and associated groundwater rights for future development. Once developed, the well field will provide El Paso and its customers with approximately 20,000 acre-feet per year in additional water supply.

Tarrant Regional Water District

The District obtained a $440 million loan commitment to implement the design and construction and to acquire land for an integrated pipeline in partnership with the City of Dallas that will provide the growing municipalities in Collin, Dallas, and Wise counties with approximately 392,000 acre-feet per year in additional water supply.

Palo Pinto County Municipal Water District No. 1

The District obtained a $17.1 million loan commitment to implement the planning and design and to acquire land for the Turkey Peak Reservoir that will provide municipalities and industries in Palo Pinto and Parker counties with approximately 7,000 acre-feet per year in additional water supply.

Glossary

Water for Texas
2017 State Water Plan
Texas Water Development Board

Acre-foot
Volume of water needed to cover 1 acre to a depth of 1 foot. It equals 325,851 gallons.

Aquifer
Geologic formation that contains sufficient saturated permeable material to yield significant quantities of water to wells and springs. The formation could be sand, gravel, limestone, sandstone, or fractured igneous rocks.

Availability
Maximum amount of water available from a source during the drought of record, regardless of whether the supply is physically or legally available to water user groups.

Brackish water
Water containing total dissolved solids between 1,000 and 10,000 milligrams per liter.

Capital cost
Portion of the estimated cost of a water management strategy that includes both the direct costs of constructing facilities, such as materials, labor, and equipment, and the indirect costs associated with construction activities, such as engineering studies, legal counsel, land acquisition, contingencies, environmental mitigation, interest during construction, and permitting.

Conjunctive use
Combined use of groundwater and surface water sources that optimizes the beneficial characteristics of each source.

County-other
An aggregation of residential, commercial, and institutional water users in cities with less than 500 people or utilities that provide less than an average of 250,000 gallons per day, as well as unincorporated rural areas in a given county.

Desalination
Process of removing salt from seawater or brackish water.

Desired future condition
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 as defined by participating groundwater conservation districts within a groundwater management area as part of the joint planning process.

Drought
Generally applied to periods of less than average precipitation over a certain period of time. Associated definitions include meteorological drought (abnormally dry weather), agricultural drought (adverse impact on crop or range production), and hydrologic drought (below-average water content in aquifers and/or reservoirs).

Drought of record
The period of time when natural hydrological conditions provided the least amount of water supply.

Environmental flows
An amount of water that should remain in a stream or river for the benefit of the environment of the river, bay, and estuary, while balancing human needs.

Estuary
A bay or inlet, often at the mouth of a river and may be bounded by barrier islands, where freshwater and seawater mix together providing for economically and ecologically important habitats and species and which also yield essential ecosystem services.

Existing water supply
Maximum amount of water available from existing sources for use during drought of record conditions that is physically and legally available for use by a water user group.

Firm yield
Maximum water volume a reservoir can provide each year under a repeat of the drought of record using reasonable sedimentation rates and assuming that all senior water rights will be totally utilized.

Groundwater availability model
A regional groundwater flow model approved by the executive administrator.

Groundwater management area
Geographical region of Texas designated and delineated by the TWDB as an area suitable for management of groundwater resources.

Infrastructure
Physical means for meeting water and wastewater needs, such as dams, wells, conveyance systems, and water treatment plants.

Instream flow
Water flow and water quality regime adequate to maintain an ecologically sound environment in streams and rivers.

Interbasin transfer of surface water
Defined and governed in Texas Water Code §11.085 (relating to Interbasin Transfers) as the diverting of any state water from a river basin and transfer of that water to any other river basin.

Major reservoir
Reservoir having a storage capacity of 5,000 acre-feet or more.

Modeled available groundwater
The amount of water that the TWDB executive administrator determines may be produced on an average annual basis to achieve a desired future condition.

Needs
Projected water demands in excess of existing water supplies for a water user group or a wholesale water provider.

Regional water planning group
Group designated pursuant to Texas Water Code §16.053.

Performing instream flow surveys of the Brazos River near Marlin, Texas

Numerous Texas cities use reclaimed water for landscape irrigation

Recharge
Water that infiltrates to the water table of an aquifer.

Relevant aquifer
Aquifers or parts of aquifers for which groundwater conservation districts have defined desired future conditions.

Reuse
Use of surface water that has already been beneficially used once under a water right or the use of groundwater that has already been used (for example, using municipal reclaimed water to irrigate golf courses).

Run-of-river diversion
Water right permit that allows the permit holder to divert water directly out of a stream or river.

Sedimentation
Action or process of depositing sediment in a reservoir, usually silts, sands, or gravel.

Storage
Natural or artificial impoundment and accumulation of water in surface or underground reservoirs, usually for later withdrawal or release.

Unmet needs
Amount of water demand that will still exceed the water supply after applying all recommended water management strategies in a regional water plan.

Water availability model
Numerical computer program used to determine the availability of surface water for permitting in the state.

Water management strategy
A plan or specific project to meet a need for additional water by a discrete water user group, which can mean increasing the total water supply or maximizing an existing supply.

Water user group
Identified user or group of users for which water demands and water supplies have been identified and analyzed and plans developed to meet water needs. These include: Incorporated Census places of a population greater than 500, including select Census Designated Places, such as significant military bases or cases in which the Census Designated Place is the only Census place in the county; retail public utilities providing more than 280 acre-feet per year for municipal use; collective Reporting Units, or groups of retail public utilities that have a common association; municipal and domestic water use, referred to as county-other; and non-municipal water use including manufacturing, irrigation, steam-electric power generation, mining, and livestock watering for each county or portion of a county in a regional water planning area.

Wholesale water provider
Any person or entity, including river authorities and irrigation districts, that has contracts to sell more than 1,000 acre-feet of water wholesale in any one year during the five years immediately preceding the adoption of the last regional water plan. The regional water planning groups shall include as wholesale water providers other persons and entities that enter into contracts or that the regional water planning group expects or recommends to enter contracts to sell more than 1,000 acre-feet of water wholesale during the period covered by the plan.

Appendices

Water for Texas
2017 State Water Plan
Texas Water Development Board

Appendix A.1 Background on Texas' water planning history, institutions, and laws

A.1.1 Early Texas water planning history

While formal statewide water planning did not begin in earnest until the 1950s, the Texas Legislature began assigning responsibility for managing and developing the state's water resources to various entities starting in the early 20th century. Partly as a result of a series of devastating droughts and floods, the early 1900s saw a flurry of activity. In 1904, a Texas constitutional amendment was adopted authorizing the first public development of water resources. The legislature authorized the creation of drainage districts in 1905, the Texas Board of Water Engineers in 1913, conservation and reclamation districts (later known as river authorities) in 1917, freshwater supply districts in 1919, and water control and improvement districts in 1925.

The creation of the Texas Board of Water Engineers, a predecessor agency to both the Texas Commission on Environmental Quality and the Texas Water Development Board (TWDB), played a significant role in the early history of water management in the state. The major duties of the Board of Water Engineers were to approve plans for the organization of irrigation and water supply districts, approve the issuance of bonds by these districts, issue water right permits for storage and diversion of water, and make plans for the storage and use of floodwater. Later, the legislature gave the agency the authority to define and designate groundwater aquifers, authorize underground water conservation districts, conduct groundwater and surface water studies, and approve federal projects, including those constructed by the U.S. Army Corps of Engineers.

The idea of a dedicated water planning agency came to fruition not long after the state experienced the worst drought in recorded history. For Texas as a whole, the drought began in 1950; by the end of 1956, all but one of Texas' 254 counties were classified as disaster areas. The drought ended in the spring of 1957 with massive rains flooding every major river and tributary in the state. This drought represents the driest seven-year period in the state's recorded history and is still considered as Texas' statewide "drought of record," upon which most water planning in the state is based.

The drought of record was unique in that a majority of Texans felt the impacts of it at some point. Small and large cities alike faced dire situations. By the fall of 1952, Dallas faced a severe water shortage and prohibited all but necessary household use of water. In 1953 alone, 28 municipalities were forced to use emergency sources of water supply, 77 were rationing water, and 8 resorted to hauling in water from neighboring towns or rural wells. The development of additional water infrastructure during the course of the drought reduced the number of communities with shortages during later years of the drought, but still more municipalities were forced to haul in water before it was over (TBWE, 1959). The drought of the 1950s cost the state hundreds of millions of dollars and was followed by floods that caused damages estimated at $120 million (TBWE, 1958).

A.1.2 State water planning history, 1957 to 1997

The Texas Legislature responded to the drought of record by establishing the Texas Water Resources Committee in 1953 to survey the state's water problems (UTIPA, 1955). As a result of some of the committee's recommendations, the legislature passed a resolution authorizing $200 million in state bonds to help construct water conservation and supply projects and created the TWDB to administer the funds from the bond sale. Then, in a special legislative session called by Governor Price Daniel, the legislature passed the Water Planning Act of 1957, which created the Texas Water Resources Planning Division of the Board of Water Engineers, which was assigned the responsibility of water resources planning on a statewide basis. The voters of Texas subsequently approved a constitutional amendment authorizing the TWDB to administer a $200 million water development fund to help communities develop water supplies.

In June of 1960, Governor Daniel called a meeting in Austin to request that the Board of Water Engineers prepare a planning report with projects to meet the projected municipal and industrial water requirements of the state in 1980. Work quickly began on statewide studies to develop the first state water plan. The first plan—*A Plan for Meeting the 1980 Water Requirements of Texas*—was published in 1961. It described historical and present uses of surface water and groundwater by municipalities, industries, and irrigation; summarized the development of reservoirs; estimated the 1980 municipal and industrial requirements of each area of the state; provided a plan for how to meet those requirements by river basin; and discussed how the plan could be implemented.

Later plans were developed by the state and adopted in 1968, 1984, 1990, 1992, and 1997. All of the plans have recognized the growth of the state's population and the need to develop future water supplies. Earlier plans placed more reliance on the federal government, while later plans developed at the state level increasingly emphasized the importance of conservation and natural resource protection. The 1968 State Water Plan recommended the federal government continue to fund feasibility studies on importing surplus water from the lower Mississippi River (a later study found that the project was not economically feasible). The 1984 State Water Plan was the first to address water quality, water conservation and water use efficiency, and environmental water needs in detail.

While previous plans were organized by river basin, the 1990 State Water Plan projected water demand, supply, and facility needs for eight regions in the state. The 1997 State Water Plan—developed by the TWDB through a consensus process with the Texas Parks and Wildlife Department and the Texas Commission on Environmental Quality—was the first to organize the state into 16 regional planning areas.

A.1.3 Regional and state water planning since 1997

Drought conditions in the mid-1990s spurred action in Texas water planning efforts, just as they had in the 1950s. In 1996, Texas suffered an intense, 10-month drought. Reservoirs and aquifer levels declined sharply and farmers suffered widespread crop failure, with estimated economic losses in the billions of dollars. Some cities had to ration water for several months and others ran out of water entirely.

The drought of 1996 was relatively short-lived, but it lasted long enough to remind Texans of the importance of water planning. When the legislature met in 1997, Lieutenant Governor Bob Bullock declared water the primary issue for the 75th Texas Legislative Session. After lengthy debate and numerous amendments, Senate Bill 1 was passed to improve the development and management of the water resources in the state. Among other provisions relating to water supplies, financial assistance, water data collection and dissemination, and additional water management issues, the bill established the regional water planning process, which directed water planning to be conducted from the ground up.

A.1.4 State and federal water supply institutions

While the TWDB is the state's primary water planning agency, a number of state and federal agencies in Texas have responsibility for managing water resources and participate in the regional planning process. The Texas Parks and Wildlife Department, the Texas Commission on Environmental Quality, and the Texas Department of Agriculture all have non-voting representatives on each regional water planning group. They participate in developing population projections and are consulted in the development and amendment of rules governing the planning process. Other state and federal entities also participate indirectly in the regional water planning process.

State entities

The TWDB is the state's primary water supply planning and financing agency. It supports the development of the 16 regional water plans and is responsible for developing the state water plan every five years. The TWDB provides financial assistance to local governments for water supply and wastewater treatment projects, flood protection planning and flood control projects, agricultural water conservation projects, and groundwater district creation expenses. It collects data and conducts studies of the fresh water needs of the state's bays and estuaries and is responsible for all aspects of groundwater studies. The TWDB also maintains the **Texas Natural Resources Information System**, which archives, maintains, and distributes the largest collection of current and historical geographic data in the state, including more than 1 million aerial photographs. Additionally, the TWDB provides technical support to the environmental flows process and is a member of the Texas Water Conservation Advisory Council, the Drought Preparedness Council, and the Emergency Drinking Water Task Force.

The State Parks Board, originally created in 1923, was later merged with other state entities and renamed the **Texas Parks and Wildlife Department**. Today, the agency is primarily responsible for conserving, protecting, and enhancing the state's fish and wildlife resources. It maintains a system of public lands, including state parks, historic sites, fish hatcheries, and wildlife management areas; regulates and enforces commercial and recreational fishing, hunting, boating, and nongame laws; and monitors, conserves, and enhances aquatic and wildlife habitats. It reviews and makes recommendations to minimize or avoid impacts on fish and wildlife resources resulting from water projects. Additionally, the Texas Parks and Wildlife Department works with regional and state water planning stakeholders and regulatory agencies to protect and enhance water quality and to ensure adequate environmental flows for rivers, bays, and estuaries. It also provides technical support to the environmental flows process.

In 1992, to make natural resource protection more efficient, the legislature consolidated several programs into one large environmental agency now known as the **Texas Commission on Environmental Quality**. The Texas Commission on Environmental Quality is the environmental regulatory agency for the state, focusing on water quality and quantity through various state and federal programs. It issues permits for the treatment and discharge of industrial and domestic wastewater and storm water, reviews plans and specifications for public water systems, and conducts assessments of surface water and groundwater quality. The Texas Commission on Environmental Quality regulates retail water and sewer utilities and administers a portion of the Nonpoint Source Management Program. In addition, it administers the surface water rights permitting program and a dam safety program, delineates and designates Priority Groundwater Management Areas, creates some groundwater conservation districts, and enforces the requirements of groundwater management planning. It also regulates public drinking water systems and is the primary agency for enforcing the federal Safe Drinking Water Act. The Texas Commission on Environmental Quality provides support to the environmental flows process and adopts rules for environmental flow standards.

The **Texas Department of Agriculture**, established by the Texas Legislature in 1907, is led by the Texas Commissioner of Agriculture. It supports protection of agricultural crops and livestock from harmful pests and diseases, facilitates trade and market development of agricultural commodities, provides financial assistance to farmers and ranchers, and administers consumer protection, economic development, and healthy living programs.

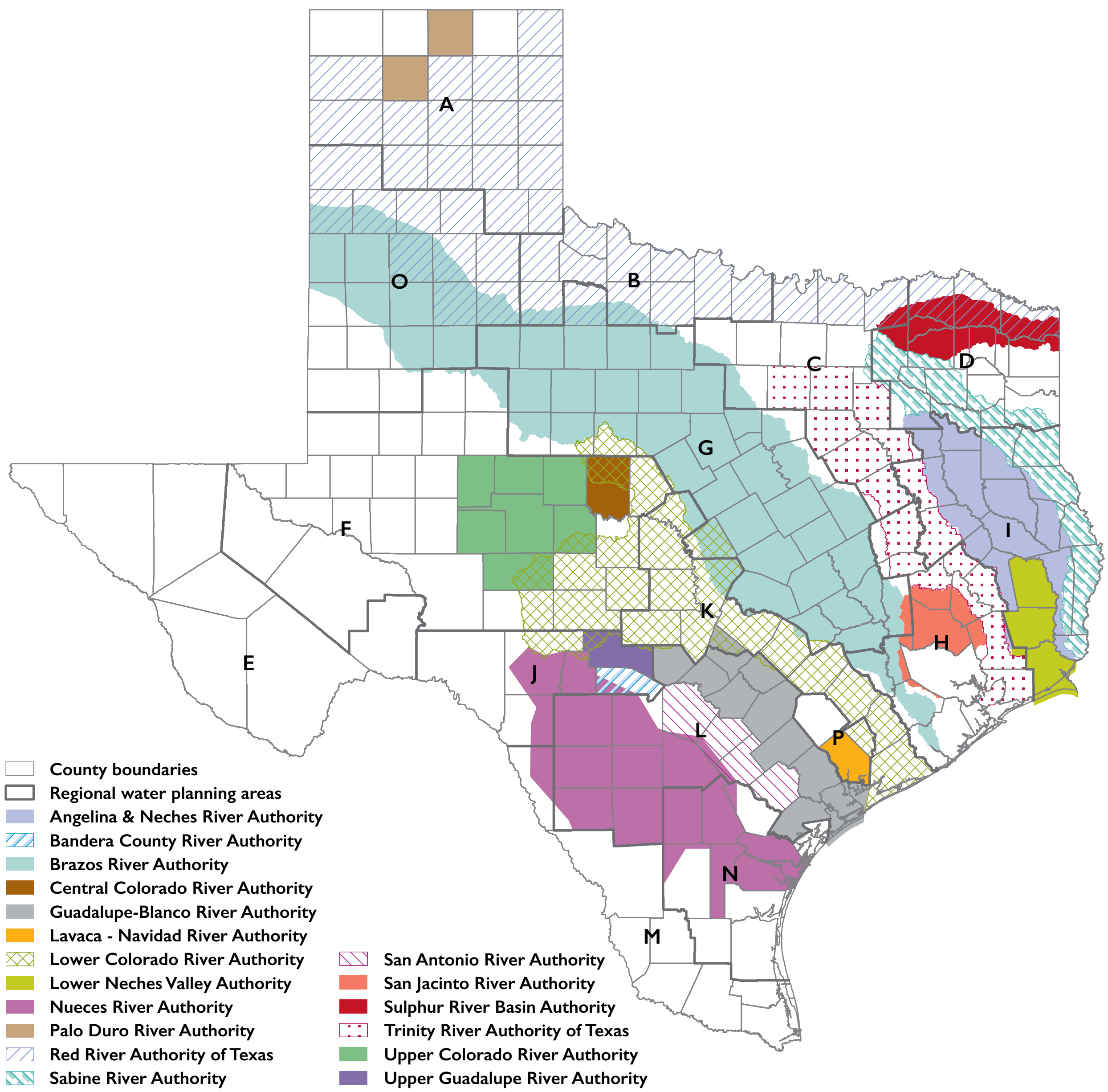
The **Public Utility Commission of Texas**, established in 1975, is led by three appointed commissioners and regulates the state's electric, telecommunication, and water and sewer utilities. In 2013, the Texas Legislature transferred the economic regulation of water and sewer utilities from the Texas Commission on Environmental Quality to the Public Utility Commission. The agency regulates water and sewer rates and services, Certificates of Convenience and Necessity, and sales/transfers/mergers.

Created in 1939, the **Texas State Soil and Water Conservation Board** administers Texas' soil and water conservation laws and coordinates conservation and nonpoint source pollution abatement programs. It also administers water quality and water supply enhancement programs.

First authorized by the legislature in 1917, **river authorities** are assigned the conservation and reclamation of the state's natural resources, including the development and management of water. They generally operate on utility revenues generated from supplying energy, water, wastewater, and other community services. There are 18 river authorities in Texas (Figure A1.1), along with similar special law districts authorized by the legislature.

The formation of **groundwater conservation districts** was first authorized by the legislature in 1949 to manage and protect groundwater at the local level. Groundwater conservation districts are governed by a local board of directors, which develops a management plan for the district with technical support from the TWDB, the Texas Commission on Environmental Quality, and other state agencies. Because most groundwater conservation districts are based on county lines and do not manage an entire aquifer, one aquifer may be managed by several groundwater districts. Each district must plan with the other districts within their common groundwater management areas to determine the desired future conditions of the aquifers within the groundwater management

Figure A1.1 - Locations of river authorities and regional water planning area boundaries



areas. As of 2015, 99 groundwater conservation districts have been established in Texas covering all or part of 174 counties, a map of which may be found on the TWDB website.

Other entities at the regional and local levels of government construct, operate, and maintain water supply and wastewater infrastructure. These include municipalities; water supply, irrigation, and municipal utility districts; flood and drainage districts; subsidence districts; and nonprofit water supply and sewer service corporations.

Federal agencies

Federal civil works projects played a major role in the early development of the state's water resources (TBWE, 1958). Historically, Texas relied heavily on federal funds to finance water development projects, with local commitments used to repay a portion of the costs. Federal agencies such as the **Soil Conservation Service**, the **U.S. Bureau of Reclamation**, and the **U.S. Army Corps of Engineers** constructed a number of surface water reservoirs in Texas. These reservoirs were built for the primary purpose of flood control but provide a large portion of the state's current water supply. The pace of federal spending on reservoir construction has declined considerably since the 1950s and 1960s, and current federal policy recognizes a declining federal interest in the long-term management of water supplies.

Several federal agencies are responsible for managing our nation's water resources. The U.S. Army Corps of Engineers investigates, develops, and maintains the nation's water and related environmental resources. Historically, the U.S. Army Corps of Engineers has been responsible for flood protection, dam safety, and the planning and construction of water projects, including reservoirs. Pursuant to the Clean Water Act and the Rivers and Harbors Act, the Corps operates a program that regulates construction and other work in the nation's waterways.

Within the **U.S. Department of the Interior**, the **U.S. Geological Survey** conducts natural resources studies and collects water-related data, and the **U.S. Bureau of Reclamation** conducts water resource planning studies and manages water resources primarily in the western United States. The **U.S. Fish and Wildlife Service**, also part of the Department of the Interior, protects fish and wildlife resources through various programs and carries out provisions of the Endangered Species Act.

The **Natural Resources Conservation Service**, part of the U.S. Department of Agriculture and successor to the Soil Conservation Service, implements soil conservation programs and works at the local level through conservation planning and assistance programs. The **U.S. Environmental Protection Agency** regulates and funds federal water quality, solid waste, drinking water, and other programs pursuant to the Clean Water Act, the Safe Drinking Water Act, and other federal laws and regulations. The **International Boundary and Water Commission** manages the waters of the Rio Grande between the United States and Mexico.

A.1.5 Management of water in Texas

Texas water law divides water into several categories for the purpose of regulation. Different rules apply to each category, determining how the water is used. This system stems from Spanish and English common law, the laws of other western states, and state and federal case law and legislation.

Surface water

In Texas, all surface water is held in trust by the state, which grants permission to use the water to different groups and individuals. Texas recognizes two basic doctrines of surface water rights: the riparian doctrine and the prior appropriation doctrine.

Under the riparian doctrine, landowners whose property is adjacent to a river or stream have the right to make reasonable use of the water. The riparian doctrine was introduced in Texas more than 200 years ago with the first Spanish settlers. In 1840, the state adopted the common law of England, which included a somewhat different version of the riparian doctrine (Templer, 2011).

In response to the scarcity of water in the western United States, Texas began to recognize the need for a prior appropriation system (Kaiser, n.d.). The prior appropriation system, first adopted by Texas in 1895, has evolved into the modern system used today. Landowners who live on many of the water bodies in the state are allowed to divert and use water for domestic and livestock purposes (not to exceed 200 acre-feet per year), but these are some of the last riparian rights still in place.

In 1913, the legislature extended the prior appropriation system to the entire state. It also established the Texas Board of Water Engineers, the agency that had original jurisdiction over all applications for appropriated water. Because different laws governed the use of surface waters at different times in Texas history, claims to water rights often conflicted with one another. In 1967, as a result of these historic conflicts, the state began to resolve claims for water rights. A "certificate of adjudication" was issued for each approved claim, limiting riparian and other unrecorded rights to a specific quantity of water. The certificate also assigned a priority date to each claim, with some dates going back to the time of the first Spanish settlements (TCEQ, 2009).

The adjudication of surface water rights gave the state the potential for more efficient management of surface waters (Templer, 2011). With only a few exceptions, surface water users today need a permit in the form of an appropriated water right from the Texas Commission on Environmental Quality. The prior appropriations system recognizes the "doctrine of priority," which gives superior rights to those who first used the water, often known as "first in time, first in right." In most of the state, water rights are prioritized only by the date assigned to them and not by the purpose for which the water will be used. Only water stored in Falcon and Amistad reservoirs in the middle and lower Rio Grande Basin is prioritized by the purpose of its use, with municipal and industrial rights having priority over irrigation rights during times of drought.

When issuing a new water right, the Texas Commission on Environmental Quality assigns a priority date, specifies the volume of water that can be used each year, and may allow users to divert or impound the water. Water rights do not guarantee that water will be available, but they are considered property interests that may be bought, sold, or leased. The agency also grants term permits and temporary permits, which do not have priority dates and are not considered property rights. The water rights system works hand in hand with the regional water planning process; the Texas Commission on Environmental Quality may not issue a new water right unless it addresses a water supply need that is consistent with the regional water plans and the state water plan.

Texas relies on the honor system in most parts of the state to protect water rights during times of drought. But in some areas, the Texas Commission on Environmental Quality has appointed a "watermaster" to oversee and continuously monitor streamflows, reservoir levels, and water use. There are three watermasters in Texas: the Rio Grande Watermaster, who among other things, coordinates releases from the Amistad and Falcon reservoir system; the Brazos Watermaster, who serves the lower portion of the Brazos River Basin; and the South Texas Watermaster, who serves the Nueces, San Antonio, Guadalupe, and Lavaca river and coastal basins. The South Texas Watermaster also serves as the Concho Watermaster, who oversees the Concho River and its tributaries in the Colorado River Basin.

Groundwater

Groundwater in Texas is managed differently than surface water. Historically, Texas has followed the English common law rule that landowners have the right to capture or remove all of the water that can be captured from beneath their land. In part, the rule was adopted because the science of quantifying and tracking the movement of groundwater was so poorly developed at the time that it would have been practically impossible to administer any set of legal rules to govern its use. The 1904 case and later court rulings established that landowners, with few exceptions, may pump as much water as they choose without liability. Today, Texas is the only western state that continues to follow the rule of capture.

In 1949, in an attempt to balance landowner interests with limited groundwater resources, the legislature authorized the creation of groundwater conservation districts to manage groundwater locally. Although the science of groundwater is much better developed (the TWDB has groundwater availability models for all of the major aquifers and most of the minor aquifers in the state), groundwater is still governed by the rule of capture, unless under the authority of a groundwater conservation district. Senate Bill 1 in 1997 reaffirmed state policy that groundwater conservation districts are the state's preferred method of groundwater management.

Since the original legislation creating groundwater districts in 1949, the legislature has made several changes to the way groundwater is managed in the state while still providing for local management. Most significantly, legislation in 2005 required groundwater conservation districts to meet regularly and to define the "desired future conditions" of the groundwater resources within designated groundwater management areas. Based on these desired future conditions, the TWDB delivers modeled available groundwater values to groundwater conservation districts and planning groups for inclusion in their plans.

Groundwater districts can be created by four possible methods: action of the Texas Legislature, petition by property owners, initiation by the Texas Commission on Environmental Quality, or addition of territory to an existing district. Districts may regulate both the location and production of wells, with certain voluntary and mandatory exemptions. They are also required to adopt management plans that include goals to provide the most efficient use of groundwater. The goals must also address drought, other natural resource issues, and adopted desired future conditions. The management plan must include estimates of modeled available groundwater based on desired future conditions and must address water supply needs and water management strategies in the state water plan.

Texas groundwater law continues to evolve through recent court cases and ongoing litigation. It is unclear exactly how these recent cases will affect the broad scope of groundwater law as appeals are decided and new litigation is brought.

The TWDB and the Texas Commission on Environmental Quality are the primary state agencies involved in supporting groundwater conservation districts to implement the groundwater management plan requirements. Along with determining values for modeled available groundwater based on desired future conditions of the aquifer, the TWDB provides technical and financial support to districts, reviews and administratively approves management plans, performs groundwater availability and water-use studies, and is responsible for the delineation and designation of groundwater management areas.

The Texas Commission on Environmental Quality provides technical assistance to districts and is responsible for enforcing the adoption, approval, and implementation of management plans. The agency also evaluates designated priority groundwater management areas—areas that are experiencing or are expected to experience critical groundwater problems within 50 years, including shortages of surface water or groundwater, land subsidence resulting from groundwater withdrawal, and contamination of groundwater supplies.

Surface water quality

The Texas Commission on Environmental Quality is charged with managing the quality of the state's surface water. Guided by the federal Clean Water Act and state law and regulations, the agency classifies water bodies and sets water quality standards. Water quality standards consist of two parts: the purposes for which surface water will be used (aquatic life, contact recreation, water supply, or fish consumption) and criteria that will be used to determine if the use is being supported. Water quality data are gathered regularly to monitor the condition of the state's surface waters and to determine if standards are being met. Through the Texas Clean Rivers Program, the Texas Commission on Environmental Quality works in partnership with state, regional, and federal entities to coordinate water quality monitoring, assessment, and stakeholder participation to improve the quality of surface water within each river basin.

Every two years, Texas submits a report to the U.S. Environmental Protection Agency that lists the status of all the waters in the state and identifies those that do not meet water quality standards. When water bodies do not meet standards, the Texas Commission on Environmental Quality may develop a restoration plan, evaluate the appropriateness of the standard, or collect more data and information. For water bodies with significant impairments, the agency must develop a scientific allocation called a "total maximum daily load" to determine the maximum amount of a pollutant that a water body can receive from all sources, including point and nonpoint sources, and still maintain water quality standards set for its use.

Drinking water

The Texas Commission on Environmental Quality is also responsible for protecting the quality and safety of drinking water through primary and secondary standards. In accordance with the federal Safe Drinking Water Act and state law and regulations, primary drinking water standards protect public health by limiting the levels of certain contaminants, and secondary drinking water quality standards address taste, color, and odor. Public drinking water systems must comply with certain construction and operational standards, and they must continually monitor water quality and file regular reports with the Texas Commission on Environmental Quality.

Interstate waters

Texas is a member of five interstate river compacts with neighboring states to manage the Rio Grande, Pecos, Canadian, Sabine, and Red rivers. The compacts, as ratified by the legislature of each participating state and the U.S. Congress, represent agreements that establish how water should be allocated. Each compact is administered by a commission of state representatives and, in some cases, a representative of the federal government appointed by the president. Compact commissions protect the states' rights and work to prevent and resolve any disputes over water. The compact commissions are authorized to plan for river operations, monitor activities affecting water quantity and quality, and engage in water accounting and rule-making. To administer the five compacts in Texas, the Texas Commission on Environmental Quality provides administrative and technical support to each commission and maintains databases of river flows, diversions, and other information.

A.1.6 Key state water planning statutes and rules

Texas Water Code §§16.022, 16.051, 16.053, 16.054, and 16.055.

31 Texas Administrative Code Chapters 355, 357, and 358.

References

Kaiser, R.A., n.d., Handbook of Texas water law—Problems and needs: Texas Water Resources Institute, Texas A&M University, 46 p. texaswater.tamu.edu/resources/2002-037_waterlaw.pdf

TBWE (Texas Board of Water Engineers), 1958, Texas water resources planning at the end of the year 1958—A progress report to the fifty-sixth legislature: Texas Board of Water Engineers, 113 p.

TBWE (Texas Board of Water Engineers), 1959, A study of droughts in Texas: Texas Board of Water Engineers Bulletin 5914, 76 p.

TCEQ (Texas Commission on Environmental Quality), 2009, Rights to surface water in Texas: Texas Commission on Environmental Quality Publication Number GI-228, 19 p.

Templer, O.W., 2011, Water law *in* Handbook of Texas Online: Texas State Historical Association, tshaonline.org/handbook/online/articles/gyw01

UTIPA (University of Texas Institute of Public Affairs), 1955, The fifty-fourth Texas legislature—A review of its work: The University of Texas, 34 p. www.lrl.state.tx.us/scanned/sessionOverviews/review/54th.pdf

Appendix B.1 Annual surface water availability by river and coastal basin (acre-feet)

Surface water basin	2020	2030	2040	2050	2060	2070	Percent change
Brazos	1,380,355	1,375,437	1,370,505	1,365,548	1,360,593	1,355,302	-2
Brazos-Colorado	12,946	12,946	12,946	12,946	12,946	12,946	0
Canadian	17,133	17,091	17,049	17,008	16,966	16,924	-1
Colorado	998,891	992,217	985,533	978,343	970,653	963,471	-4
Colorado-Lavaca	4,852	4,852	4,852	4,852	4,852	4,852	0
Cypress	306,648	304,974	303,438	301,932	300,323	298,683	-3
Guadalupe	206,660	206,520	206,380	206,240	206,100	205,960	0
Lavaca	79,710	79,710	79,710	79,710	79,710	79,710	0
Lavaca-Guadalupe	319	319	319	319	319	319	0
Neches	2,344,766	2,342,204	2,339,778	2,337,623	2,335,690	2,333,680	0
Neches-Trinity	95,440	95,440	95,440	95,440	95,440	95,440	0
Nueces	164,666	163,266	161,867	160,467	159,068	157,668	-4
Nueces-Rio Grande	8,471	8,471	8,471	8,471	8,471	8,471	0
Red	507,065	502,923	498,777	494,643	490,513	486,307	-4
Rio Grande	1,228,488	1,227,132	1,225,775	1,224,419	1,223,063	1,221,706	-1
Sabine	1,706,628	1,701,787	1,696,937	1,691,770	1,686,448	1,682,147	-1
Sabine-Louisiana	336	336	336	336	336	336	0
San Antonio	62,823	62,824	62,824	62,825	62,834	62,834	0
San Antonio-Nueces	991	991	991	991	991	991	0
San Jacinto	271,322	268,622	265,922	263,222	260,522	257,822	-5
San Jacinto-Brazos	38,826	38,826	38,826	38,826	38,826	38,826	0
Sulphur	447,273	416,132	382,992	350,154	315,150	272,012	-39
Trinity	2,443,343	2,431,229	2,418,982	2,406,698	2,394,474	2,382,646	-2
Trinity-San Jacinto	35,316	35,316	35,316	35,316	35,316	35,316	0
Texas	**12,363,268**	**12,289,565**	**12,213,966**	**12,138,099**	**12,059,604**	**11,974,369**	**-3**

Appendix B.2 Annual groundwater availability by aquifer (acre-feet) *(page 1 of 2)*

Aquifer	2020	2030	2040	2050	2060	2070	Percent change
Austin Chalk	7,863	7,863	7,863	7,863	7,863	7,863	0
Blaine	346,180	346,180	346,180	346,180	344,878	343,593	-1
Blossom	2,273	2,273	2,273	2,273	2,273	2,273	0
Bone Spring-Victorio Peak	101,429	101,429	101,429	101,429	101,429	101,429	0
Brazos River Alluvium	107,960	107,960	107,960	107,960	107,960	107,960	0
Buda Limestone	758	758	758	758	758	758	0
Capitan Reef Complex	29,021	29,021	29,021	29,021	29,021	29,021	0
Carrizo-Wilcox	881,948	896,875	917,443	935,524	943,637	943,601	7
Dockum	116,685	116,685	116,685	116,685	116,685	116,685	0
Edwards (Balcones Fault Zone)	342,700	342,700	342,700	342,700	342,700	342,700	0
Edwards-Trinity (High Plains)	56,766	40,707	33,270	26,783	22,924	11,480	-80
Edwards-Trinity (Plateau)	473,455	473,455	473,455	473,455	473,455	473,455	0
Ellenburger-San Saba	46,896	46,896	46,896	46,896	46,896	46,896	0
Guadalupe River Alluvium	215	215	215	215	215	215	0
Gulf Coast	1,766,661	1,696,170	1,696,151	1,696,230	1,696,513	1,696,513	-4
Hickory	33,634	33,634	33,634	33,634	33,634	33,634	0
Hueco-Mesilla Bolsons	496,000	496,000	496,000	496,000	496,000	496,000	0
Igneous	11,333	11,333	11,332	11,329	11,327	11,327	0
Leona Gravel	31,402	31,402	31,402	31,402	31,402	31,402	0
Lipan	45,579	45,579	45,579	45,579	45,579	45,579	0
Marathon	7,327	7,327	7,327	7,327	7,327	7,327	0
Marble Falls	16,389	16,389	16,389	16,389	16,389	16,389	0
Nacatoch	13,774	13,774	13,774	13,774	13,774	13,774	0
Navasota River Alluvium	2,216	2,216	2,216	2,216	2,216	2,216	0
Nueces River Alluvium	5,719	5,719	5,719	5,719	5,719	5,719	0
Ogallala	4,790,905	4,361,654	3,929,605	3,508,380	3,112,588	2,753,590	-43
Ogallala/Rita Blanca[a]	742,022	646,077	561,411	485,779	419,589	362,421	-51
Other	294,136	294,136	294,136	294,136	294,136	294,136	0

[a] The Ogallala/Rita Blanca and the Pecos Valley/Edwards-Trinity (Plateau) are aquifer combinations that reflect specific and mutual aquifer properties, undifferentiated groundwater usage, and groundwater availability model characteristics. In these cases, the modeled available groundwater and existing supply values have likewise been developed to honor these aquifer combinations.

Appendix B.2 Annual groundwater availability by aquifer (acre-feet) *(page 2 of 2)*

Aquifer	2020	2030	2040	2050	2060	2070	Percent change
Pecos Valley	55,588	55,588	55,588	55,588	55,588	55,588	0
Pecos Valley/ Edwards-Trinity (Plateau)[a]	354,412	354,412	354,412	354,412	354,412	354,412	0
Queen City	263,925	265,354	263,215	262,541	262,202	262,202	-1
Rustler	15,222	15,222	15,222	15,222	15,222	15,222	0
San Bernard River Alluvium	520	520	520	520	520	520	0
San Jacinto River Alluvium	1,450	1,450	1,450	1,450	1,450	1,450	0
Seymour	169,375	159,281	151,401	147,751	149,652	148,728	-12
Sparta	33,334	39,625	37,890	39,015	38,968	38,968	17
Trinity	414,898	414,805	414,503	414,170	414,125	414,125	0
Trinity River Alluvium	3,913	3,913	3,913	3,913	3,913	3,913	0
West Texas Bolsons	79,045	78,844	78,553	78,349	78,220	78,220	-1
Woodbine	44,885	44,885	44,885	44,885	44,885	44,885	0
Yegua-Jackson	100,988	100,988	100,988	100,988	100,605	100,605	0
Texas	**12,308,801**	**11,709,314**	**11,193,363**	**10,704,440**	**10,246,649**	**9,816,794**	**-20**

[a] The Ogallala/Rita Blanca and the Pecos Valley/Edwards-Trinity (Plateau) are aquifer combinations that reflect specific and mutual aquifer properties, undifferentiated groundwater usage, and groundwater availability model characteristics. In these cases, the modeled available groundwater and existing supply values have likewise been developed to honor these aquifer combinations.

Appendix B.3 Annual surface water existing supplies by river and coastal basin (acre-feet)

Surface water basin	2020	2030	2040	2050	2060	2070	Percent change
Brazos	1,120,993	1,118,742	1,116,839	1,111,664	1,108,955	1,103,767	-2
Brazos-Colorado	10,225	10,225	10,225	10,225	10,225	10,225	0
Canadian	13,216	13,216	13,216	13,216	13,216	13,216	0
Colorado	832,901	832,566	831,819	827,893	820,917	815,303	-2
Colorado-Lavaca	4,353	4,353	4,353	4,353	4,353	4,353	0
Cypress	188,532	187,839	187,170	186,614	187,141	187,158	-1
Guadalupe	194,982	194,961	192,885	192,758	192,624	192,488	-1
Lavaca	78,517	78,517	78,517	78,517	78,517	78,517	0
Lavaca-Guadalupe	319	319	319	319	319	319	0
Neches	660,920	765,093	784,057	802,068	821,037	840,951	27
Neches-Trinity	90,617	90,617	90,617	90,617	90,617	90,617	0
Nueces	127,977	139,319	149,002	155,414	156,026	155,903	22
Nueces-Rio Grande	949	949	949	949	949	949	0
Red	242,852	238,974	233,993	229,320	225,218	221,248	-9
Rio Grande	897,351	896,504	895,163	894,781	893,621	892,999	0
Sabine	506,627	478,236	475,466	475,013	469,817	466,842	-8
Sabine-Louisiana	336	336	336	336	336	336	0
San Antonio	62,823	62,824	62,824	62,825	62,834	62,834	0
San Antonio-Nueces	991	991	991	991	991	991	0
San Jacinto	189,676	190,824	191,533	190,825	190,089	189,305	0
San Jacinto-Brazos	35,860	35,929	35,998	36,068	36,137	36,206	1
Sulphur	260,074	258,748	255,668	254,442	253,054	217,880	-16
Trinity	1,906,762	1,885,047	1,857,794	1,836,776	1,816,072	1,799,146	-6
Trinity-San Jacinto	35,316	35,316	35,316	35,316	35,316	35,316	0
Texas[a]	**7,463,169**	**7,520,445**	**7,505,050**	**7,491,300**	**7,468,381**	**7,416,869**	**-1**

[a] *Does not reflect some portions of existing supplies that are associated with purely saline water sources such as untreated seawater*

Appendix B.4 Annual groundwater existing supplies by aquifer (acre-feet) *(page 1 of 2)*

Aquifer	2020	2030	2040	2050	2060	2070	Percent change
Austin Chalk	2,663	2,663	2,663	2,663	2,663	2,663	0
Blaine	29,108	28,492	27,554	25,922	24,282	22,646	-22
Blossom	723	679	351	351	351	351	-51
Bone Spring-Victorio Peak	63,929	63,929	63,929	63,929	63,929	63,929	0
Brazos River Alluvium	52,467	52,467	52,467	52,467	52,467	52,467	0
Buda Limestone	525	525	525	525	525	525	0
Capitan Reef Complex	12,685	12,685	12,685	12,685	12,685	12,685	0
Carrizo-Wilcox	591,099	592,343	593,974	595,377	594,052	593,758	0
Dockum	43,906	44,869	45,081	46,029	45,860	45,740	4
Edwards (Balcones Fault Zone)	308,168	308,168	308,168	308,168	308,168	308,168	0
Edwards-Trinity (High Plains)	4,881	4,881	4,881	4,881	4,777	4,673	-4
Edwards-Trinity (Plateau)	255,991	254,540	250,267	245,545	240,637	238,004	-7
Ellenburger-San Saba	17,274	17,264	17,242	17,211	16,880	16,276	-6
Guadalupe River Alluvium	215	215	215	215	215	215	0
Gulf Coast	1,234,093	1,169,936	1,175,026	1,179,715	1,183,329	1,186,458	-4
Hickory	20,304	20,101	19,728	19,460	19,229	19,022	-6
Hueco-Mesilla Bolsons	146,555	146,555	146,555	146,555	146,555	146,555	0
Igneous	7,311	7,311	7,311	7,311	7,311	7,311	0
Leona Gravel	10,767	10,967	11,270	11,551	11,851	12,094	12
Lipan	45,439	45,463	45,452	45,395	45,417	45,439	0
Marathon	127	127	127	127	127	127	0
Marble Falls	6,151	6,151	6,151	6,151	6,151	6,151	0
Nacatoch	6,527	6,563	6,565	6,510	6,471	6,388	-2
Navasota River Alluvium	-	-	-	-	-	-	na
Nueces River Alluvium	748	748	748	748	748	748	0
Ogallala	2,865,940	2,581,492	2,246,007	1,985,484	1,766,241	1,474,056	-49
Ogallala/Rita Blanca[a]	564,727	495,177	433,544	377,961	328,607	279,322	-51
Other	203,540	203,562	202,022	201,107	200,708	200,509	-1

[a] The Ogallala/Rita Blanca and the Pecos Valley/Edwards-Trinity (Plateau) are aquifer combinations that reflect specific and mutual aquifer properties, undifferentiated groundwater usage, and groundwater availability model characteristics. In these cases, the modeled available groundwater and existing supply values have likewise been developed to honor these aquifer combinations.

na = not applicable

Appendix B.4 Annual groundwater existing supplies by aquifer (acre-feet) *(page 2 of 2)*

Aquifer	2020	2030	2040	2050	2060	2070	Percent change
Pecos Valley	19,210	19,786	19,632	19,372	19,109	18,924	-1
Pecos Valley/ Edwards-Trinity (Plateau)[a]	127,310	128,302	127,515	126,110	124,738	123,523	-3
Queen City	23,252	23,564	23,837	24,161	24,303	24,776	7
Rustler	2,521	2,521	2,521	2,521	2,521	2,521	0
San Bernard River Alluvium	-	-	-	-	-	-	na
San Jacinto River Alluvium	-	-	-	-	-	-	na
Seymour	152,886	144,959	137,738	134,121	135,379	133,548	-13
Sparta	18,930	20,367	20,446	20,498	20,523	20,577	9
Trinity	256,804	258,511	260,628	262,414	264,763	267,363	4
Trinity River Alluvium	-	-	-	-	-	-	na
West Texas Bolsons	44,216	44,216	44,216	44,216	44,216	44,216	0
Woodbine	33,726	33,635	33,649	33,572	33,608	33,561	0
Yegua-Jackson	16,462	16,553	16,624	16,714	16,411	16,437	0
Texas[b]	**7,191,180**	**6,770,287**	**6,367,314**	**6,047,742**	**5,775,807**	**5,431,726**	**-24**

[a] The Ogallala/Rita Blanca and the Pecos Valley/Edwards-Trinity (Plateau) are aquifer combinations that reflect specific and mutual aquifer properties, undifferentiated groundwater usage, and groundwater availability model characteristics. In these cases, the modeled available groundwater and existing supply values have likewise been developed to honor these aquifer combinations.

[b] Does not reflect some portions of existing supplies that are associated with purely saline water sources

na = not applicable

Appendix C.1 Annual water needs by region and water use category (acre-feet) (page 1 of 3)

Region	Water use category	2020	2030	2040	2050	2060	2070
A	Irrigation	156,704	185,043	192,876	180,151	165,133	148,519
	Manufacturing	4,017	6,986	10,048	14,243	18,369	22,538
	Municipal	10,074	24,142	38,521	52,624	66,847	81,559
A Total		**170,795**	**216,171**	**241,445**	**247,018**	**250,349**	**252,616**
B	Irrigation	22,518	23,214	24,287	25,717	28,281	30,841
	Livestock	130	130	130	130	130	130
	Manufacturing	1,254	1,361	1,518	1,710	1,771	1,829
	Mining	1,570	583	476	131	67	67
	Municipal	8,060	8,607	9,092	9,652	10,252	10,848
	Steam-electric	1,289	2,140	2,990	3,841	4,691	5,541
B Total		**34,821**	**36,035**	**38,493**	**41,181**	**45,192**	**49,256**
C	Irrigation	460	484	509	526	539	548
	Manufacturing	2,649	11,322	20,899	29,076	36,694	44,363
	Mining	6,204	5,756	7,089	9,635	12,198	15,956
	Municipal	106,718	319,284	539,183	750,997	981,697	1,227,956
	Steam-electric	9,006	30,361	36,336	44,038	55,098	67,549
C Total		**125,037**	**367,207**	**604,016**	**834,272**	**1,086,226**	**1,356,372**
D	Irrigation	30,763	30,696	30,479	30,021	29,589	29,402
	Manufacturing	61,557	72,166	87,466	100,894	120,136	175,740
	Mining	2,888	3,265	2,935	2,274	1,700	1,363
	Municipal	22,341	25,306	29,850	32,424	39,003	51,390
	Steam-electric	32,643	45,291	64,237	88,459	117,157	152,800
D Total		**150,192**	**176,724**	**214,967**	**254,072**	**307,585**	**410,695**
E	Irrigation	170,012	162,417	148,458	138,978	130,982	123,894
	Manufacturing	8,841	9,968	11,058	11,985	13,461	15,050
	Mining	740	1,577	1,694	1,521	1,885	2,440
	Municipal	5,623	10,265	14,734	28,319	43,442	58,011
	Steam-electric	3,651	4,825	6,255	7,998	10,124	12,651
E Total		**188,867**	**189,052**	**182,199**	**188,801**	**199,894**	**212,046**
F	Irrigation	113,745	113,158	111,096	111,365	111,501	109,960
	Livestock	368	397	403	420	446	445
	Manufacturing	3,528	3,718	4,202	4,663	5,277	5,917
	Mining	15,516	15,180	10,334	5,402	2,629	1,480
	Municipal	36,262	45,204	56,120	66,651	77,674	88,349
	Steam-electric	13,568	15,847	18,560	22,029	26,317	30,786
F Total		**182,987**	**193,504**	**200,715**	**210,530**	**223,844**	**236,937**

Appendix C.1 Annual water needs by region and water use category (acre-feet) *(page 2 of 3)*

Region	Water use category	2020	2030	2040	2050	2060	2070
G	Irrigation	83,218	83,258	83,455	77,447	70,261	67,066
	Manufacturing	7,179	7,263	8,620	9,771	11,040	12,319
	Mining	41,731	50,127	50,494	53,675	57,802	64,121
	Municipal	32,314	61,776	102,132	149,644	202,496	259,402
	Steam-electric	70,834	88,264	99,300	128,694	144,204	162,658
G Total		**235,276**	**290,688**	**344,001**	**419,231**	**485,803**	**565,566**
H	Irrigation	108,121	107,656	110,704	113,170	115,336	117,339
	Livestock	2,397	2,664	2,919	3,065	3,248	3,418
	Manufacturing	88,084	122,722	150,674	186,714	199,735	212,904
	Mining	4,817	5,619	5,114	5,160	5,388	5,746
	Municipal	141,908	310,606	420,866	523,604	635,865	760,957
	Steam-electric	1,707	5,325	9,115	14,707	24,383	61,400
H Total		**347,034**	**554,592**	**699,392**	**846,420**	**983,955**	**1,161,764**
I	Irrigation	3,518	4,011	4,452	4,812	5,076	5,427
	Livestock	3,011	4,212	5,663	7,419	9,541	9,983
	Manufacturing	195,313	286,821	308,893	329,416	348,617	368,917
	Mining	9,586	7,160	2,794	2,338	2,048	1,916
	Municipal	121	534	1,476	4,582	8,871	13,629
	Steam-electric	25,422	32,807	43,269	56,482	80,437	108,136
I Total		**236,971**	**335,545**	**366,547**	**405,049**	**454,590**	**508,008**
J	Irrigation	143	143	142	142	141	141
	Livestock	214	214	214	214	214	214
	Mining	38	98	112	76	47	43
	Municipal	3,462	3,768	3,925	4,033	4,143	4,228
J Total		**3,857**	**4,223**	**4,393**	**4,465**	**4,545**	**4,626**
K	Irrigation	335,489	319,584	304,106	289,044	274,387	260,124
	Manufacturing	570	692	810	913	1,059	1,216
	Mining	4,260	8,618	9,747	10,719	12,153	14,164
	Municipal	7,881	28,176	45,883	67,359	119,888	182,173
	Steam-electric	25,363	26,751	26,775	31,974	42,212	54,627
K Total		**373,563**	**383,821**	**387,321**	**400,009**	**449,699**	**512,304**
L	Irrigation	105,799	97,325	89,057	81,302	73,968	67,383
	Manufacturing	6,308	9,897	13,453	18,929	28,871	40,034
	Mining	10,822	10,481	8,694	5,138	2,073	666
	Municipal	72,636	108,068	148,627	197,279	249,846	304,164
	Steam-electric	4,506	29,778	37,178	53,599	70,696	70,696
L Total		**200,071**	**255,549**	**297,009**	**356,247**	**425,454**	**482,943**

Appendix C.1 Annual water needs by region and water use category (acre-feet) *(page 3 of 3)*

Region	Water use category	2020	2030	2040	2050	2060	2070
M	Irrigation	658,049	608,580	557,158	502,526	447,439	448,029
	Manufacturing	2,529	3,388	4,243	4,994	5,992	7,067
	Mining	5,290	4,641	5,488	5,565	5,758	6,337
	Municipal	48,534	86,393	132,173	190,834	251,976	312,410
	Steam-electric	2,984	5,635	8,866	12,805	17,608	23,501
M Total		**717,386**	**708,637**	**707,928**	**716,724**	**728,773**	**797,344**
N	Irrigation	40	42	44	545	2,112	4,242
	Manufacturing	6,451	8,804	11,126	15,077	26,735	38,132
	Mining	2,733	3,269	3,219	1,087	315	0
	Municipal	1,583	1,575	1,567	1,607	1,646	1,683
	Steam-electric	0	0	0	0	2,846	6,893
N Total		**10,807**	**13,690**	**15,956**	**18,316**	**33,654**	**50,950**
O	Irrigation	1,683,573	1,795,897	1,948,130	2,003,648	2,024,629	2,139,648
	Livestock	12,134	14,505	12,889	16,273	18,793	17,631
	Manufacturing	5,224	4,968	4,462	4,935	6,769	7,316
	Mining	9,921	11,705	11,291	10,314	8,626	7,337
	Municipal	13,233	24,556	30,937	38,977	47,923	56,371
	Steam-electric	7,747	6,617	3,189	4,185	5,474	11,793
O Total		**1,731,832**	**1,858,248**	**2,010,898**	**2,078,332**	**2,112,214**	**2,240,096**
P	Irrigation	50,285	50,285	50,285	50,285	50,285	50,285
P Total		**50,285**	**50,285**	**50,285**	**50,285**	**50,285**	**50,285**
	Texas	**4,759,781**	**5,633,971**	**6,365,565**	**7,070,952**	**7,842,062**	**8,891,808**

Texas Water Development Board

www.twdb.texas.gov

texasstatewaterplan.org

2017 State Water Plan

Water — *for* — Texas

Texas Water Development Board

1700 North Congress Avenue
P.O. Box 13231
Austin, Texas 78711-3231

www.twdb.texas.gov
texasstatewaterplan.org