2022

State Water Plan

WATER FOR TEXAS

Texas Water Development Board

2022 State Water Plan

Water
for
Texas

Texas Water Development Board

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Our Mission

To lead the state's efforts in ensuring a
secure water future for Texas and its citizens.

Texas Water Development Board

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Austin, TX 78711-3231, www.twdb.texas.gov
Phone (512) 463-7847, Fax (512) 475-2053

Dear Fellow Texans:

On behalf of my fellow Board member, Kathleen Jackson, I am honored to deliver to you the 2022 State Water Plan. Adoption of this plan marks the fifth state water plan created through a near quarter century of successful implementation of Texas' widely recognized regional water planning process. This transparent process continues to evolve and provide Texas with a clear and credible path to providing water to protect its growing economy and the more than 50 million Texans anticipated to be here by 2070.

Developing the state water plan is only possible through the support of our sister agencies, regional water planning group sponsors and their staff, and many technical consultants, along with input from water providers, water districts, and professionals representing a wide variety of relevant interest groups. I am impressed by the dedication of the more than 480 regional water planning group members who volunteered their time and sustained their focus throughout the process to ensure water is available for Texans in the years to come. I am also deeply grateful to every stakeholder, especially the general public, who offered their own time and energy to improve our regional and state water plans as part of this bottom-up process.

Texas' visionary water planning approach is founded on extensive data and science and guided by a robust framework that requires all 16 regional planning groups to address their water supply needs openly and genuinely. The resulting regional and state water plans set forth thousands of specific, actionable strategies and projects—costs and sponsors included—that clearly demonstrate how Texas will be able to withstand future droughts. No other state delivers this level of specificity and credibility in its water plan.

We do not, in other words, just plan for the sake of planning. Through vision and foresight and a commitment and endorsement by the legislature and citizens of Texas, those strategies and projects are being implemented to ensure a secure water future for Texas. Our agency is committed to continually improve data collection, water science, and other tools in support of better planning that will result in projects with tangible benefits for the state.

Since establishing the State Water Implementation Fund for Texas (SWIFT) funding program in 2015, the Texas Water Development Board has, through its innovative structure and efficient subsidies, helped finance the implementation of more than 50 recommended state water plan projects that will provide about 1.5 million acre-feet per year of additional water supply—a clear testament to the state's wisdom and commitment to protect Texans and our economy. SWIFT has already funded, among many other projects, the construction of Texas' first new major reservoirs in decades and one of the largest active water treatment plant construction projects in the country.

I cannot thank enough the hundreds of water planning stakeholders who poured thousands of hours of effort into this process. I also want to acknowledge that developing these robust state water plans would be impossible without our statutory planning framework and the substantial support we consistently receive from the Texas Legislature.

Brooke T. Paup

Brooke T. Paup, Chairwoman

Acknowledgments

The 2022 State Water Plan would not have been possible without the time, dedication, guidance, and expertise of numerous people and organizations throughout Texas. The Texas Water Development Board (TWDB) would like to extend its sincere gratitude and appreciation to everyone who participated in developing the 16 regional water plans and this state water plan: the more than 480 regional water planning group voting members (listed below), their consultants, and their administrative agents (also listed below); staff of the TWDB, Texas Parks and Wildlife Department, Texas Department of Agriculture, Texas Commission on Environmental Quality, Texas State Soil and Water Conservation Board, and other state and federal agencies; and the individuals and organizations that provided public input throughout the planning process.

The TWDB would also like to thank the leadership of the State of Texas for their continued support of the state's water planning process.

Regional Water Planning Group Voting Members

(Region - Member) *planning group chairs at the time the 2021 regional water plans were adopted

A - Allred, Don
A - Autrey, Emmett
A - Auvermann, Ph.D., Brent
A - Baumgardner, Joe
A - Clark, Nolan
A - Cook, Vernon
A - Cooke, Dean
A - Derington, Jim
A - Gibson, Rick
A - Gilmore, Rusty
A - Green, Glen
A - Guthrie, Janet
A - Hallerberg, William
A - Hartman, Floyd
A - Kidd, Bobbie
A - Kleuskens, Tonya
A - Krienke, Danny
A - Landis, David
A - Messer, Roy (Hank)
A - Pool, Dillon
A - Raef Kizziar, Donna
A - Satterwhite, Kent
A - Smith, Lynn
A - Stephens, Beverly
A - Sweeten, John M.
A - Tregellas, Janet
A - Walthour, Steve
A - Weinheimer, Ben
*A - Williams, C.E.**
B - Armstrong, Tamela
B - Banks, Jimmy
B - Brite, J.K. Rooter
B - Campbell, Curtis
B - Campsey, Jack
B - Christopher, Mark
B - Deweber, N.E.
B - Dodge, Rebecca L.
B - Dodson, Carrie
B - Holub, Tommy
B - Hughes, Dale
B - Jackson, Randy
B - Jarosek, Joe
B - Kennon, Darell
B - Kidd, Bobby
B - Lewis, Steve
B - Liggett, Kenneth
B - McGuire, Mike
B - McMahon, Monte
B - Mesler, Tracy
B - Miller, Kyle
B - Myers, Dean
B - Ownbey, Heath
B - Payne, Jerry
B - Scaling, Wilson
*B - Schreiber, Russell**
B - Simpson, Gayle
B - Thomas, Todd
B - Whiteman, Randy
C - Bailey, David
C - Banks, Kenneth
C - Barksdale, Jay
C - Boyd, Chris
C - Carman, John
C - Ceverha, Bill
C - Darling, Grace
C - Dineen, III, John Paul
C - Douglas, Gary
C - Fisher, Tim
C - Harder, P.E., Christopher
C - Hotopp, James
C - Kula, Tom
C - Latham, Harold
C - Laughlin, Russell
C - Lingenfelder, John
C - Maenius, G.K.
C - Martin, Howard
C - McCarter, Jim
C - Mundt, Steve
C - Puckett, Jo "Jody"
C - Rickman, Mike
C - Riley, Bob
C - Satterwhite, Drew
C - Shaffer, Rick
C - Spicer, Gary
C - Standridge, Connie
C - Stevens, Jack
C - Wagner, P.E., Richard
*C - Ward, Kevin**
C - Woodward, Tom
D - Acker, Russell
D - Bartley, Wade
D - Beeler, Allen
D - Belcher, Brandon
D - Bradley, Bruce
D - Bradley, Johnny Mack
D - Brooks, John
D - Bumgarner, Joe
D - Calvin, Larry
D - Carter, Greg
D - Coats, Joe
D - Conner, Doug
D - Duffee, Donnie
D - Dumon, JoAnn
D - Evans, Danny
D - Fierro, Nicolas
D - Frost, George
D - Gaskill, Jerry
D - Glidewell, Brice
D - Gwinn, Cindy
D - Hilliard, Dennis
D - King, Conrad
D - Kirby, Bill
D - LeTourneau, Richard
D - McCoy, Janet
D - McCoy, Mike
D - McPhee, Rolin
D - Milton, Fred
D - Muse, Ned
D - Nabors, David
D - Nabors, Sharron
D - Parker, Lloyd
D - Speight, Jr., Robert
D - Staton, Bob
D - Stuart, Cheri
D - Taylor, Harlton
*D - Thompson, Jim**
E - Adams, Janet
E - Allen, Ann
E - Barker, Randy
E - Beard, Tom
E - Bennett, Jeff
E - Borunda Firth, Sylvia
E - Brewster, Rebecca L.
E - Butcher, Sterry
E - Chacon, Roger
E - Christianson, Jessica

E - Davidson, Michael
E - Dunlap, Dan
E - Etzold, David
E - Hall, Dave
E - Leary, Tim
E - Livingston, Mike
E - Marquez, Michelle
E - Miller, Albert
E - Miller, Jim Ed
E - Mitchell, Scott
E - Newton, Brad
E - Palacios, Arlina
E - Perez, Vincent
E - Reinert, Scott
*E - Reyes, Jesus "Chuy"**
E - Sanchez, Mike
E - Tate, Rick
E - Todd, Teresa
E - Waggoner, Paige
E - Webb, Summer
F - Arsuffi, Tom
F - Bearden, Jerry
F - Brown, Chuck
F - Brown, Stephen
F - Carlile, Jimmy
F - Daniel, Don
F - Deishler, Ben
F - Dickson, Ricky
F - Dierschke, Kenneth
F - Edwards, Ty
F - Ervin, Tommy
F - Gerke, Ava
F - Gist, Richard
*F - Grant, John**
F - Guelker, Michelle
F - Hagood, Charles
F - Halfmann, Kim
F - Holland, Scott
F - McWilliams, Scott
F - Moody, Wendell
F - Rodriguez, Raul
F - Runge, Caroline
F - Shepard, John
F - Straub, Jr, Raymond
F - Strube, Allison
F - Taylor, Merle
F - Van Deventer, Gilbert
F - Warren, Tim
F - Weatherby, Paul
F - Wilde, Doug
F - Wilson, Len
F - Yanez, Rhetta
G - Aaron, Dirk
G - Adams, Dale
G - Beseda, Charles
G - Blackburn, David
G - Briggs, Jim
G - Brown, Tim
G - Collinsworth, David
G - Cooper, Joe
G - Cox, Alva
G - Dunn, Luci
G - Felton, Scott
G - Floyd, Travis
G - Ford, Phil
G - Holland, Zach
G - Kinard, Kelly
G - McGuire, Mike
G - Myers, Gary
G - Newman, Gary
G - O'Brien, Tommy
G - Parker, Judy
G - Peek, Gail
G - Spicer, Gary
G - Spurgin, Dale
G - Stem, Wiley
G - Sutherland, Mike
G - Tomacek, Terrill
G - Wagner, Kevin
G - Weldon, Kenny
G - Westbrook, Gary
*G - Wilson, Wayne**
H - Ashmore, Gary
H - Baker, W.R.
H - Bailey, David
H - Bartos, John R.
H - Blount, John
H - Bruner, Robert
H - Brunett, Brad
H - Burch, Carl
H - Chang, Jun
H - Collinsworth, David
H - Comin, James
*H - Evans, Mark**
H - Fisseler, Gene
H - Forrest, Yvonne W.
H - Hebert, Bob
H - Henson, Art
H - Houston, Jace
H - Howard, John
H - Istre, Robert
H - Jones, Kathy Turner
H - Langford, Ivan
H - Lord, Glenn
H - Marcell, Marvin
H - Masterson, Carl
H - Morrison, James
H - Neighbors, Ron J.
H - Schindewolf, Jimmie
H - Stultz, Ruth
H - Teer, William (Bill)
H - Turco, Michael
H - Wade, Brandon
H - Ward, Kevin
H - Willcox, Pudge
I - Adams, Leah
I - Alders, David
I - Branick, Jeff
I - Brock, David
I - David, Josh Wilson
I - Davis, Chris
I - Dunn, Mark
I - Fussell, Roger
I - Gelwicks, Steven
I - Gorsich, David
I - Hall, Scott
I - Harbordt, Dr. C. Michael
I - Heugel, William
I - Holcomb, Joe
*I - Holcomb, Kelley**
I - Isles, Don
I - Jackson, Fred
I - Kimbrough, Bill
I - Maloukis, Amanda
I - Martin, John
I - McBroom, Dr. Matthew
I - McFarland, John
I - Montagne, David
I - Morgan, Gregory
I - Peddy, Dale
I - Shank, Monty
I - Smith, Darla
I - Stanton, Randy
I - Stelly, Terry
I - Whitehead, Worth
I - Young, Ph.D., J. Leon
J - Barron, Stuart
J - Buck, Ray
J - Davis, Zack
J - Dickinson, Dell
J - Flatten, Charlie
J - Gonzalez, Otila
J - Heffley, Jerry
J - Hobbs, Genell
J - Jeffery, David
*J - Letz, Jonathan**
J - Lomas, Mitch
J - Loveland, Scott
J - Martin, Max
J - Mauk, David
J - McDaniel, Joseph
J - Pigg, Joel
J - Qualia, Thomas M.
J - Robinson, Wes
J - Shahan, Tully
J - Simpton, Jerry
J - Stevens, Jr., Homer T.
J - Sweeten, Lee
J - Trees, Roland
J - Villareal, Rene
J - Wiedenfeld, Charles (Charlie)
J - Williams, Gene
J - Wilson, William F. (Feather)
K - Bachelor, Brent
K - Barho, Jim
K - Berglund, Daniel
K - Brasher, Jim
*K - Burke, John E.**
K - Caldwell, David
K - Dockery, Jo Don
K - Dupnik, P.G., John T.
K - Fieseler, Ronald G.
K - Gary, Robin
K - Gertson, Ronald
K - Gillam, Lauri
K - Haschke, Karen
K - Hoffman, John
K - Johnson, Barbara
K - Klaeger, Donna
K - Lewis, Brenton
K - Lindsay, David
K - Ludwig, Jason
K - Luedecke, Bill
K - Lutes, Teresa
K - Luther, Jim
K - McElroy, Ann
K - Olfers, Charles
K - Powell, Doug
K - Reagor, Mike
K - Reinmund-Martinez, Alicia
K - Roeder, W.A. (Billy)
K - Ruggiero, Rob
K - Shell, Charlie
K - Simon, Haskell
K - Sliva, Paul
K - Sodek, Mitchell
K - Sultemeier, James
K - Theodosis, Byron
K - Totten, Jim
K - Van Dresar, David
K - Walker, Jennifer
K - Wheelock, David
K - Wilson, William F.
L - Andruss, Tim
L - Balin, Donna
L - Byrum, John
L - Calhoun, Pat
L - Camargo, Gene
L - Campbell, Curt
L - Chavez, Rey
L - Cockerell, Alan
L - Conley, Will
L - Dietzmann, Don
L - Dohmann, Art
L - Fitzsimons, Blair
L - Flatten, Charlie
L - Hilderbran, Vic
L - Janak, Kevin
L - Jungman, Tom
L - Kight, John
L - Labus, Russell

L - Lord, Glenn
L - McGookey, Doug
L - Meyer, Daniel
L - Middleton, Gary
L - Mims, Con
L - Patteson, Kevin
L - Pena, Illiana
L - Puente, Robert
L - Ramos, Humberto
L - Ramsey, Steve
L - Riggs, Weldon
L - Roberts, David
L - Ruiz, Roland
L - Savage, Diane
L - Scott, Suzanne B.*
L - Sengelmann, Greg
L - Sowards, Mitchell
L - Sumpter, Heather
L - Taggart, Tom
L - Taylor, Ian
L - Wassenich, Diane
L - West, Bill
L - Yablonski, Adam
M - Barrera, Jorge
M - Benavides, Nick
M - Bruciak, John
M - Darling, James (Jim)
M - Flores, Jaime
M - Flores, Jorge
M - Fuentes, David
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 - McLemore, Tom
M - Mia, Riazul
M - Murden, Dale
M - Pena, Jr., Robert
M - Rathmell, Joe
M - Rodriguez, Jr., Tomas*
M - Schuster, Frank
M - Vela, Armando
M - Wilkins, Neal
N - Almaraz, Joe
N - Bledsoe, III, Scott*
N - Burns, Chuck
N - Burris, John
N - Carillo, Teresa
N - Crull, Carl
N - Dove, Bill
N - Durham, Lavoyger
N - Eddins, Gary
N - Garza, Andy
N - Hennings, Bill
N - Hubert, Pancho
N - Koenig, Lindsey
N - Kunkel, Robert
N - Ornelas, Martin
N - Reaves, Barbara
N - Reding, Jr., Thomas
N - Ring, Charles
N - Rosson, Donna
N - Scott, Mark
N - Serrato, Carola*
N - Stewart, Lonnie
N - Stockton, William (Bill)
N - Sugarek, Mark
N - Tunnell, Jace
O - Barnes, Melanie
O - Campsey, Jack
O - Coleman, Jason
O - DeWit, Harry
O - Dodson, Carrie
O - Ellison, Jr., Delmon
O - Everheart, Harvey
O - Freeman, Andrew
O - Grotegut, DVM, Chris
O - Hardbin, Bill
O - Hardin, Joey
O - Hopper, Ronnie
O - Hutcheson, Doug
O - Jones, Shane
O - Kirkpatrick, Mark
O - McClendon, Mike
O - McElroy, Don
O - McMinn, Shane
O - Monroe, Alan
O - Morris, Charlie
O - Rainwater, Ken
O - Sammon, Jeff
O - Satterwhite, Kent
O - Simons, Tom
O - Snyder, Jeffrey
O - Spear, Aubrey*
O - Steiert, Jim
O - Taylor, John
O - Wedel, Jimmy
O - Weinheimer, Sr., Ben
O - Yeary, Bret
P - Brzozowski, Patrick
P - Butschek, John
P - Chandler, Tom
P - Clark, Gerald
P - Coleman, Jim
P - Cooper, Steve
P - Day, Marie
P - Hafernick, Lee
P - Hudgins, Neil
P - Little, Lester
P - Maloney, Jack
P - Martin, Robert
P - McBeth, Bart
P - Ottis, Richard
P - Pustka, Edward
P - Raun, L.G.
P - Shoemate, Robert
P - Simons, Dennis
P - Skalicky, Gary
P - Skalicky, Michael
P - Sklar, Jill
P - Spenrath, Phillip*
P - Stafford, II, Harrison
P - Wagner, David
P - Weinheimer, Ed

Administrative Agents

A – Panhandle Regional Planning Commission
B – Red River Authority of Texas
C – Trinity River Authority
D – Northeast Texas Municipal Water District
E – Rio Grande Council of Governments
F – Colorado River Municipal Water District
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 – South Plains Association of Governments and High Plains Underground Water Conservation District No. 1
P – Lavaca-Navidad River Authority

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QUICK FACTS

Texas' state water plans are based on future conditions 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 anticipated to increase 73 percent between 2020 and 2070, from 29.7 million to 51.5 million, with approximately half of this growth occurring in Regions C and H. Water demands are projected to increase less significantly, by approximately 9 percent between 2020 and 2070, from 17.7 million to 19.2 million acre-feet per year.

Texas' existing water supplies—those that can already be relied on in the event of drought—are projected to decline by approximately 18 percent between 2020 and 2070, from 16.8 million to 13.8 million acre-feet per year primarily due to depletion of aquifers, with relatively small losses in reservoir yield due to sedimentation.

Water user groups face a potential water shortage of 3.1 million acre-feet per year in 2020 and 6.9 million acre-feet per year in 2070 in drought of record conditions.

Approximately 5,800 water management strategies recommended in this plan would provide 1.7 million acre-feet per year in additional water supplies to water user groups in 2020 and 7.7 million acre-feet per year in 2070.

Conservation strategies represent approximately 29 percent, or 2.2 million acre-feet per year, of all recommended water management strategy volumes in 2070 and were recommended for more than half of the water user groups in the plan.

The estimated capital cost to design, construct, and implement the more than 2,400 recommended water management strategy projects by 2070 is $80 billion in 2018 dollars, without accounting for future inflation.

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

If Texas does not implement the water supply strategies and projects in the state water plan, a severe drought could cause $110 billion of economic damages in 2020, increasing to $153 billion per year by 2070.

Through SWIFT and other financial assistance programs, the TWDB has closed on approximately $6.5 billion in financial assistance for 61 state water plan projects recommended in the 2017 State Water Plan.

Since inception, the SWIFT program has committed almost $9 billion to state water plan projects, of which almost $8.2 billion is toward recommended projects in this state water plan.

Why do we plan?

Planning is necessary to responsibly manage and develop the state's water resources for the benefit of future generations. Reliable water supply is essential to supporting Texas' robust economy, its agricultural and natural resources, and one of the fastest growing populations in the country. By 2070, 51.5 million people are anticipated to live in the state, all requiring water to work and thrive.

The goal of the state's water planning process is to ensure adequate water supplies for all Texans in times of drought. Texas has a long history of drought, and there is no indication of that pattern changing; in fact, recent droughts remind us that more severe drought conditions are likely to continue to occur at some point in the future. Although the drought of the 1950s is considered the *statewide* "drought of record" for Texas—and remains the statewide benchmark for the water planning process—there are much more recent *regional droughts of record*, the new 2007–2016 Colorado Basin drought of record being a recently documented example. As they continue to occur, each of those new regional droughts of record must be incorporated directly into the regional and state water plans to reflect the new regional planning benchmark.

Because the state water plan is based on providing water supplies under benchmark drought conditions when water demands are usually highest and supplies are lowest, its implementation will also generally support most of the same water demands under average or wetter hydrologic conditions. Significant portions of identified water needs in this state water plan, particularly certain irrigation needs, are not, however, entirely attributable to an onset of drought conditions. Even under average hydrologic conditions, irrigated agriculture requires significant water supplies to support it, and sizable portions of those irrigation demands will likely be unmet even under average hydrologic periods, due largely to the managed and unmanaged depletion of aquifers.

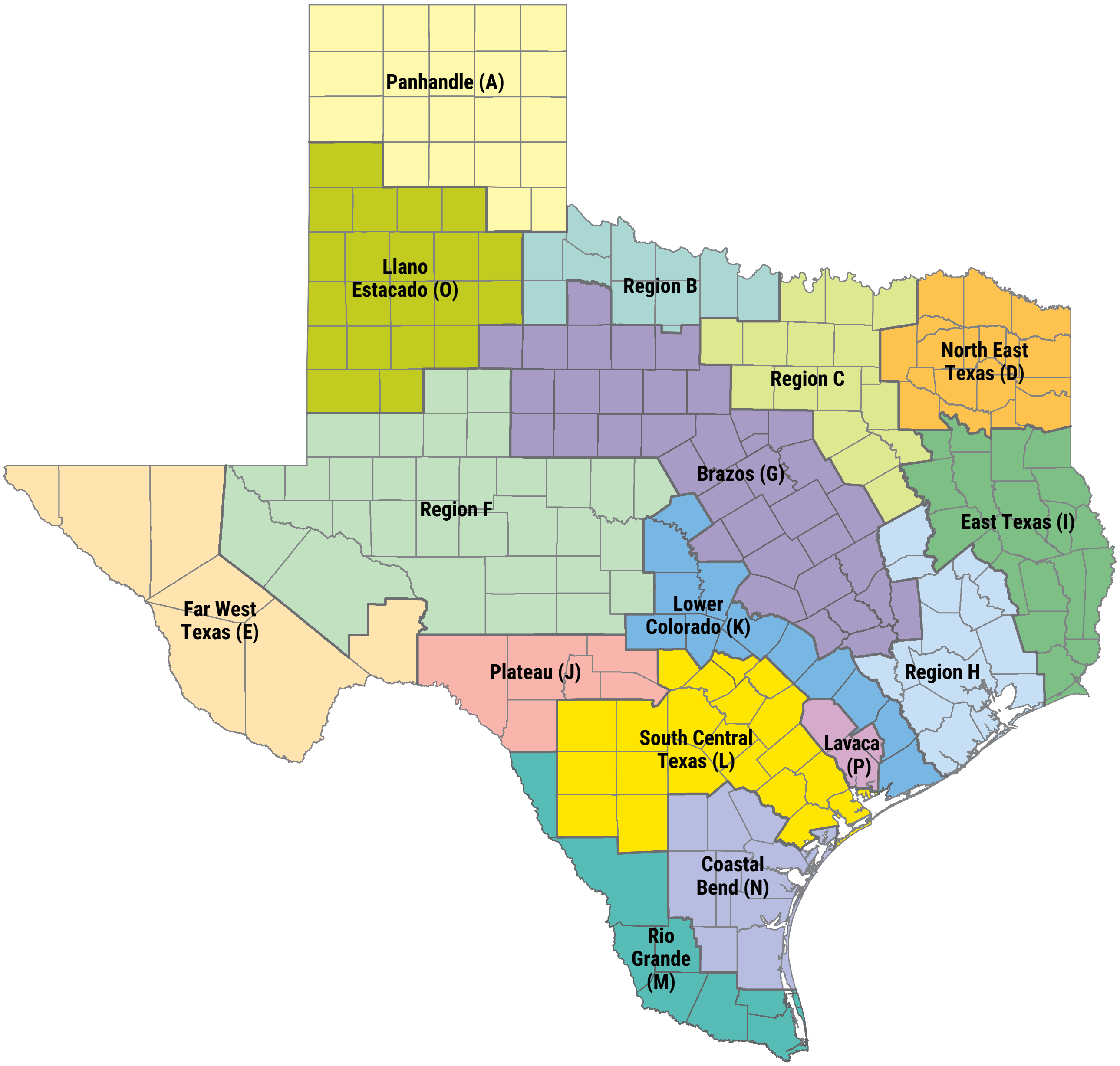
Ensuring adequate and affordable water supplies for all Texans to withstand future droughts requires both advance planning and implementation prior to the onset of drought. The Texas Water Development Board (TWDB) is the state's lead water planning and infrastructure financing agency and is statutorily 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. The Texas Legislature has long recognized that water is critical to the future of Texas and, in 1997, created a strong state and regional framework for responsibly planning to address both the short- and long-term water needs of the state. However, providing sufficient water supplies at reasonable costs continues to present new challenges with each planning cycle. Among those challenges are the continued increase in the estimated cost of developing water supply projects that often require many years to implement and adequately preparing in the face of continued uncertainty of future droughts that may be worse than the drought of record.

How do we plan?

Since 1997, water planning in Texas has been based on local involvement 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 approximately 22 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

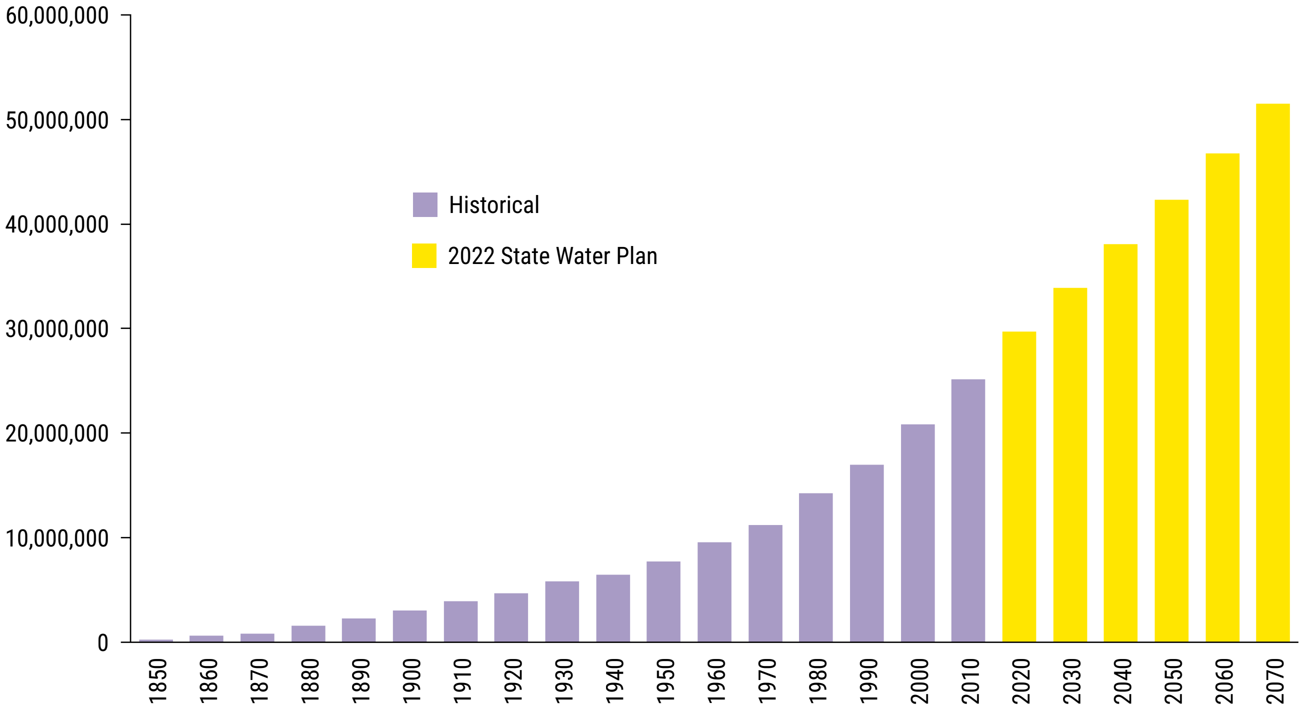
Figure ES-1. Regional water planning areas



water supplies. Each planning group then identifies potential water shortages under drought of record conditions (water needs) and recommends water management strategies (with cost estimates) to address those potential shortages. This 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. Importantly, Texas' planning framework directly involves the entities—regional water providers, cities, or water utilities—that will actually be responsible for developing and delivering those future water supplies.

Once the planning groups adopt their regional water plans, the plans are sent to the TWDB for review and 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

Figure ES-2. Historical and projected population growth in Texas (1850–2070)



to the public and provides numerous opportunities for public input.

How many Texans will there be?

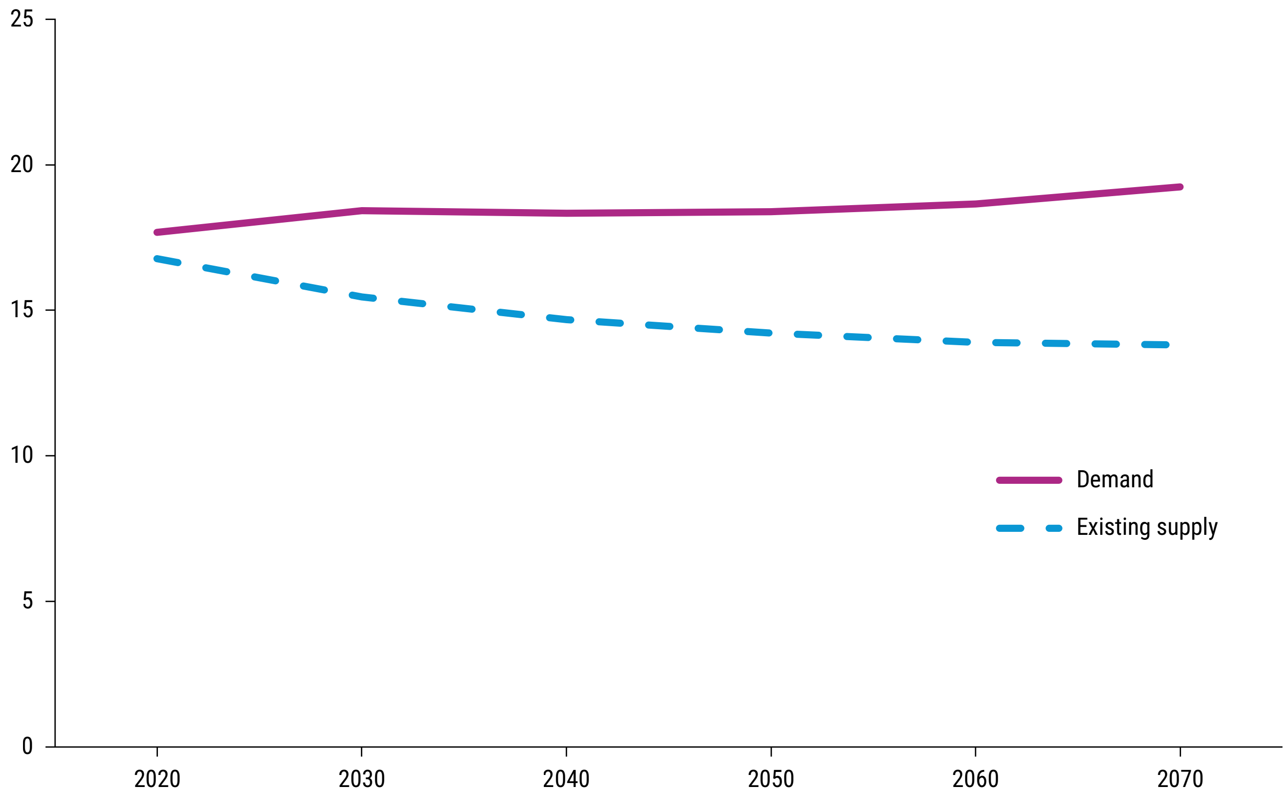
The population in Texas is projected to increase 73 percent between 2020 and 2070, from 29.7[1] million to 51.5 million people (Figure ES-2). Growth rates vary considerably throughout the state. For example, 31 counties are projected to at least double their population by 2070; the rest are projected to remain the same, decline, or experience modest growth. Approximately half of the statewide population growth between 2020 and 2070 is projected 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 population is projected to increase 73 percent over the next 50 years, total water demand for all sectors in Texas is projected to increase by only 9 percent, from about 17.7 million acre-feet per year in 2020 to about 19.2 million in 2070 (Figure ES-3). Municipal demand is projected to increase in greater proportion and total volume over the next 50 years than any other water use category, from 5.2 million acre-feet per year in 2020 to 8.5 million in 2070. This projected demand includes passive conservation from plumbing codes that are similar in magnitude to the volume of recommended municipal conservation strategies in this plan as detailed in Chapter 8. Agricultural irrigation demand is projected to decrease, from 9.4 million acre-feet per year in 2020 to about 7.6 million in 2070, due to more efficient irrigation systems, reduced groundwater availability, and the transfer of surface water rights from agricultural to municipal users. Manufacturing and livestock demands are projected to increase, while mining demand is projected to decline. Water demand for steam-electric power generation is projected to remain constant over the next 50 years primarily due to a combination of anticipated factors, including a projected increase in wind and solar power generation and increased water efficiencies at existing facilities.

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

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



How much water do we have now?

Existing water supply—categorized as surface water, groundwater, and reuse water—is projected to decrease approximately 18 percent, from 16.8 million acre-feet per year in 2020 to about 13.8 million in 2070. For planning purposes, existing supply represents water supplies that are physically and legally available to be produced and delivered with current permits, current contracts, and existing infrastructure immediately in the event of an onset of drought of record conditions.

Existing surface water supplies are projected to decrease by about 2 percent, from 7.2 million acre-feet per year in 2020 to 7.1 million in 2070 due to sedimentation and changes in water contracts.

Groundwater supplies are projected to decrease 32 percent, from 8.9 million acre-feet per year in 2020 to 6 million in 2070. This decrease is primarily due to reduced groundwater availability from the Ogallala Aquifer (as a result of its managed depletion over time) and the Gulf Coast Aquifer (due to mandatory reductions in pumping to prevent land surface subsidence). Additionally, groundwater conservation districts made policy decisions through the groundwater management area joint planning process that also resulted in changes to groundwater availability.

Total annual reuse supply makes up nearly 4 percent of total supplies in 2020, with approximately half of this supply occurring in Region C. Reuse supplies are estimated to increase statewide about 15 percent from 2020 to 2070.

Do we have enough water for the future?

Because the existing water supply is not enough to meet the future demand for water during times of drought, Texas would need 6.9 million acre-feet of *additional* water supplies, including in the form of water savings through conservation, to meet the demand for water in 2070. If a recurrence of

*Figure ES-4. Annual water needs by water use category (acre-feet)**

** Water use categories are presented in the order listed in the legend.*

the drought of record had occurred in 2020, the state would have faced an immediate need for 3.1 million acre-feet per year in additional water supplies (Figure ES-4). Of that, 7 percent (215,000 acre-feet) would have been required for municipal water users, who face the largest water demand increase over the next 50 years. Total water needs (potential shortages) are projected to increase by 120 percent between 2020 and 2070, from 3.1 million to 6.9 million acre-feet per year. In 2070, 3.1 million acre-feet per year, or 46 percent of the total projected needs, is associated with municipal users.

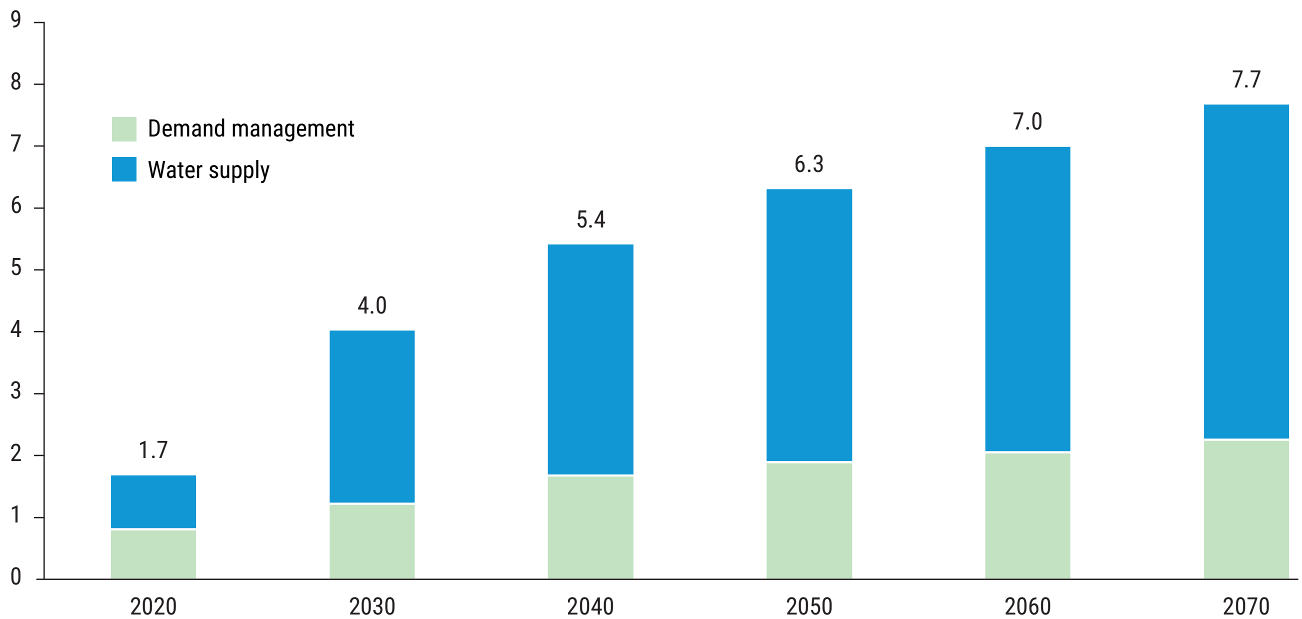
What can we do to get more water?

When projected demand for water exceeds existing supply, planning groups recommend water management strategies—specific plans and associated projects—to address the gap either by providing additional water supply or by reducing water demand. Water management strategies include reduction in water use through conservation or additional water supply from new reservoirs, groundwater wells, water reuse, seawater and groundwater desalination plants, and more.

In the 2022 State Water Plan, planning groups recommended approximately 5,800 water management strategies and more than 2,400 specific water management strategy projects to increase 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 7.7 million acre-feet per year in additional water supplies to water user groups by 2070 (Figure ES-5).

The full capacity of all recommended projects and strategies that are included in the approved regional water plans, including any associated capacities or volumes of water that may not be

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



immediately assigned to a specific water user group, is also considered to be part of the state water plan.

By 2070, about 31 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 long-term conservation and short-term drought management measures. Drought management includes activities that temporarily restrict water use for certain types of activities and businesses.

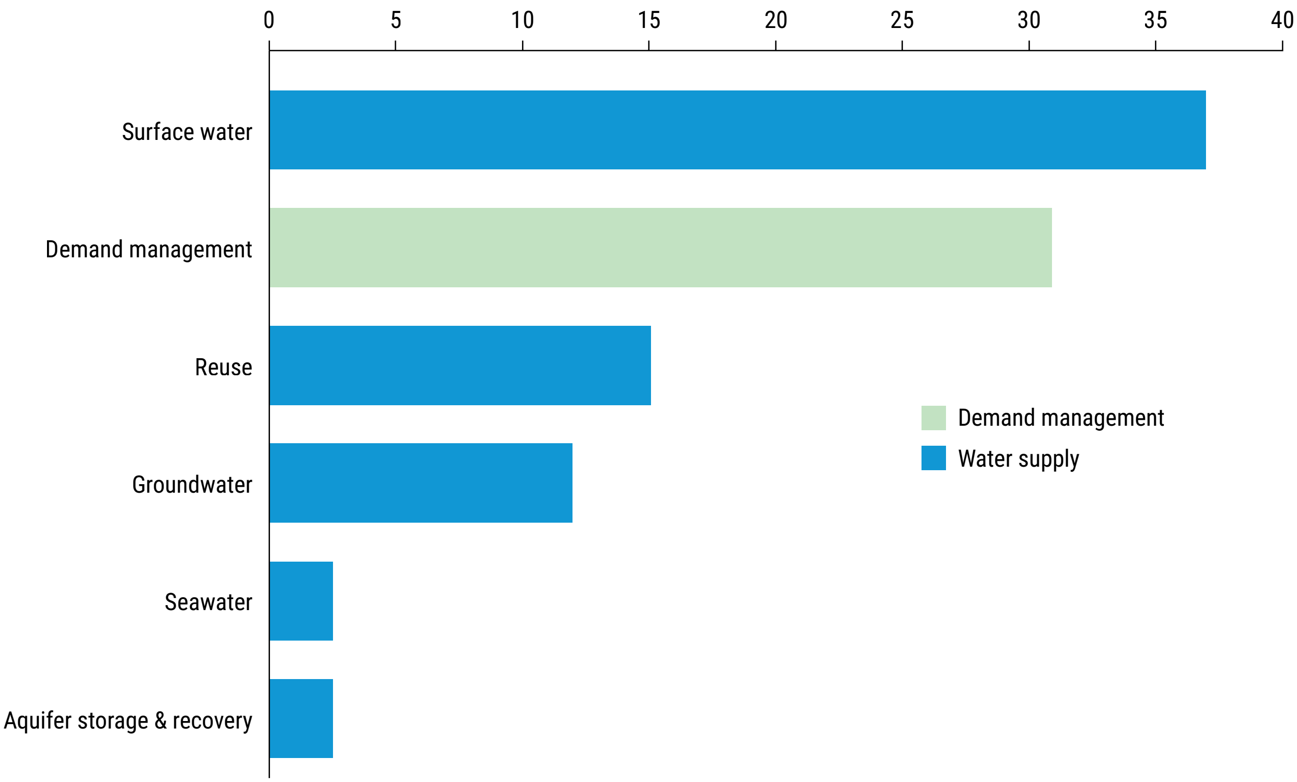
Surface water resources, including new reservoirs, compose the greatest portion of the recommended water management strategy supplies in 2070 at approximately 37 percent. Reuse is expected to provide approximately 15 percent, groundwater resources approximately 12 percent, aquifer storage and recovery resources approximately 3 percent, and seawater desalination about 3 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 and mixture of strategies recommended by each regional planning group were shaped by the regional geography, availability of 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;
- the occurrence of a drought worse than the drought of record;
- unanticipated reduction in existing water supplies;
- water system operation, treatment losses, and operational safety factors; and
- potential difficulties in financing and implementing water supply projects.

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



Are all the water supply needs met?

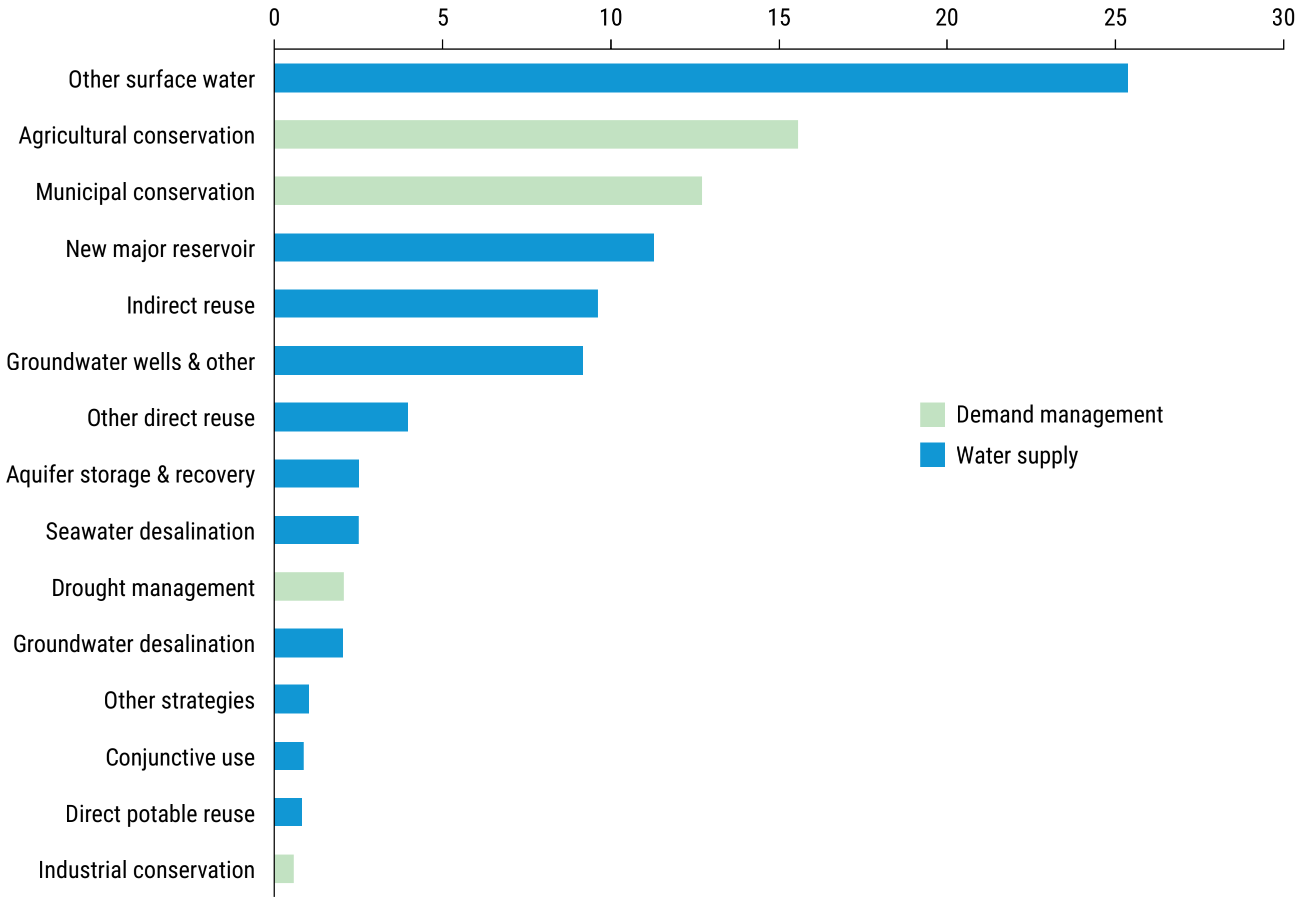
Two planning groups (Regions N and P) were able to recommend water management strategies that, if implemented, can fully meet the needs for all their water user groups. The remaining 14 planning groups were unable to identify sufficient feasible strategies that could meet both Texas' planning requirements and all the projected needs in their regions (Figure ES-8).

Statewide, the vast majority of projected water needs associated with municipal, manufacturing, livestock, and mining water user groups are met by the plan through 2070 (Figure ES-9). However, approximately 2.2 million acre-feet of water supply needs remain unmet by this plan in 2020, increasing to approximately 2.5 million acre-feet in 2070 (Table ES-1). Irrigation represents the vast majority (ranging from 86 percent to 94 percent) of these unmet needs in all decades. At least some volume of unmet water supply needs occur for all categories of water user groups in the plan. Often these unmet needs comprise a relatively small share of an entity's total water demands, meaning that they could be addressed through a drought contingency 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?

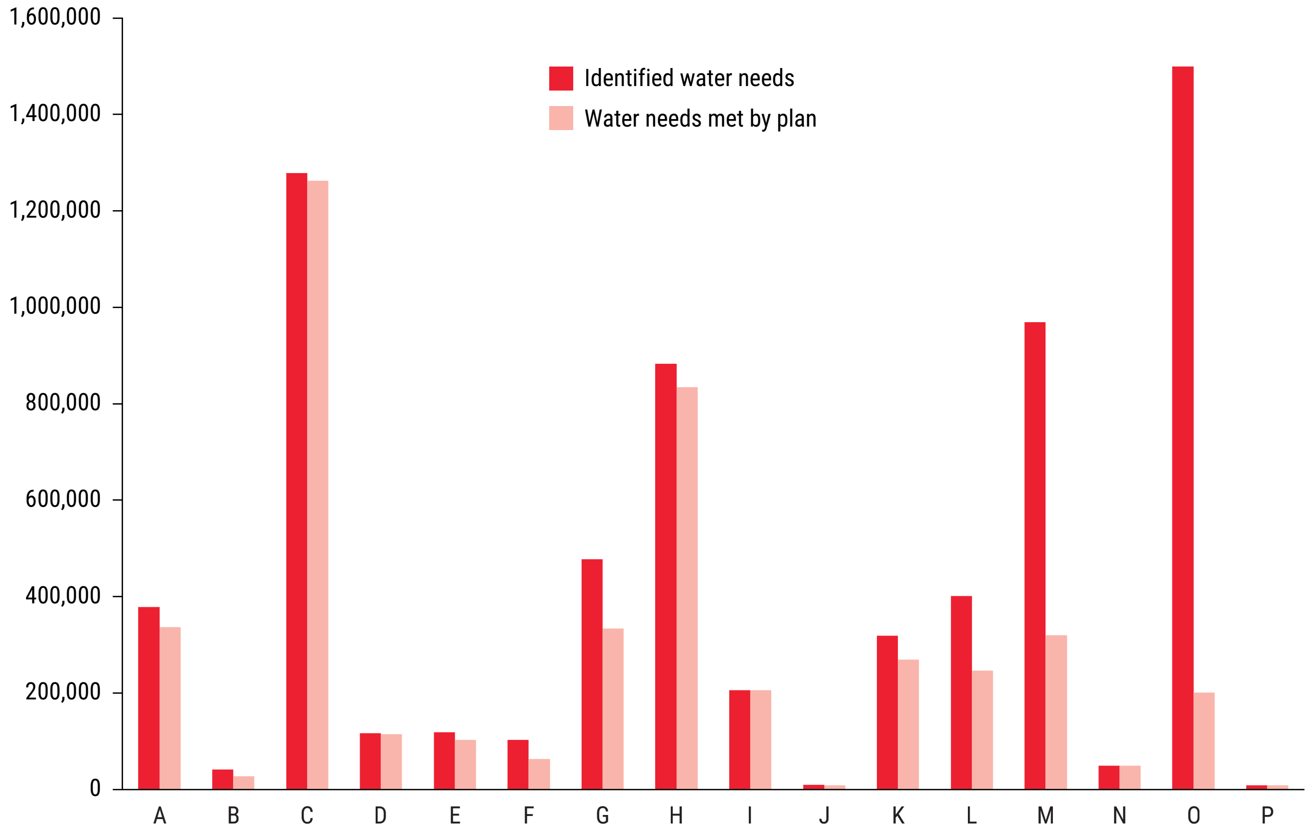
The estimated total capital cost of the 2022 State Water Plan, which represents the capital costs of all recommended water management strategies and projects in the 2021 regional water plans, is $80 billion in 2018 dollars, without accounting for future inflation. These costs include the funds needed to permit and design projects, acquire water rights and land, and construct projects necessary to implement the recommended strategies. The vast majority of the cost, approximately $77.1 billion, is associated with projects sponsored by municipal water user groups and wholesale water providers that provide water to municipal water users.

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



Center pivot irrigation system

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



What if we do nothing?

Texas would suffer significant economic losses should the recommended water management strategies not be implemented and another drought of record, or worse, occur. Economic modeling indicates that Texas businesses and workers could have lost approximately $110 billion in income annually in 2020 and could lose $153 billion annually in 2070. Job losses could have totaled approximately 615,000 in 2020 and could total 1.4 million in 2070. This estimate is likely conservative and 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 attempt to quantify the potential for greater impacts that would result from a drought that is worse than the drought of record.

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

How are strategies in the state water plan funded?

Strategy sponsors, such as cities or wholesale water providers, must take action, including obtaining financing, to develop water projects and conservation measures, many of which may require financial assistance. Water providers surveyed during the planning process reported an anticipated need of $47 billion in state financial assistance to implement strategies in their regions. Of this amount, approximately $46.6 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.

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

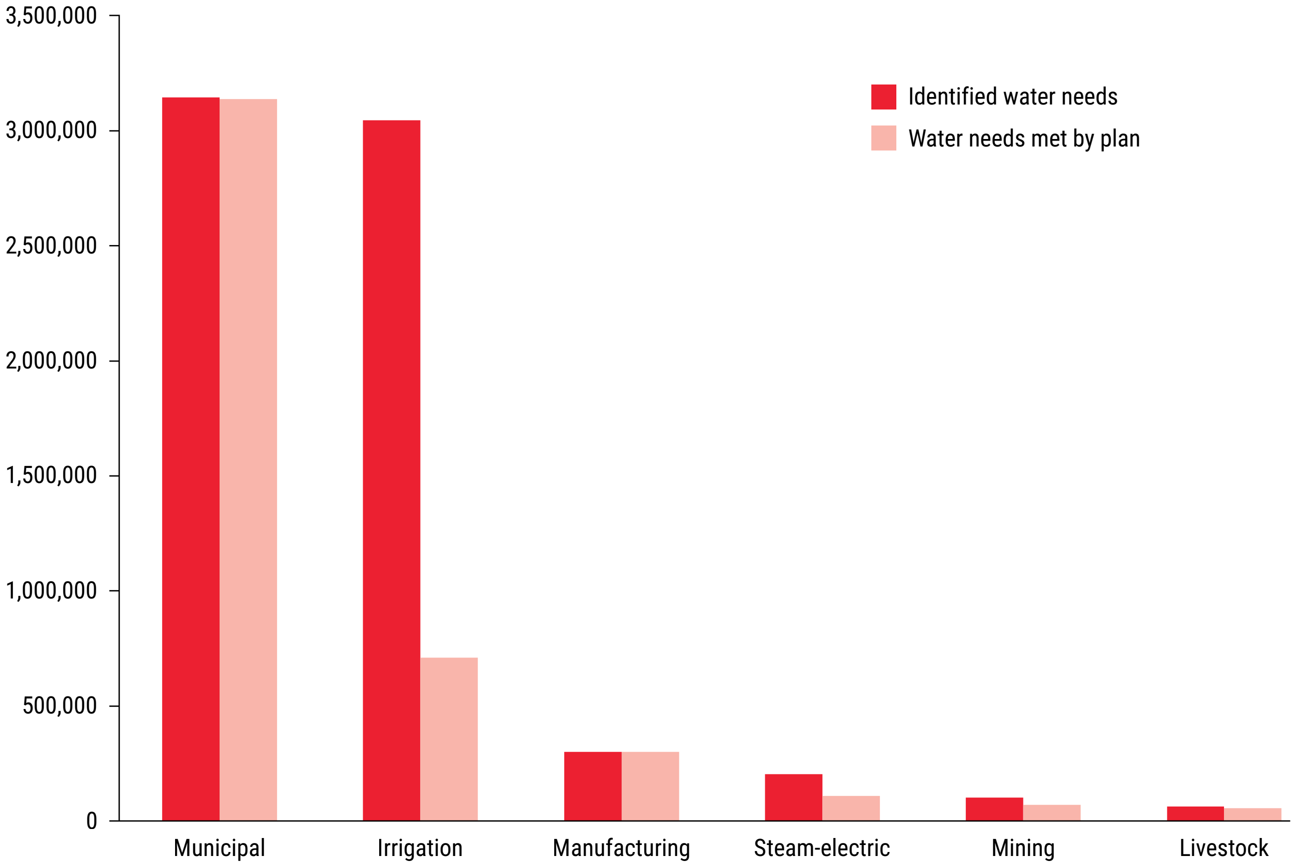


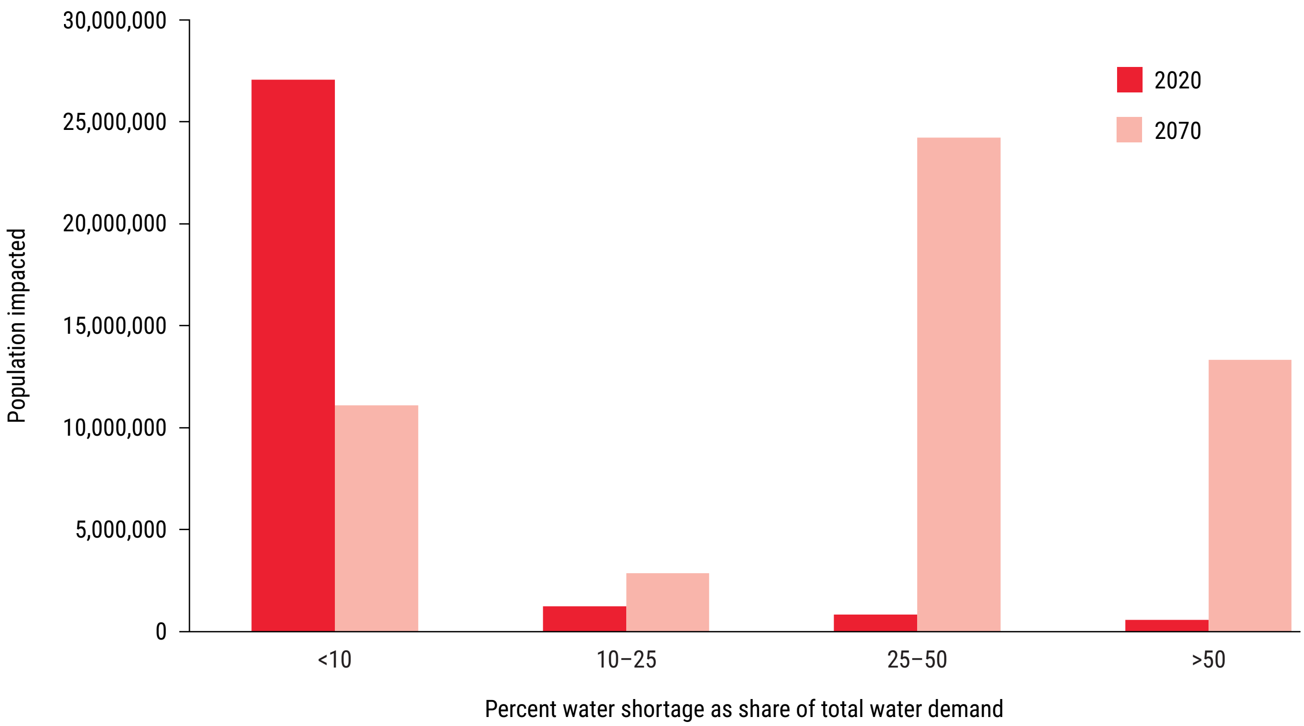
Table ES-1. Statewide annual water supply needs that are unmet by the plan (acre-feet)

Water use category	2020	2030	2040	2050	2060	2070
Irrigation	1,917,000	2,724,000	2,512,000	2,421,000	2,377,000	2,336,000
Steam-electric	122,000	94,000	94,000	94,000	95,000	95,000
Manufacturing	110,000	1,000	1,000	1,000	1,000	1,000
Mining	52,000	46,000	41,000	35,000	29,000	32,000
Municipal	18,000	1,000	2,000	3,000	4,000	6,000
Livestock	9,000	2,000	3,000	4,000	5,000	7,000
Total	**2,228,000**	**2,868,000**	**2,653,000**	**2,558,000**	**2,511,000**	**2,477,000**

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

[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.

Figure ES-10. Projected statewide population impacted by municipal water needs in 2020 and 2070



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. 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 has the TWDB done to implement water management strategies in the 2017 State Water Plan?

Since adopting the 2017 State Water Plan, the TWDB has closed[3] on more than $6.5 billion, including in SWIFT financing, for implementation of 61 projects recommended in the 2017 State Water Plan. Many of these water management strategy projects continue to be recommended strategies in this new plan and are in various stages of implementation across the state.

What were impediments to implementing the previous plan?

Planning groups listed several impediments to implementation, with access to funding and the permitting process being the most common impediments mentioned. Other impediments included lack of a project sponsor, land acquisition, and water availability constraints. However, the impediments reported do not necessarily indicate that a project will not be implemented; rather, it usually appears to indicate that it may take longer or more effort to implement. During each planning cycle, planning groups update their water management strategies and reflect any changes to when the projects are anticipated to be needed and/or fully operational.

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

What has the TWDB done already to implement water management strategies in this new plan?

The TWDB has already committed almost $8.2 billion in SWIFT financing toward projects that are recommended in this 2022 State Water Plan. The projects include groundwater wells, conservation, brackish groundwater and seawater desalination, and reservoir projects.

What more can we do?

Planning groups made a variety 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. Having considered their recommendations and other potential policy considerations, the TWDB recommends the following:

Legislative recommendation 1: Unique stream segment designation

The legislature should designate the five river or stream segments of unique ecological value recommended by the 2021 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).

Legislative recommendation 2: Unique reservoir site designation

The legislature should designate for protection under Texas Water Code § 16.051(g) three sites of unique value for constructing reservoirs as recommended in the 2021 regional water plans: Coryell County Off-Channel Reservoir, Millers Creek Off-Channel Reservoir, and Parkhouse II (North).

Reverse osmosis membranes at a brackish groundwater desalination plant

1

Introduction

QUICK FACTS

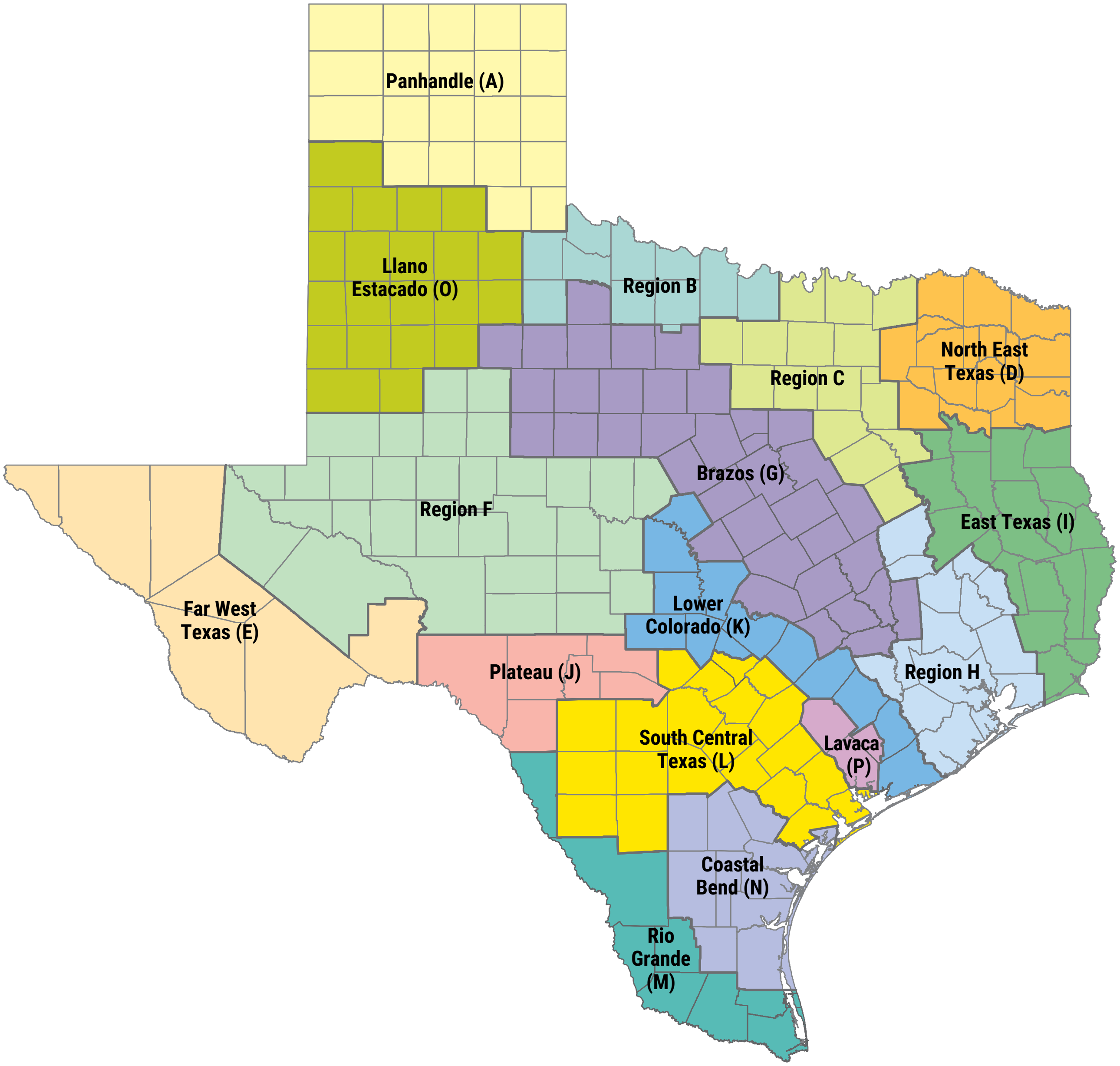
- Texas' state water plans are based on future conditions that would exist in the event of a recurrence of the worst recorded drought in Texas' history—known as the "drought of record"—a time when, generally, water supplies are lowest and water demands are highest.
- Details from the regional and state water plans, including summaries by region, county, and water user group, can be explored through the interactive state water plan at 2022.texasstatewaterplan.org.
- Historical water use and projected water demand data can be further explored through interactive data dashboards at www.twdb.texas.gov/waterplanning/data/index.asp.

Water is the lifeblood of Texas. It sustains the state's booming cities and rural communities, farms and ranches, diverse economy, and natural environment. Indeed, the availability of water has always influenced patterns of settlement and economic opportunity in Texas. Due in large part to significant investments in water supply infrastructure in the mid-20th century, including many reservoirs, Texas now has dependable water supplies during most years. However, the Texas climate is famously unpredictable from one year to the next, often oscillating between extended periods of insufficient rainfall and extreme, short-lived precipitation events and flooding. The statewide drought during the 1950s is cemented in Texan legend, resulting in 244 of the state's 254 counties being declared disaster areas and long-term demographic changes with many rural residents abandoning their farms and ranches to live in cities (NPR, 2012). This drought was punctuated by damaging floods in the spring of 1957 in every river basin in the state (TBWE, 1957). Texas' most recent severe drought from 2010 to 2014 reminded Texans of the importance of water planning and conservation, as water supplies around the state declined significantly and 2011 took its place as the single driest and second hottest year in Texas' modern meteorological record.

In response to the drought of the 1950s and in recognition of the need to better plan for the future, the 55th Texas Legislature created the Texas Water Development Board (TWDB) in 1957 to prepare plans and provide funding to address the state's future water needs. In 1997, as a result of a brief but intense drought and recognition of increasing population pressure on water resources, the 75th Texas Legislature established a new, bottom-up, stakeholder-driven regional water planning process and formed 16 regional water planning areas (Figure 1-1). In this process, local stakeholders representing cities, farmers, ranchers, industries, river authorities, the environment, and other interests work together to create long-range plans to ensure Texas will have reliable water supplies during times of drought.

The 2022 State Water Plan is the fifth plan completed under the regional water planning process and the state's 11th water plan overall. It is the culmination of the fifth cycle of regional water planning, comprising the hard work and dedication of more than 480 volunteer planning group members across Texas' 16 regional water planning groups. With each state plan, the TWDB compiles new and updated information and recommendations from the 16 adopted regional

Figure 1-1. Regional water planning areas



water plans into one document to serve as a guide to state water policy. With each five-year cycle, the TWDB creates a comprehensive state plan that is more substantive, data driven, forward looking, transparent, and user friendly than previous plans. This is exemplified by the development of the interactive state water plan website and various online data dashboards, which are continuously enhanced for policy makers, local officials, and citizens to better engage with the water planning information that affects them.

The TWDB's experience and commitment to continually improving the process keep Texas at the forefront of state water planning in the United States. Indeed, no other fast-growing state has produced a water plan that more clearly demonstrates how its local water suppliers can provide long-term, affordable water supplies to its residents. Sustained investments by the Texas Legislature have developed surface water and groundwater availability models that have provided constraint-based and actionable data as a basis of the planning process. Although the terms "update" or "revision" are sometimes—rightfully—used in discussing water plans, each regional and state water plan is, in fact, a standalone plan based on a renewed look at water demands, potential shortages, and potentially feasible strategies. At the same time, the recurring nature of five-year planning cycles allows the process to respond to legislative policy changes, stakeholder input, and new methodological approaches, while remaining updated and relevant.

1.1 Regional water planning overview

Senate Bill 1, passed by the Texas Legislature in 1997, outlined an entirely new process in which local and regional stakeholders were tasked with developing consensus-driven regional plans for how to meet water needs during times of drought. The TWDB was charged with implementing the program, which meant developing rules and guidelines as well as establishing the planning regions. Senate Bill 1 stipulated that the TWDB could only provide financial assistance for water supply projects and the Texas Commission on Environmental Quality could only grant new surface water rights if they were consistent with the regional and state water plans. These incentives were important to encourage water project sponsors to actively participate in the planning process.

The 16 regional water planning areas were designated by considering river basin and aquifer delineations, political subdivision boundaries, socioeconomic characteristics, public comments, and other factors. The TWDB is required to review and update the planning area boundaries at least once every five years. These boundaries were last reviewed in October 2020, and no changes have been made since their initial establishment.

1.1.1 Regional water planning groups

Each of the 16 regional water planning areas has an associated planning group composed of local stakeholders who volunteer their time for this process. 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, and input from planning group members and the general public. In accordance with the Texas Open Meetings Act, all planning groups and their committees 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 (also called *steam-electric*)
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 12 voting members, with the largest having over 30. More than 480 voting members participated in the development of the 2021 regional water plans (see 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

The North East Texas (Region D) Regional Water Planning Group unanimously adopts their draft regional water plan

Department of Agriculture, the Texas Parks and Wildlife Department, and the Texas State Soil and Water Conservation Board, as well as liaisons from adjacent planning groups and representatives of any additional interest categories deemed appropriate by the planning group, such as the Texas Commission on Environmental Quality.

The enduring success of Texas' regional water planning process rests with the service of planning group members who dedicate many hours to ensuring the long-term viability of Texas' water supplies. Strong leadership from planning group chairs and other long-time members, as well as the ability to attract new members who bring fresh ideas to the table, ensure the dynamic continuity of the planning process.

1.1.2 Program requirements

A regional water plan must meet all statutory, administrative rule, and contract requirements. During 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 municipality, 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 its region's expense, to perform these administrative services);
- apply to the TWDB for regional water planning grant funding through its 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;
- 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 an assigned TWDB regional water planner who serves as a project manager and non-voting planning group member that attends every planning group meeting and manages the associated grant contract. The planners also provide technical and administrative assistance during meetings and throughout the development of the regional water plans to help ensure the planning groups meet their deadlines and all planning requirements.

1.1.3 Development of the regional water plans

Every five years, each of the 16 planning groups is tasked with producing long-range regional water plans that ensure water needs will be met during times of drought for the next 50 years. These plans generally follow a standard format across the regions based upon statute, administrative rules, and an established scope of work for each planning cycle.

Regional water planning is based on several fundamental parameters that guide the entire process, the most important of which is anticipating a repeat of drought of record conditions when, generally, water supplies are lowest and water demands are highest. Planning groups conduct evaluations of future water demands, existing supplies, potential water shortages, and feasible water management strategies for wholesale water providers and approximately 3,000 water user groups in six categories (municipal, manufacturing, steam-electric power generation, mining, irrigation, and livestock). Planning groups report the associated data by decade over a 50-year planning period (in this cycle from 2020 to 2070) by water user group, county, river basin, and regional water planning area. The regional plans also include drought response information, policy recommendations, information on project implementation, and a comparison to previous plans. Planning groups must also separately submit their region's prioritized list of all recommended water management strategy projects to the TWDB in support of the State Water Implementation Fund for Texas (SWIFT) prioritization

Covers of the 2021 regional water plans, www.twdb.texas.gov/waterplanning/rwp/plans/2021/index.asp process. The prioritization at the planning group level is based on uniform standards developed by a stakeholder committee composed of the planning group chairs and approved by the TWDB.

The 16 regional water plans are the product of hundreds of meetings; the effort and many hours of hard work by 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 underlying information entered directly into the TWDB's state water planning database.

1.1.4 Development of the state water plan

After planning groups adopt their regional water plans, they submit them 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 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 its intent to adopt the state water plan in the Texas Register, and holds, at a minimum, one public hearing.

1.2 The interactive state water plan

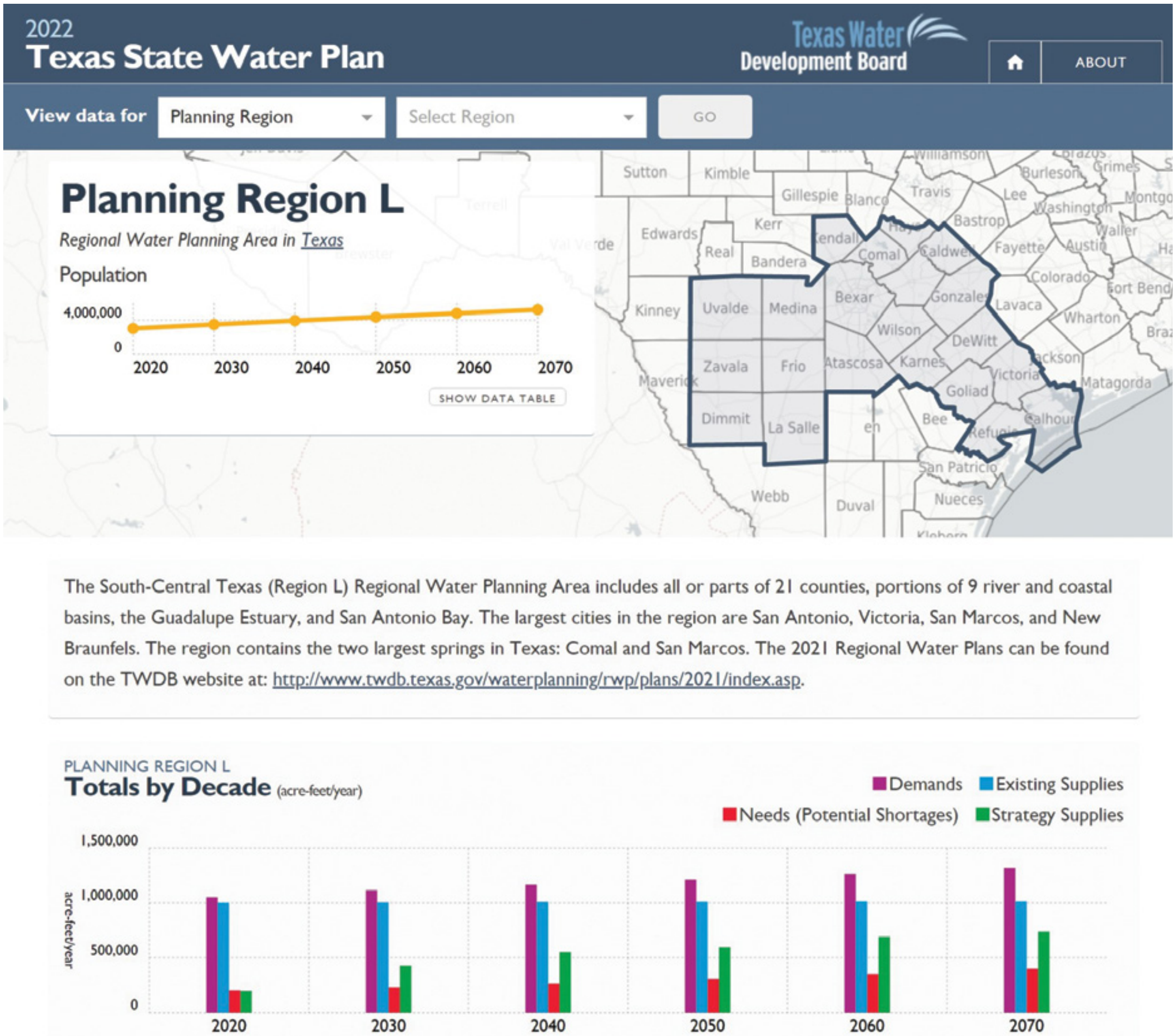
The 2022 State Water Plan is supported by an interactive website (2022.texasstatewaterplan.org) that is part of the TWDB's approved and adopted plan. The interactive plan allows water users to take an up-close look at data thematically and at discrete levels not found in the electronic and bound versions of the plan. Data is presented in geographical and tabular forms with clickable links to help users navigate and download data (Figure 1-2). The site allows users to view 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.

This approach to the delivery of water planning data to the public provides views at a variety of scales, from a snapshot for a single utility to the big picture outlook for the entire state. Users can view the interactive state water plan in numerous ways and from various perspectives:

- At varying geographic scales—utility, county, region, or state
- By specific planning decades—spanning the 50-year planning horizon (2020–2070)
- By water use categories—irrigation, livestock, manufacturing, mining, municipal, and steam-electric power
- By water source—specific aquifers, reservoirs, reuse, and other supplies
- By category of planning information—projected water demands, existing water supplies, water needs, and recommended water management strategies and projects
- By type of water management strategy—to see projects by categories such as aquifer storage and recovery, direct potable reuse, or seawater desalination
- By water user—to see geographically all the water sources a user relies upon

The TWDB administers the state water planning database that facilitates the interactive state water plan. Planning groups directly populate a unique online database for each planning cycle. Planning groups rely on this database to produce portions of their regional water plans, including calculating water needs for each water user group, and to help avoid over-allocating water sources. Some of the planning data, such as water demand projections and modeled available groundwater volumes, are developed and entered directly by the TWDB. The state water planning database greatly accelerates our ability to review

Figure 1-2. View of interactive state water plan website



and approve the final regional plans and develop the draft state water plan.

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. During the review period for the draft 2021 regional water plans, it allowed the regions to visually present the draft regional plan data during their 18 public hearings. The interactive state water plan is also viewable on most mobile devices, and users can download data into a spreadsheet for further use. Overall, the interactive plan gives Texans the opportunity to access and understand more information and put that information into context based on their specific needs.

1.3 New to the 2022 State Water Plan

During the fifth cycle of regional water planning, state legislators, water planning stakeholders, and TWDB staff continued to refine the process to produce more realistic, data-driven plans to guide water resources management in Texas.

1.3.1 Legislative changes since the 2017 State Water Plan

Every two years, the Texas Legislature convenes and has an opportunity to refine the iterative regional water planning process. Several bills that passed during recent legislative sessions resulted in modest changes to the fifth cycle of planning. In 2017, the 85th Texas Legislature passed three bills relevant to the planning process. The widest ranging was Senate Bill 1511, which included several provisions to the process:

- It allowed planning groups to pursue a simplified version of the planning process every other five-year planning cycle if they determine there has been no significant changes to water availability, existing supplies, or demands since the last adopted plan (the 2021 planning cycle was the first time planning groups had this option and it was not utilized, suggesting that the regions had meaningful changes to their plans).
- It required planning groups to consider the impediments to successfully implementing projects in the region (summarized in Chapter 10).
- It added one new non-voting member representing the Texas State Soil and Water Conservation Board to each planning group.
- It required certain planning group meetings be held in a central location readily accessible to the public within the planning area.
- It required further assessment of the feasibility of projects and will require removing infeasible projects by amendment in the 2026 regional water plans.
- It directed the TWDB to report on the implementation and impediments to the development of projects funded through SWIFT in the state water plan (see Chapter 10 for this information).

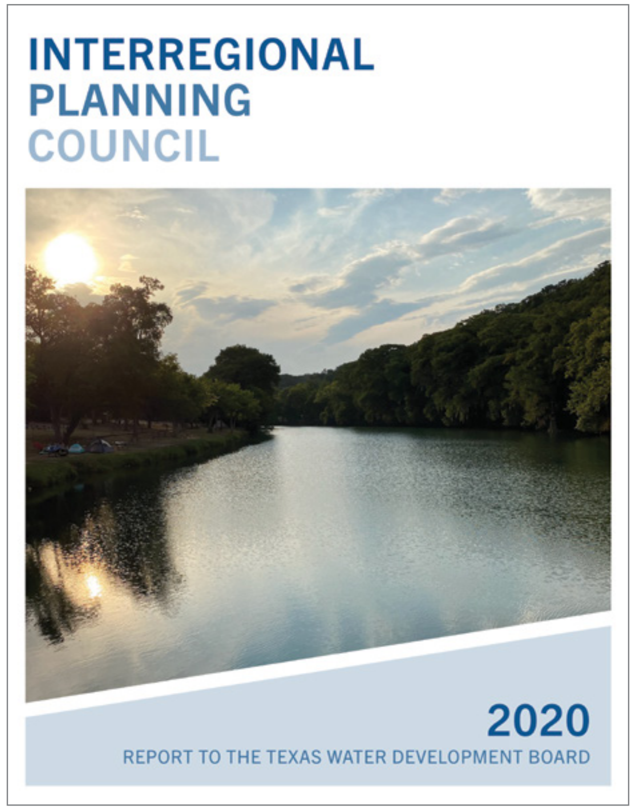
Because Senate Bill 1511, 85th Texas Legislature, now requires planning groups to actually amend their regional water plans if recommended water management strategies or projects become infeasible prior to the next plan adoption, including 'infeasible in time,'[4] the need to ensure realistic reservoir development timelines, for example, was emphasized by the TWDB in the contract guidance and at planning group meetings. Partly in response to this feasibility review, online decades for six recommended new major reservoir strategies were shifted from 2020 in the draft regional plans to 2030 in the final, adopted regional water plans.

The 85th Texas Legislature also passed Senate Bill 347, which stipulates that, in addition to planning groups, any committees or subcommittees designated by the groups are also subject to the Texas Open Meetings Act and the Public Information Act (Chapters 551 and 552, Texas Government Code). House Bill 2215 synchronizes the schedules of the state water plan and the joint groundwater planning and regional water planning cycles. This change, which was a TWDB recommendation in the 2017 State Water Plan, shifted the proposal and adoption dates for desired future conditions so modeled available groundwater values would become available earlier each planning cycle.

In 2019, the 86th Texas Legislature passed several additional bills relevant to the regional water planning process and state water plan development. House Bill 807 called for the TWDB to appoint an interregional planning council composed of members of each planning group that must meet at least once during each five-year planning cycle. The inaugural meeting was held April 29, 2020. As part of its work, the council produced a report, submitted October 16, 2020, which included recommendations for the TWDB (Interregional Planning Council, 2020). The bill also added several specific new requirements to the regional water plans:

[4] Although all projects recommended in the plan are considered technically feasible, a project may become infeasible 'temporally' meaning that obstacles and related delays to implementation might make it impractical to build the project quickly enough to meet water needs intended to be met in an early decade, and the project would need to be shown as meeting needs later on.

- Identify any counterproductive drought response strategies (summarized in Chapter 3)
- Provide a specific assessment regarding the potential for aquifer storage and recovery projects to meet significant identified water needs in the planning area (summarized in Chapter 7)
- Set specific per capita per day water use goals for each municipal water user group for each planning decade (highlighted in Chapter 8)
- Assess the progress in encouraging cooperation among water user groups to develop strategies that achieve economies of scale and benefit the entire region (summarized in Chapter 10)
- Encourage planning groups to provide feedback to the state regarding water planning process improvements (these policy recommendations are summarized in an ancillary document on the state water plan website, www.twdb.texas.gov/waterplanning/swp/2022/index.asp)



Interregional Planning Council report

House Bill 721 requires the TWDB to assess aquifer storage and recovery projects and aquifer recharge projects in the state water plan or identified by other stakeholders and conduct a statewide survey to broadly identify the relative suitability of various major and minor aquifers for use in aquifer storage and recovery projects or aquifer recharge projects. The TWDB delivered this survey to state leadership in December 2020, and the results will inform the next planning cycle. House Bill 723 requires the Texas Commission on Environmental Quality to obtain or develop updated water availability models for the Brazos, Neches, Red, and Rio Grande river basins by December 2022. These new model updates are important and will be utilized to develop the 2026 regional water plans and 2027 State Water Plan.

1.3.2 New developments and process improvements

With each cycle of regional water planning, the TWDB strives to make the process more accessible, coherent, and informative for stakeholders and the public. During the fifth planning cycle, the TWDB increased opportunities for stakeholder input, including holding two work sessions with planning group chairs. However, the most significant change during this cycle was the shift to utility-based planning. In previous plans, municipal water user groups were defined mostly by political boundaries, such as city limits, rather than water utility service areas. Utility-based planning provides many benefits and allows planning groups to plan for the entities responsible for maintaining infrastructure, planning for future growth, and sponsoring the projects that are recommended in the plans. It also better aligns the planning process in a more one-to-one manner with data the TWDB collects through Water Use Surveys, Water Loss Audits, and Water Conservation Plans. Additionally, the rule changes that accompanied this shift to utility-based planning lowered the threshold for how much water entities need to provide to be classified as discrete water user groups, increasing the number of small communities identified in the plans. More information on utility-based planning as the basis for the municipal water demand projections can be found in Chapter 4.

The TWDB implemented several other significant process improvements during the fifth cycle of planning. The TWDB launched the Texas Water Service Boundary Viewer (www3.twdb.texas.gov/apps/waterserviceboundaries), an online mapping application to house the active water service boundaries for all retail water suppliers in the state and serve as a hub for related water utility information. The Viewer operates in conjunction with the TWDB's annual Water Use Survey, which allows utility managers to review and propose modifications to boundaries every year via a mapping platform. This results in more accurate estimates of per capita water use. The TWDB also accelerated the development of the socioeconomic impact analyses prepared for the planning groups so these analyses could be included in the draft plans and subject to greater public review. Based upon results from the socioeconomic impacts analyses, the TWDB developed a drought management strategy costing tool to assist planning groups in their strategy evaluations and decision making.

The TWDB also placed a greater emphasis on visualizing planning data and making it more accessible throughout the planning process by

- launching an online planning data dashboard where users can compare population and water demand projections from previous water plans and compare adopted projections to historical water use estimates in each category;
- developing a regional data visualization map for the planning groups to reference as they developed their plans. The dynamic map displayed water needs and surpluses to identify and inform potential regionalization of projects;
- developing a data dashboard to facilitate understanding of the socioeconomic impact analyses developed for the planning groups; and
- making available the interactive state water plan platform with draft regional plan data for planning groups to utilize while reviewing their initially prepared (draft) plans and when presenting at public hearings. This improved the transparency and understanding of plan content during the public comment period of the initially prepared plans.

1.4 Advent of regional flood planning and the first state flood plan

Following the widespread devastation from flooding caused by Hurricane Harvey as well as other recent tragic flood events around the state, the 86th Texas Legislature passed landmark legislation to address the persistent threats of flooding in Texas. In addition to providing new funding mechanisms for flood mitigation projects (the Flood Infrastructure Fund and the Texas Infrastructure Resiliency Fund), the legislation mandated that the TWDB establish and administer a statewide flood planning process, with the first state flood plan due to state leadership in 2024. The TWDB established 15 flood planning regions, appointed initial members to each group, and held initial meetings of the planning groups in October and November 2020. It is truly a testament to the success of regional water planning that the legislature chose to emulate the process to address flood risks in Texas.

There are several fundamental differences between water supply planning and flood mitigation planning, though, that necessitate a different focus of attention. Water supply planning is generally about addressing long time periods of low water supplies that unfold somewhat slowly and have their greatest impact on the economy, with potential risks to health and safety, whereas flood mitigation planning is about coping with very intense rainfall events over short time periods that quickly take lives, destroy public and private property, and disrupt the economy. In addition, flood planning groups are organized by river basin, and the underlying science, data, and methodologies are very different between these efforts. For instance, reservoir storage must be treated entirely differently. Reservoir storage for water supply aims to keep sources as full as possible to provide water supply during times of drought, whereas reservoir storage for flood control must be kept at lower levels in preparation for the next flood event. Although water planning and flood planning are separate programs, there will be data sharing and opportunities for collaboration, such as when flood mitigation projects can provide water supply benefits.

1.5 Organization of the plan

The next chapter summarizes the TWDB's policy recommendations to the Texas Legislature, and Chapter 3 describes Texas droughts and provides drought response information and recommendations. Chapters 4 through 7 summarize the steps to develop the regional water plans, including the population and water demand projections, existing water supply analysis, needs identification, and recommended water management strategies and projects that are the fundamental building blocks of each state water plan. Chapter 8 highlights conservation planning, programs, and implementation. Chapter 9 presents the financing needs required to implement strategies and projects recommended in the 2022 State Water Plan, based on surveys compiled by the regional water planning groups. Chapter 10 provides information on the implementation of the 2017 State Water Plan, including projects funded through SWIFT as well as a discussion of impediments to implementing projects.

Each regional water plan must be consistent with all laws, rules, and regulations applicable to water use in the planning area. Appendix A provides additional information on water quality, drinking water, interstate waters, how surface water and groundwater are managed in Texas, and a brief history of water planning in Texas. Appendix B provides more detailed information on the processes of determining surface water and groundwater availability in the regional water plans. It also presents tabular reports summarizing annual water availability and annual existing supplies for surface water and groundwater. Appendix C summarizes annual water needs by region and water use category, and Appendix D presents information on regional socioeconomic impacts. As noted above, the adopted plan includes the online interactive state water plan, and the plan is also supported by a webpage that includes additional reference information and ancillary analyses.

References

Interregional Planning Council, 2020, Interregional Planning Council: Report to the Texas Water Development Board, 252 p., www.twdb.texas.gov/waterplanning/rwp/ipc/docs/09302020mtg/IPC_FinalReport-Apps_091620.pdf

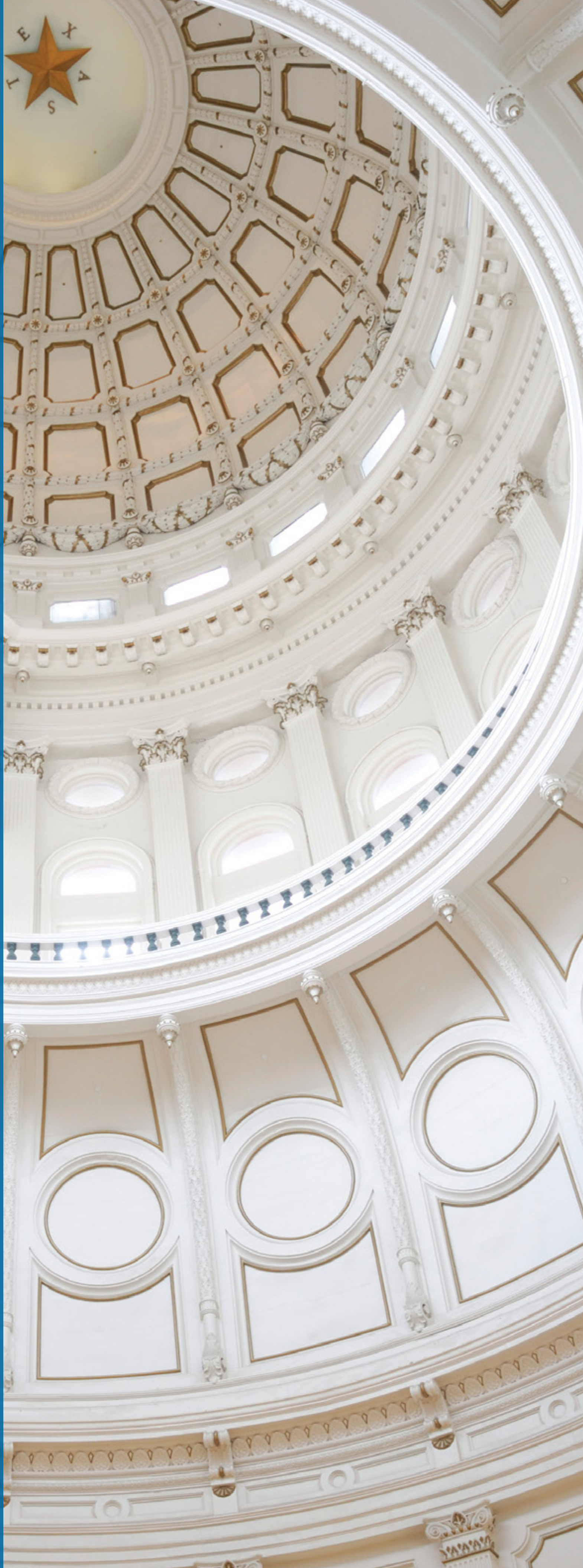
NPR (National Public Radio), 2012, How one drought changed Texas agriculture forever, www.npr.org/2012/07/07/155995881/how-one-drought-changed-texas-agriculture-forever#mainContent

TBWE (Texas Board of Water Engineers), 1957, Texas floods, 126 p., www.twdb.texas.gov/publications/reports/historic_groundwater_reports/doc/M278.pdf

2

Policy recommendations

- Legislative recommendation 1: Unique stream segment designation
- Legislative recommendation 2: Unique reservoir site designation



The state water plan, as formally adopted by the Board, serves as a guide to state water policy and includes legislative recommendations and may include policy statements 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 reservoir construction. No recommendations regarding voluntary water transfers are included in this plan.

The TWDB based the recommendations for this plan largely on recommendations contained in the 2021 regional water plans.

Regional water planning groups made several regulatory, administrative, and legislative recommendations[5] 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 2021 regional water 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 designating 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 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.

[5] Available at www.twdb.texas.gov/waterplanning/rwp/plans/2021/index.asp

Legislative recommendation 1: Unique stream segment designation

The legislature should designate the five river or stream segments of unique ecological value recommended by the 2021 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 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.
- **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 southern 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 the passage of House Bill 1016. Some of these designated stream segments included multiple, separate reaches of the same stream (Figure 2-1).

Legislative recommendation 2: Unique reservoir site designation

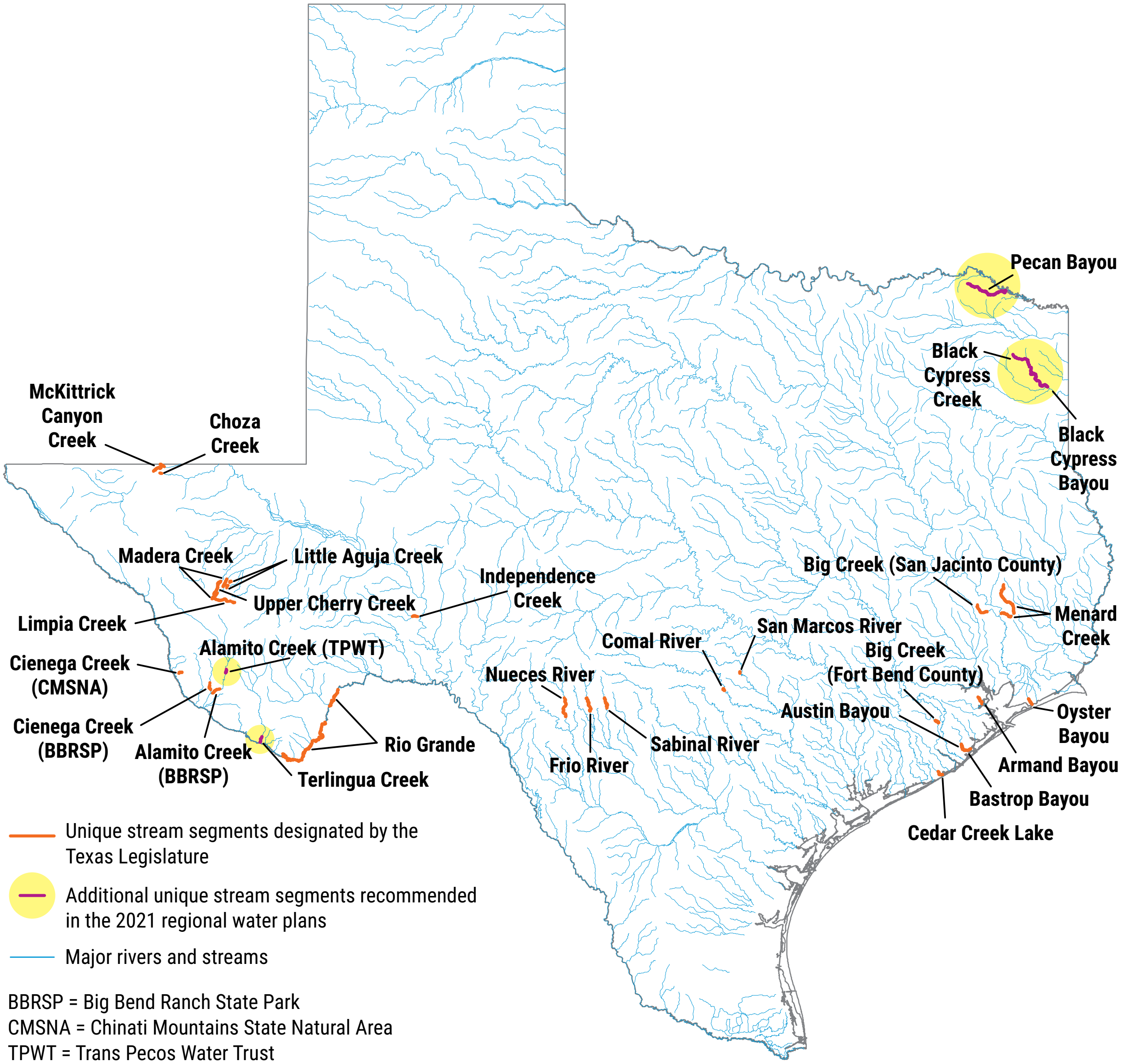
The legislature should designate for protection under Texas Water Code § 16.051(g) three sites of unique value for constructing reservoirs as recommended in the 2021 regional water plans: Coryell County Off-Channel Reservoir, Millers Creek Off-Channel Reservoir, and Parkhouse II (North).

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

Figure 2-1. Unique stream segments previously designated by the Texas Legislature and additional recommended segments

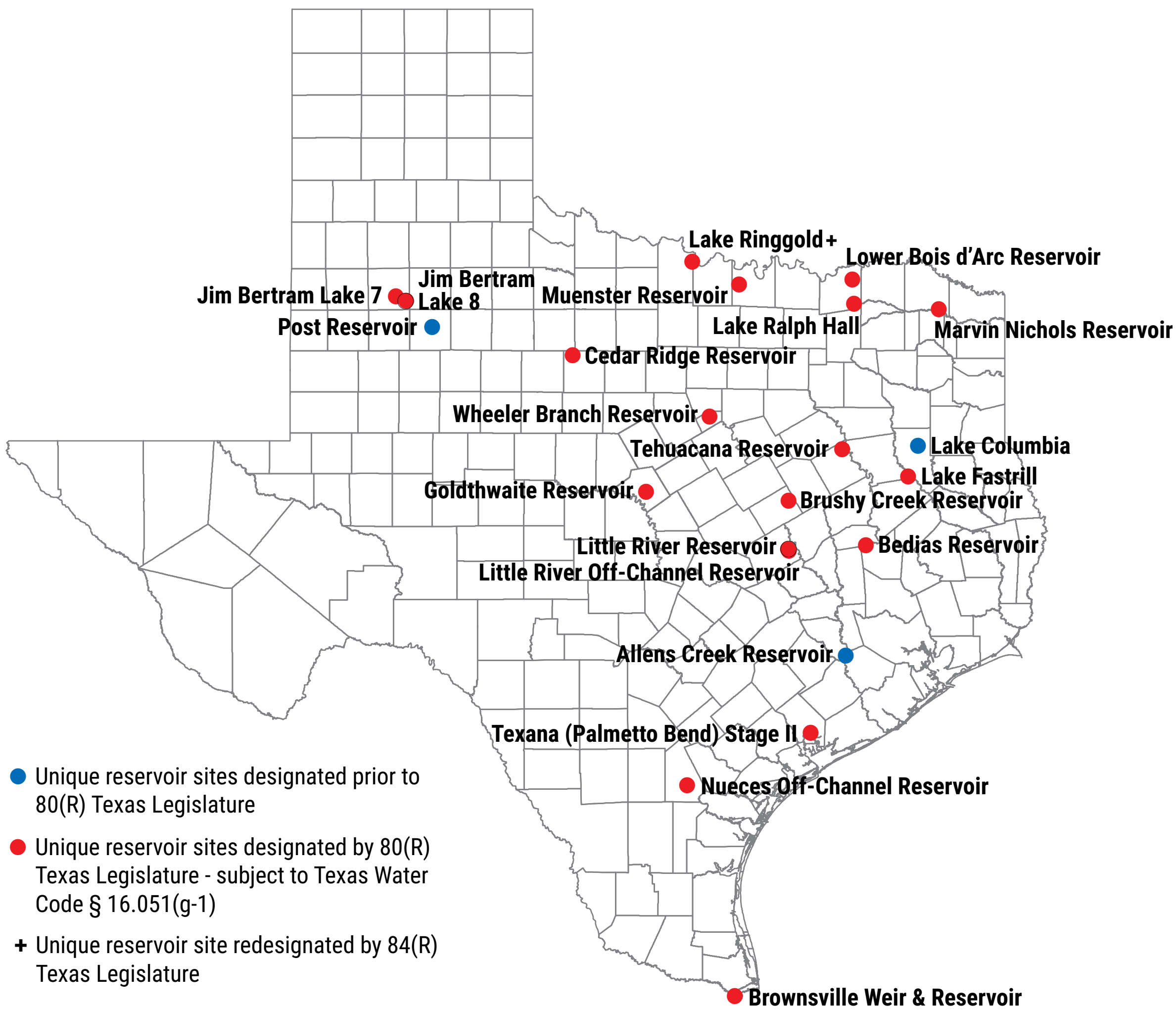


construction or enlargement of dams and reservoirs for conservation of the public waters of the state, which waters are held in trust for the use and benefit of the public, and to encourage the optimum regional development of systems built for the filtration, treatment, and transmission of water and 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 constructing 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.

Figure 2-2. Unique reservoir sites previously designated by the Texas Legislature



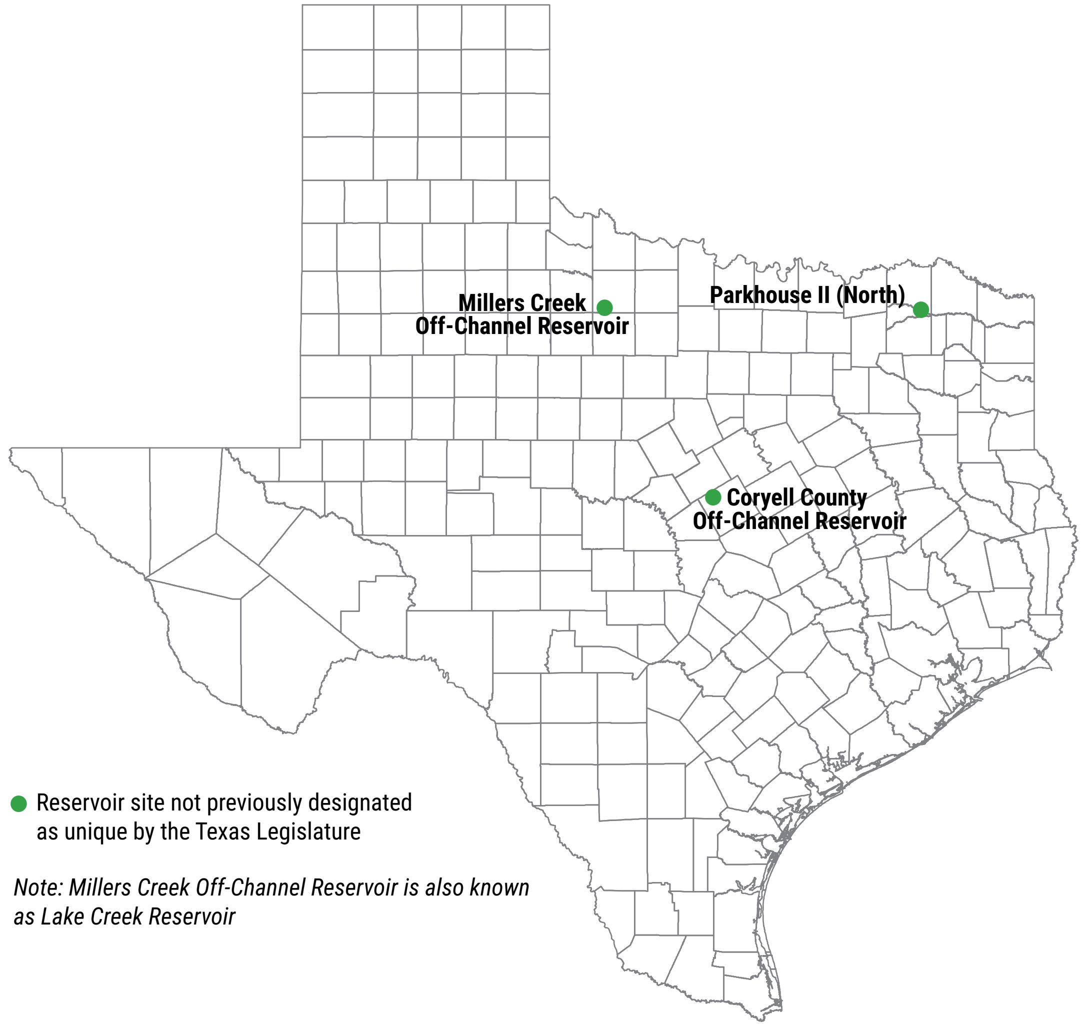
For many water users, development of reservoirs is an important means for providing large volumes of renewable, affordable water supply. As evidenced in the 2021 regional water plans and this state water plan, surface water resources, including the development of additional major reservoirs, will continue to play an essential role in Texas' water plans throughout and beyond the current planning horizon.

Approximately 37 percent of all recommended water management strategy supplies in 2070 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 by developing the most promising reservoir sites requires a stable, long-term commitment.

Designation of sites of unique value for reservoir construction by the Texas Legislature provides an important measure of protection for these sites for future development. While the legislature's designation of unique sites 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).

Figure 2-3. Reservoir sites recommended for designation as unique



With the passage of Senate Bill 3 in 2007, the 80th Texas Legislature designated an additional 19 reservoir sites 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 re-designated the Lake Ringgold reservoir site as unique.

The Texas Legislature should consider designating the following three additional reservoir sites for protection: Coryell County Off-Channel Reservoir, Millers Creek Off-Channel Reservoir, and Parkhouse II (North) (Figure 2-3). These reservoir sites were recommended for designation in the 2021 regional water plans and have never been previously designated by the legislature as having unique value for the construction of reservoirs. Another site, Turkey Peak Reservoir, is recommended for designation in the 2021 Region G Regional Water Plan; however, it is not recommended in the 2022 State Water Plan because the sponsor, Palo Pinto County Municipal Water District No. 1, requested that it not be recommended for designation due to the project already being in the development stage.

3

Drought and drought response in Texas

QUICK FACTS

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

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

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

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

3.1 Measuring drought status and severity

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

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

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

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

and observations from contributors throughout the country.

3.2 Historical and potential new droughts of record

3.2.1 Historical droughts

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

3.2.2 Confirmed and potential new droughts of record

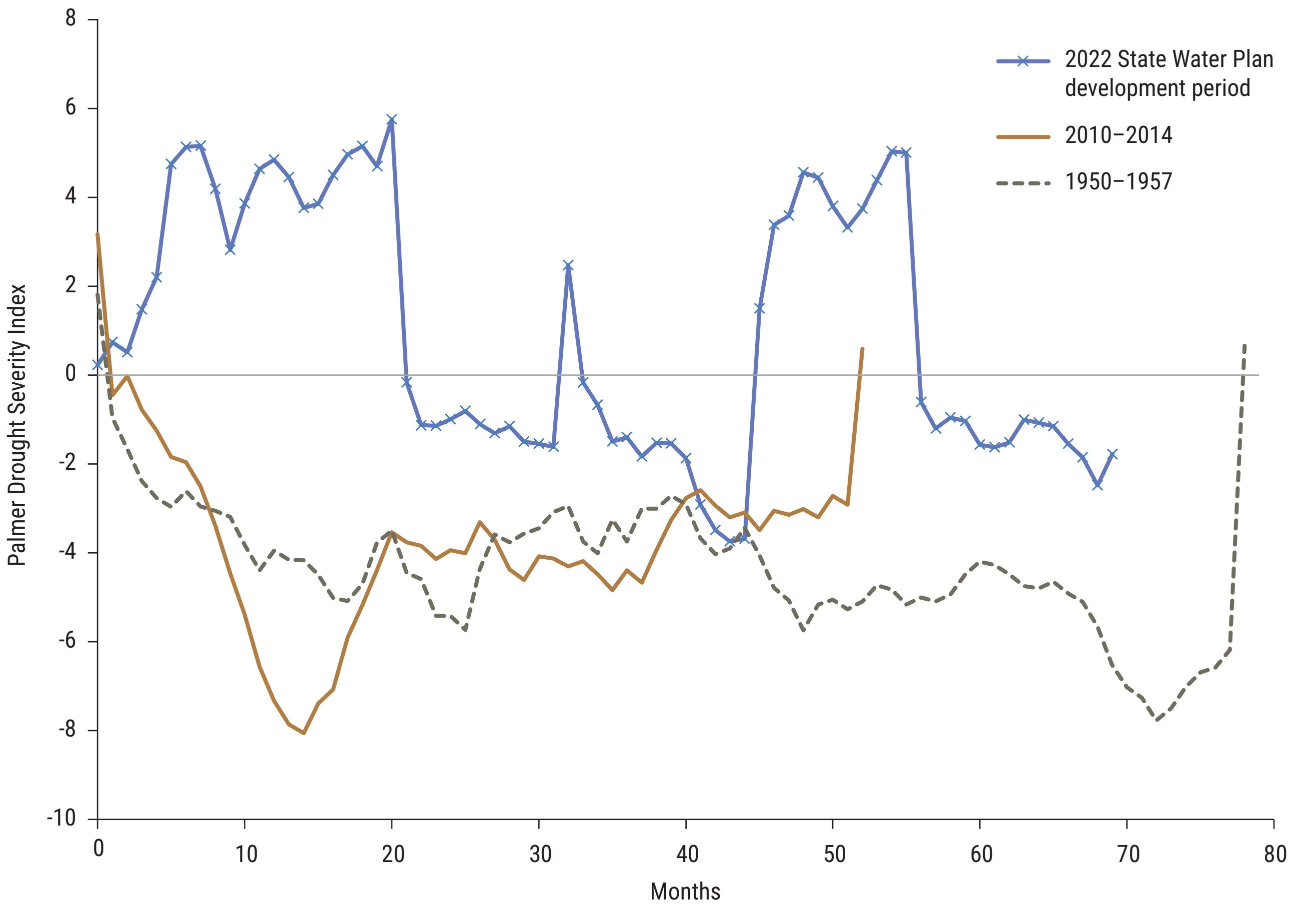
Occurring within the 2010–2014 drought, 2011 ranks as the worst one-year drought on record. A record low measurement of the Palmer Drought Severity Index occurred in September 2011, having followed the driest 12-month period of statewide precipitation on record. Conditions in that year were so severe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

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

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

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

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



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

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

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

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

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

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

Pedernales Falls State Park, Johnson City, Texas

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

3.3 Drought planning and response

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

3.3.1. Statewide drought planning and response

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

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

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

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

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

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

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

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

3.3.2 Regional drought planning and response

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

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

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

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

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

Response to potential loss of supply for small entities

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

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

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

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

Existing and potential emergency interconnects

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

Variations in drought response strategies that may impede drought response efforts

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

Five planning groups (Regions B, C, G, I, and M) identified that confusion among the public occurs as a result of variation in water supply sources within the same region, requiring different drought responses and timing. Additionally, variations in drought stage definitions, the variety of drought triggers in use, and the variety of responses implemented across the region are contributing factors. Not only can these factors create confusion among the public, they represent challenges to consider when crafting solutions. Although local entities are best suited to develop responses tailored to manage local conditions, they must ensure that awareness and coordination occur among water providers and that corresponding communications match local drought contingency plans. Public outreach targeted at educating customers on their source of water supply can be an important method for utilities in preventing confusion.

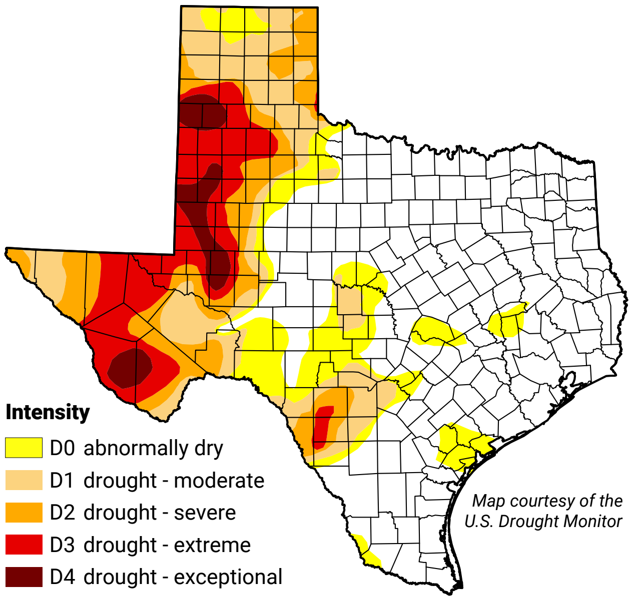
Drought management recommendations by planning groups

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

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

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

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



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

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

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

Region-specific model drought contingency plans

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

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

3.3.3 Local drought planning and response

Drought contingency plans are implemented at the local level and focus on potential issues related to retail distribution system capacity rather than the total supply volume to which the entity has access. The plans contain triggers, which are typically based on supply or demand levels to initiate and terminate each stage, and responses associated with the triggers. They also include descriptions of drought indicators and notification and enforcement procedures. Within five days of implementing any mandatory drought contingency measures, wholesale and retail public water suppliers must notify the Texas Commission on Environmental Quality.

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

3.4 Regional drought recommendations

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

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

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

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

3.5 Uncertainty of drought

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

Although the state's planning process does not prevent regions from planning for conditions worse than the drought of record, there is no established state framework by which to do so. Scenario planning has been suggested in the literature (Banner and others, 2010; Nielsen-Gammon and others, 2020), and the Interregional Planning Council, established by House Bill 807 (86th Texas Legislature, 2019), developed recommendations for the TWDB to consider regarding potential enhancements to the regional and state planning framework. One of those suggestions is to conduct additional, high-level planning for a drought event that is worse than the drought of record. However, implementing a formal change to how the TWDB considers drought risks will likely require additional financial resources and development of a coherent and accepted approach.

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

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

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

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

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

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4

Future population and water demand

QUICK FACTS

Texas' population is projected to increase by more than 70 percent during the planning horizon, from 29.7 million in 2020 to nearly 51.5 million in 2070.

Over 60 percent of all the statewide population growth between 2020 and 2070 is projected to occur within Regions C, H, and L.

Statewide water demand is projected to increase by approximately 9 percent, from 17.7 million acre-feet per year in 2020 to 19.2 million acre-feet per year in 2070. This is a smaller magnitude increase as compared to the 2017 State Water Plan, primarily due to revised methodologies for the irrigation, manufacturing, and steam-electric power generation sectors of water use.

Irrigation is the largest water demand category in each planning decade through 2050, but municipal demand is projected to surpass irrigation demand by 2060.

Population and water demand projections by region, county, and water user group can be explored through the dashboard at www.twdb.texas.gov/waterplanning/data/dashboard/index.asp.

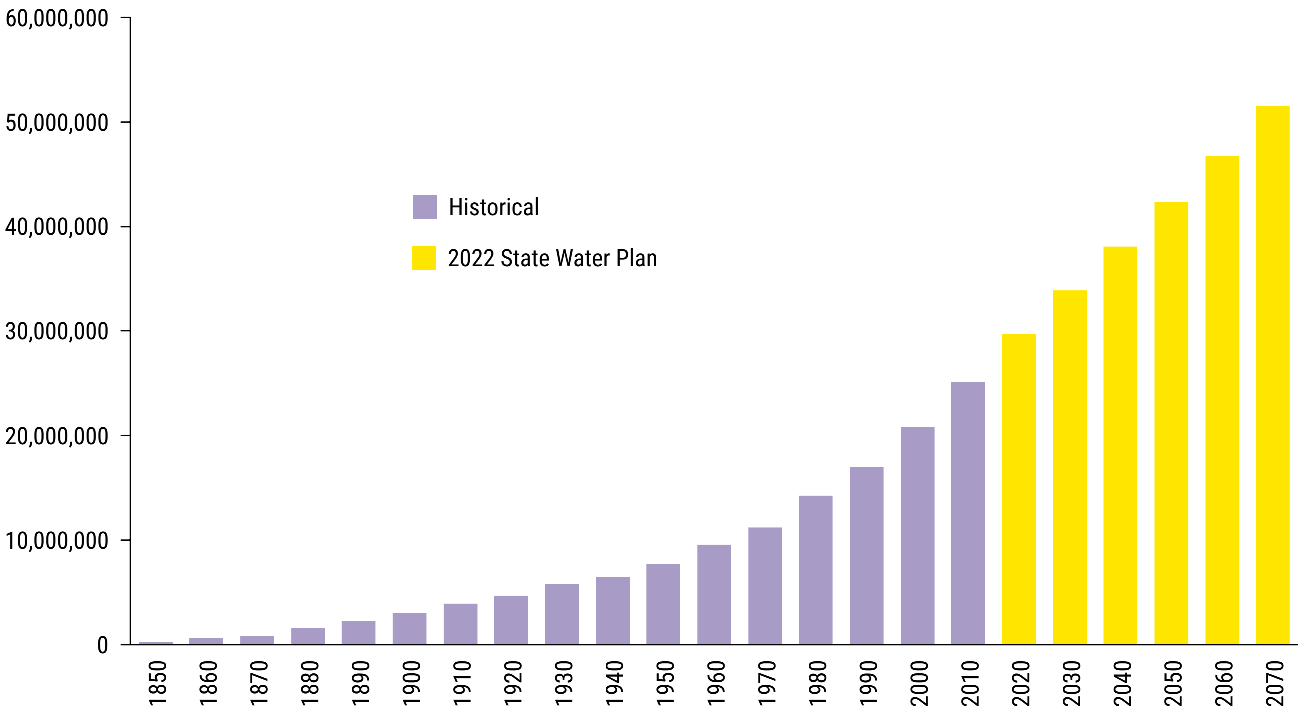
The first major milestone in the five-year regional water planning process is the development of population and water demand projections to determine how much water will be needed during a repeat of drought of record conditions over the 50-year planning horizon. Developing the most likely set of projections for a long-term plan is challenging and is accomplished through a collaborative process based on best available data and designed to develop consensus between state agencies, regional water planning groups, and local stakeholders.

The TWDB developed and distributed draft population and water demand projections using statewide, uniform methodologies for all 16 regional water planning groups. 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 then helped determine the final projections by providing local data and information. This often involves determining the most likely locations where anticipated populations will reside geographically rather than adjusting the anticipated population growth within an entire planning region. The TWDB established water demand projections for municipal water users as well as five non-municipal water demand categories: irrigation, livestock, manufacturing, mining, and steam-electric power. This chapter delves into each of these categories, summarizing methodologies and analyzing the major trends and current outlook for water demands across the state.

4.1 Population projections

Texas has the second largest population in the United States and has gained more residents than any other state since 2000 (U.S. Census Bureau, 2011), as its booming economy and metropolitan areas continue to draw more people from across

Figure 4-1. Historical and projected population growth in Texas (1850–2070)



the country and around the world. Indeed, Texas has experienced robust population growth since it joined the United States, with growth outpacing the national average in each decade since the 1850s (Murdock and Cline, 2018). This trend is expected to continue, with Texas' population projected to increase by more than 70 percent during the planning horizon, from 29.7 million in 2020 to more than 51.5 million in 2070 (Figure 4-1).

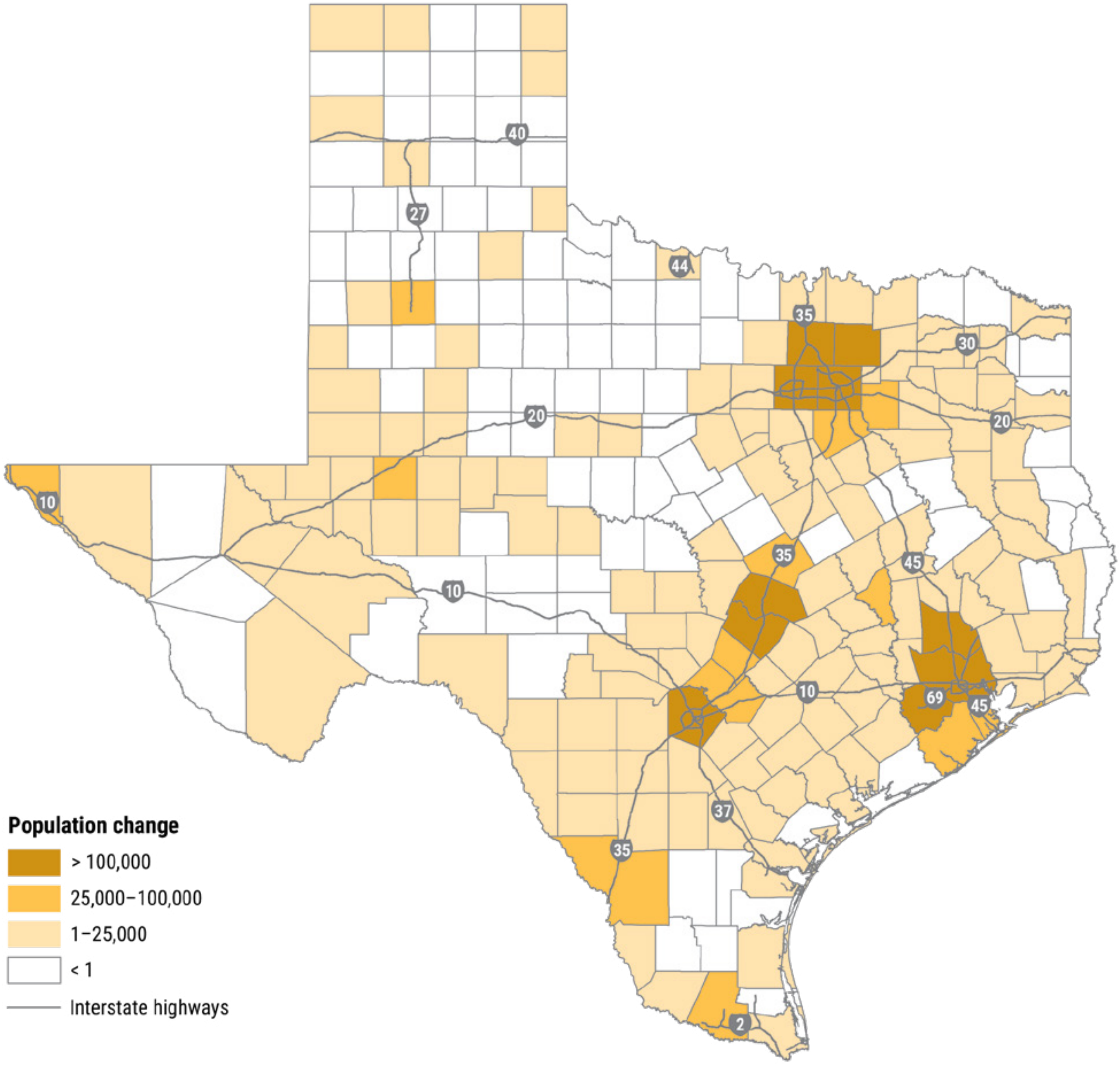
According to 2018 U.S. Census Bureau population estimates, Texas has four of the top 10 counties in the country with the largest annual numeric growth since 2010: Bexar, Dallas, Harris, and Tarrant. At the same time, Texas has 96 rural counties that experienced negative population growth between 2010 and 2018 (Figure 4-2).

While Texas is projected to remain one of the fastest growing states in the nation, not all regions will experience this growth equally (Table 4-1). Growth is projected to be concentrated around the state's major metropolitan areas, especially Austin, Dallas-Fort Worth, Houston, San Antonio, and the Rio Grande Valley. Regions C and H (which include the Dallas-Fort Worth metropolitan area and Houston, respectively) are projected to capture more than 50 percent of the state's growth over the next 50 years (Figure 4-3). Significant growth is not projected to occur in many rural areas of the state, reflecting the increasingly urban character of Texas and the nation. Even in West Texas, most population growth is projected to occur within regional urban hubs, such as Amarillo, Lubbock, Midland, and Odessa.

At a county level, 29 Texas counties are projected to double or more in population between 2020 and 2070 (Figure 4-4). These highest-growth counties are predominantly suburban areas surrounding the state's major metropolitan areas. On the other end of the spectrum, 22 predominantly rural counties around the state are projected to experience zero population growth across the planning horizon.

In addition to its highly variable climate, Texas' sustained population growth is a fundamental reason why the state has been at the forefront of long-range water supply planning since the

Figure 4-2. Historical population change by county (2010–2018)



1960s. Additional growth over the planning horizon will put increasing pressure on existing water supplies, as there will simply be many more Texans needing water, even alongside the significant advances in municipal conservation in recent years. This plan projects population growth from 2020 to 2070 for nearly 1,900 municipal water user groups across Texas' 254 counties. The next section provides detailed information on the methodology for determining population projections for this planning cycle.

4.1.1 Population projections methodology

Developing population projections involved two steps: first, projecting population at the county level and, then, projecting population at the municipal water user group level, including water utilities and rural areas. The state demographer at the Texas Demographic Center (Texas State Demographer, 2014) developed population projections for counties by using a standard demographic methodology known as a cohort-component model. This procedure uses separate

Table 4-1. Projected population by region (2020–2070)

Region	2020	2030	2040	2050	2060	2070	Percent growth from 2020
A	418,000	460,000	503,000	546,000	591,000	637,000	52
B	206,000	214,000	219,000	223,000	226,000	229,000	11
C	7,638,000	8,858,000	10,150,000	11,533,000	13,052,000	14,685,000	92
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	716,000	798,000	859,000	919,000	978,000	1,040,000	45
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	1,763,000	2,095,000	2,417,000	2,697,000	2,971,000	3,290,000	87
L	3,013,000	3,491,000	3,937,000	4,357,000	4,795,000	5,219,000	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[a]	**29,694,000**	**33,914,000**	**38,064,000**	**42,295,000**	**46,764,000**	**51,486,000**	**73**

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

Figure 4-3. Projected population growth by region (2020–2070)

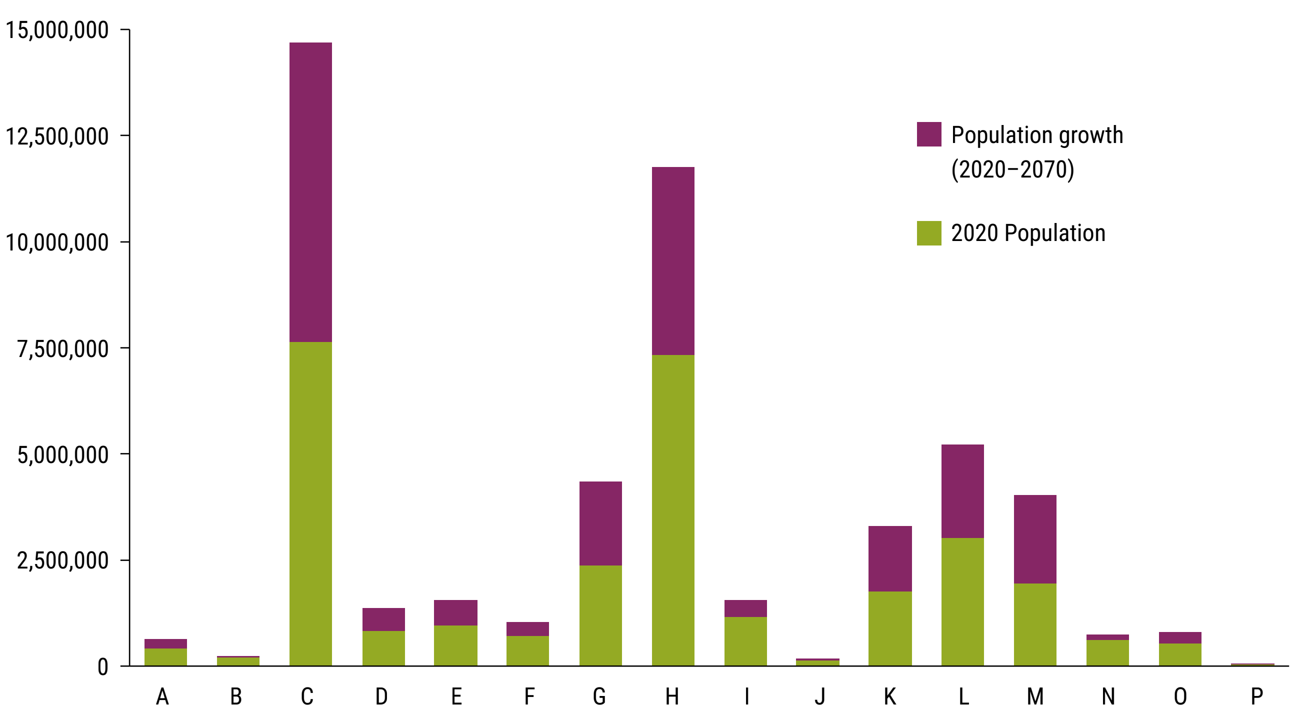
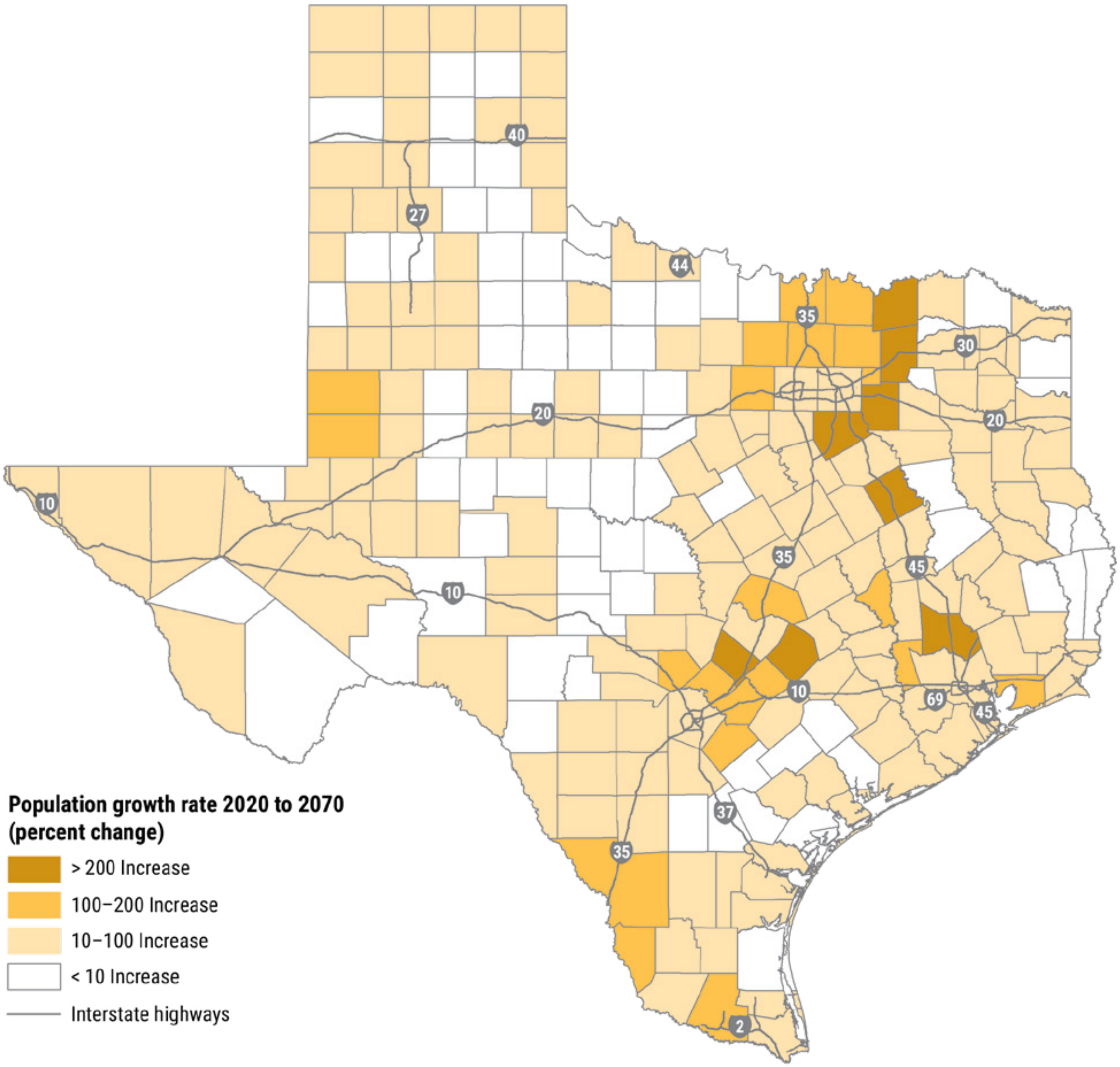


Figure 4-4. Projected population growth (2020–2070)



cohorts (combinations of age, gender, and racial-ethnic groups) and components of cohort change (birth, survival, and migration rates) to estimate future populations by county. These provided the TWDB with initial, 30-year projections by county. The TWDB then extrapolated the 30-year projections to the state water plan's 50-year planning horizon and distributed them beyond the county level to individual water user groups. Because there was no new decennial census data available for use during this planning cycle, population projections from the 2017 State Water Plan were carried forward and used as the starting point for the county-level draft projections for this 2022 State Water Plan.

Of the three components of cohort change, the migration rate, which calculates how many people move in and out of counties, is the most critical assumption. While birth and survival rates tend to closely follow historical trends, the state of the economy heavily influences migration rates, reflecting movement that results from economic opportunity. Other unforeseen events, such as

Deploying a data buoy to measure evaporation rates at Lake Buchanan

catastrophic weather, can also influence migration. Although the Coronavirus Disease 2019 (COVID-19) pandemic occurred late in this planning cycle, the TWDB reviewed available, related population data and determined that, as of this drafting, there is not likely a significant enough impact or sufficient data to make any meaningful changes to these long-term population or water demand projections. If there are any resulting population shifts or anticipated persistent shifts in water demands resulting from human or economic impacts from the pandemic, these will be reflected in the population projections developed for the next planning cycle.

During the previous cycle of regional water planning and development of the 2017 State Water Plan, the TWDB and the planning groups together evaluated three sets of projections to determine the most appropriate migration patterns to utilize in each region:

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

The one-half migration scenario was used for most counties, based on historical precedence and the state demographer's recommendations for long-range projections. Alternative migration scenarios other than one-half were used for 39 counties where 1) a comparison of the 2012 State Water Plan projections, the actual 2010 Census population, and the Texas Demographic Center's half-migration scenario 2020–2050 population projections indicated the half-migration scenario growth rates were under-projected, and 2) recent population estimates showed that a county has been continuing to grow at a much higher rate than that from 2000 to 2010.

4.1.2 Utility-based planning

Prior to this state water plan, regional and state water planning data were organized largely around political boundaries, such as city limits, rather than by water providers. One of the major process improvements of this planning cycle has been the transition to utility-based planning (away from political boundaries), which redefines municipal water user groups based on water utility service boundaries.

Utility-based planning delivers a more transparent and efficient planning process by planning directly for the entities in charge of providing water to Texans now and in the future. It also allows for better one-to-one continuity of data and responsibilities regarding water demand, water supply, implementation of water management strategies, and water project sponsors in the water plans. This provides a more direct, "cradle-to-grave" alignment of strategies and projects from the planning process to financing and implementation through the TWDB's state and federal financial assistance programs.

Additionally, at the request of the water planning community, the TWDB reduced the volumetric threshold required to designate individual water user groups from 280 acre-feet per year to 100 acre-feet per year, which increased the number of individual small utilities that are now explicitly planned for. As before, the remaining municipal and domestic water use that falls outside this threshold is aggregated for each county and planned for as a county-other water user group.

Table 4-2. Projected water demand by water use category (acre-feet)

Category	2020	2030	2040	2050	2060	2070	Percent growth from 2020
Irrigation	9,448,000	9,383,000	8,703,000	8,154,000	7,737,000	7,594,000	-20
Livestock	332,000	343,000	353,000	363,000	374,000	382,000	15
Manufacturing	1,339,000	1,531,000	1,531,000	1,531,000	1,531,000	1,531,000	14
Mining	407,000	409,000	365,000	323,000	287,000	281,000	-31
Municipal	5,223,000	5,826,000	6,440,000	7,089,000	7,783,000	8,507,000	63
Steam-electric	931,000	935,000	935,000	935,000	935,000	935,000	0
Texas[a]	**17,680,000**	**18,427,000**	**18,327,000**	**18,395,000**	**18,647,000**	**19,230,000**	**9**

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

The TWDB prepared the final list of municipal water user groups for this planning cycle based on the new criteria using TWDB Water Use Survey data from 2010 to 2014. Utility population estimates for 2010 were developed based on utility boundaries and served as the baseline population estimate to be projected for the 2020–2070 horizon for this planning cycle.

The combined net impact of transitioning to utility-based planning and lowering the threshold for designating unique water user groups was an increase of 258 additional water user groups with their own designated planning data to support a combined associated population of over 1 million people in 2020. Regions G, H, and I had the greatest increase in unique water user groups, and almost half the regions saw a net shift of approximately 90,000 or more people included in unique groups.

4.2 Water demand projections

The TWDB projects water demand across the 50-year planning horizon for municipal and all non-municipal sectors of the Texas economy to determine how much water the state will need during a single year repeat of drought of record conditions. The five non-municipal categories are irrigation, livestock, manufacturing, mining, and steam-electric power. Water demand projections exclude demands associated with purely saline supplies, much of which are associated with industrial uses located along the coast.

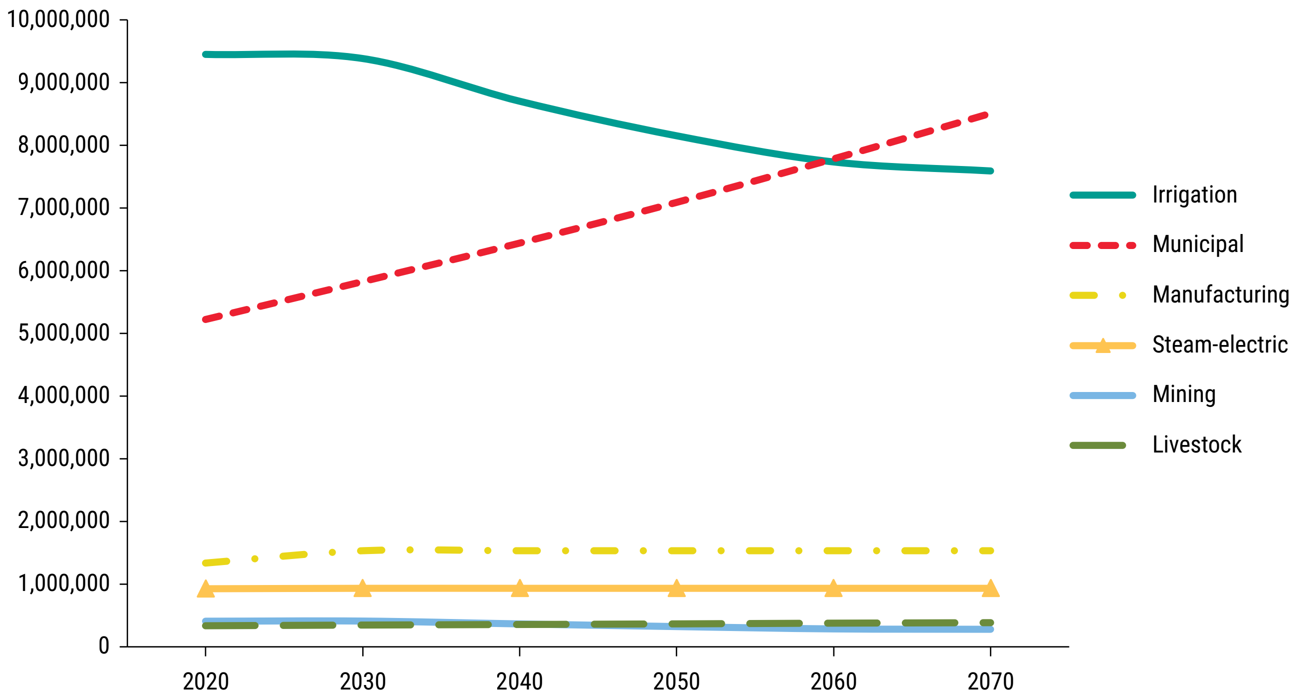
Across the planning horizon, the TWDB projects total demand across all water use categories to increase by 9 percent, from 17.7 million acre-feet in 2020 to 19.2 million acre-feet in 2070.

While irrigation is the largest water demand category in each planning decade through 2050, it is projected to gradually decrease by 20 percent over the planning horizon (Table 4-2, Figure 4-5). Municipal demand is projected to steadily increase in each planning decade due to Texas' projected population growth and eventually surpass irrigation demand by 2060. Livestock water demand is projected to increase roughly 15 percent across the planning horizon, while manufacturing and steam-electric power demands are projected to remain constant from 2030 to 2070. Water demand for mining, which includes oil and gas operations, is projected to increase through 2030 then decrease by roughly 30 percent in later planning decades, although the sector is a relatively small water user overall compared to irrigation and municipal water use categories.

4.2.1 Projected water demand by region

As with population projections, total water demand projections vary significantly by regional water planning area (Table 4-3, Figure 4-6). Water demand in Region C is projected to increase by 67 percent over the planning period, by far the

*Figure 4-5. Projected annual water demand by water use category (acre-feet)**



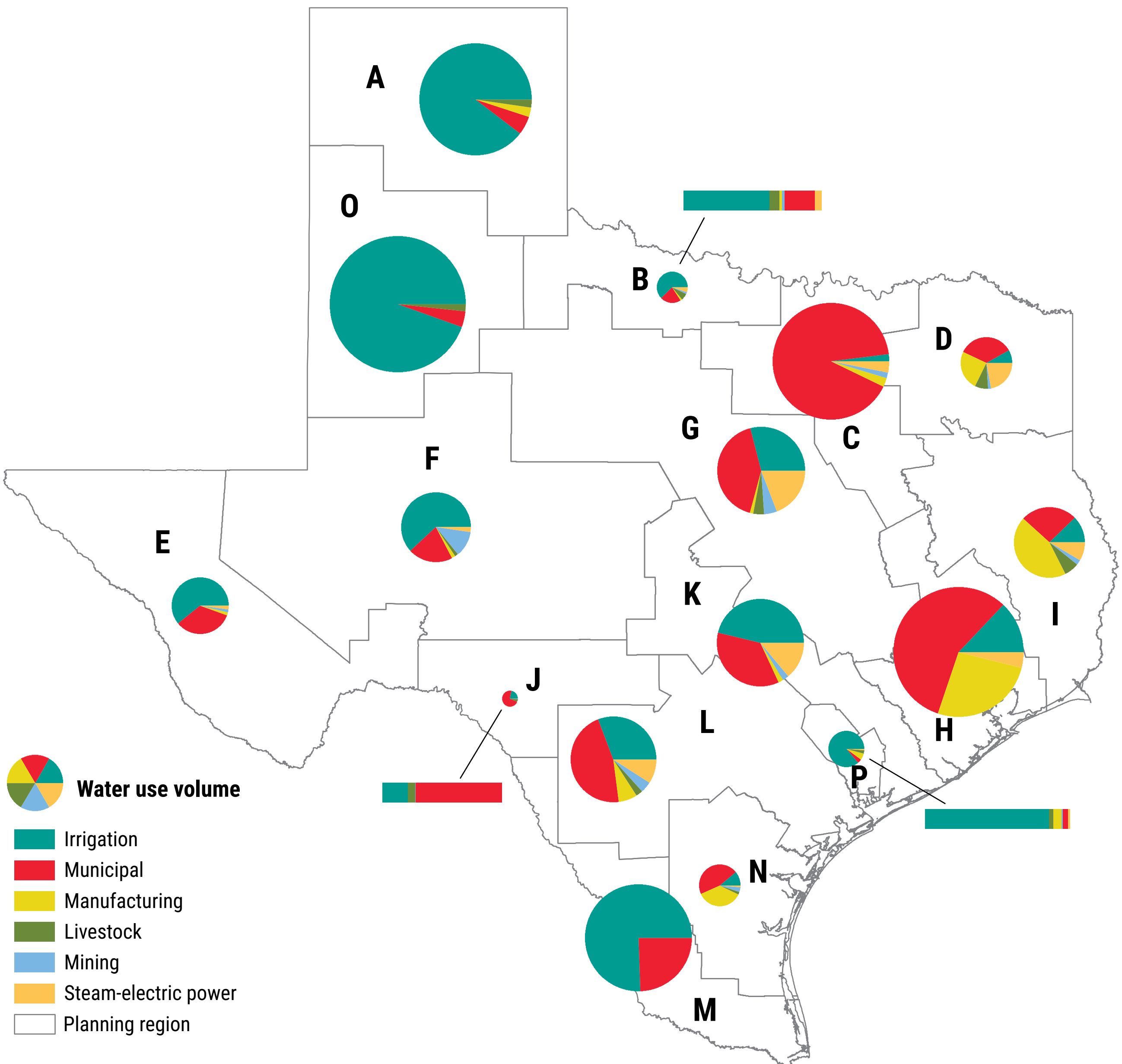
* *Water use categories are presented in the order listed in the legend.*

Table 4-3. Projected annual water demand by region (acre-feet)

Region	2020	2030	2040	2050	2060	2070	Percent growth from 2020
A	2,131,000	2,138,000	1,995,000	1,789,000	1,586,000	1,598,000	-25
B	156,000	156,000	155,000	154,000	154,000	155,000	-1
C	1,734,000	1,937,000	2,152,000	2,391,000	2,641,000	2,899,000	67
D	401,000	415,000	425,000	438,000	456,000	479,000	19
E	480,000	498,000	513,000	528,000	544,000	560,000	17
F	765,000	780,000	770,000	755,000	745,000	744,000	-3
G	1,121,000	1,178,000	1,220,000	1,279,000	1,350,000	1,422,000	27
H	2,337,000	2,561,000	2,675,000	2,796,000	2,931,000	3,077,000	32
I	738,000	793,000	799,000	811,000	826,000	840,000	14
J	37,000	39,000	40,000	41,000	42,000	43,000	16
K	1,117,000	1,163,000	1,204,000	1,237,000	1,265,000	1,308,000	17
L	1,051,000	1,115,000	1,164,000	1,211,000	1,264,000	1,320,000	26
M	1,784,000	1,797,000	1,809,000	1,822,000	1,837,000	1,853,000	4
N	253,000	270,000	273,000	273,000	275,000	276,000	9
O	3,368,000	3,382,000	2,928,000	2,663,000	2,527,000	2,453,000	-27
P	206,000	206,000	205,000	205,000	204,000	204,000	-1
Texas[a]	**17,679,000**	**18,428,000**	**18,327,000**	**18,393,000**	**18,647,000**	**19,231,000**	**9**

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

*Figure 4-6. Projected annual water demand by region and category in 2040**



* *Relative size of pie charts is based on volume of water use.*

most of any planning area, largely driven by the increase in municipal water demands due to projected population growth in the area. Significant water demand increases are also projected for Regions G, H, and L, where water demand is projected to increase by more than 25 percent between 2020 and 2070, also largely driven by projected population growth.

Regions A and O in the Texas Panhandle are the only planning areas projected to show significant declines in total water demand due to anticipated long-term groundwater drawdowns associated with irrigated agriculture between 2020 and 2070.

4.2.2 Water demand methodology

In a process similar to establishing the population projections, the TWDB produced draft water demand projections for municipal water use and each of the five non-municipal water use categories. The Texas Commission on Environmental Quality, the Texas Department of Agriculture, and

Texas' population is projected to increase from 29.7 million in 2020 to nearly 51.5 million in 2070

the Texas Parks and Wildlife Department reviewed the draft projections, which were then sent to the planning groups for their review and comments. The TWDB worked extensively with each planning group and local entities through an iterative, data-intensive review process and ultimately approved more than 350 requested changes to projections for specific water user groups. These revision requests were intended to reflect the best available data and most likely projections and were reviewed by the four agencies before the TWDB ultimately adopted them. The methodology for developing water demand projections for each of the six water use categories is summarized in the sections below.

4.2.3 Irrigation water demand

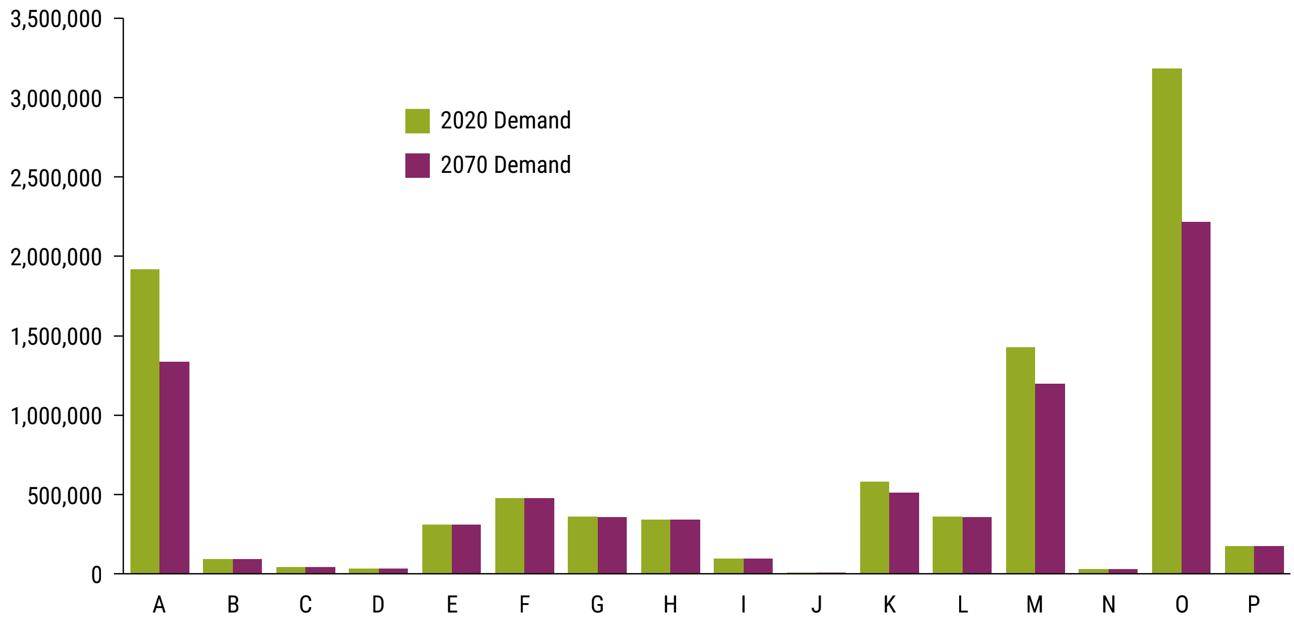
Irrigation water demand includes water used for irrigated field crops, vineyards, orchards, and self-supplied golf courses. The baseline methodology for irrigation water demand projections was to average the most recent five years (2010–2014) of water use estimates and then hold this value constant between 2020 and 2070. However, in certain counties, the total groundwater availability over the planning period was projected to be less than the groundwater portion of the baseline water demand projections. Where this occurs, the demand projections decline in later decades roughly commensurate with the groundwater availability but at a delayed rate to recognize the fact that water demands will likely remain higher than water availability even as they both predictably decline. This projection methodology was supported by a study (CDM Smith, 2016) funded by the TWDB. The goal of the study was to find the best projection method for this sector that the TWDB can update regularly and which transparently and more directly considers foreseeable declines in water availability than previous methods. The planning groups reviewed and provided input on drafts of both this new methodology and the resulting projections. This approach to groundwater-constrained areas was utilized in 36 counties.

Overall irrigation demand is projected 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, in addition to limited available groundwater. In total, irrigation accounts for 53 percent of Texas' water demand in 2020, declining to 39 percent of demand by 2070. Regions A, M, and O account for over 60 percent of statewide irrigation water demand in 2070 (Figure 4-7).

4.2.4 Livestock water demand

Livestock water demand includes water used in the production of various types of livestock, including cattle (beef and dairy), poultry, hogs, horses, sheep, and goats. The 2020 water demand projections for each county were based on the average of the most recent five years (2010–2014) of water use estimates. Water use estimates were calculated by applying a water use coefficient for each livestock category to county-level inventory estimates from the Texas Agricultural Statistics Service. The rate of change for projections in each planning area was carried forward from the 2017 State Water Plan and

Figure 4-7. Projected annual irrigation water demand by region in 2020 and 2070 (acre-feet)



applied to the new baseline estimate. Livestock accounts for roughly 2 percent of Texas' total water demand across the planning horizon. Livestock water demand occurs throughout Texas but is highest in Regions A, G, I, and O, due in part to the concentration of confined animal feeding operations in these areas.

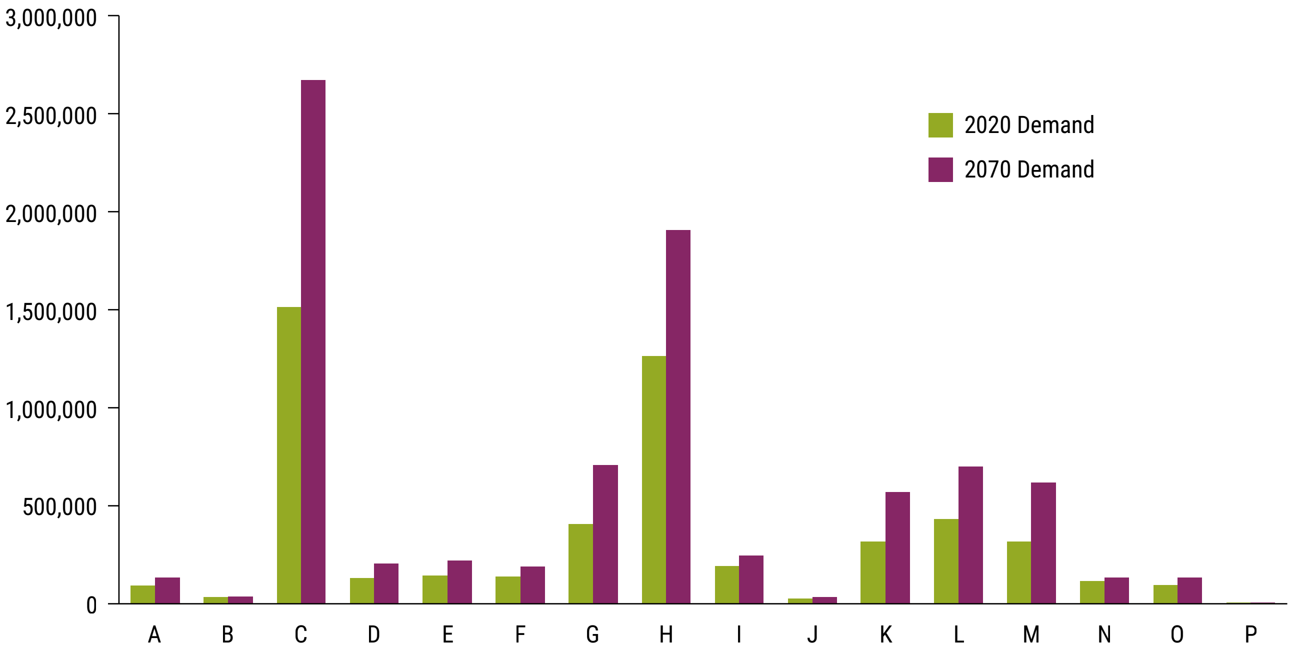
4.2.5 Municipal water demand

Municipal water demand includes water used by a variety of consumers in Texas communities, ranging from single and multi-family residences to nonresidential establishments (commercial, institutional, and light industrial). Residential, nonresidential, and even many commercial consumers use water for similar purposes, such as drinking, cooking, sanitation, cooling, and landscape watering. Water-intensive industrial customers, such as large manufacturing plants, steam-electric power generation facilities, and mining operations, are not included in municipal water demand, despite their presence within municipalities. Instead they are included in their associated non-municipal demand categories.

To project total annual municipal water demand, the TWDB multiplied the populations for each municipal water user group by the associated projected per capita water use (also referred to as gallons per capita daily or GPCD) during a historical dry year. The per capita water use was based on annual Water Use Survey data for each water user group. Per capita water use values exclude sales to other retail water utilities and large manufacturing, mining, or steam-electric power generating customers that are captured elsewhere to avoid double counting. For most municipal water user groups, the 2011 per capita dry-year water use was used in estimating demand because of the severity of the 2011 drought. Based on local circumstances, some water user groups used per capita use during drought conditions in a year other than 2011 when that was more representative of dry-year conditions. Counterintuitively, the dry-year water use usually reflects the highest per capita water use.

In all regions, the municipal water demand projections incorporated certain 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 297,000 acre-feet per year in 2020, increasing to 889,000 acre-feet per year in 2070.

Figure 4-8. Projected annual municipal demand by region in 2020 and 2070 (acre-feet)



Water savings due to existing legal requirements are embedded in the municipal water demand projections because they can be expected to occur and should require no additional action on the part of cities and water utilities.

Planning groups estimated and incorporated additional future water savings from municipal conservation programs as recommended water management strategies in the regional plans to be implemented by water providers (see Chapter 7). These strategy volumes represent voluntary water conservation savings that would not otherwise occur if not for additional, proactive actions and investments by water providers and customers.

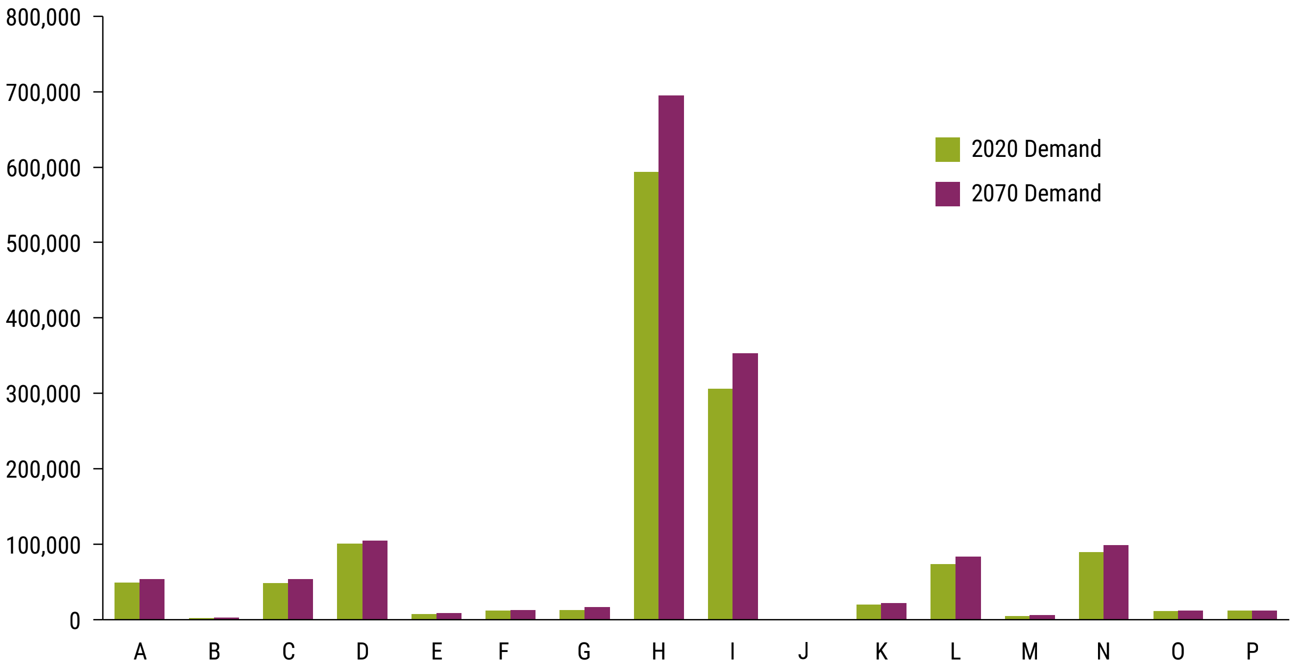
Regions C, G, H, K, L, and M account for over 80 percent of statewide municipal demand in 2070 (Figure 4-8).

4.2.6 Manufacturing water demand

Manufacturing water demand consists of the water necessary for large facilities, including those that process chemicals, oil and gas, food, paper, and other materials. The 2020 water demand projections for each county were based on the highest county-aggregated manufacturing water use in the most recent five years of survey data between 2010 and 2014. Then the most recent 10-year projections for employment growth from the Texas Workforce Commission were used as a proxy for projected growth in each manufacturing sector between 2020 and 2030. In cases where employment was projected to decrease for a specific sector, the water demand projections were held constant for that sector. After 2030, the manufacturing water demand was held constant through 2070.

This projection methodology was supported by a study (CDM Smith, 2016) funded by the TWDB. The goal of the study was to find the best projection method for this sector that the TWDB can update regularly. It was also partially influenced by the fact that, historically, the TWDB has seen the manufacturing sector continue to become more efficient in its water use while increasing its economic output. This resulted in the most significant relative change (reduction) in water demand projections and intentionally reflects the encouraging fact that declining water use can

Figure 4-9. Projected annual manufacturing demand by region in 2020 and 2070 (acre-feet)



be experienced even in the midst of increasing economic production (Hoffman, 2016).

Overall, manufacturing accounts for approximately 8 percent of Texas' water demand across the planning horizon. The majority of Texas manufacturing occurs along the Gulf Coast, with Regions H and I accounting for nearly 70 percent of all manufacturing demand in 2070 (Figure 4-9). Regional water plans for Regions C and H noted concern that the assumption of no growth in manufacturing water demand after 2030 does not reflect ongoing manufacturing growth in the regions. The Region C plan stated that several water suppliers have included a management supply factor to help mitigate this concern. The Region H plan stated that it is unlikely that reductions in water use per production unit will offset all growth in manufacturing in the region and acknowledged the need for continuing evaluation of this topic in future planning cycles to consider the potential for mitigating influence from changes in regional industry categories, water use characteristics, and implementation of water-efficient technologies.

4.2.7 Mining water demand

Mining water demand consists of water used in exploring, developing, and extracting oil, gas, coal, aggregates, and other minerals. Initial draft mining water demand projections were carried forward from the 2017 State Water Plan and were based upon two TWDB-contracted studies with the University of Texas at Austin's Bureau of Economic Geology (BEG, 2011, 2012). The TWDB estimated and projected historical mining water use across the planning horizon using data collected from trade organizations, government agencies, and other industry representatives. Mining demand is projected to increase through 2030 and then decline in later planning decades based on the oil and gas industry outlook. More than half of all mining water demand in Texas is projected to occur in Regions F, G, and L in 2030. Region F requested to increase mining demands due to recent increases in non-conventional oil and gas activities in the Permian Basin, which is predominately located in that region. Across the planning horizon, mining accounts for roughly 2 percent of total water demand statewide.

Municipal water demand is projected to increase in each planning decade

4.2.8 Steam-electric power water demand

Steam-electric water demand consists of water used for the purpose of generating power. A generation facility typically diverts surface water, uses it for cooling purposes, and then returns a large portion to a body of water. Landfill gas, wood waste biomass, and battery power plants, as well as any power generating facilities using renewable energy sources, were not included in the water demand projections. Water demand projections for 2020 were based on the highest county-aggregated historical steam-electric power water use in the most recent five years of survey data (2010–2014). The anticipated water use for future power generation facilities listed in state and federal reports was added to the demand projections from the anticipated operation date through 2070, while projected water demands from facilities scheduled for retirement were subtracted. Subsequent demand projections after 2020 were held constant throughout the planning period to reflect increasing trends in using renewable energy and more water-efficient technology.

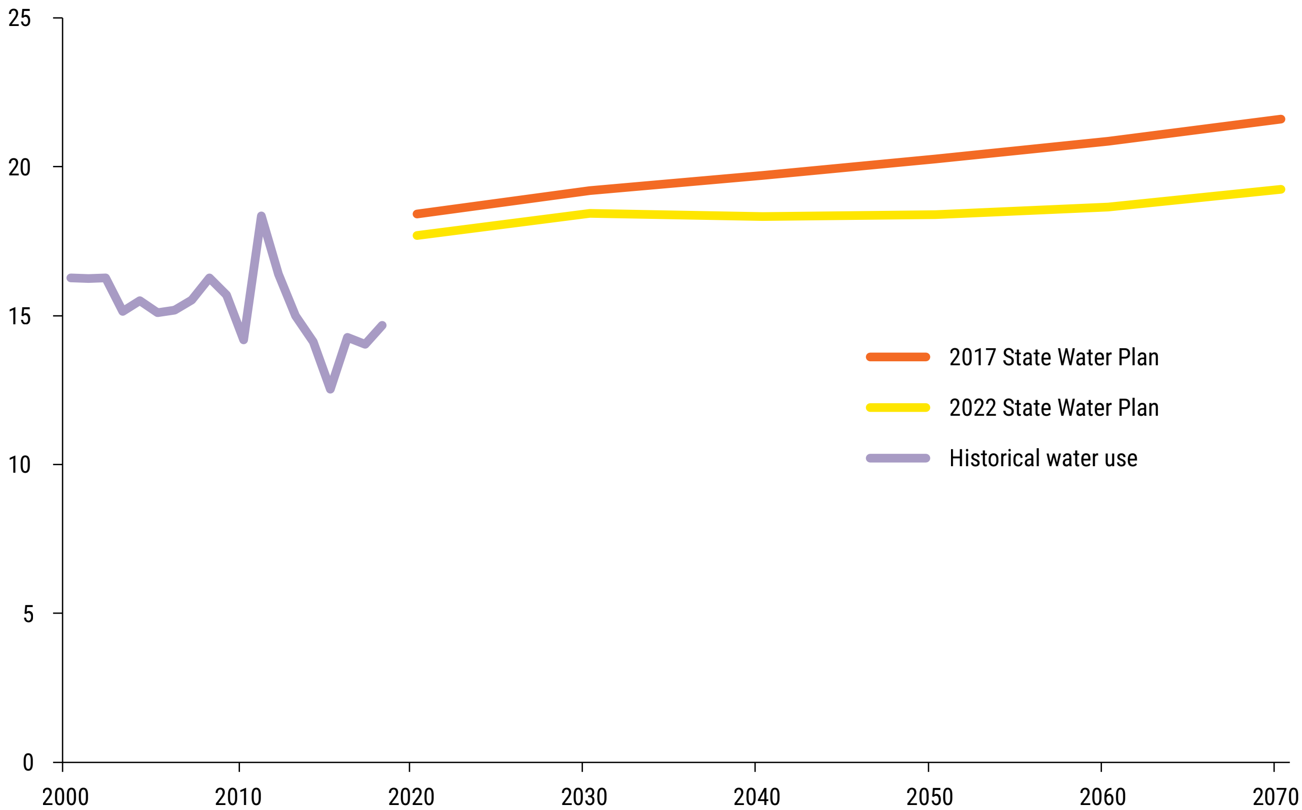
Based on data reported to the U.S. Energy Information Administration (EIA, 2018), more than 60 percent of all capacity of proposed electricity generators in Texas will come from renewable sources, mainly wind and solar, which use far less water than conventional fossil fuel sources to generate power. This projection methodology was based on a study (CDM Smith, 2016) funded by the TWDB. The study's goal was to find the best projection method for this sector that the TWDB can update regularly and that better reflects overall, historic patterns of water demand in this sector.

Steam-electric power accounts for roughly 5 percent of Texas' total water demand across the planning horizon. Regions G and K (occupying the Brazos and Lower Colorado basins) account for over 40 percent of statewide steam-electric power water demand. Regional water plans for Regions C and H noted concern that the assumption of no growth in steam-electric water demand after 2020 does not reflect ongoing growth in the electric demands in the regions. The Region C plan stated that several water suppliers have included a management supply factor to help mitigate this concern. The Region H plan acknowledged the need for continuing evaluation of this topic in future planning cycles to consider the potential for mitigating influence from changes in regional power generation water use characteristics, power generation facility types, and implementation of less water-intensive technologies.

4.3 Comparison to the 2017 State Water Plan

Overall, population projections in the new plan increased by less than 1 percent within each planning decade largely due to adjustments requested by five planning groups and based on more recent population estimates from the U.S. Census Bureau. The most significant changes occurred in Region C, which expects more than 330,000 additional residents by 2070 than were included in the previous plan. These are rather small changes in the big picture: where the 2017 plan projected 51 million Texans by 2070, the new plan projects that there will be 51.5 million.

Figure 4-10. Comparison of water demand projections between 2017 and 2022 state water plans (millions of acre-feet)



Note: Historical water use and projected demand can be further explored through the TWDB's state water plan comparison tool, www.twdb.texas.gov/waterplanning/data/dashboard/index.asp

Total water demand projections across all six categories decreased considerably this planning cycle, primarily due to methodological revisions grounded in reported historical use. Statewide, this plan projects water demand to be about 727,000 acre-feet per year lower in 2020 (a 4 percent decrease) and more than 2.3 million acre-feet per year lower by 2070 (an 11 percent decrease) (Figure 4-10). This can be attributed mainly to significant declines in long-range projections for manufacturing and steam-electric power water demand due to revisions to TWDB methodologies in these categories. Substantial decreases in irrigation demand projections in some regions were mostly offset by increases in other regions. Mirroring the small increases to population projections, total municipal water demand increased in the new plan by less than 1 percent in each planning decade.

4.4 Uncertainty of population and water demands

The population and water demand projections used to develop the regional and state water plans are re-evaluated each five-year planning cycle because they are products of many complex and dynamic real-world forces and data-driven calculations. The baseline for population projections is adjusted every other planning cycle when new decadal data from the U.S. Census Bureau is released. In each planning cycle, the TWDB relies on input from the planning groups to adjust draft projections based on local data and information from a diverse range of stakeholders, including the U.S. Census Bureau and the state demographer. Many of the underlying factors that influence water use are difficult to accurately predict, especially at the micro level and over the long term, resulting in the inherent uncertainty of water demand projections. The uncertainty of these types of projections tends to decline as you increase their geographic extent by aggregating more entities, whereas uncertainty increases as you focus more locally on smaller numbers. In other words, there is a high level of confidence in the approximate total number of Texans to expect by 2070 even if the individual zip codes are unpredictable.

For example, a wide range of factors can influence the long-range outlook for municipal and non-municipal water demand through 2070. Population growth and distribution depend on economic and social factors including individual preferences. Municipal water demand depends on population growth and distribution and how much water residents are using. Per capita water use depends on individual preferences, culture and habits, the weather, local conservation ordinances, and the adoption of more water-efficient appliances.

Irrigation and livestock demands are strongly influenced by the economy and the weather. 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. Economic factors also contribute to irrigation demand, including prices of agricultural commodities and agricultural production inputs like fuel and fertilizer. Complex government policies such as farm subsidies and disaster assistance can also be influential. The TWDB is currently working toward developing remote sensing expertise and capabilities through collaborative efforts with the OpenET project team to assist in better refining irrigation water use estimates and projected demands for future state water plans.

Manufacturing, mining, and steam-electric power demands are influenced by numerous economic factors such as price levels of their inputs and outputs, the resources needed for production, technology, and markets, as well as government regulation. Because most industrial processes are energy intensive, the prices of energy sources such as gasoline, natural gas, coal, and renewable sources are also of particular importance.

Rather than attempting to predict this complex array of future economic conditions and government policies and trying to translate those often contradictory factors into water demand projections, the TWDB grounds its projections in the reported data of its historic annual water use estimates and strives to adhere to relatively straightforward, highly credible, and fully transparent projection methodologies that can be revisited each five-year cycle. This allows each state water plan to be adaptive to changes and incorporate the most recent and best available information.

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Livestock accounts for roughly 2 percent of Texas' total water demand across the planning horizon

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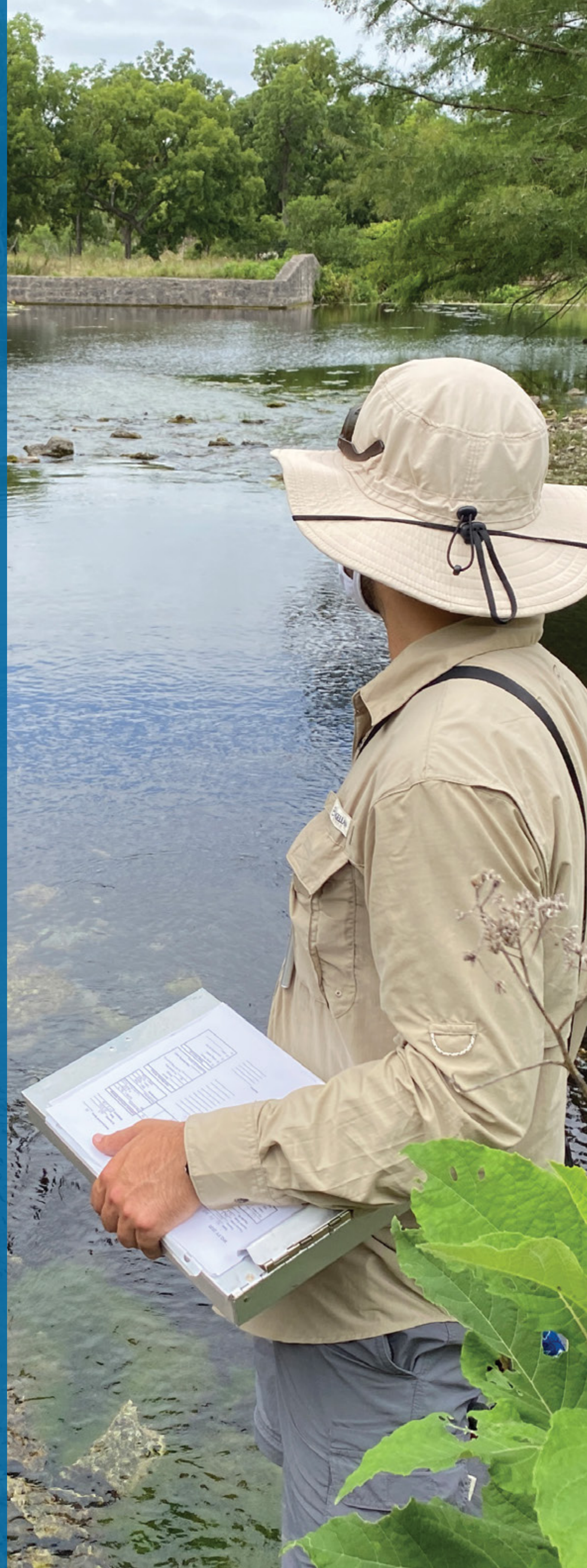
5

Water availability and existing supplies



QUICK FACTS

Total surface water availability is approximately 3 percent higher in both 2020 and 2070 than in the 2017 State Water Plan, primarily due to new systems operations and surface water availability model updates. However, total surface water availability declines by 3 percent over the planning horizon.

Total groundwater availability is approximately 1.9 million acre-feet, or 15 percent, higher in 2020 and 857,000 acre-feet, or 9 percent, higher in 2070 than in the 2017 State Water Plan, primarily due to changes in groundwater management policy. However, total groundwater availability declines by 25 percent over the planning horizon.

The existing water supplies—water already being provided in a drought from sources including surface water, groundwater, and reuse—are expected to decline approximately 18 percent between 2020 and 2070.

In 2020, more than one-third of irrigation and livestock water supplies is from the Ogallala/Edwards-Trinity (High Plains) Aquifer, while more than one-fifth of all non-agricultural-related water supply in Texas is from the Trinity River Basin.

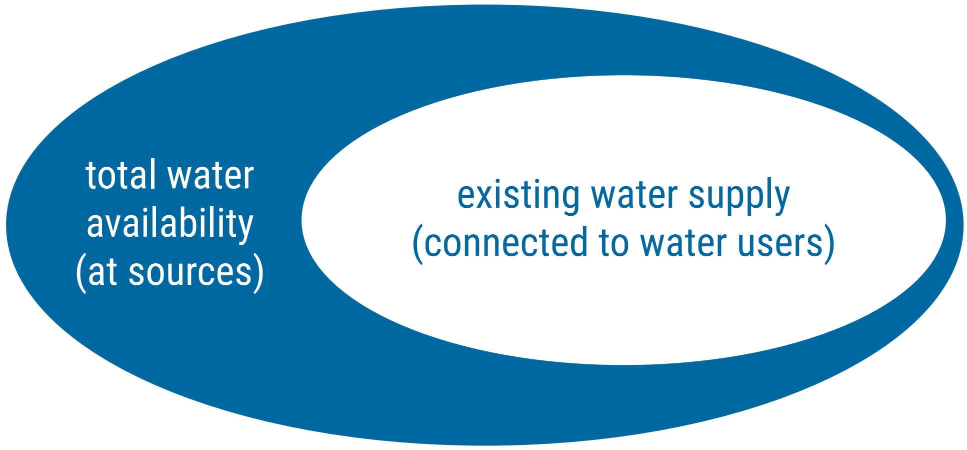
The state water plan is mandated to prepare for and respond to drought conditions. Essential to this process is estimating how much water Texans will have to meet their water demands during drought conditions, without over-allocating any water sources. To do that, the planning groups must determine how much total water is available and how much of that is already in use.

5.1 Evaluating water resources for planning

During development of the regional plans, each water planning group must identify all water sources within their planning area and their associated annual availability volumes. Water availability refers to the maximum volume of raw water that can 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. Availability is analyzed from the perspective of the water source and answers the question: *How much water from this source could be delivered to water users during a repeat of the drought of record, as either existing water supply or as part of a future water management strategy?* Determining water availability is the first step in assessing potential water supply volumes (Figure 5-1).

Next, planning groups quantify the subset of that total water availability volume that is already connected to water user groups. This subset is defined as the existing supply. Existing water supplies are determined by legal access to the water as well as existing infrastructure (such as pipelines and treatment plant capacity) to treat and deliver the water to the “doorstep” of a water user group. Existing supply is analyzed from the perspective of water users and answers the question: *How much water supply could each water*

Figure 5-1. Water availability as relates to existing supply



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 available 100,000 acre-feet, the current pipeline to that source only conveys 60,000 acre-feet per year to users; 60,000 acre-feet is the existing supply. There remains an additional 40,000 acre-feet per year of available water that can serve as the basis for a future water management strategy.

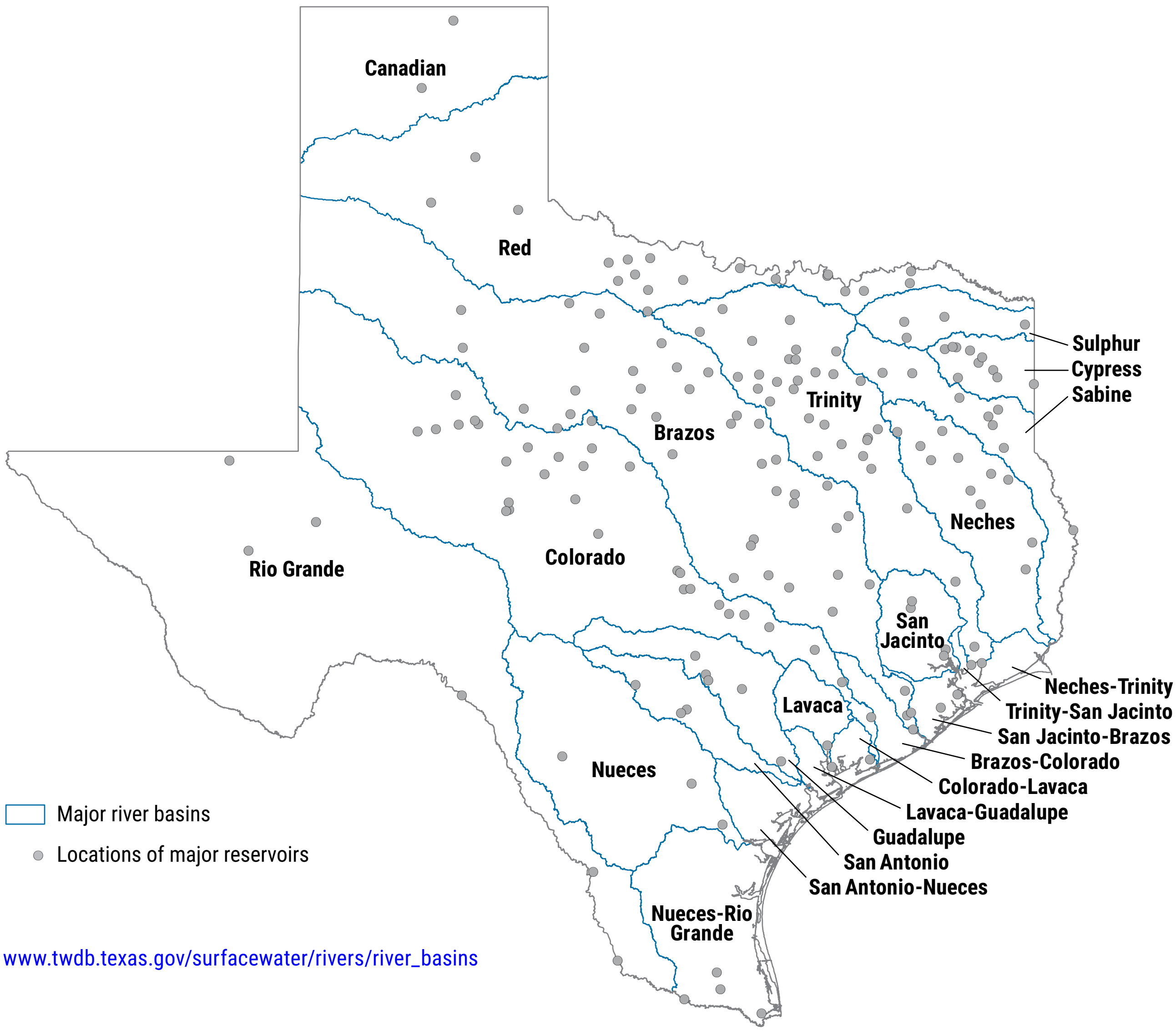
As another example, there may be within a county a modeled available groundwater volume of 50,000 acre-feet per year, but because current permits and pumping facilities are only able to pump 20,000 acre-feet per year for existing supplies, there remains 30,000 acre-feet per year in available groundwater that can support a future water management strategy.

Because existing supplies are a subset of the availability of water sources, existing supplies cannot exceed availability without the risk of running short of water in a drought of record. If existing supplies exceed availability it is an over-allocation. To ensure that planning groups do not assign more water supply to a water source than the source can provide in a drought, the TWDB performs a detailed, statewide accounting of all assigned existing water supply volumes and notifies planning groups of over-allocations. Planning groups then adjust their plans accordingly.

5.2 Surface water availability within river basins

Surface water supplies in Texas come from Texas' 15 major river basins and 8 coastal basins via 187 major reservoirs and numerous river diversions, known as run-of-river supplies (Figure 5-2). Surface water availability is determined using the Texas Commission on Environmental Quality's surface water availability models (WAMs), which estimate the monthly and annual water volumes that can be diverted each year in drought of record conditions, all of which assume a repeat of the historic hydrologic record. The default model for planning purposes, known as WAM Run 3, conservatively assumes that all existing water rights are fully used without returning any flows to the river, unless a permit requires such returns, and is adjusted to consider the impacts due to sedimentation on reservoir yields. The state's WAM models are based on historic data, including inflows, that was available as of their last updates. WAMs reflect historic changes to hydrology, including inflows, but do not attempt to make predictions about the future changes to inflows or other parameters. However, planning groups are allowed and encouraged to modify

Figure 5-2. Major river and coastal basins and major surface water supply reservoir locations



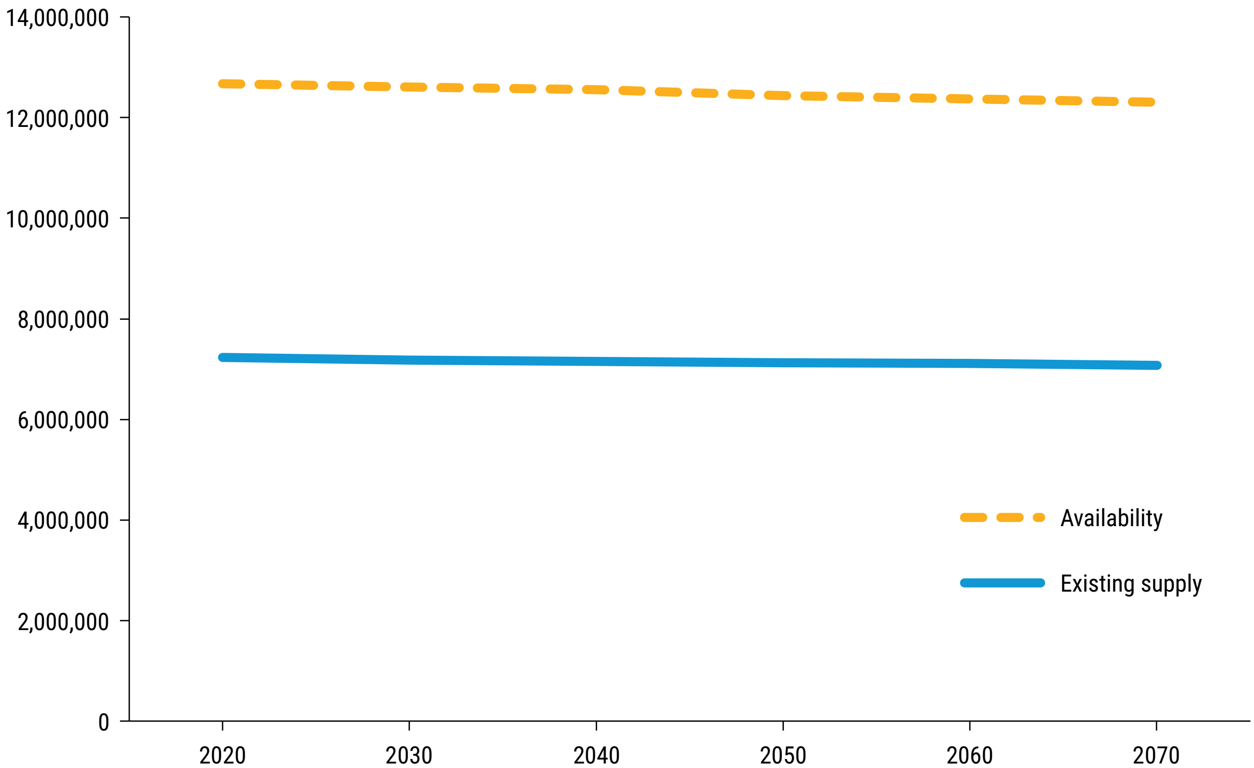
www.twdb.texas.gov/surfacewater/rivers/river_basins

the default model to reflect appropriate conditions not included in WAM Run 3 when evaluating *existing* water supplies for planning purposes.

Justifiable modifications to the water availability models, which are expected to better reflect conditions encountered during a drought, include correcting known model errors; reflecting increased sedimentation or current river system operations; updating reservoir inflows to reflect recent drought conditions, including return flows; or utilizing a reservoir safe yield instead of firm yield. Safe yield is a reduced annual water volume that continues to be available from a reservoir for periods longer than a drought of record, which may provide a buffer against uncertainty for water supply purposes.

All regional water planning groups requested and received approval to modify their surface water availability analysis for the purpose of evaluating existing water supplies. Select modifications utilized in the development of the surface water availability models are summarized in Appendix B and available at www.twdb.texas.gov/waterplanning/rwp/planningdocu/2021/hydroassumptions.asp. Of note is that House Bill 723, enacted by the 86th Texas Legislature (2019),

Figure 5-3. Texas' annual surface water availability and existing surface water supply (acre-feet)



directed the Texas Commission on Environmental Quality to update the Brazos, Neches, Red, and Rio Grande water availability models by December 1, 2022. These updated models will be available and utilized in the next state water plan.

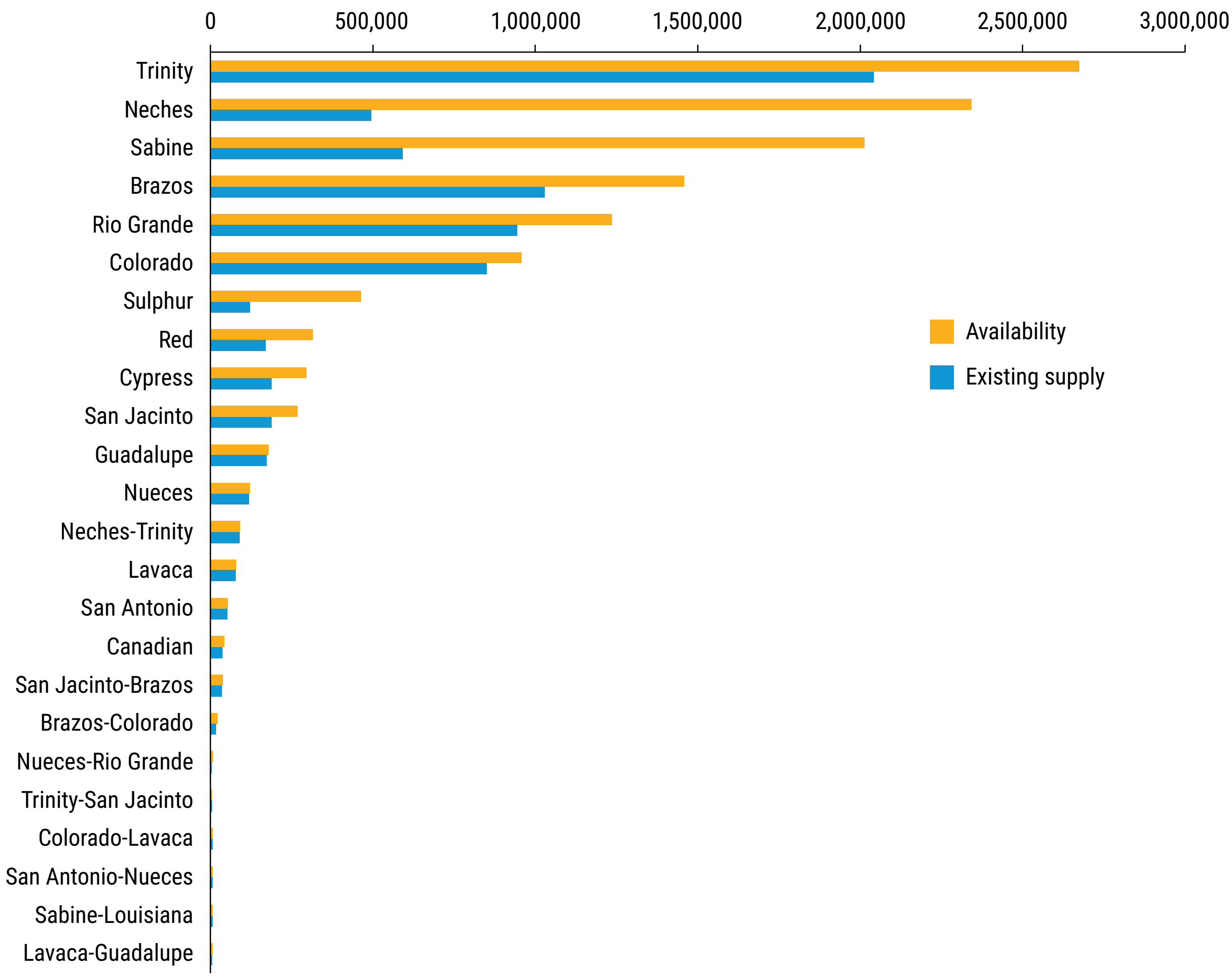
Surface water availability for *future* water management strategies (Chapter 7) was evaluated using WAM Run 3 unless an alternative model produced more conservative yields or the water management strategy itself was based on departing from the default model parameters. For example, if a senior water right is to be "subordinated" to a junior water right to increase the reliability of the junior water right, the alternative model would be used.

Overall surface water availability in Texas, represented as the sum of all reservoir firm yields, approved safe yields, and run-of-river availabilities as determined by the planning groups, is anticipated to decline by approximately 3 percent from 2020 to 2070 (Figure 5-3). The decline is primarily due to sedimentation, which reduces reservoir storage. Other factors not presently accounted for in the methodology for assessing surface water availability, but which may impact it, include stream-aquifer interactions, changes over time to reservoir inflows, and evaporative loss from reservoirs. More than half of the annual statewide surface water availability of 12.7 million acre-feet in 2020 occurs within the Trinity, Neches, and Sabine river basins (Figure 5-4, Table B-2).

5.3 Future surface water availability

Surface water availability may actually 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. However, future surface water availability may also be limited to address environmental needs, such as environmental flow standards placed on permits and reflected in water availability modeling.

Figure 5-4. Annual surface water availability and existing surface water supplies by river and coastal basin in 2020 (acre-feet)

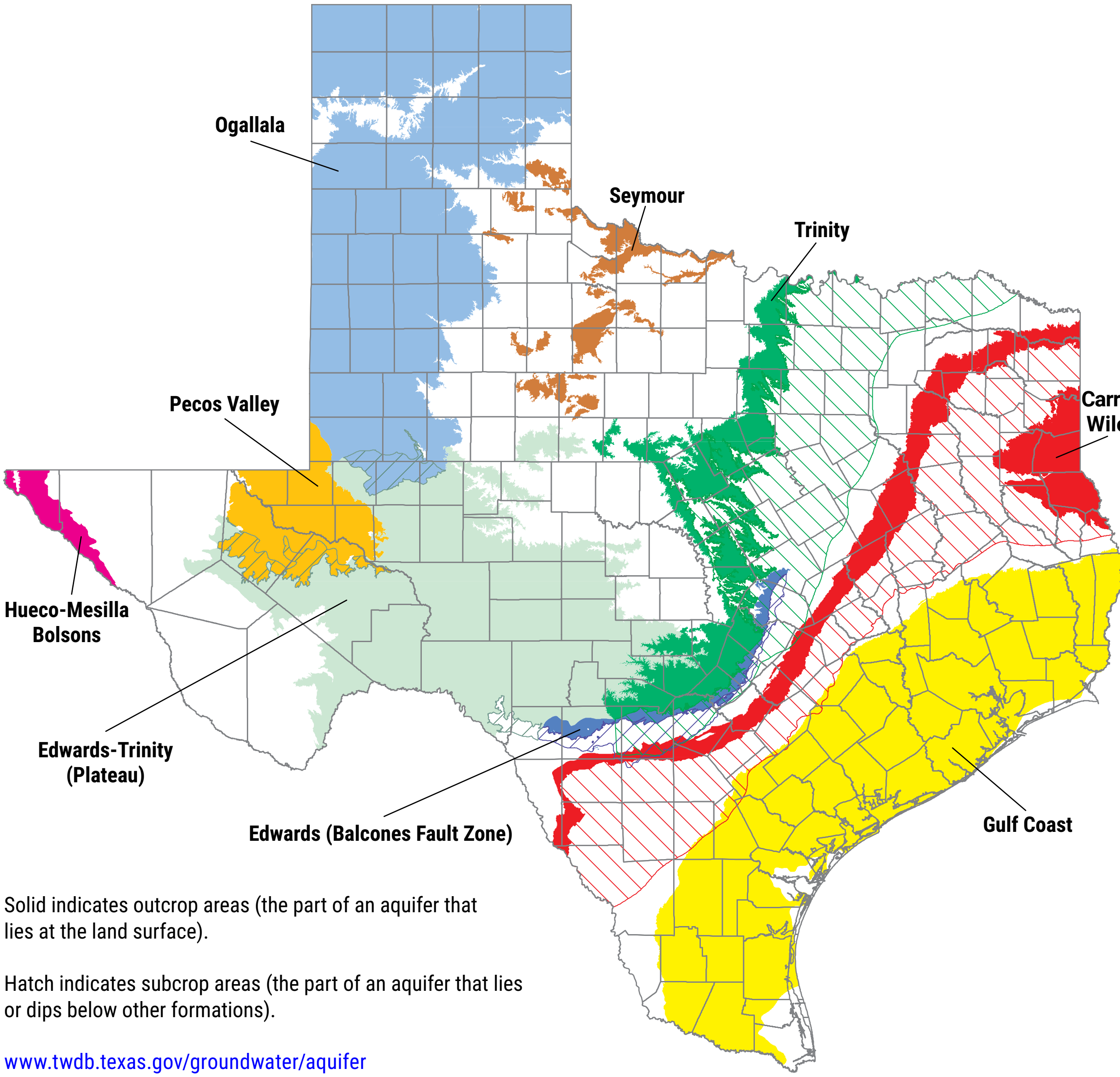


In cases where no environmental flow standards were adopted by the Texas Commission on Environmental Quality, planning groups were required to model diversions based on the Consensus Criteria for Environmental Flow Needs developed through a stakeholder process by the TWDB, the Texas Parks and Wildlife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

5.4 Groundwater availability of aquifers

Groundwater supply in Texas comes from 9 major and 22 minor aquifers as well as other water-bearing geologic formations around the state. Major aquifers produce large amounts of water over large areas (Figure 5-5), whereas minor aquifers produce minor amounts of water over large areas or major amounts of water over small areas (Figure 5-6). Since the 2017 State Water Plan was adopted, the TWDB designated the Cross Timbers Aquifer as a minor aquifer. Groundwater availability is estimated through a combination of policy decisions made by groundwater conservation districts through joint groundwater planning and the ability of an aquifer to transmit water to wells.

Figure 5-5. Major aquifers of Texas



Solid indicates outcrop areas (the part of an aquifer that lies at the land surface).

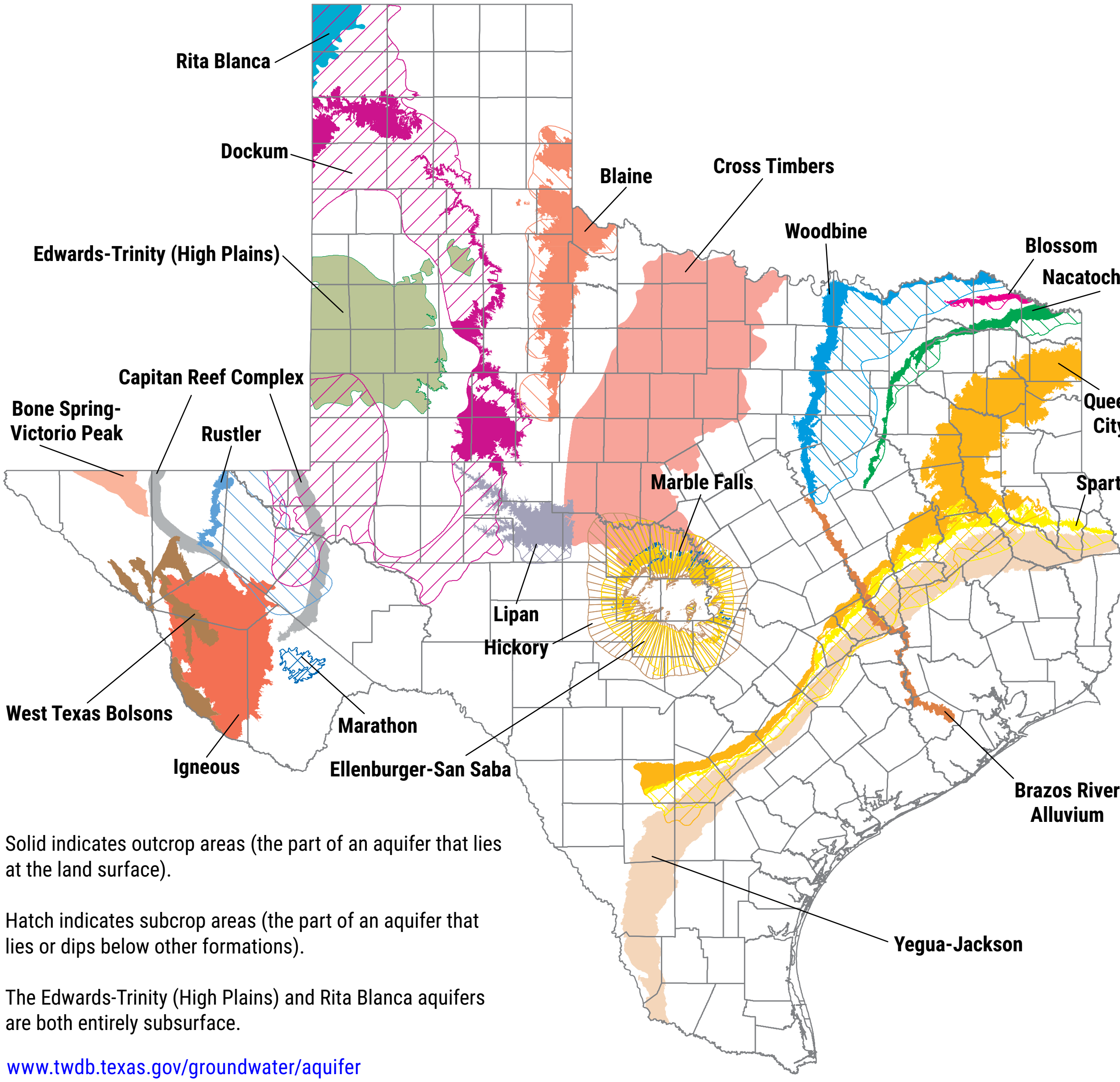
Hatch indicates subcrop areas (the part of an aquifer that lies or dips below other formations).

www.twdb.texas.gov/groundwater/aquifer

Groundwater is governed by the rule of capture, which may be modified where groundwater conservation districts and subsidence districts exist (Figure 5-7). Districts may issue permits that regulate pumping of groundwater and spacing of wells within their jurisdictions. Groundwater conservation districts within the state's groundwater management areas work together to determine groundwater management policies (desired future conditions of relevant aquifers) within that area. These policies inform the groundwater availability utilized in the state's water planning process.

Desired future conditions are the desired, quantified conditions of groundwater resources (such as water levels, water quality, spring flows, or storage volumes) at one or more specified future times. The desired future conditions are defined by participating groundwater conservation districts within a groundwater management area as part of the joint planning process. 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

Figure 5-6. Minor aquifers of Texas



Solid indicates outcrop areas (the part of an aquifer that lies at the land surface).

Hatch indicates subcrop areas (the part of an aquifer that lies or dips below other formations).

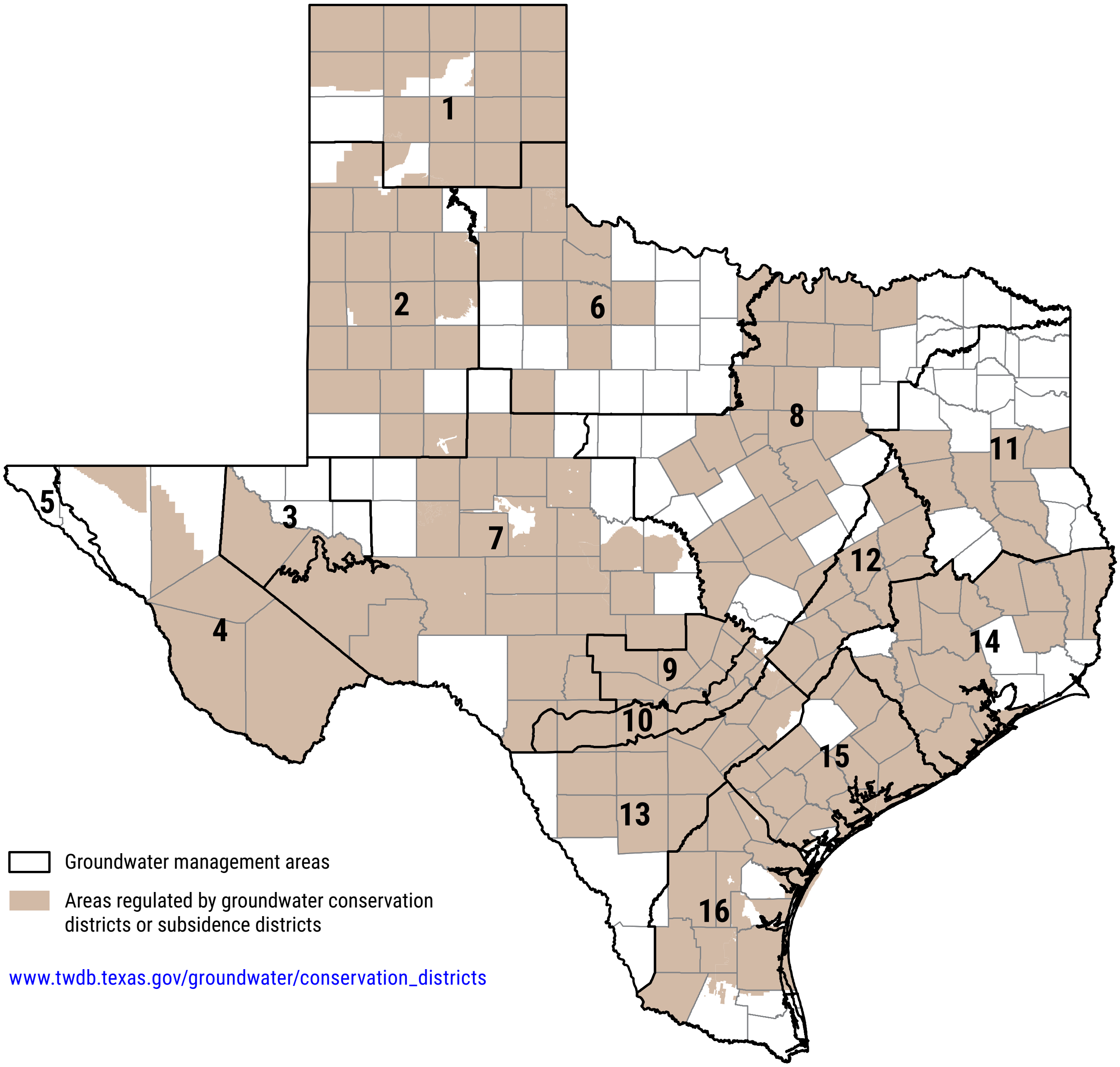
The Edwards-Trinity (High Plains) and Rita Blanca aquifers are both entirely subsurface.

www.twdb.texas.gov/groundwater/aquifer

groundwater value is the volume of groundwater production, on an average annual basis, that will achieve a 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 amount of brackish groundwater in modeled available groundwater values may require local and regional supply evaluations.

Modeled available groundwater volumes account for most of the groundwater availability considered in this plan. In response to concerns that most of these volumes were developed using groundwater availability models calibrated for long-term average conditions rather than drought of record, the TWDB revised its planning rules after the 2017 State Water Plan to allow for use of a *modeled available groundwater peak factor*.

Figure 5-7. Locations of groundwater conservation districts or subsidence districts and 16 groundwater management areas



A peak factor allows regional water planning groups to develop plans, where appropriate, that reflect more realistic groundwater availability in drought conditions. The modeled available groundwater peak factor accommodates short-term pumping above the modeled available groundwater value as long as it can be shown that the desired future conditions will still be met. It can accommodate anticipated fluctuations in pumping between wet and dry periods or account for other shifts in the timing of pumping while remaining consistent with desired future conditions. This approach reflects additional potential groundwater that could be available for pumping over limited periods of time in drought and is utilized for regional water planning purposes only—not permitting. The peak factor is not intended as a limit to permits or as guaranteed approval or pre-approval of any future permit application.

Subject to many variables, some examples of when the modeled available groundwater peak factor might be considered, while still achieving the desired future conditions, are the following:

- Actual pumping in wetter years is expected to fall below the modeled available groundwater, thereby allowing intermittent pumping of volumes greater than the modeled available groundwater during drought.
- Groundwater pumping in early decades is expected to consistently remain well below the modeled available groundwater, thereby accommodating pumping volumes somewhat higher than the modeled available groundwater in later decades.

The use of modeled available groundwater peak factors requires review and approval by relevant groundwater conservation districts, groundwater management areas, regional water planning groups, and the TWDB executive administrator. The peak factor is optional for planning groups, and two planning groups (Regions G and H) utilized the approach in this round of planning.

For aquifers and portions of aquifers that did not have modeled available groundwater values, planning groups determined availability in consultation with the TWDB. An exception to this is Texas Water Code Section 16.053(e)(2-a) that allows a regional water planning group to define all groundwater availability within its region as long as there are no groundwater conservation districts within the regional water planning area. This was added through Senate Bill 1101 from the 84th Legislative Session, and this is the first state water plan in which this provision applies. It is only applicable to the Northeast Texas Regional Planning Group, or Region D. The groundwater availability values estimated by Region D were reviewed by the TWDB to ensure physical compatibility with desired future conditions in groundwater conservation districts within co-located groundwater management areas.

The TWDB has been charged by the legislature to identify and designate brackish groundwater production zones in the state for certain aquifers by December 1, 2032. The TWDB's Brackish Resources Aquifer Characterization System, or BRACS, program has completed 12 studies and has four ongoing studies. As of publication of the 2022 State Water Plan, the TWDB has designated a total of 31 brackish groundwater production zones in the following aquifers: Carrizo-Wilcox, Gulf Coast, Rustler, Blossom, Nacatoch, and Northern Trinity aquifers. Since the last state water plan, there has been a net increase in the 2020 brackish groundwater availability of approximately 138,000 acre-feet per year and approximately 182,000 acre-feet per year in 2070. The BRACS program continues to study the aquifers of the state, which will enable the identification of additional possible brackish groundwater sources for planning purposes.

On a statewide basis, total groundwater availability is projected to decline by approximately 25 percent from 2020 to 2070 (Figure 5-8). This decrease is primarily due to reductions in groundwater availability in the Ogallala/Edwards-Trinity (High Plains), Ogallala/Rita Blanca, and Ogallala aquifers and revised desired future conditions since the 2017 State Water Plan (Appendix B).

Annual statewide groundwater availability in 2020 is estimated to be 14.2 million acre-feet. Just over half of that comes from the Ogallala/Edwards-Trinity (High Plains), Ogallala, and Gulf Coast aquifers (Figures 5-9 and 5-10, Table B-4).

5.5 Future groundwater availability

For planning purposes, future groundwater availability cannot be increased by implementing water management strategies other than aquifer recharge-type projects. These are different from aquifer storage and recovery projects, which generally provide underground storage of water from another source and are not a mechanism to actually increase an aquifer's groundwater availability. Changes in groundwater availability

Figure 5-8. Texas' annual groundwater availability and existing groundwater supplies (acre-feet)

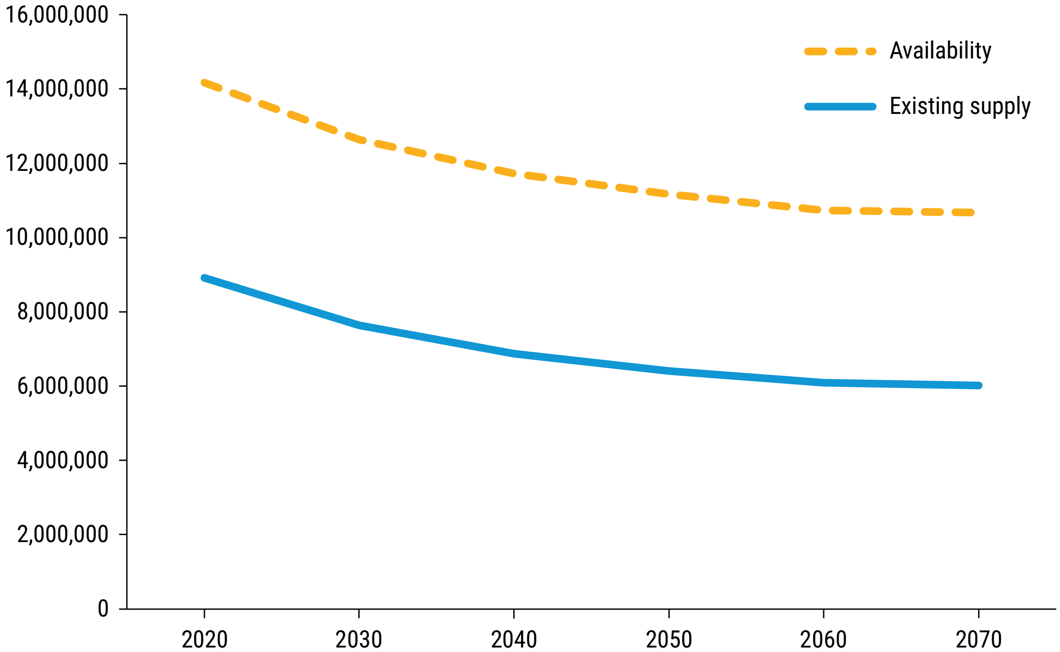
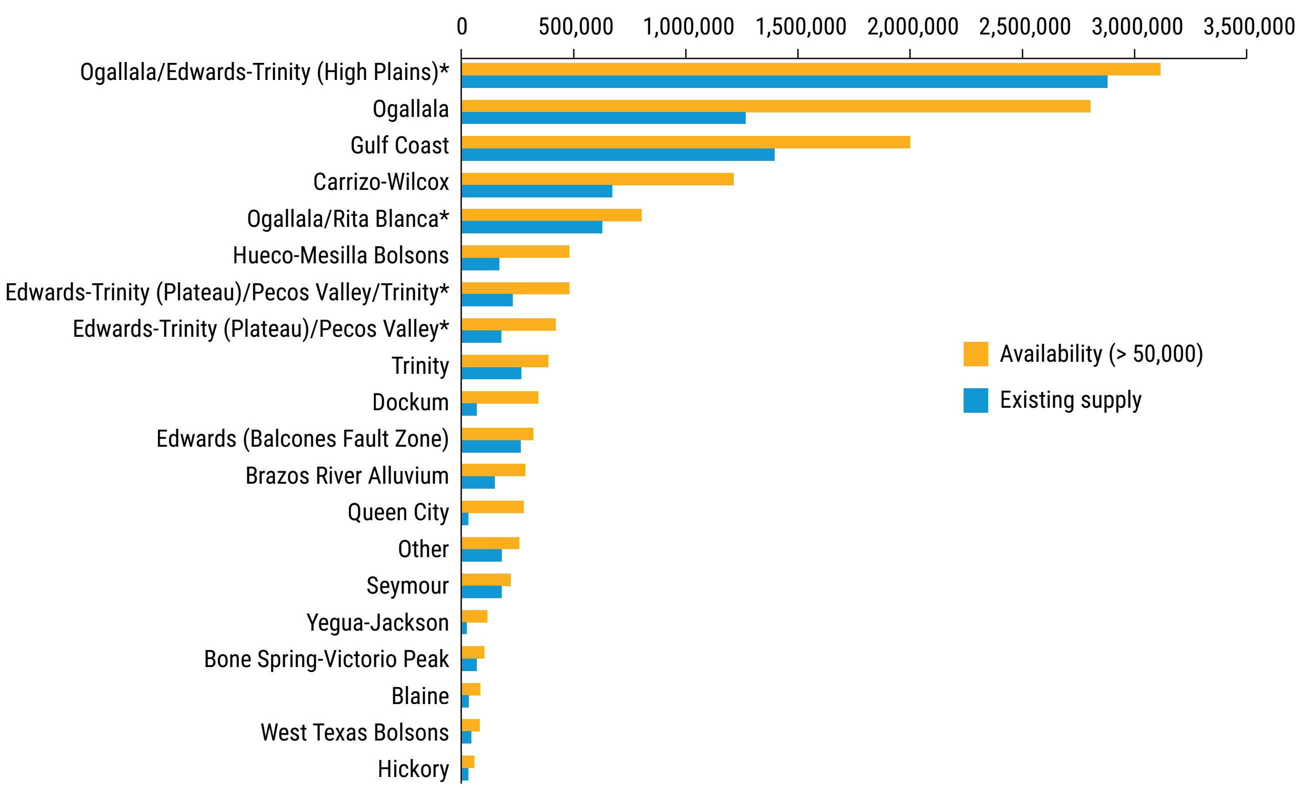
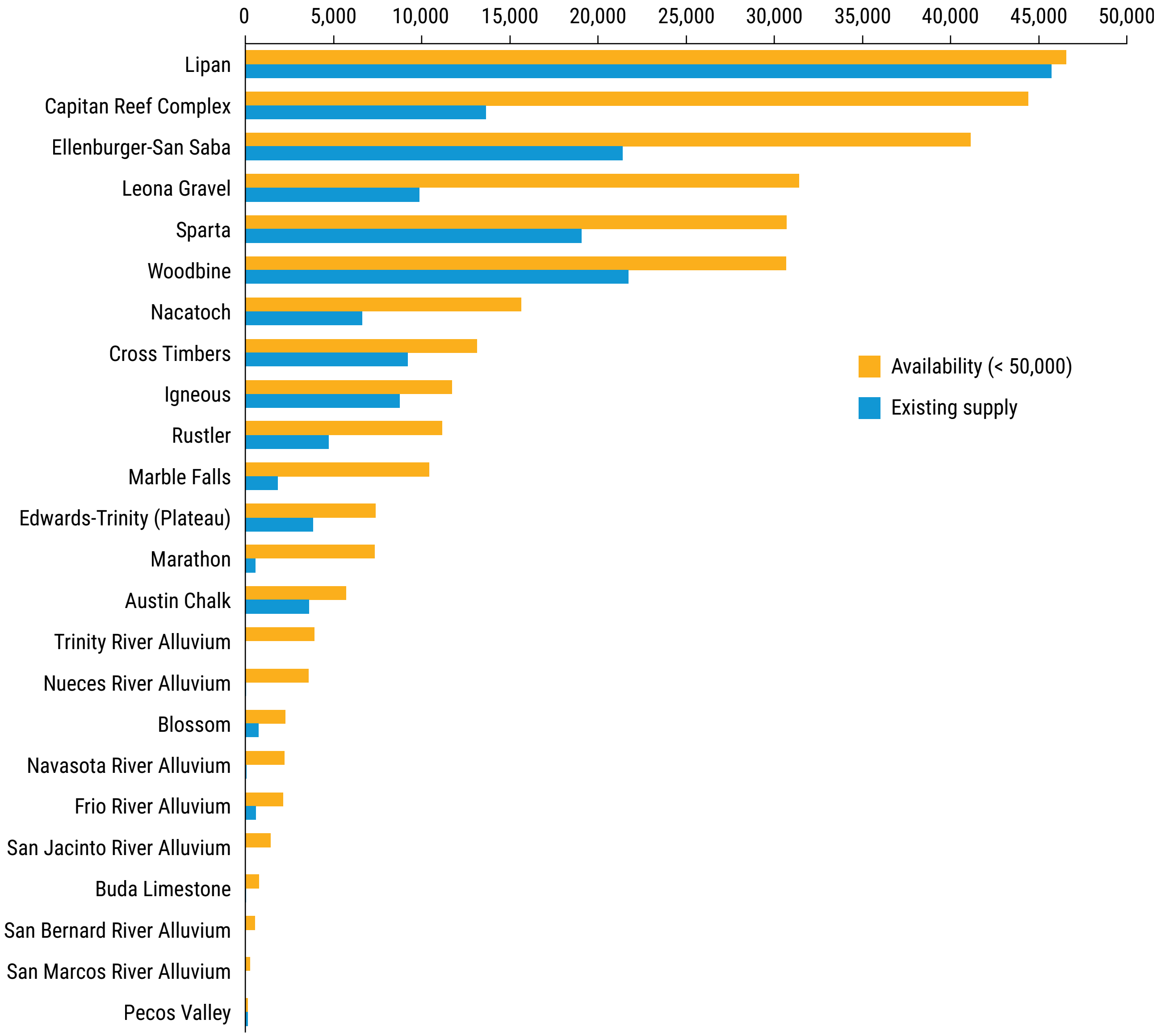


Figure 5-9. Annual groundwater availability greater than 50,000 acre-feet and existing groundwater supplies by aquifer in 2020 (acre-feet)



** The Ogallala/Edwards-Trinity (High Plains); Ogallala/Rita Blanca; Edwards-Trinity (Plateau)/Pecos Valley/Trinity; and the Edwards-Trinity (Plateau)/Pecos Valley are aquifer combinations that reflect specific groundwater management policy decisions based on aquifer properties. In these cases, the modeled available groundwater and existing supply values have likewise been developed to honor these aquifer combinations.*

Figure 5-10. Annual groundwater availability less than 50,000 acre-feet and existing groundwater supplies by aquifer in 2020 (acre-feet)

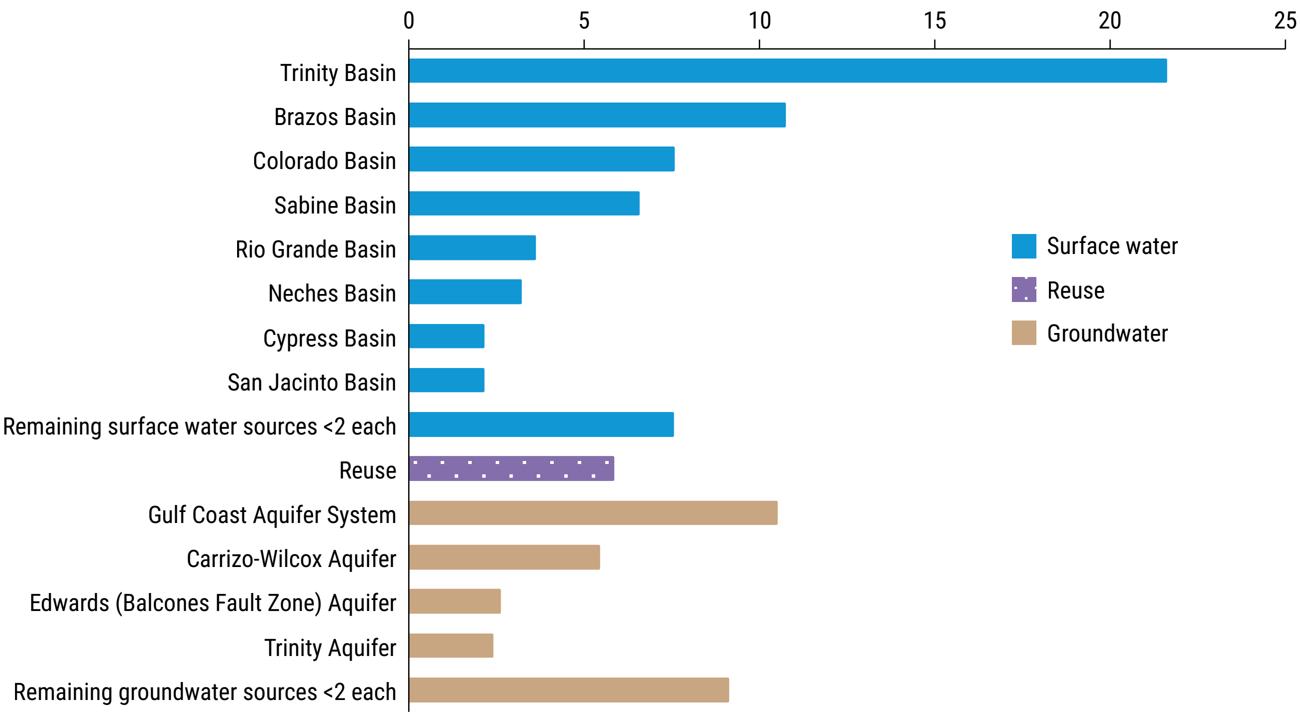


between state water plans is largely attributed to changes in groundwater management policies as revised through the state's groundwater joint planning process. Additionally, updates or revisions to groundwater availability models or newly developed local studies bring new data to the process and may result in different availability estimates from previous plans. More details on differences across the groundwater joint planning process cycles are included in Appendix B.

5.6 Availability of other sources

The vast majority of Texas' water supply comes from river basins and aquifers, but seawater and reclaimed wastewater for reuse represent other widely available sources of water. Seawater availability is generally limited only by the ability to legally access it along the coast. The availability of reclaimed wastewater for reuse, on the other hand, changes over time and is limited by the amount of wastewater generated by water users

Figure 5-11. Shares of total, statewide existing municipal, steam-electric, manufacturing, and mining supply by water source in 2020 (percent)



at any given time unless a water use permit or agreement states otherwise.

5.7 Existing supplies

The share of available surface and groundwater that can be legally produced and delivered to water user groups based on existing infrastructure—the existing supply—during a repeat of the drought of record is influenced by many factors. For example, a reservoir may have a large volume of available water, but existing water supplies that can be delivered to users may be limited by pipeline infrastructure, treatment plant capacity, or legal permits to divert water. Based on the volume of available water at each source, planning groups evaluated the share of supplies that can be relied upon to meet water demands in the event of drought. The planning group analyses considered both legal and physical limitations of the supplies for each water user group.

Relying on and combining water sources for each water user group varies greatly by group and location. Statewide, surface water makes up almost two-thirds of the total existing water supply (8.9 million acre-feet per year) for municipal, manufacturing, steam-electric, and mining users (Figure 5-11). However, irrigation and livestock users rely on groundwater for 80 percent of their total existing water supply (7.9 million acre-feet per year) (Figure 5-12). Overall, reuse contributes 4 percent to total existing supplies, primarily in the municipal, irrigation, and manufacturing sectors.

In 2020, Texas' existing water supply of approximately 16.8 million acre-feet consists roughly of half surface water and half groundwater, with reuse contributing 4 percent. By 2070, existing water supply is projected to decline 18 percent, to approximately 13.8 million acre-feet per year (Table 5-1, Figure 5-13), although changes in supply to water user groups vary significantly by location.

Figure 5-12. Shares of existing irrigation and livestock supply by water source in 2020 (percent)

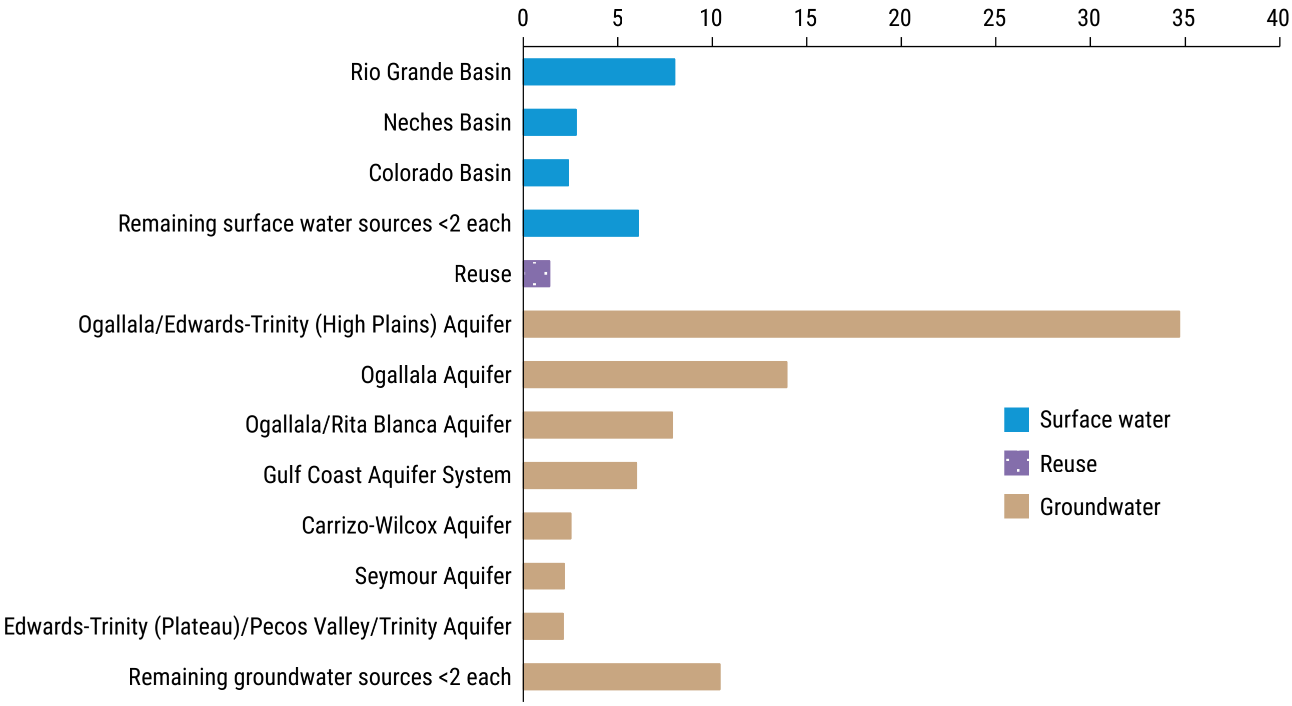


Table 5-1. Texas' annual existing water supply (acre-feet)

Source	2020	2030	2040	2050	2060	2070	Percent change
Surface water	7,232,000	7,184,000	7,153,000	7,126,000	7,107,000	7,080,000	-2
Groundwater	8,912,000	7,638,000	6,869,000	6,407,000	6,092,000	6,023,000	-32
Reuse	620,000	640,000	661,000	676,000	704,000	714,000	15
Texas[a]	**16,764,000**	**15,462,000**	**14,683,000**	**14,209,000**	**13,903,000**	**13,817,000**	**-18**

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

Surface water supply

Total annual existing surface water supply is anticipated to remain generally stable, declining approximately 2 percent from 2020 through 2070 (Figure 5-3, Table B-3). The decrease is primarily due to sedimentation decreasing the storage capacity of many reservoirs. However, factors not projected in the model results, including changes to inflow or evaporative loss, contribute uncertainty to the noted decline.

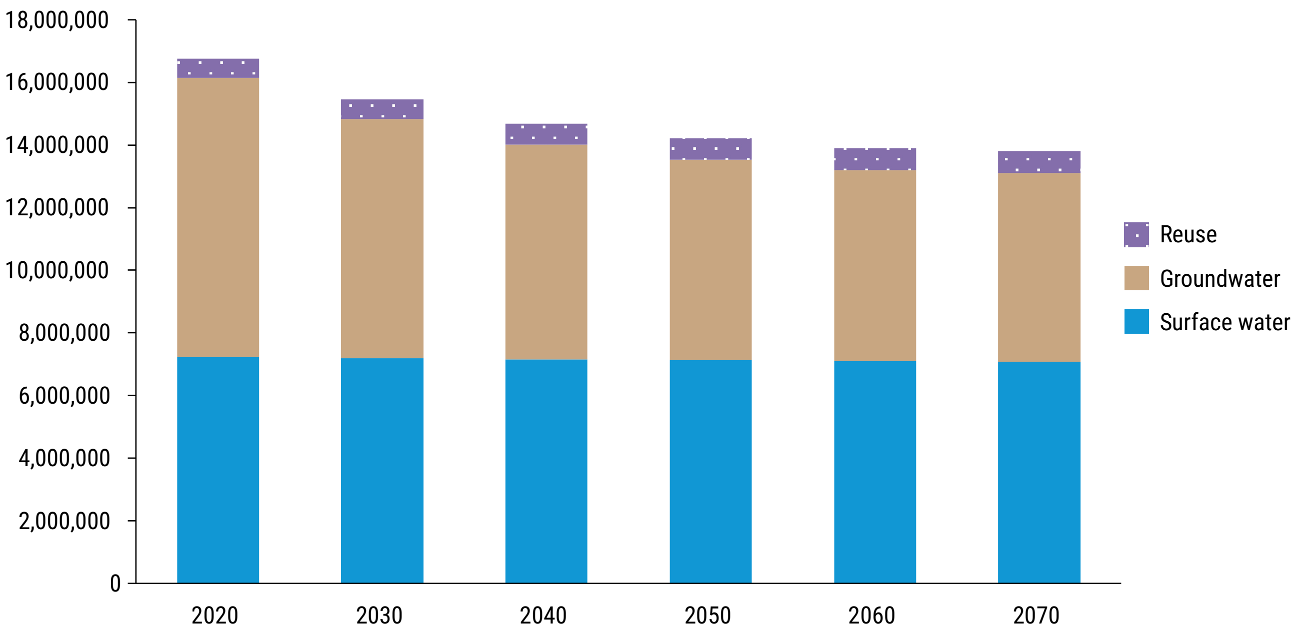
Groundwater supply

Total annual existing groundwater supply is anticipated to decline about 32 percent from 2020 to 2070 (Table B-5). The decline is due primarily to reduced availability from the Ogallala Aquifer, based on its managed depletion, and the Gulf Coast Aquifer, based on regulatory limits and management goals aimed at reducing groundwater pumping in the long-term to limit land surface subsidence (Figure 5-8). Of these groundwater supplies, the total annual supply from brackish sources remains relatively stable from 2020 to 2070.

Reuse supply

Total annual reuse supply makes up nearly 4 percent of total supplies in 2020, with approximately

*Figure 5-13. 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.*

half of this supply occurring in Region C. Reuse supplies are estimated to increase statewide about 15 percent from 2020 to 2070 (Table 5-1).

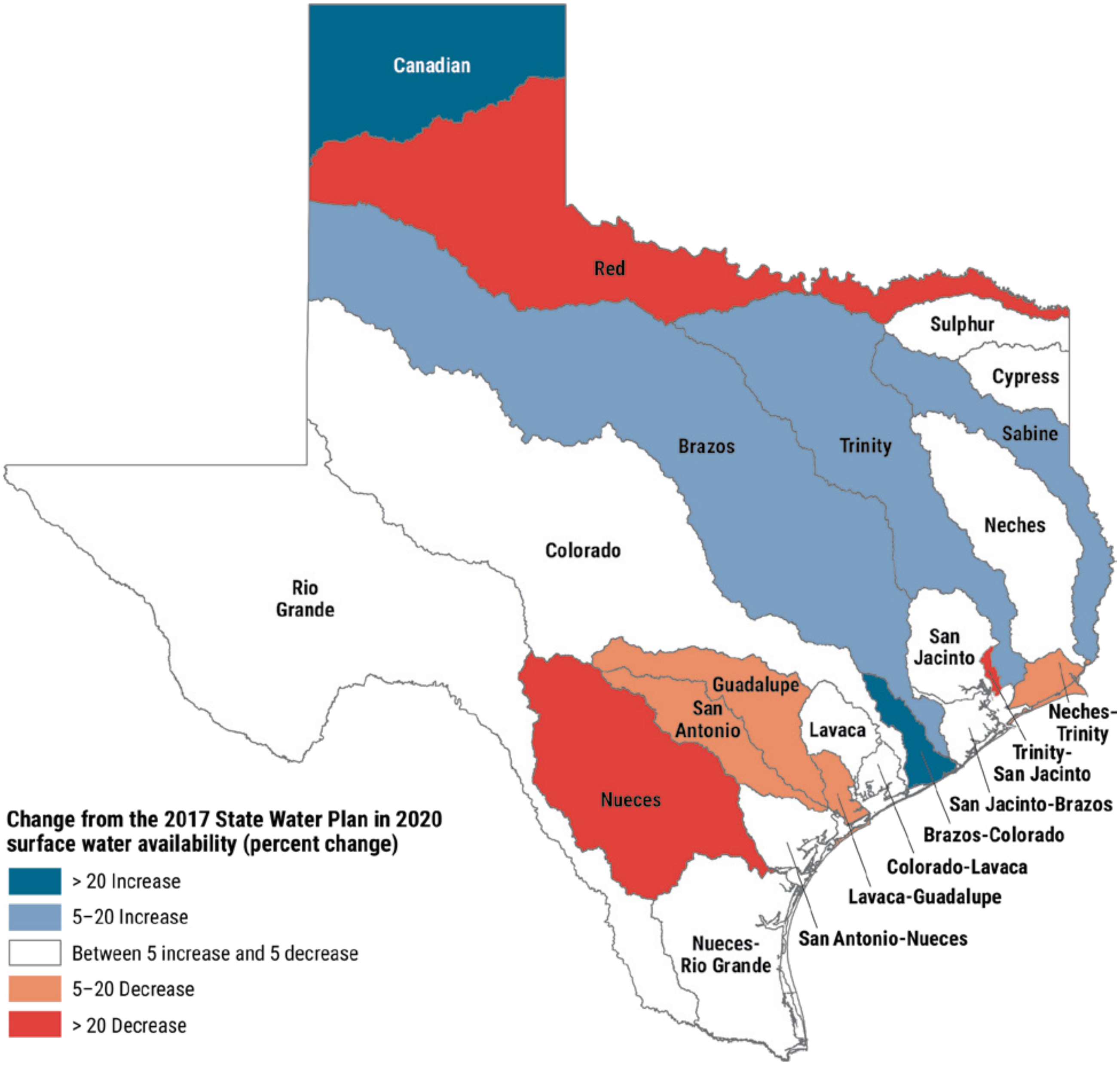
Source availability for future development

The share of available water that remains to be developed for water supply varies by water source. In the Trinity River Basin, three-fourths of the available water is committed as existing surface water supplies, but only about one-third of the Sabine and one-fifth of the Neches basins' availability are similarly connected as supply (Figure 5-4). In the Ogallala/Edwards-Trinity (High Plains), Edwards (Balcones Fault Zone), Seymour, and several other, smaller aquifers, more than 80 percent of the available water is connected as existing supply, whereas less than 20 percent of the Dockum and Queen City aquifers is connected as existing supply (Figure 5-9). Any remaining available water beyond that already connected as existing supply can, in concept, be the water source to support a recommended water management strategy, subject to many feasibility factors including its proximity to identified water needs and costs. However, there are factors unrelated to water source availability that can also reduce the existing supply of specific water users, including declines in groundwater levels relative to a well pump intake, reduced reservoir surface levels relative to an intake elevation, groundwater quality degradation, and expiring water supply contracts.

5.8 Comparison to the 2017 State Water Plan

Many factors have affected estimates of water availability and existing water supplies since adopting the 2017 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 2070 statewide, changes range greatly by water source location and user.

Figure 5-14. Changes from the 2017 State Water Plan in annual surface water availability in 2020



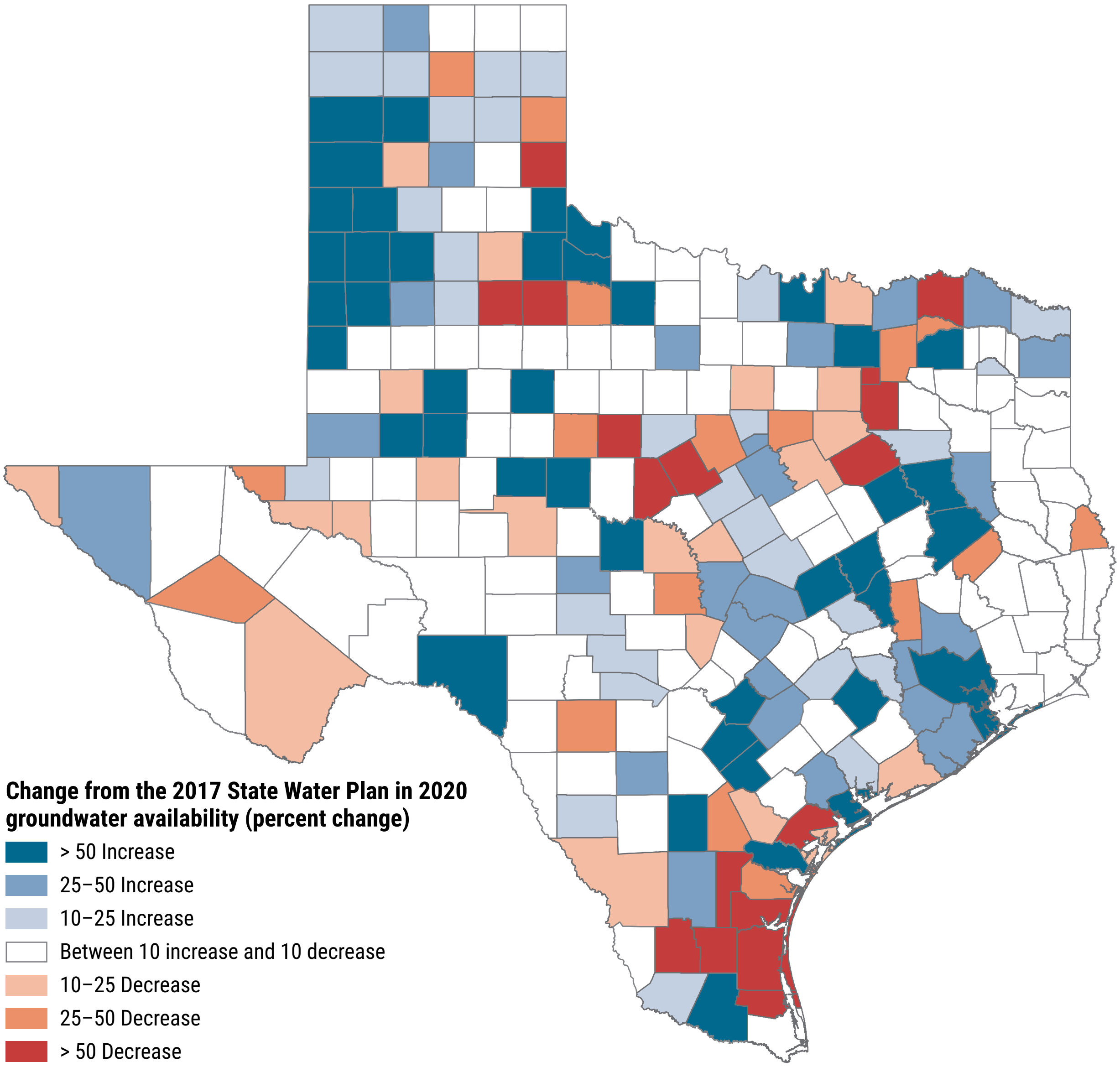
Surface water

Statewide, there is more surface water availability but less existing supply as compared to the last plan, although this varies significantly by location (Figure 5-14). The greatest relative change is an approximate 186 percent increase in existing surface water supplies in 2020 in the Canadian Basin due to revised modeling assumptions.

Groundwater

Both groundwater availability and supply increased as compared to the 2017 State Water Plan. Statewide, availability increased, though there was considerable variation by county, including relatively more decreases in western and southern counties (Figure 5-15). The greatest relative change in statewide availability occurred for the planning decade 2020, with an approximate 15 percent increase primarily due to policy decisions made as part of the groundwater management

*Figure 5-15. Changes from the 2017 State Water Plan in annual groundwater availability in 2020**



** In the 2022 State Water Plan, modeled available groundwater peak factors were used to determine groundwater availability for certain aquifers in the following counties: Austin, Brazoria, Brazos, Madison, Montgomery, Walker, and Waller. Availability increases shown in these counties reflect changes in groundwater availability reported for regional water planning purposes and do not necessarily reflect increases in resource availability since the 2017 State Water Plan.*

area joint planning process, although updated groundwater availability models may have contributed to noted differences. Additionally, groundwater availability reported for regional water planning purposes increased in several counties in Regions G and H where modeled available groundwater peak factors were utilized. Statewide, existing supply increased in all decades as compared to the 2017 State Water Plan.

Reuse

Existing reuse supply is slightly higher in the decades from 2020 to 2050 but decreases slightly in the 2060 and 2070 decades as compared to the 2017 State Water Plan. The greatest relative change was an approximate 10 percent increase in 2020, attributed to the implementation of direct and indirect reuse projects primarily in Regions B, C, and H.

5.9 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. Further, the interrelated nature of these variables makes it difficult to quantify and predict when, where, or to what degree hydrologic events will impact water supply. In some cases, snowfall in southern Colorado and rainfall in northern Mexico impact Texas' water availability. Additionally, non-climate-related variables, such as the introduction and spread of invasive species, can also impact the use of certain water sources.

Texas' water plans are based on benchmark drought of record conditions using historical hydrologic data. While the TWDB recognizes that the full sequence of historical hydrologic events will never be repeated exactly, the droughts have been of such severity that it is reasonable to use them for the purpose of planning. However, uncertainty about the likelihood or severity of worse future droughts limits the ability to predict future water availability. Some planning groups have begun to address drought uncertainty by utilizing conservative (safe) yields or a management supply factor, a pre-determined or other ratio to which existing and future supplies will exceed demands, to assess project needs. Some larger water providers across the state have conducted drought scenario planning that considers the possibility of worse droughts for their individual long-range plans, but smaller entities may not have the resources or technical expertise to develop similar analyses for managing their systems. These types of assessments are integral to identifying the likelihood and severity of potential future water supply shortages.

Quantifying surface water availability for state water planning purposes relies largely on deriving a single firm yield or safe yield value that has been generated based on the historical record that includes the drought of record, which serves as the benchmark condition for Texas' long-term water planning. This approach has provided a reasonable basis for long-term planning. The implicit assumption that any firm yield is 100 percent reliable is a weak assumption and an inherent uncertainty. A single, specific water supply firm yield estimated using a specific hydrologic time-series has a singular probability of occurring. Likewise, it has a risk (the inverse probability) of *not* occurring, which is not generally acknowledged or mitigated against in the current planning process. Similarly, quantifying groundwater availability involves inherent uncertainty related to the complexity of aquifer systems, the overlay of evolving state laws, and the dynamic nature of legal cases that may affect groundwater policy and management.

Regional and state water planning address uncertainties related to water supply and demand, including related to climate variability, in a primarily adaptive manner rather than in a speculative manner. There currently isn't much agreement among climate models (or scientists) about the nature of long-term changes to water resources in Texas and no forecasting tools capable of providing quantitative certainty about future water resources in Texas at the resolution needed for water planning. However, efforts to improve technical capabilities and address uncertainty are in progress. To provide the best available, actionable science, grounded in observed data and trends, the TWDB continues to collect data, provide technical services, improve water availability models, and support studies for consideration in developing the next state water plan. Further, the TWDB will continue to expand its understanding of the interactive relationship between the rivers and aquifers of Texas to improve planning and better inform future water management and policy decisions.

6

Water supply needs

QUICK FACTS

If no additional water supplies are developed or water management strategies such as conservation are implemented, water users face a potential water shortage of 3.1 million acre-feet per year in 2020 and 6.9 million acre-feet per year in 2070 in the event of a repeat of the drought of record.

Without additional supplies being developed through the recommended strategies and projects, approximately one-quarter of Texas' population would have less than half of the municipal water supplies they will require in 2070.

In aggregate, population growth leads to Texas' municipal water users potentially facing water shortages almost 15 times larger in 2070 (approximately 3.1 million acre-feet) than in 2020 (approximately 215,000 acre-feet) unless recommended strategies and projects are implemented.

Without additional water supplies, the annual economic losses resulting from drought of record water shortages are estimated to range from approximately $110 billion in 2020 to $153 billion in 2070.

There are significant irrigation water needs that would remain unmet under drought even if the plan is fully implemented, largely due to managed depletion of aquifers and a lack of economically feasible alternatives.

When existing water supplies—water that is already anticipated to be legally and physically available during a drought of record—are less than the projected water demands required to support regular economic and domestic activities, potential water shortages exist. These potential water shortages are referred to as identified water supply needs. The identified water needs discussion in this chapter focuses on aggregated, total needs that, for the purpose of clarity, assume none of the water management strategies are implemented.

Water shortages pose enormous risks to the Texas economy and public health and safety. Economically, a perceived lack of water in a region can bias decision makers against starting a new business or expanding their existing enterprise in Texas. More fundamentally, public health and safety depend on adequate water supplies for drinking water, sanitation, and hygiene. Water shortages resulting from inadequate planning and implementation can also strain water resources that have already been developed as water supplies.

To determine if 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 supplies. More than 17,000 comparisons over the 50-year planning horizon revealed foreseeable water supply surpluses and potential shortages in a repeat of the drought of record based on existing supplies.

Once planning groups have identified potential shortages, they evaluate and recommend water management strategies to meet those water supply needs. Strategies for meeting or reducing potential shortages include conservation, groundwater wells, new reservoirs, and desalination plants, all of which are discussed in Chapter 7.

Planning groups reported the economic and socioeconomic impacts of not implementing water management strategies and summarized the specific subset of total water needs that, unfortunately, could not feasibly be met by the plan during drought of record conditions. These *unmet* needs constitute a small portion of the total identified needs and are not anticipated to negatively impact public health or safety.

Because the state water plan is based on providing water supplies under drought conditions when water demands are usually highest and supplies are lowest, its implementation will also generally support most of the same water demands under average or wetter hydrologic conditions. Significant portions of identified water needs in this state water plan, particularly certain irrigation needs, are not, however, entirely attributable to an onset of drought conditions. Instead, those needs are associated largely with 1) either declining groundwater supplies combined with a lack of economically feasible strategies to replace that irrigation supply or 2) increases in future demand in high-growth urban areas. Even under average hydrologic conditions, irrigated agriculture requires significant water supplies to support it, and although strategies are recommended to address needs to the extent economically feasible, sizable portions of those irrigation demands will likely be unmet even under average hydrologic periods, due largely to the managed and unmanaged depletion of aquifers.

When considering potential water shortages, it is also important to keep in mind that the significance of an identified water need is best judged not in terms of the magnitude of its nominal volume, but rather in comparison to the entire water demand of that entity with the need. For example, a water need (potential shortage) of 10,000 acre-feet that represents only 5 percent of one entity's entire demand is actually much less concerning to that entity than a nominally, much smaller, 10 acre-foot shortage that comprises 50 percent of the total demand of a different entity.

6.1 Identification of water needs

For the purposes of this state planning perspective, the TWDB aggregates data provided by the planning groups and identifies water needs for each water use category and water user group for each decade over the next 50 years. In some instances, these aggregated existing water supplies over a combined geographic area may appear sufficient to meet all the water needs within that area, but in fact are not distributed user by user in a manner that would meet all needs. Therefore, for many geographic areas that as a whole may appear to have sufficient supplies, individual entities may experience shortages and others may have surpluses. In these situations, water needs might be met by implementing water management strategies such as the transfer or reallocation of surplus water supplies from one water provider to another. Delivery and treatment of additional water supplies from these strategies may or may not require new or expanded water infrastructure.

In 2020, Texas faces a near-term potential water shortage of slightly more than 3.1 million acre-feet in a drought of record. By 2070, the potential shortage more than doubles to nearly 6.9 million acre-feet (Table 6-1). These needs vary considerably by water use category (Figure 6-1). Although all 16 regions face water needs in all planning decades, the magnitude of needs varies significantly between regional water planning areas (Table 6-2). Region C faces the greatest combined overall increase in water needs from 2020 to 2070, with water needs increasing to more than

Table 6-1. Projected annual water needs by water use category (acre-feet)

Category	2020	2030	2040	2050	2060	2070[b]	Percent change
Irrigation	2,396,000	3,319,000	3,280,000	3,188,000	3,094,000	3,046,000	27
Municipal	215,000	802,000	1,371,000	1,912,000	2,502,000	3,144,000	1,362
Steam-electric	187,000	192,000	196,000	199,000	201,000	203,000	9
Manufacturing	159,000	264,000	275,000	286,000	295,000	301,000	89
Mining	119,000	123,000	111,000	102,000	96,000	101,000	-15
Livestock	40,000	44,000	48,000	54,000	60,000	63,000	58
Texas[a]	**3,116,000**	**4,744,000**	**5,281,000**	**5,741,000**	**6,248,000**	**6,858,000**	**120**

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

[b] *In 2070, 77 percent of statewide irrigation water needs remain unmet by the plan. Non-irrigation unmet needs represent 6 percent of statewide unmet needs.*

Figure 6-1. Projected annual water needs by water use category (acre-feet)*

** Water use categories are presented in the order listed in the legend.*

1.2 million acre-feet in 2070, while Region P does not anticipate an increase in its water needs over the same period. This is primarily driven by the differences in population growth.

6.2 Municipal needs

Municipal water users face the greatest overall increase as a relative share of all state water needs over the planning horizon, from 7 percent of all state water needs in 2020 to 46 percent in

Table 6-2. Projected annual water needs by region (acre-feet)

Region	2020	2030	2040	2050	2060	2070
A	148,000	394,000	411,000	394,000	369,000	378,000
B	25,000	26,000	30,000	32,000	36,000	41,000
C	66,000	307,000	530,000	769,000	1,016,000	1,278,000
D	81,000	87,000	91,000	98,000	106,000	117,000
E	61,000	66,000	76,000	89,000	104,000	119,000
F	63,000	72,000	75,000	81,000	91,000	103,000
G	211,000	255,000	291,000	345,000	404,000	478,000
H	145,000	405,000	578,000	667,000	769,000	883,000
I	139,000	182,000	183,000	190,000	199,000	206,000
J	6,000	6,000	7,000	8,000	8,000	9,000
K	283,000	281,000	289,000	291,000	297,000	319,000
L	204,000	232,000	268,000	305,000	350,000	401,000
M	937,000	924,000	926,000	937,000	953,000	970,000
N	15,000	31,000	36,000	40,000	45,000	49,000
O	726,000	1,467,000	1,483,000	1,485,000	1,493,000	1,500,000
P	8,000	8,000	8,000	8,000	8,000	8,000
Texas[a]	**3,118,000**	**4,743,000**	**5,282,000**	**5,739,000**	**6,248,000**	**6,859,000**

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

2070 (Table 6-1). Except for Region P, each region faces at least some potential municipal water shortages over the next 50 years unless strategies are implemented. Municipal water needs are projected to become the highest water use category by 2070, after remaining second only to irrigation needs through the year 2060.

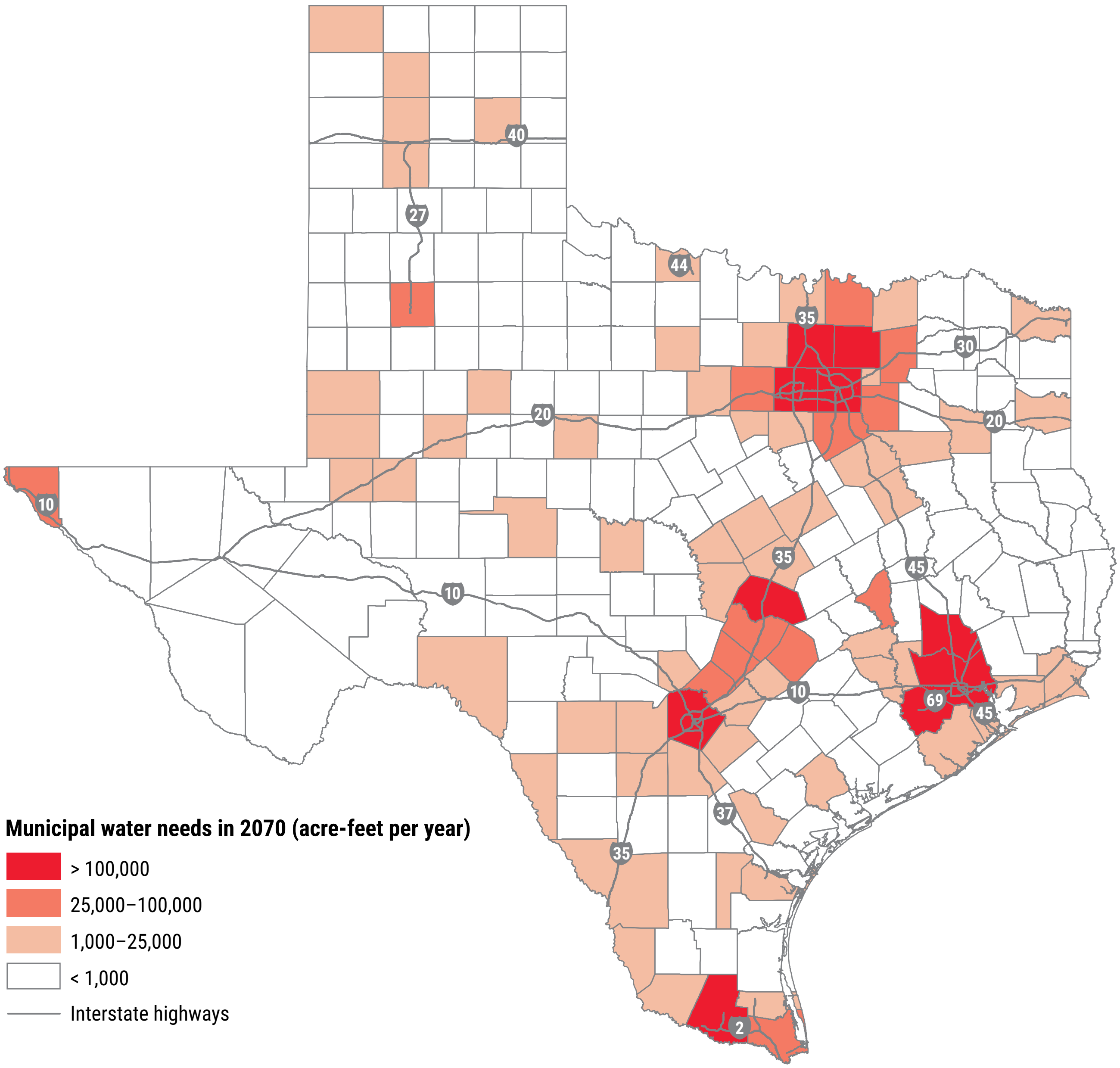
For each decade of the planning period, Region C has the largest annual municipal needs, increasing from approximately 43,000 acre-feet in 2020 to more than 1.2 million acre-feet in 2070 (Appendix C). In 2070, municipal needs would vary widely across the state, with 10 counties facing municipal water needs of more than 100,000 acre-feet (Figure 6-2).

Texas' growing population faces highly variable degrees of potential municipal water shortages over the next 50 years, with the severity of shortages ranging significantly among individual water users. Shortages that constitute a larger percentage of an entity's total demand indicate a more severe potential shortage (Figure 6-3) that would likely cause economic harm. The ability to absorb modest shortages through temporary measures such as drought management will depend in large part on the amount of demand hardening that has already occurred within the service area of an entity. In other words, areas that have already implemented significant conservation measures will, by the nature of their lower and more efficient water use, have less room to maneuver to lower water use during a drought without economic harm.

If no recommended municipal water management strategies are implemented by the onset of another drought of record,

- approximately 78 percent (40.4 million) of all Texans in 2070 would face at least a 10 percent water shortage in their cities and residences;
- approximately 26 percent (13.3 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 increases from 166,000 in 2020 to nearly 550,000 in 2070.

Figure 6-2. Projected municipal water needs by county in 2070



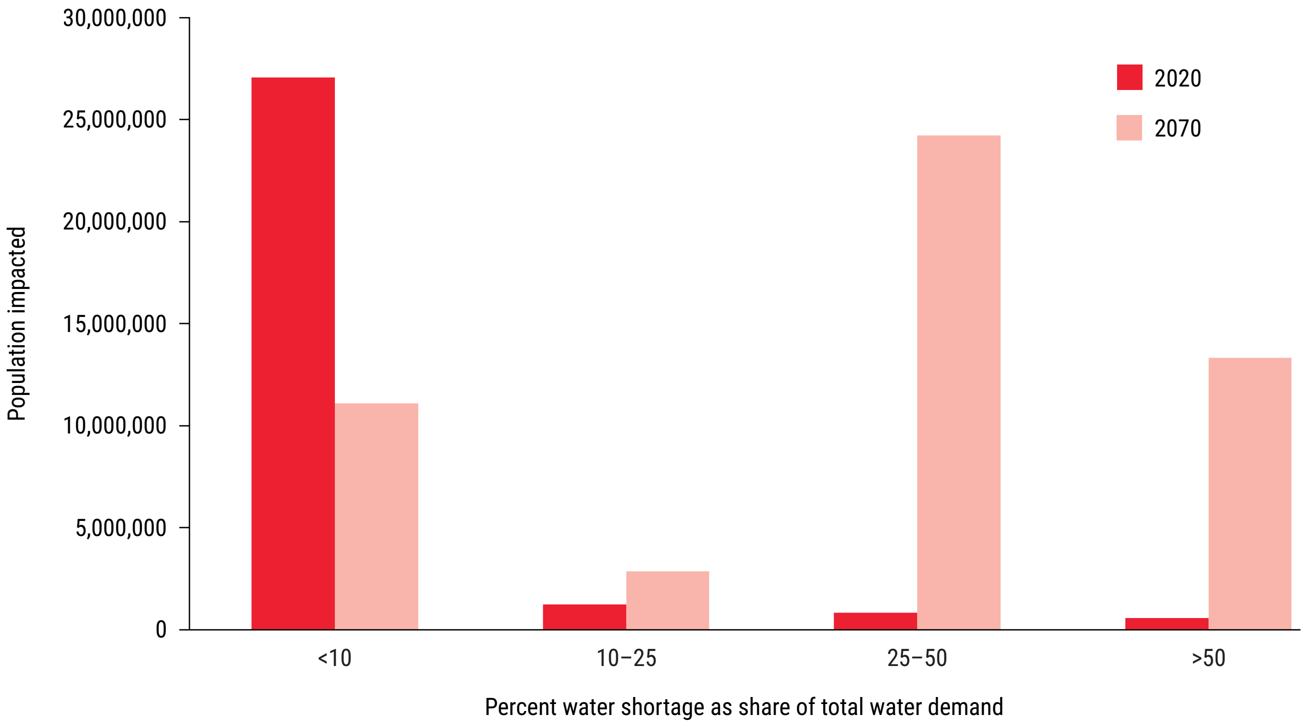
6.3 Non-municipal needs

From 2020 to 2070, of the non-municipal water use categories, irrigation has the highest volume of water needs statewide, while livestock has the lowest (Table 6-1). A breakdown of annual water needs by region and water use category is included in Appendix C.

Irrigation water needs are projected to peak in 2030 at approximately 3.3 million acre-feet per year and then gradually decline to just over 3 million acre-feet in 2070. Region M has the greatest volume of irrigation water needs in 2020, but Region O has the greatest volume of needs from 2030 to 2070.

Manufacturing water needs are greatest in Region I. Total statewide manufacturing water needs nearly double over the planning period, increasing from 159,000 acre-feet per year in 2020 to 301,000 acre-feet in 2070.

Figure 6-3. Projected statewide population impacted by municipal water needs in 2020 and 2070



Steam-electric water needs are greatest in Region G and reach a statewide maximum of 203,000 acre-feet per year in 2070.

Mining water needs are greatest in Region G. Mining needs increase slightly in the near term, peaking at 123,000 acre-feet in 2030, and are relatively constant for the remainder of the planning horizon.

Livestock water needs are greatest in Region I. The statewide total increases from 2020 to 2070 but remains no more than 63,000 acre-feet per year.

6.4 Major water provider needs

The *major water provider* classification was modified by rule prior to this state water plan to provide the regions more flexibility in addressing the intentionally subjective term *major* as appropriate in each region. By and large, this category includes mostly the same entities that have been planned for as major water providers in previous state water plans. Major water providers are water user groups or wholesale water providers identified by regional water planning groups to be of particular significance to a region's water supply.

A single entity such as Dallas Water Utilities may be considered a water user group, wholesale water provider, and also a major water provider. Major water providers include public or private entities, such as river authorities, water districts, municipal utility districts, or water supply corporations that 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 identified water needs of major water providers are based on aggregating the water needs of their customer water user groups and are used for developing major provider water management strategies. To avoid double counting water user needs in the plans, the needs of major water providers are not included in the total water needs presented in the regional or state water plans. Instead, only the potential shortages are presented for individual water user groups to calculate needs.

In 2020, 103 out of a total of 219 major water providers identified by the planning groups face shortages, with annual total statewide shortages of approximately 1.1 million acre-feet, increasing to 4.7 million acre-feet in 2070.

6.5 Impacts of not meeting identified water needs

Insufficient water supplies would negatively affect existing businesses and industry, future economic development efforts, and public health and safety in Texas. Because of water's importance to the state, planning groups are required to include the economic and social impacts of not mitigating future water needs in their water plans. At the request of the planning groups, the TWDB assisted with this requirement by assessing the socioeconomic impacts of not meeting water needs and providing that information to each region.

The economic impact portion of the analysis measures potential impacts of unmet water needs, including effects of economic losses to regions from reduced economic output for agricultural, industrial, and commercial water uses. The TWDB performed the analysis using a static economic impact modeling software package, IMPLAN (Impact for Planning Analysis), as well as other economic analysis techniques. This analysis represents a snapshot estimate of statewide socioeconomic impacts in the event of a single year repeat of the drought of record, with the fundamental assumption that no water management strategies are implemented to reduce the identified water needs.

The social impact portion of the analysis focuses on potential demographic effects, including changes in population and school enrollment, by incorporating results from potential job losses due to unmet water needs. The analysis estimates how changes in a region's economy could affect patterns of migration from a region. This relied partially on a simplified ratio of job and net population losses calculated for the state as a whole, based on a recent study of how job layoffs impact the labor market population (Foote and others, 2015).

Because statewide water needs more than double during the planning horizon, from 3.1 to 6.9 million acre-feet (Table 6-1), the associated economic and social impacts also rise significantly over the 50 years (Table 6-3). The estimated statewide impacts of not meeting the identified water needs in Texas would result in an annual combined lost income of $110 billion in 2020, increasing to $153 billion by 2070. Lost jobs would increase from 615,000 in 2020 to almost 1.4 million in 2070. To put these impact estimates in perspective, the projected annual lost income estimates for 2020 account for approximately 6 percent of the 2018 annual gross domestic product, which was approximately $1.8 trillion (BEA, 2020).

Projected impacts vary with the magnitude of needs over time as well as with the changes in estimated lost income per acre-foot of water needs, which range greatly between economic sectors as shown in Figure 6-4.

In attempting to estimate a wide range of socioeconomic impacts over a large geographic area for 50 years, the impact model requires making many assumptions and acknowledging the model's uncertainty and limitations. Those include a lack of reliable water use data for significant portions of the economy, coupled with limited knowledge concerning how a given economic sector might respond to a long-term drought.

Because of data and methodological limitations, the model cannot capture all economic impacts. As a result, the actual economic impacts are likely significantly larger than those that resulted from this analysis.

*Table 6-3. Projected statewide annual socioeconomic impacts from not meeting water needs**

Impact measure	2020	2030	2040	2050	2060	2070
Income loss (billions of dollars)[a]	$110	$128	$128	$132	$140	$153
Job loss	615,000	785,000	883,000	1,019,000	1,179,000	1,371,000
Population loss	113,000	144,000	162,000	187,000	217,000	252,000

** These statewide impacts vary from the impact results presented in the regional water plans (Appendix D) and online dashboards. This is primarily due to a difference in the quantity of water needs used to estimate the impacts. The results included in the regional water plans and online dashboards were from an analysis conducted in September 2019 to allow for public comment in the draft regional plans. Final regional water plans included updated water needs estimates, and the TWDB performed the statewide impact estimates in this chapter based upon the final needs data in November 2020.*

[a] *Year 2018 dollars, rounded.*

Analysis of this type is better at predicting relative percent differences brought about by a shock to a complex system (such as a water shortage imposed upon a regional economy) than the precise size of an impact. It is the general and relative magnitudes of impacts as well as the changes of these impacts over time that should be the focus rather than the absolute numbers. Key assumptions and limitations behind the analysis include the following:

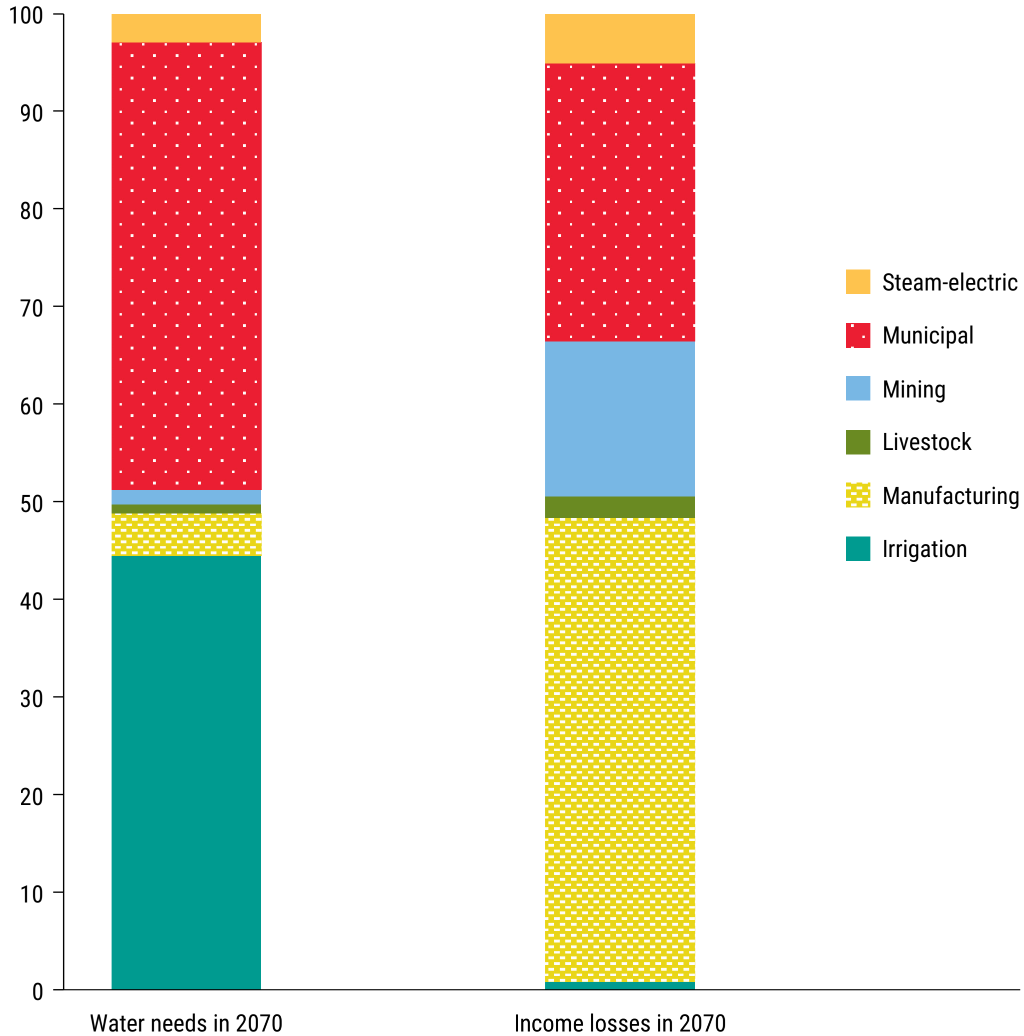
- Changes in the future structure of the Texas economy are not considered.
- All estimated socioeconomic impacts are snapshots of a one-year repeat of the drought of record. These independent and distinct *what if* scenarios for each planning region for each particular year with water shortages are assumed to be temporary events, thereby underestimating the total impacts of a longer term drought event.
- The analysis focuses only on the water-intensive economic sectors for which the TWDB has adequate water use estimates. Other water use sectors contribute to the value of production in the state economy, but the TWDB does not have sufficient data to include them. For example, data limitations for many of the commercial sectors within municipal use precluded an estimate of the adverse impacts of water shortages in those sectors.
- Lost income within forwardly linked sectors of the economy is not considered. Traditional input-output analysis using IMPLAN or similar models cannot determine the adverse impacts on downstream sectors within the economy.
- The significant economic spillover impacts (indirect and induced) on adjoining regions are not accounted for.
- The analysis does not attempt to estimate the possible impacts of lost growth opportunities over time due to chronic water shortages. Possible building moratoriums and similar longer term impacts were not examined.
- The analysis does not attempt to estimate or include many other significant impacts that a drought of record would have, such as to dryland farming, because these activities are not directly associated with water needs identified in the regional plans.

Additional detail on the methodologies and the impact estimate results for each planning group and county, along with the final regional impact reports, are available on the TWDB website at www.twdb.texas.gov/waterplanning/data/analysis.

6.6 Water needs not met by implementing the plan

An unmet water need is the portion of an identified water need that would not be met even after implementing all the recommended water management strategies. This generally occurs when a planning group cannot identify a feasible water management strategy to address the potential

*Figure 6-4. Estimated relative percent share, by sector statewide, of water needs and potential income losses in 2070**



** Water use sectors are presented in the order listed in the legend.*

shortage. Most unmet needs are within the irrigation water use category (Tables 6-4 and 6-5). For many irrigation water users, the returns on investments are likely insufficient for the water supply projects that would be required to maintain or increase irrigation water supplies under drought of record conditions.

Statewide, more than 30 percent of the total projected irrigation demand and less than 1 percent of the total projected municipal demand in 2070 would be unmet by the plan. 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 less, depending upon future regulatory decisions.

Six planning groups (Regions C, D, F, G, I, and J) were unable to identify potentially feasible strategies to fully meet all identified municipal water needs for 25 water user groups. Reasons for this ranged from a lack of economically feasible supply alternatives to pending changes in local regulations that were anticipated to mitigate the shortage. Municipal unmet needs account for approximately 1 percent or less of municipal demands for these regions in most decades.

Table 6-4. Statewide projected annual water needs that are unmet by the plan (acre-feet)

Water use category	2020	2030	2040	2050	2060	2070
Irrigation	1,917,000	2,724,000	2,512,000	2,421,000	2,377,000	2,336,000
Steam-electric	122,000	94,000	94,000	94,000	95,000	95,000
Manufacturing	110,000	1,000	1,000	1,000	1,000	1,000
Mining	52,000	46,000	41,000	35,000	29,000	32,000
Municipal	18,000	1,000	2,000	3,000	4,000	6,000
Livestock	9,000	2,000	3,000	4,000	5,000	7,000
Total	**2,228,000**	**2,868,000**	**2,653,000**	**2,558,000**	**2,511,000**	**2,477,000**

Table 6-5. Projected annual unmet water needs by region and water use category (acre-feet) – continued on next page

Region	Water use category	2020	2030	2040	2050	2060	2070
A	Irrigation	81,000	260,000	123,000	66,000	48,000	42,000
B	Irrigation	15,000	15,000	16,000	14,000	14,000	13,000
B	Mining	1,000	<500	<500	<500	<500	<500
B	Steam-electric	2,000	0	0	0	0	0
C	Irrigation	3,000	3,000	3,000	3,000	3,000	3,000
C	Mining	5,000	5,000	5,000	5,000	5,000	6,000
C	Municipal	<500	<500	<500	<500	<500	<500
C	Steam-electric	7,000	7,000	7,000	7,000	7,000	7,000
D	Irrigation	<500	<500	<500	<500	<500	<500
D	Manufacturing	1,000	0	0	0	0	0
D	Municipal	<500	<500	<500	1,000	1,000	2,000
E	Irrigation	13,000	10,000	15,000	15,000	15,000	15,000
E	Mining	<500	1,000	1,000	<500	1,000	1,000
F	Irrigation	11,000	13,000	17,000	19,000	22,000	25,000
F	Livestock	<500	<500	<500	<500	<500	<500
F	Manufacturing	<500	<500	<500	<500	<500	<500
F	Mining	6,000	6,000	3,000	2,000	1,000	1,000
F	Municipal	<500	1,000	1,000	1,000	2,000	3,000
F	Steam-electric	11,000	11,000	11,000	11,000	11,000	11,000
G	Irrigation	61,000	61,000	52,000	51,000	51,000	54,000
G	Manufacturing	<500	0	0	0	0	0
G	Mining	16,000	16,000	16,000	16,000	17,000	19,000
G	Municipal	17,000	0	0	0	0	0
G	Steam-electric	72,000	71,000	71,000	71,000	71,000	72,000
H	Irrigation	47,000	47,000	47,000	47,000	47,000	47,000
H	Livestock	1,000	1,000	1,000	1,000	1,000	1,000
I	Irrigation	1,000	0	0	0	0	0
I	Livestock	8,000	0	0	0	0	0
I	Manufacturing	101,000	0	0	0	0	0

Table 6-5. Projected annual unmet water needs by region and water use category (acre-feet) – continued

Region	Water use category	2020	2030	2040	2050	2060	2070
I	Mining	8,000	0	0	0	0	0
I	Municipal	<500	0	0	0	0	0
I	Steam-electric	3,000	0	0	0	0	0
J	Livestock	<500	<500	<500	<500	<500	<500
J	Municipal	<500	<500	<500	<500	<500	1,000
K	Irrigation	76,000	84,000	70,000	63,000	54,000	44,000
K	Mining	<500	4,000	5,000	3,000	0	0
K	Steam-electric	5,000	5,000	5,000	5,000	5,000	5,000
L	Irrigation	137,000	138,000	140,000	142,000	151,000	155,000
L	Manufacturing	8,000	0	0	0	0	0
L	Mining	10,000	10,000	8,000	5,000	2,000	<500
L	Steam-electric	19,000	0	0	0	0	0
M	Irrigation	839,000	791,000	761,000	723,000	682,000	644,000
M	Manufacturing	<500	1,000	1,000	1,000	1,000	1,000
M	Mining	5,000	4,000	4,000	4,000	4,000	5,000
M	Steam-electric	3,000	<500	<500	<500	<500	<500
O	Irrigation	634,000	1,302,000	1,268,000	1,279,000	1,288,000	1,293,000
O	Livestock	<500	<500	1,000	2,000	4,000	5,000
Texas[a]	**All**	**2,227,000**	**2,867,000**	**2,652,000**	**2,557,000**	**2,508,000**	**2,475,000**

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

The exceptions are Region G, with 4 percent of municipal demands unmet in 2020 under drought of record conditions, and Regions F and J, with about 2 percent of municipal demands unmet in 2070.

Regions with unmet municipal needs provided the following explanations as to how affected water user groups will ensure protection of public health, safety, and welfare in the event of a repeat of the drought of record:

- Developing additional groundwater supplies, as legally allowable, to meet needs
- Coordinating with groundwater conservation districts to temporarily develop groundwater supplies above the modeled available groundwater volume
- Implementing drought management measures as outlined in individual drought contingency plans to prolong supply and reduce impacts to communities by limiting water use to only essential water uses
- Implementing strategies planned for the 2030 decade early to address 2020 needs
- Expanding utility service areas to incorporate county-other communities with needs

An unmet need in a regional plan does not prevent an associated entity from developing additional water supplies. In some instances, portions of an underlying, projected increase in demand that is the cause of an unmet need in the plan may simply not occur where anticipated, instead arising in a less water-scarce geographic location. An example would be when power generators change locations of future power production facilities from where they are currently anticipated to be built.

A pump station as part of a TWDB-funded water supply project

6.7 Comparison to the 2017 State Water Plan

This water plan estimates annual statewide water needs of 3.1 million acre-feet in 2020 and 6.9 million acre-feet in 2070. These amounts are less than the 2017 State Water Plan estimates of 4.8 million acre-feet and 8.9 million acre-feet for the same decades. The differences are primarily due to revised methodologies for estimating manufacturing, irrigation, and steam-electric power generation water demands, resulting in more credible and often lower projections.

When the planning data is aggregated at the state level, it masks the variable geographic and categorical mismatches between water needs and sources that can be significant at the local level. Many factors can affect the water need calculations, making it difficult to draw broad conclusions about why there are changes from the previous state water plan. Notable changes to the projected water needs from the 2017 State Water Plan are summarized below:

- Statewide unmet needs are approximately 24 percent lower in 2020 and 19 percent lower in 2070 than the 2017 plan. The net change in unmet needs is due to a variety of interrelated factors that vary geographically and can have both positive and negative effects, including lower-than-anticipated water supplies due to more severe drought conditions, changes in demand projections, and changes in groundwater management policies.
- Statewide, annual municipal water needs in 2020 are projected to be almost 300,000 acre-feet less than those from the previous plan, primarily due to lower water demand projections. Municipal needs in Region N, however, are significantly higher for each decade of the 50-year planning period. Municipal needs in Regions I and J are also significantly higher in several decades in the planning period. In general, these changes are due to a varying mix of increased demands driven by population growth and a reduced volume of water supplies available during drought.
- Comparisons with the 2017 plan show that manufacturing needs decreased by more than half for each decade of the planning horizon due to revising the manufacturing demand methodology that ties projections of demands more closely to reported historical use.
- The projected socioeconomic impacts of not meeting water needs are higher than the previous plan. This is due to many factors, including inflation, updates of the relevant water use volumes and economic output values, refinements to socioeconomic impact assessment methodology, and underlying changes in the economy.
- A variety of conservation and other projects have been implemented since 2017, which results in increasing the existing volume of water on the existing supply side of the planning equation, thereby reducing the resulting water need calculation.

6.8 Uncertainty of future water needs

Water needs during drought of record conditions are difficult to predict due to the uncertainties that already affect both water demand (Section 4.4) and water supply (Section 5.9). For example,

Hurst Creek Arm of Lake Travis, Lakeway, Texas

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 need projections will continue to be updated as a result of 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. In an attempt to address shifts behind Texas' overall water needs over time, the regional and state water planning process incorporates the emerging impacts of all these complex changes as a whole into the regional and state water plans during each five-year planning cycle through historic data and other newly available information.

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7

Water management strategies and projects

QUICK FACTS

More than 5,800 recommended water management strategies would provide about 7.7 million acre-feet per year in additional water supplies to water user groups in 2070.

The cost of implementing the more than 2,400 recommended water management strategy projects by 2070 is $80 billion in 2018 dollars, without accounting for future inflation.

Conservation strategies represent approximately 29 percent, or 2.2 million acre-feet per year, of all recommended water management strategy volumes in 2070 and were recommended for more than half of the water user groups in the plan.

Planning groups recommended 23 new major reservoirs that, if implemented, would provide 866,000 acre-feet per year in additional supplies by 2070.

Approximately 37 percent of the recommended new water supplies in 2070 are based on surface water, 15 percent on reuse, and 12 percent on groundwater.

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

Water management strategies allocate water supply (in acre-feet per year) 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 generally associated directly with water user groups.

Strategies may or may not require new water infrastructure—referred to as "water management strategy *projects*." Construction of most new water infrastructure projects requires long-term financing of the capital costs. The TWDB may provide financial assistance to support the implementation of water supply projects only if the needs to be addressed by the project are consistent with the regional water plans and the state water plan. This same provision applies to the Texas Commission on Environmental Quality's granting of water right permits, although the governing bodies of these agencies may grant waivers to the consistency requirement. The TWDB financial program that specifically targets implementation of state water plan projects, the State Water Implementation Fund for Texas (SWIFT) program, further requires that projects, including their capital costs, must be recommended water management strategy projects in the most recently adopted state water plan to be eligible for that financial assistance.

7.1 Selecting water management strategies

Each planning group identifies and evaluates feasible water management strategies for consideration to be included as a recommended final set of strategies. In selecting strategies, planning groups are required to consider certain factors, including

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

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

The types of strategies recommended depend upon the size and nature of identified water needs, geographic location, available water resources, associated strategy impacts, and costs of implementation. Some water management strategies do not require infrastructure projects with capital costs to implement while others may require significant capital investments, including various combinations of pipelines, wells, pump stations, river diversion facilities, or water treatment plants. 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 convey increased water deliveries. Other strategies, such as new reservoirs and seawater desalination plants, require significant upfront investment in infrastructure to implement. However, the significance of any infrastructure investment is relative and varies by community and entity. For example, installing a single new groundwater well can be a more major investment for a small community than a large city.

The complexity of recommended strategies and the projects supporting them 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 from one or more wholesale water providers; may require a variety of infrastructure including intakes, major pipelines, and pump stations; and ultimately serve numerous retail water providers.

Just over 5,800 water management strategies were recommended by the 16 regional planning groups. If all were implemented, they would provide almost 1.7 million acre-feet per year, including in the form of conservation savings, to water user groups in 2020 and nearly 7.7 million acre-feet per year in 2070 (Table 7-1). The total capital cost of the approximately 2,400 recommended water management strategy projects associated with these 5,800 strategies is $80 billion (Table 7-2). Detailed lists of the recommended water management strategies, including projects, may be found on the 2022 State Water Plan webpage at www.twdb.texas.gov/waterplanning/swp/2022/index.asp and the interactive state water plan website at 2022.texasstatewaterplan.org.

7.2 Water resources for recommended strategies

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

- by the water resources on which they rely; or

Table 7-1. Annual volume of recommended water management strategies by region (acre-feet)

Region	2020	2030	2040	2050	2060	2070
A	155,000	295,000	529,000	616,000	618,000	658,000
B	10,000	14,000	38,000	43,000	45,000	49,000
C	129,000	361,000	588,000	830,000	1,075,000	1,336,000
D	83,000	149,000	161,000	175,000	192,000	221,000
E	82,000	118,000	130,000	146,000	150,000	156,000
F	79,000	141,000	166,000	171,000	176,000	182,000
G	119,000	291,000	353,000	396,000	443,000	492,000
H	251,000	978,000	1,412,000	1,725,000	1,845,000	1,942,000
I	24,000	251,000	272,000	285,000	295,000	279,000
J	13,000	26,000	26,000	26,000	26,000	26,000
K	251,000	297,000	373,000	418,000	476,000	565,000
L	199,000	429,000	551,000	596,000	692,000	737,000
M	141,000	219,000	296,000	372,000	440,000	508,000
N	24,000	255,000	266,000	271,000	278,000	282,000
O	119,000	199,000	249,000	236,000	239,000	242,000
P	16,000	17,000	17,000	17,000	17,000	17,000
Texas[a]	**1,695,000**	**4,040,000**	**5,427,000**	**6,323,000**	**7,007,000**	**7,692,000**

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

- by the combination of specific water resource(s), projects, and/or technology required for implementation.

Recommended water management strategies will rely on both future demand management (reducing the demand for water) and a variety of Texas' water resources (Figures 7-1 and 7-2). If implemented, all recommended water management strategies would provide approximately 7.7 million acre-feet per year in additional water supplies to water user groups in 2070.

Surface water is the most significant water resource on which strategies are based, providing over 2.8 million acre-feet per year to water user groups, which is approximately 37 percent of the total recommended strategy supplies in 2070.

Demand management, mostly in the form of conservation savings but also including drought management, will address almost 2.4 million acre-feet per year in water user group water demands, which is approximately 31 percent of the recommended strategy volume in 2070.

Reuse provides 1.2 million acre-feet per year to water user groups, which is approximately 15 percent of the total recommended strategy supplies in 2070.

Groundwater resources provide just over 920,000 acre-feet per year to water user groups, which is approximately 12 percent of the total recommended strategy supplies in 2070.

Seawater provides nearly 190,000 acre-feet per year to water user groups, which is approximately 3 percent of the total recommended strategy supplies in 2070.

Aquifer storage and recovery, which can use a variety of water source types that are then stored underground, provides over 190,000 acre-feet per year to water user groups, or approximately 3 percent of the total recommended strategy supplies in 2070.

Table 7-2. 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[a]	Number of projects[b]
A	$308	$584	$88	$49	$5	$113	$1,147	65
B	$212	$1	$443	$0	$0	$0	$656	20
C	$4,363	$5,482	$4,796	$7,437	$4,061	$3,793	$29,932	506
D	$157	$295	$39	$118	$31	$90	$730	103
E	$371	$243	$569	$320	$0	$0	$1,503	39
F	$439	$954	$66	$171	$6	$0	$1,636	111
G	$2,169	$2,377	$426	$496	$5	$13	$5,486	221
H	$4,124	$9,166	$4,125	$1,279	$907	$451	$20,052	818
I	$871	$1,466	$726	$11	$31	$6	$3,111	59
J	$70	$150	$0	$0	$0	$0	$220	45
K	$1,539	$1,484	$873	$173	$15	$510	$4,594	162
L	$1,176	$1,592	$1,019	$132	$203	$0	$4,122	57
M	$1,033	$449	$124	$165	$39	$25	$1,835	131
N	$166	$3,110	$0	$0	$0	$0	$3,276	64
O	$184	$118	$275	$1	$104	$126	$808	26
P	$26	$56	$340	$0	$0	$0	$422	12
Texas	**$17,208**	**$27,527**	**$13,909**	**$10,352**	**$5,407**	**$5,127**	**$79,530**	**2,439**

[a] Capital costs represent approximations based on anticipated online dates. Projects with capital costs that would occur over multiple decades are reported as a single, total capital cost in the project's online decade and may therefore differ from those presented in the regional water plans.

[b] Some projects are associated with multiple sponsors.

Figure 7-1. Share of recommended water management strategy volume by water resource in 2070 (percent)

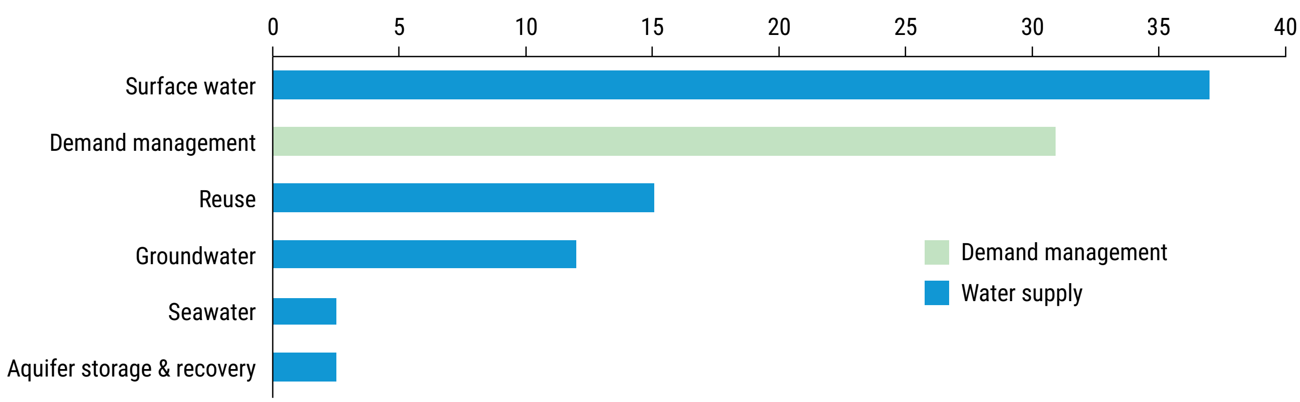
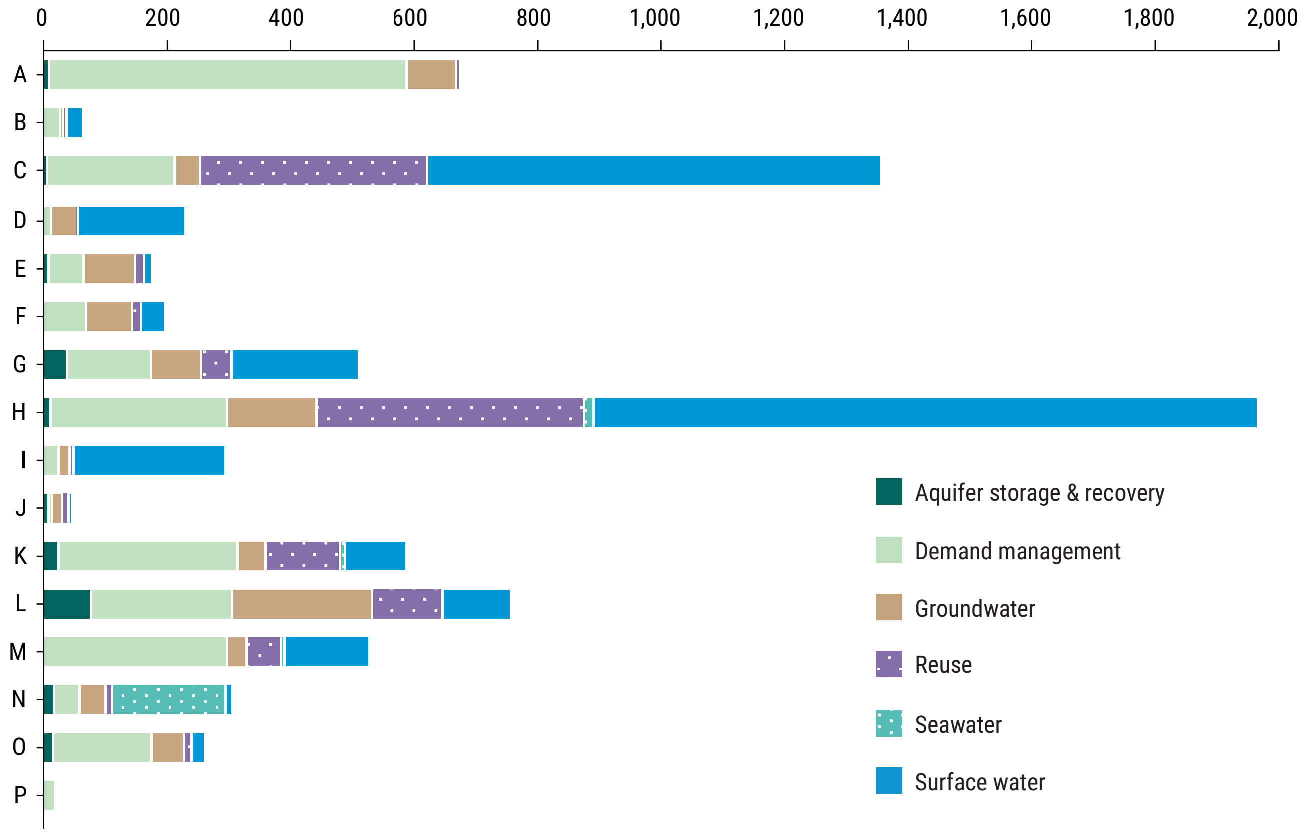


*Figure 7-2. Annual volume of recommended water management strategies by region and water resource in 2070 (thousands of acre-feet)**



** Strategy types are presented left to right in the order listed in the legend.*

7.3 Strategy types

Planning groups recommended a wide variety of water management strategies to serve water user groups, each of which relies on a specific combination of water source(s), infrastructure, and technology (Figure 7-3, Table 7-3).

7.3.1 Conservation

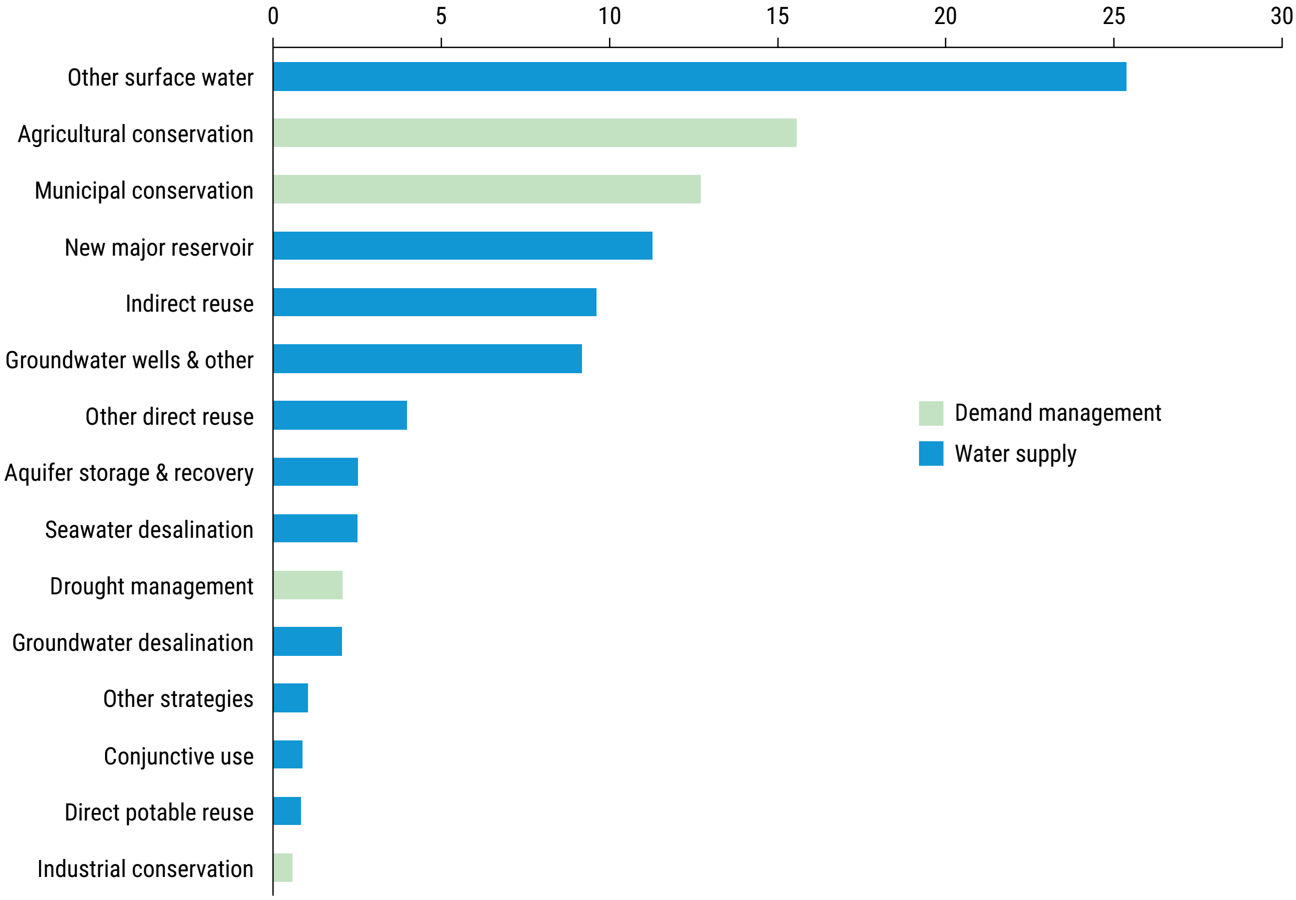
Conservation includes a variety of activities that either reduce everyday water consumption or increase water use efficiency, allowing more to be done with the same amount of water. Conservation occurs throughout both wet and dry weather and maintains all normal economic and domestic activities. Conservation strategies are divided into several types, including municipal; agricultural, which includes strategies predominantly for irrigation and some livestock water users; and industrial, which includes conservation strategies for steam-electric, manufacturing, and mining water users.

Conservation is a recommended strategy in all 16 regional water plans and is associated with over 1,500 water user groups (Table 7-4). About 778,000 acre-feet per year in conservation strategy volume is recommended in 2020, and 2.2 million acre-feet per year is recommended in 2070. Additional information on conservation strategies, planning, and programs is provided in Chapter 8.

7.3.2 Drought management

Drought management reduces water use during times of drought by temporarily restricting certain economic and domestic activities such as car washing and landscape irrigation. These measures vary and are generally implemented by local

Figure 7-3. Share of total recommended water management strategies volume by strategy type in 2070 (percent)



water providers. Planning groups recommended drought management strategies for certain water user groups and in limited instances to address, for example, near-term shortages that will eventually be met in future decades from other water supply strategies. It is important to recognize that in the absence of sufficient water, restricting water use through drought management is likely the primary, and often the only, means by which water providers will be able to successfully navigate their way through a severe drought. About 87,000 acre-feet per year in drought management strategies is recommended in 2020, and 158,000 acre-feet per year is recommended in 2070.

7.3.3 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 involves further treating of wastewater effluent at an advanced water treatment plant and then either introducing it ahead of the water treatment plant or directly into the potable water distribution system. About 12,000 acre-feet per year in direct potable reuse strategies is recommended in 2020, and 62,000 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 landscape irrigation or industrial processes. About 51,000 acre-feet per year in other direct reuse (as opposed to direct potable reuse) strategies is recommended

Table 7-3. Annual volume of recommended water management strategies by online decade and strategy type (acre-feet)

Water management strategy type	2020	2030	2040	2050	2060	2070
Agricultural conservation	535,000	757,000	1,066,000	1,142,000	1,151,000	1,197,000
Aquifer storage & recovery	19,000	132,000	155,000	162,000	180,000	193,000
Conjunctive use	5,000	57,000	65,000	64,000	64,000	67,000
Direct potable reuse	12,000	34,000	44,000	57,000	61,000	62,000
Drought management	87,000	110,000	129,000	140,000	149,000	158,000
Groundwater desalination	19,000	97,000	123,000	124,000	154,000	157,000
Groundwater wells & other	255,000	418,000	543,000	604,000	665,000	705,000
Indirect reuse	58,000	209,000	510,000	560,000	648,000	739,000
Industrial conservation	23,000	32,000	35,000	37,000	39,000	44,000
Municipal conservation	220,000	395,000	530,000	675,000	822,000	977,000
New major reservoir	60,000	324,000	468,000	658,000	793,000	866,000
Other direct reuse	51,000	179,000	202,000	232,000	265,000	305,000
Other strategies	8,000	44,000	52,000	57,000	67,000	78,000
Other surface water	345,000	1,071,000	1,314,000	1,620,000	1,757,000	1,951,000
Seawater desalination	0	179,000	190,000	192,000	192,000	192,000
Texas[a]	**1,697,000**	**4,038,000**	**5,426,000**	**6,324,000**	**7,007,000**	**7,691,000**

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

in 2020, and 305,000 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 potable or non-potable use. About 58,000 acre-feet per year in indirect reuse strategies is recommended in 2020, and 739,000 acre-feet per year is recommended in 2070.

7.3.4 Conjunctive use

Conjunctive use 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 be to rely intermittently on groundwater to supplement surface water supplies that are not fully available under drought of record conditions. About 5,000 acre-feet per year in conjunctive use strategies is recommended in 2020, and 67,000 acre-feet per year is recommended in 2070.

7.3.5 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 19,000 acre-feet per year in aquifer storage and recovery strategies is recommended in 2020, and 193,000 acre-feet per year is recommended in 2070.

Aquifer storage and recovery strategies can be associated with a variety of water source types that are stored underground. Recommended aquifer storage and recovery strategies are categorized under their own water resource type in this plan (Figure 7-1) but may be associated with one or a combination of initial surface water, groundwater, and reuse sources. Approximately 60 percent of 2070 aquifer storage and recovery strategy supplies are associated with stored surface water sources, while 30 percent are associated with a combination of groundwater and surface water sources. The remaining 10 percent are associated with groundwater or a combination

*Table 7-4. 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
Agricultural conservation	21	3	4	0	2	30	20	8	0	3	6	0	8	5	18	1	**129**
Aquifer storage & recovery	2	0	111	1	1	0	20	1	0	3	7	9	0	1	5	0	**161**
Conjunctive use	0	0	0	0	1	0	30	95	0	0	0	0	0	0	0	0	**126**
Direct potable reuse	1	0	0	0	0	1	1	0	0	1	4	1	9	0	0	0	**18**
Drought management	0	0	0	0	0	0	0	0	0	1	118	39	40	1	0	8	**207**
Groundwater desalination	0	0	0	0	4	1	2	1	0	1	1	5	11	3	0	0	**29**
Groundwater wells & other	32	8	150	49	13	19	77	28	23	17	31	64	11	24	26	0	**572**
Indirect reuse	0	5	240	10	0	7	11	9	5	0	7	0	0	0	0	0	**294**
Industrial conservation	0	12	2	3	0	32	40	0	0	0	5	0	17	13	12	3	**139**
Municipal conservation	40	23	283	9	10	68	114	345	58	9	70	106	58	23	38	6	**1260**
New major reservoir	0	18	246	9	0	0	30	10	15	0	18	4	0	0	1	0	**351**
Other direct reuse	0	0	10	0	2	2	18	18	0	2	14	11	5	2	2	0	**86**
Other strategies	0	0	36	0	1	11	0	1	0	1	8	0	7	0	0	0	**65**
Other surface water	0	5	277	40	2	41	91	132	28	2	11	5	47	4	1	0	**686**
Seawater desalination	0	0	0	0	0	0	0	1	0	0	0	0	1	3	0	0	**5**

** Water user groups associated with more than one planning region may be counted more than once with different region and strategy type combinations.*

of surface water and reuse or groundwater and reuse supplies.

As planning groups considered and evaluated water management strategies, House Bill 807 from the 86th Legislative Session required that they also provide a specific assessment of the potential for aquifer storage and recovery projects to meet any identified significant water needs. Each planning group defined its own threshold of significant water need. Most regions defined a quantitative threshold for significant water need. Quantitative thresholds ranged from water needs greater than 800 acre-feet (Region B) to greater than 25,000 acre-feet (Region H) in any decade and were generally determined by evaluating needs across a planning region or comparing needs to demands. In some regions, quantitative thresholds were limited to municipal water users. Two regions utilized categorical thresholds to define significant water need. Region C defined significant need as any major water provider need, and Region O defined significant need as any non-irrigation water need. Assessments of the potential for aquifer storage and recovery projects to meet significant water needs also varied by region but generally considered available water sources, suitable geology, and interested project sponsors.

Ten regions recommended aquifer storage and recovery strategies. Associated with these strategies are 27 recommended projects that would establish aquifer storage and recovery systems or pilot projects. More than 160 water user groups could benefit from these projects. Regions not recommending aquifer storage and recovery strategies (Regions B, D, F, I, M, and P) cited reasons such as the lack of suitable geology in proximity to needs, cost constraints, or a lack of interested project sponsors. Although Region D does not have project sponsors recommending aquifer storage and recovery, there are beneficiaries within Region D of an aquifer storage and recovery project sponsored in Region C. This information is reflected in Tables 7-4 and 7-5.

7.3.6 New major reservoirs

A major reservoir has a storage capacity of 5,000 acre-feet or more. Regional planning groups recommended 23 new major reservoirs during this planning cycle (Figure 7-4). About 60,000 acre-feet per year from new major reservoir strategies, including some that rely on indirect reuse, is recommended in 2020, and 866,000 acre-feet per year is recommended in 2070. Several of these reservoir sites are off-channel, meaning they would not be built on the main stem of the river, although they might rely on the main stem flows.

Because Senate Bill 1511, 85th Texas Legislature, now requires planning groups to amend their regional water plans if recommended water management strategies or projects become infeasible prior to adopting the next plan, including "infeasible in time,"[8] the TWDB emphasized in contract guidance and at planning group meetings the need to ensure realistic reservoir development timelines. Fourteen of the recommended new major reservoirs in this plan are anticipated to be online and providing water supply by 2030 (Figure 7-5). An additional eight new major reservoirs are planned to be online by 2050. Planning groups with new major reservoir strategies recommended for the 2020 decade were required to provide the specific basis on which the planning group anticipates that it is feasible for these major strategies to be online and providing water supply by January 5, 2023. Partly in response to this feasibility review, online decades for six recommended new major reservoir strategies were shifted from 2020 in the draft regional plans to 2030 in the final, adopted regional water plans.

7.3.7 Other surface water

Other surface water supplies include strategies that are not associated with new major reservoirs, surface water desalination, conjunctive use, or aquifer storage and recovery. The other surface water category includes minor reservoirs (less than 5,000 acre-feet of storage) and the subordination of surface water rights 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 and new water right permits but simply convey previously developed and permitted surface water to users. In addition to pipelines, the types of projects associated with these strategies may include, but are not limited to, constructing pump stations, adding water treatment capacity, or lowering the elevation of a reservoir intake to allow a water provider to continue to draw water when lake levels are low.

Another portion of these strategies is based on reassigning existing surplus water supplies or more fully utilizing the capacity of existing infrastructure to deliver additional surface water to wholesale and/or retail water providers. Many of these strategies are based on transactions (such as sales, contracts, or purchases) between

[8] Although all projects recommended in the plan are considered technically feasible, a project may become infeasible on its projected timeline, meaning that obstacles and related delays to implementation might make it impractical to build the project quickly enough to meet water needs intended to be met in an early decade. Thus, the project would need to be shown as meeting needs later on.

***Table 7-5. Weight-averaged unit costs (dollars per acre-foot)* of strategy water supplies by region and strategy type in 2070** – continued on next page*

Water management strategy type	A	B	C	D	E	F	G	H	I
Agricultural conservation	$66	$83	$307	na	$39	$0	$1,330	$132	na
Aquifer storage & recovery	$391	na	$99	$99	$212	na	$418	$3,256	na
Conjunctive use	na	na	na	na	$251	na	$235	$1,060	na
Direct potable reuse	$1,228	na	na	na	na	$2,443	$606	na	na
Drought management**	na	na	na	na	na	na	na	na	na
Groundwater desalination	na	na	na	na	$818	$403	$1,540	$4,927	na
Groundwater wells & other	$355	$396	$408	$383	$710	$340	$407	$481	$173
Indirect reuse	na	$698	$273	$1,032	na	$269	$275	$326	$435
Industrial conservation	na	$385	$147	$0	na	$0	$0	na	na
Municipal conservation	$779	$356	$103	$679	$92	$663	$546	$584	$398
New major reservoir	na	$384	$625	$540	na	na	$659	$411	$281
Other direct reuse	na	na	$278	na	$479	$201	$384	$525	na
Other strategies	na	na	$899	na	$307	$10	na	$1,560	na
Other surface water	na	$828	$527	$199	$290	$80	$521	$273	$475
Seawater desalination	na	na	na	na	na	na	na	$1,293	na

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

*** Unit costs for drought management strategies represent possible costs to municipal water users from foregone consumer surplus of imposed reduced water use rather than capital expended to produce water supply.*

na = not applicable or not available.

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 could otherwise be delivered. Expanding the capacity of a water treatment plant to better align with the larger capacity of a conveyance pipeline that already delivers water to the plant is an example of this type of strategy.

About 345,000 acre-feet of water supply per year from other surface water strategies is recommended in 2020, and almost 2 million acre-feet per year is recommended in 2070.

7.3.8 Groundwater wells and other

All but one of the 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 are often the only economically feasible strategy to meet the water needs of rural municipal water users.

Other groundwater strategies do not involve installing 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.

Table 7-5. Weight-averaged unit costs (dollars per acre-foot) of strategy water supplies by region and strategy type in 2070 – continued*

Water management strategy type	J	K	L	M	N	O	P	Texas
Agricultural conservation	$0	$151	na	$315	$3,597	$450	$200	$181
Aquifer storage & recovery	$148	$2,109	$221	na	$171	$824	na	$664
Conjunctive use	na	na	na	na	na	na	na	$814
Direct potable reuse	$6	$1,961	$1,980	$1,709	na	na	na	$1,505
Drought management**	$0	$66	$358	$55	$0	na	$100	$169
Groundwater desalination	$294	$2,995	$1,227	$1,085	$1,088	na	na	$1,080
Groundwater wells & other	$154	$523	$435	$85	$93	$174	na	$402
Indirect reuse	na	$214	na	na	na	na	na	$297
Industrial conservation	na	$109	na	$2,983	$0	$0	$0	$292
Municipal conservation	$408	$999	$625	$582	$502	$332	$1,990	$515
New major reservoir	na	$715	$97	na	na	$518	na	$511
Other direct reuse	$56	$1,036	$625	$354	$157	$1,407	na	$630
Other strategies	$0	$1,618	na	$10	na	na	na	$1,066
Other surface water	$244	$143	$621	$2,890	$229	$783	na	$523
Seawater desalination	na	na	na	$3,188	$1,364	na	na	$1,371

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

*** Unit costs for drought management strategies represent possible costs to municipal water users from foregone consumer surplus of imposed reduced water use rather than capital expended to produce water supply.*

na = not applicable or not available.

About 255,000 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 705,000 acre-feet per year is recommended in 2070.

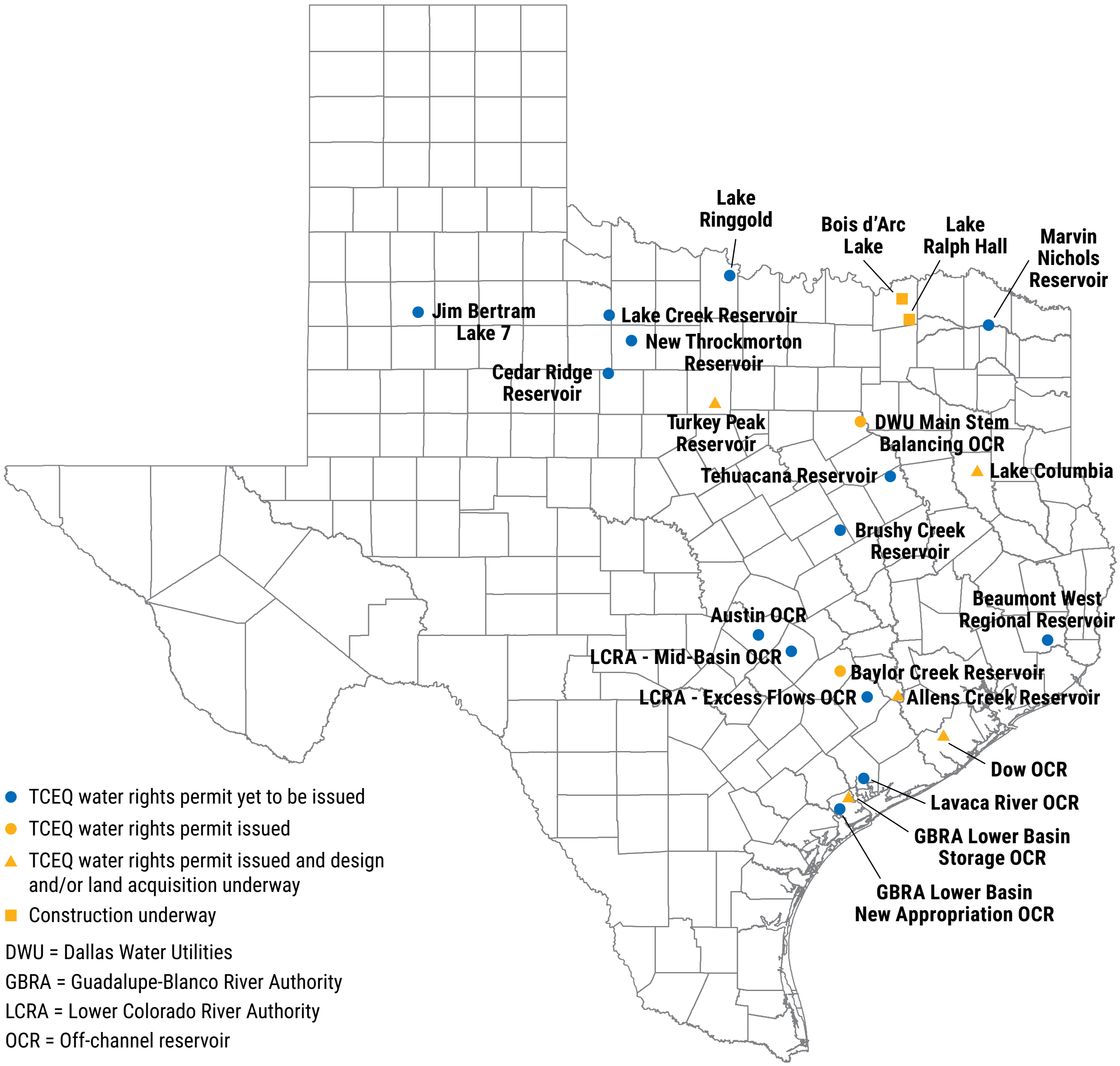
7.3.9 Desalination of groundwater and seawater

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 amount of total dissolved solids, 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 ponds, discharge to surface water, or an ocean outfall diffuser.

About 19,000 acre-feet per year of supply from groundwater desalination strategies is recommended in 2020, and 157,000 acre-feet per year is recommended in 2070. For seawater desalination strategies, no additional supply is recommended by 2020; however, 179,000 acre-feet per year of supply is recommended to be online by 2030, and 192,000 acre-feet per year is recommended in 2070.

Nine planning groups recommended groundwater desalination strategies and three recommended seawater desalination strategies. Planning groups cited the cost of desalination treatment and infrastructure, a lack of interested project sponsors, and the existing availability of non-brackish water sources as reasons for not recommending groundwater desalination strategies. Finding qualified operators in rural areas to operate these sophisticated systems is an implementation issue that has been raised on these projects. The primary reason for not recommending seawater

Figure 7-4. Recommended new major reservoirs



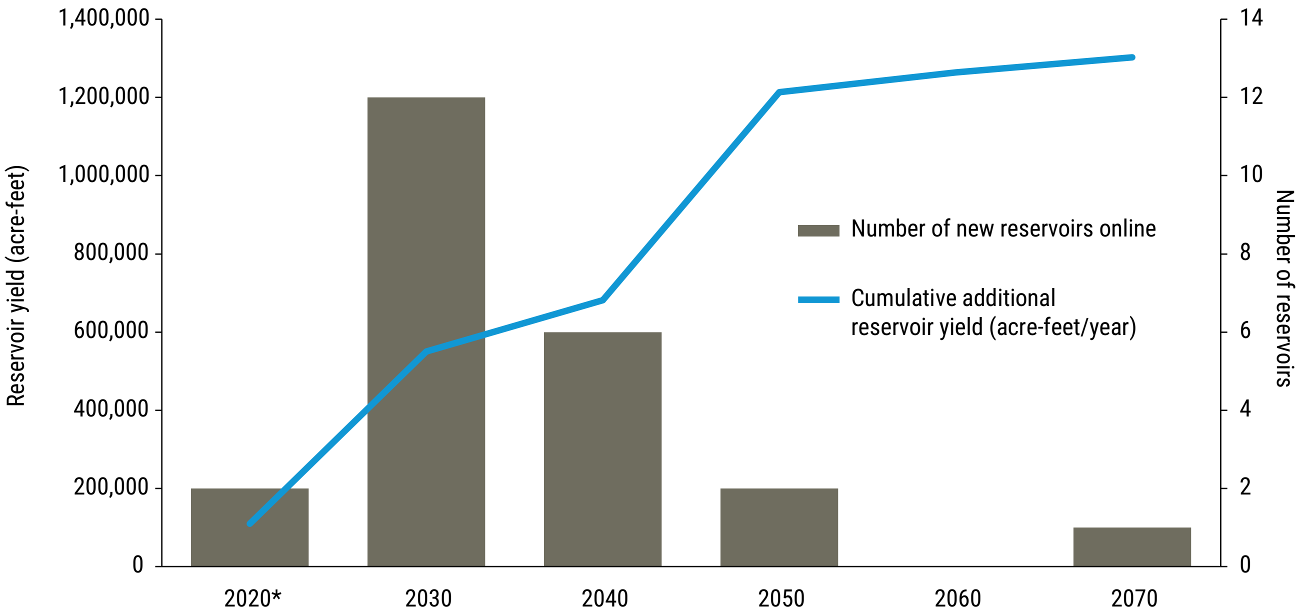
desalination strategies was based on cost, particularly as related to the distance supplies would have to be conveyed from the Gulf of Mexico.

7.3.10 Other strategies

Four remaining strategy types complete the portfolio of recommended water management strategies. Each individually provides approximately 1 percent of the total recommended strategy supplies in 2070. For two of these, weather modification and brush control, it is difficult to quantify the reliable supplies they are capable of providing under extended drought of record conditions when there is less cloud cover, precipitation, runoff, and infiltration of precipitation into the soil. For this reason, they are not often recommended as strategies to meet needs.

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 63,000 acre-feet per year of supply from surface water desalination strategies is recommended in 2070.

Figure 7-5. Online decade count and cumulative yield of recommended new major reservoirs



** Reservoirs shown as online in 2020 are anticipated to have construction completed by January 2023.*

Weather modification, sometimes referred to as cloud seeding, is the application of technology to enhance precipitation from clouds. About 5,000 acre-feet per year of supply from weather modification strategies is recommended in 2070 to address needs for select irrigation water users that also have recommended irrigation conservation strategies.

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. About 5,000 acre-feet per year of supply from brush control strategies is recommended in 2070 to address needs for select non-municipal water users that also have other recommended strategies.

Rainwater harvesting involves capturing, diverting, and storing rainwater for landscape irrigation, drinking and domestic use, aquifer recharge, and stormwater abatement. Rainwater harvesting can reduce municipal outdoor irrigation demand on potable systems. Building-scale level of rainwater harvesting, as was generally considered by planning groups and which meets planning rules, requires active management by each system owner to economically develop it to a scale that is large and productive enough to ensure a meaningful supply sustainable through a drought of record. About 5,000 acre-feet per year of supply from rainwater harvesting strategies is recommended in 2070 to address needs for select water users that have multiple additional recommended strategies.

7.4 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, for example, 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 unassigned water volumes may require additional water infrastructure that may not be included in this 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. There are 22 recommended projects that are associated with only unassigned strategy supplies, meaning the supplies from these projects have not yet been allocated to a specific water user group. Approximately 210,000 acre-feet per year of unassigned strategy supply is recommended in 2020, and 1.1 million acre-feet per year is included in the recommended strategies in 2070. Unassigned strategy supplies account for 11 percent of the total supply share in 2020 and 13 percent in 2070. Assigned and unassigned strategy supplies recommended in 2070 are presented by region in Figure 7-6.

7.5 Costs of recommended strategies

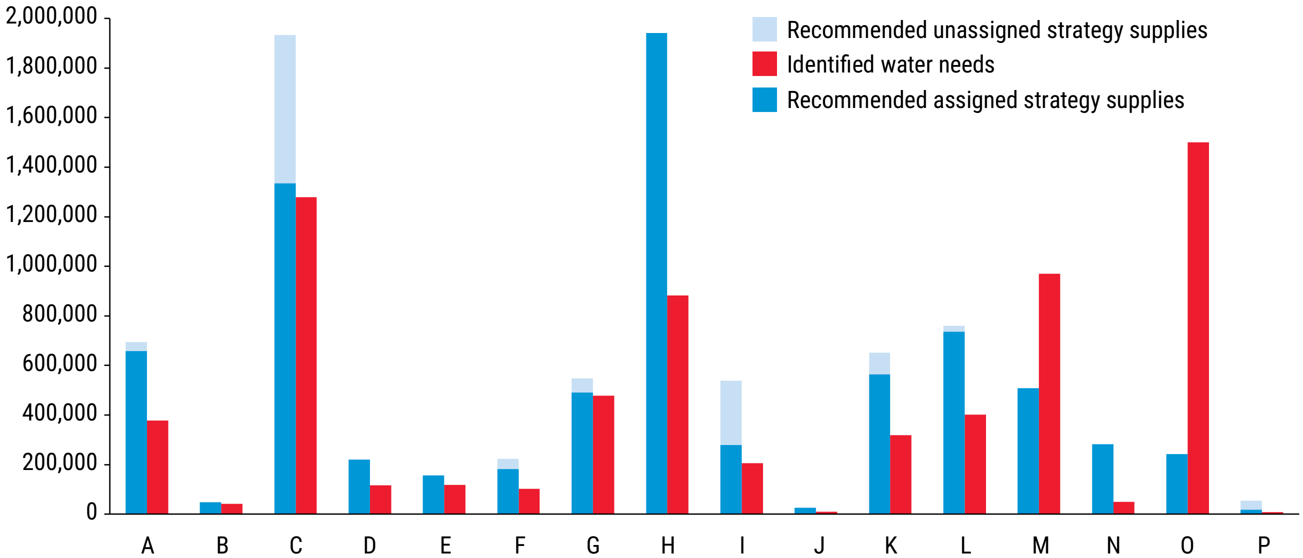
Planning groups estimated the costs of their recommended water management strategy projects using common cost elements and methodologies. This is the second cycle of regional plans in which planning groups utilized a cost estimation tool that was developed under a TWDB-funded research study and the first in which a cost estimation tool for drought management strategies was made available.[9] 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 maintaining or replacing existing infrastructure as well as retail distribution projects, such as expanding 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 $80 billion in 2018 dollars, without

[9] The costing of drought management strategies is a significantly different cost concept (economic cost) than the explicit capital cost of implementing other strategy types. Additional detail on lost consumer surplus appears in the user guide for the Drought Management Tool at www.twdb.texas.gov/waterplanning/rwp/planningdocu/2021/doc/current_docs/project_docs/TWDB_Drought_Management_Costing_Tool_User_Manual_2019.pdf.

Figure 7-6. Recommended assigned and unassigned strategy supplies and needs by region in 2070 (acre-feet)



accounting for future inflation. This includes approximately 2,400 projects that would be built and completed at various times over the next five planning decades.

The estimated unit cost of water (dollars per acre-foot of water delivered to water user groups in each year) varies greatly depending on the type of strategy, location, water source, and infrastructure required to convey and treat the water. Statewide, based on a weighted average cost,[10] the least expensive recommended water management strategy type in the year 2070 is drought management followed by irrigation conservation. The most expensive is direct potable reuse followed by seawater desalination (Table 7-5). There can be a substantial range in unit cost even within a single type of strategy depending on the source water quality, geographic distances, and whether the unit cost includes debt service in the later decades; this is true between regions as well. 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.

Similarly, unit costs of water were estimated by strategy type at a statewide level for each decade in the planning horizon (Table 7-6). Statewide weight-averaged unit costs are higher than the 2017 State Water Plan for every strategy type except groundwater well development, seawater desalination, and the grouped category Other strategies, which includes such strategies as rainwater harvesting (Section 7.3.10).

7.6 Strategies benefiting multiple regions

Several wholesale and major water providers in this plan serve customers in multiple planning regions. Additionally, regional water planning groups coordinate with each other throughout each cycle to identify and consider potential regionalized projects during the development of their plans. In this plan, 35 recommended strategies recommended by 7 planning groups benefit water user groups in more than those 7 primary regions. This regionalization provides shared water supplies to 10 of the 16 regions across the

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

Table 7-6. Statewide weight-averaged unit costs (dollars per acre-foot) of strategy water supplies by strategy type 2020–2070*

Water management strategy type	2020	2030	2040	2050	2060	2070
Agricultural conservation	$284	$273	$202	$188	$186	$181
Aquifer storage & recovery	$437	$666	$904	$609	$509	$664
Conjunctive use	$1,724	$1,729	$1,986	$1,147	$903	$814
Direct potable reuse	$1,321	$1,456	$1,402	$1,587	$1,590	$1,504
Drought management**	$70	$119	$168	$168	$169	$169
Groundwater desalination	$920	$1,618	$1,430	$899	$994	$1,080
Groundwater wells & other	$599	$659	$592	$523	$439	$402
Indirect reuse	$391	$697	$541	$391	$266	$297
Industrial conservation	$680	$597	$513	$339	$311	$292
Municipal conservation	$675	$607	$503	$498	$519	$515
New major reservoir	$114	$598	$818	$678	$521	$511
Other direct reuse	$962	$892	$865	$483	$559	$630
Other strategies	$10	$2,128	$2,016	$1,073	$1,055	$1,066
Other surface water	$744	$1,037	$986	$581	$550	$523
Seawater desalination	na	$2,402	$2,394	$1,440	$1,383	$1,371

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

*** Unit costs for drought management strategies represent possible costs to municipal water users from foregone consumer surplus of imposed reduced water use rather than capital expended to produce water supply.*

na = not applicable or not available.

state. The volume of water from these regionalized strategies represents 13 percent of the total recommended strategy water supply volume in 2070 that includes groundwater development, transfers of existing water supplies, development of new major reservoirs, direct and indirect reuse, and aquifer storage and recovery projects. Planning groups also assessed progress toward regionalization, a new requirement in this plan from House Bill 807, 86th Legislative Session. This discussion is included with other implementation results in Chapter 10.

7.7 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.

7.7.1 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 of how implementing 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 commonly used the Texas Surface Water Quality Standards, which include the following:

- **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**: Nutrients are chemical constituents, most commonly as a form of nitrogen or phosphorus, that can occur in high concentrations, contributing to the overgrowth of aquatic vegetation and impacting water uses.
- **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, indicate 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 commonly used to evaluate groundwater quality impacts of the recommended water management strategies include the following:

- **Total dissolved solids (salinity)**: As noted above, total dissolved solids is a measure of the salinity of water and represents the amount of minerals dissolved in water.
- **Nitrates**: Although nitrates are naturally occurring nutrients, 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 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.

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

In developing the regional plans, planning groups honored all existing water rights and contracts and considered conservation strategies based on identified best management practices for all water user groups with a water supply need or that relied on an interbasin transfer. Planning groups also accounted for environmental flow standards adopted by the Texas Commission on Environmental Quality, Consensus Criteria for Environmental Flow Needs, or, when available, site-specific studies. Regional plans do not include any recommended strategies incompatible with the desired future conditions of aquifers or that divert greater-than-permitted surface water volumes.

Planning groups quantified and considered the impacts of water management strategies to agricultural resources. In developing the plans, planning groups were also required to consider and, when feasible, recommend water management strategies to meet the water supply needs of irrigated agriculture and livestock production. Recommended strategies involving 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.

In considering the protection of natural resources, planning groups included estimated costs of anticipated mitigation requirements for project construction and quantified the potential impacts of water management strategies related to environmental factors. These factors were quantified and summarized primarily based on existing data and the potential to avoid or mitigate impacts. Some categorized assessments as “high,” “moderate,” or “low” based on underlying quantified impacts or quantified ranges of impacts. For example, a “low” impact rating indicated that impacts could generally be avoided or mitigated relatively easily. In contrast, an impact rated as “high” generally indicated that impacts would be significant with the potential for substantial mitigation requirements.

In their environmental reviews, planning groups also considered a variety of factors, including the volume of discharge a strategy would produce, the number of acres of habitat potentially affected, changes to streamflows, and changes to bay and estuary inflow patterns. The groups 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 affected. 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 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.

7.8 Needs met by recommended strategies

Planning groups were required to consider all identified water needs (potential shortages) and identify possible strategies to meet them, when feasible. Two planning groups (Regions N and P) were able to recommend water management strategies that, if implemented, can meet the needs for all their water user groups. The remaining 14 planning groups were unable to identify sufficient feasible strategies that could meet both Texas’ planning requirements and all the needs in their regions (Figure 7-7).

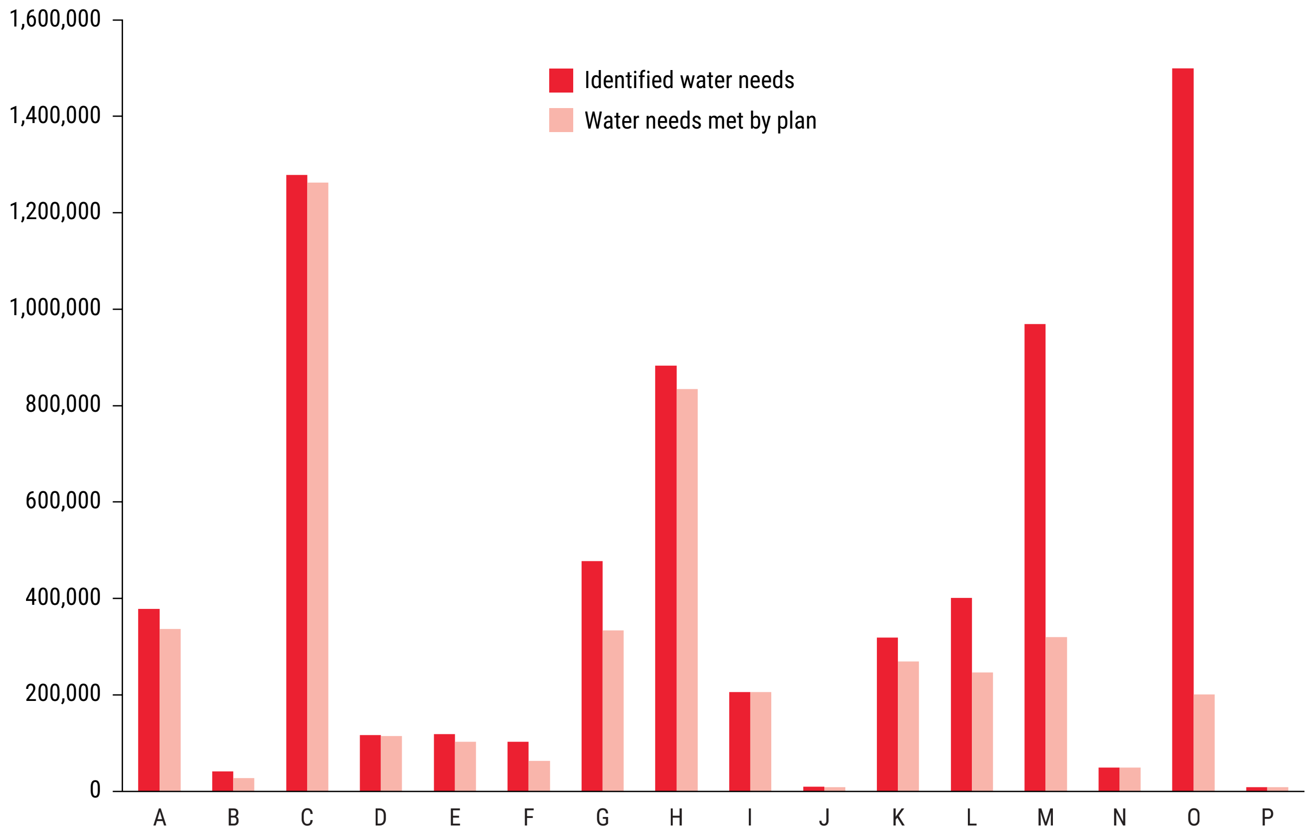
Statewide, most water needs associated with municipal, manufacturing, livestock, and mining water user groups are met by the plan in 2070 (Figure 7-8). However, at least some unmet water supply needs occur for all categories of water user groups, with irrigation water user groups accounting for the majority of unmet water needs. 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. The significant unmet irrigation water needs are largely due to managed depletion of aquifers and a lack of economically feasible alternatives to meet agricultural needs. An unmet need does not prevent an associated entity from pursuing development of additional water supply.

7.9 Comparison to the 2017 State Water Plan

The volumes and relative mix of recommended water management strategies 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 those “new” supplies are then accounted for as existing water supplies (Chapter 5) and thereby reduce the resulting water needs.

Counts of recommended strategies in this plan vary from the 2017 State Water Plan partly due to both the transition to utility-based planning and a shift by some planning regions toward grouping strategies under project sponsors. Such strategy grouping by sponsors has occurred as projects get further defined over time, serving multiple customers with interrelated needs, such as meeting groundwater reduction requirements by regional water authorities around the

Figure 7-7. Annual water supply needs and needs met by the plan by region in 2070 (acre-feet)

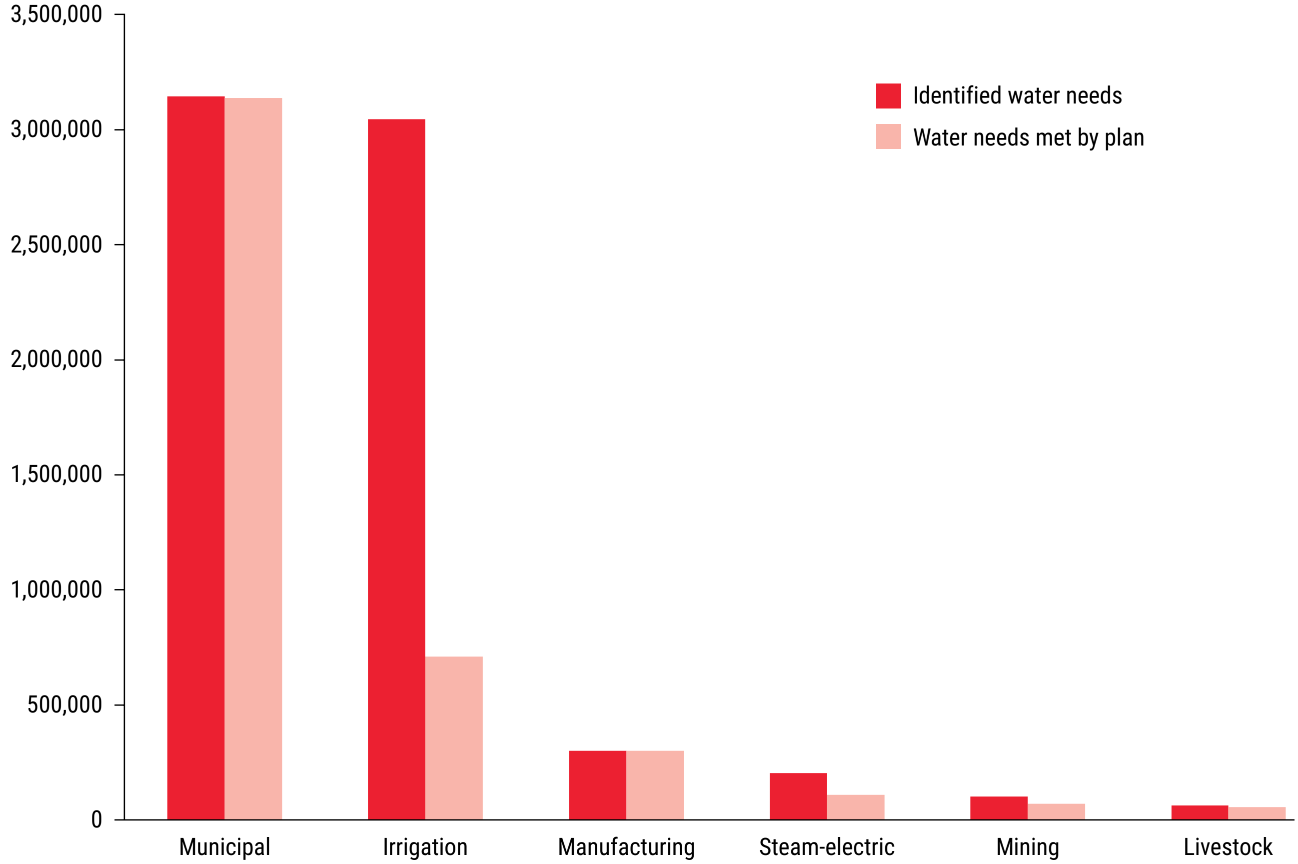


Houston area. There are approximately 5,800 recommended strategies described in this plan that represent the total number of recommended strategies assigned to water user groups and account for individual and grouped strategies. This represents a net increase of approximately 500 in the count of recommended strategies over the count in the 2017 plan, some of which is the result of the transition to utility-based planning.

As is the case with this plan, the 2017 State Water Plan also included a varying mixture of water supply volumes not directly associated with water user groups. However, the associated volumes and project sponsors differ, which makes comparisons between plans difficult. The recommended water management supplies, as presented here, are those supply volumes that planning groups associated with specific water user groups. In addition to the shift in timing of several major reservoirs previously discussed, notable changes from the 2017 State Water Plan include the following:

- The anticipated total strategy supplies directly associated with water user groups in the 2070 decade decreased from 8.5 million acre-feet per year in the 2017 State Water Plan to 7.7 million acre-feet per year in this plan, primarily due to a lower volume of needs to address in 2070 than in the 2017 State Water Plan.
- The total capital costs of all recommended strategies increased significantly from $63 billion in the previous plan to $80 billion, due to many factors but largely because of increased construction costs, refinement of projects through the planning phases, increased engagement of water providers and communities in the planning process, and a more comprehensive effort to include all projects that will conserve water or increase treated water supply volumes.

Figure 7-8. Annual water supply needs and needs met by the plan by water use category in 2070 (acre-feet)



- The number of water user groups benefiting from recommended aquifer storage and recovery strategies increased significantly from the previous plan.
- Capital-intensive conservation strategies increased to $7.4 billion—$2.7 billion more than in the previous plan.
- The volume of recommended municipal conservation savings of 977,000 acre-feet per year in 2070 is greater than the 811,000 acre-feet per year recommended in the 2017 plan.
- The volume of recommended direct potable reuse strategies in 2070 decreased from approximately 87,000 acre-feet per year in the 2017 plan to 62,000 acre-feet per year.
- The volume of recommended desalination strategies in 2070 nearly doubled, from approximately 229,000 acre-feet per year in the 2017 plan to almost 412,000 acre-feet per year.
- The volume of recommended aquifer storage and recovery strategies in 2070 increased from approximately 123,000 acre-feet per year in the 2017 plan to 193,000 acre-feet per year.

7.10 Uncertainty of future strategies

Implementation of any given recommended water management strategy or project is not a certainty, and project sponsors are ultimately responsible for implementing water management strategies. Many of the more significant projects will require obtaining a surface water right or groundwater 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.

Comal Springs flow from the limestone rocks, New Braunfels, Texas

Implementing all water supply projects also 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 be shelved or abandoned.

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 if a recommended strategy becomes infeasible. The further into the 50-year planning horizon, the greater the uncertainty of implementing any given strategy. Regulations may change or technological advances may make some strategies 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

Conservation

QUICK FACTS

This is the first state water plan in which planning groups were required to set a per capita water use goal for municipal water users. About half of the planning groups selected 140 gallons per capita per day, a goal first established by the state's Water Conservation Implementation Task Force report to the legislature (WCITF, 2004).

About 977,000 acre-feet in municipal conservation strategies is recommended in 2070, of which 320,000 acre-feet is associated with water loss reduction activities at a capital cost of approximately $3.8 billion.

Although measuring and tracking conservation implementation can be challenging, statewide average municipal per capita use has generally declined over the past decades, partly due to conservation implementation funded through multiple state financing programs.

Conservation will continue to play an essential role in meeting the future water demands of Texas' rapidly growing population. Significant strides in both indoor and outdoor water use efficiency have been made over the past decade. Within the regional and state water planning process, those strides are reflected in water conservation measures that include practices, techniques, programs, and technologies that will protect water resources; reduce water consumption, loss, or waste; or improve the efficiency of water use.

Conservation is one of the measures water user groups can choose to help address their water needs. As a result, conservation is a water management strategy that can make a water supply available for future or alternative uses,[11] without restricting desired economic or other activities.

This new chapter of the state water plan aggregates conservation information similarly to that of the regional water plans, which are required to provide conservation information in Chapter 5 of each of the plans. More detail may be found in each regional water plan, including consolidated conservation-related recommendations and model water conservation plans.

8.1 Agency program and legislated conservation initiatives

Various TWDB conservation programs provided information used to develop the regional water plans. Water conservation activities and water loss information provided to the regions included data from the agency's collection of water conservation plans (approximately 650 are submitted every five years); conservation plan annual implementation reports (approximately 650 are submitted annually); and water loss audits (approximately 4,000 utilities submit every five years and 750 submit annually).[12] Information from the

[11] Texas Water Code Section 11.002 generally defines conservation as the development of water resources. For regional planning purposes, water conservation measures do not include reservoirs, aquifer storage and recovery, or other types of projects that develop new water supplies. Additionally, for planning purposes, water reuse is considered a unique strategy type separate from conservation.

[12] www.twdb.texas.gov/conservation/municipal/index.asp

conservation plan annual reports and water loss audits is also posted on the TWDB website.[13]

In addition, the TWDB has undertaken numerous legislatively directed initiatives over this recent planning cycle. These include developing a statewide water conservation quantification project, creating a municipal water conservation planning tool, and the continued issuing of grant funds to support agricultural water conservation programs. The background of these initiatives is summarized below. These initiatives and the tools and other resources that they have produced, as well as an ongoing water loss audit validation study anticipated to be completed in 2021, will support the development of the next regional and state water plans.

House Bill 3605 of the 83rd Legislative Session was implemented during this planning cycle. It requires all retail public utilities to use a portion of the financial assistance they receive from the TWDB to address water loss if it is above a utility-specific threshold. Data collected will be provided to planning groups for consideration in the development of their 2026 regional water plans.

To address the requirements of state budget Rider 26 from the 84th Legislative Session, the TWDB contracted a statewide water conservation quantification study[14] (Averitt, 2017). The study collected water conservation activity information from 170 water utilities across the state and estimated the water and water loss reduction savings from the various programs. Those estimates were then compared to the projected conservation savings from each utility's recommended conservation water management strategies in the 2017 State Water Plan. The study's estimated collective savings to date were projected to exceed the collective 2020 water conservation strategy supply volumes but fall short of the 2030–2070 strategy supply volumes reported in the 2017 State Water Plan. The TWDB provided these findings to planning groups for their consideration in developing conservation strategies for the 2021 regional water plans. Many planning groups acknowledged the difficulty of quantifying conservation savings with the results of this study. At least one planning group utilized the information to estimate demand reduction since 2011, the base year of the municipal water demands, and refine the costs of demand reduction.

To fulfill the requirements under Rider 24 of the 85th Legislative Session, the TWDB contracted for the development of a municipal water conservation planning tool,[15] which built upon the previous water conservation quantification study results. The planning tool was primarily developed to assist water utilities with their own water conservation planning and reporting, though planning groups were given the option to use the tool to estimate the volumes of recommended conservation water management strategies in their plans. This tool provides an accounting framework for estimating future conservation program costs and water savings as well as estimating the water savings from implementing previous conservation measures.

House Bill 1648 from the 85th Legislative Session requires certain retail public water utilities to designate a water conservation coordinator to implement conservation plans, a named position that must be included in the conservation plan annual report for each utility. House Bill 3339 from the 86th Legislative Session consolidates all water conservation plan requirements for financial applicants to the TWDB and requires the TWDB to provide educational and technical assistance to develop such plans.

[13] www.twdb.texas.gov/conservation/municipal/waterloss/historical-annual-report.asp

[14] www.twdb.texas.gov/conservation/doc/StatewideWaterConservationQuantificationProject.pdf

[15] www.twdb.texas.gov/conservation/municipal/plans/doc/TWDB_MWCPT_v1.xlsm

House Bill 1573 from the 85th Legislative Session requires individuals submitting a water loss audit to have received TWDB training regarding these audits, and the agency provides this training online or through in-person workshops. This initiative contributes to improving the quality of water loss data reported and considered in developing the state water plan.

The TWDB has also contracted for a water loss audit validation study to be completed by summer 2021. This study will meet the requirements of Rider 22 from the 86th Legislative Session by furthering water conservation through quantification and measurement. The project is intended to provide insight into certain aspects of conducting water loss audit validations in Texas. The study will validate water loss data for at least 10 volunteer utilities of various sizes across the state. Improved data will allow the utilities to make better decisions regarding improving the efficiency of their systems and will assist regional planning groups in identifying those entities that might benefit most from water management strategies, such as water loss mitigation through meter testing and replacement, rapid leak repair, and pipe replacement.

The TWDB's Agricultural Water Conservation Grants Program offers grants to state agencies, political subdivisions, and universities to demonstrate agricultural water conservation best management practices and support the implementation of agricultural irrigation conservation strategies in alignment with the state water plan. Each year, applications are solicited to address topics related to agricultural water conservation. Some examples of previously awarded grants include technical assistance, demonstration projects, technology transfer, equipment cost share, and research and education. The TWDB also provides low-interest, fixed-rate loans to political subdivisions that are used to pass through funds to individual producers, enabling them to upgrade irrigation equipment and improve irrigation efficiency. Through Fiscal Year 2020, the TWDB has awarded approximately $113.1 million from these programs. In 2020 alone, the TWDB awarded nearly $1.2 million in grants to five recipients and a $725,000 loan to one recipient for their projects.

8.2 Conservation's role in the state water planning process

Every five years, the TWDB develops water demand projections for the regional planning groups' review and use in their regional plans (Chapter 4). The municipal water demands incorporate anticipated water savings (passive conservation savings) from federal and state water-efficiency standards for plumbing fixtures and appliances, because these passive water savings won't require any additional action on the part of water utilities to realize the savings. Importantly, the per capita per day water use in these municipal projections *already reflect previous and often significant conservation savings already achieved.* That includes, for example, benefits from conservation best management practices that water providers may have been following for years. Past conservation achievements necessarily limit the future capacity for achieving additional conservation, especially in areas with limited growth.[16]

Under efficiency standards in place at the time of this plan's development, the additional combined savings of water-efficient showerheads, toilets, clothes washers, and dishwashers are anticipated to reduce the future municipal water demands of the state by approximately 5.4 percent in 2020 and 9.5 percent in 2070 (Chapter 4). Passive saving volumes and recommended municipal conservation strategies will together amount to about 517,000 acre-feet of water in 2020 and approximately 1.9 million acre-feet in 2070 (Table 8-1).

Once water supply needs are identified, each planning group is required to first consider water

[16] This tendency for past conservation to increase the difficulty and cost of additional future conservation is called "demand hardening."

Table 8-1. Anticipated (passive and strategy) municipal conservation water volumes in 2020 and 2070 (acre-feet)

		2020	2070
Projections	**Passive water savings by fixtures/appliances**		
	Showerheads	40,000	175,000
	Clothes washers	134,000	284,000
	Toilets	75,000	334,000
	Dishwashers	48,000	96,000
	Subtotal	**297,000**	**889,000**
Strategies	**Subtotal recommended municipal conservation strategy supplies**	**220,000**	**977,000**
	Total	**517,000**	**1,866,000**

conservation strategies to address those needs. As planning groups identify and evaluate water management strategies, they must also consider utility water conservation plans and data from water loss audits submitted by water providers in the region. If a planning group determines that recommending a conservation strategy for an identified water need is not feasible, it must document the reason in its plan.

Each plan must also include region-specific model water conservation plans as a resource for entities to reference when developing their own water conservation plans. In doing so, planning groups have generally chosen to reference the Texas Commission on Environmental Quality's requirements for compulsory conservation plans from certain entities every five years. These include such factors as a utility profile that describes the entity, water system, and water use data; quantified 5-year and 10-year water savings goals; and documentation of coordination with the regional water planning group.

For water users dependent upon water management strategies involving interbasin transfers, planning groups are required to include the highest practicable level of water conservation for those entities. To help each planning group evaluate whether they are meeting those associated conservation expectations, the TWDB uses the state water planning database to provide summaries of each region's conservation strategy savings associated with water users who depend on interbasin transfers.

8.3 Establishing regional conservation goals

New to this round of planning was a requirement from House Bill 807, 86th Legislative Session, that directs planning groups to set one or more specific goals for municipal water use in gallons per capita per day in each decade of the period covered by the plan. These goals are not necessarily the same as goals set by utilities as part of their water conservation plans, which are often based on multi-year averages and use total gallons per capita per day. Some, but not all, planning groups set per capita goals specifically intended as goals for dry-year use, which is consistent with the underlying benchmark of the regional and state water plans, and generally correspond to higher per capita water use rates than the goals shown in water conservation plans.

Approximately half of the planning groups set a per capita water use goal of 140 gallons per capita per day for municipal water users, a goal largely informed by a similar goal for average conditions that was in the state's Water Conservation

Implementation Task Force report to the legislature (WCITF, 2004). The Task Force defined gallons per capita per day as the total amount of water diverted and/or pumped for potable use, including industrial use, divided by total population. Additionally, indirect reuse diversion volumes were to be credited against total diversion volumes for the purpose of calculating gallons per capita per day for targets and goals. There are various methodologies for calculating gallons per capita per day as discussed below. Planning group goals were generally established considering dry-year projected demands and potential future savings from recommended conservation strategies. Other regions determined individual goals for municipal water users based on calculating the expected per capita use after incorporating anticipated efficiency savings and recommended conservation strategy savings. One region used a combination of both methods for setting their municipal water use goals.

The TWDB provided historical water use estimates and other reported information from conservation annual reports to support planning groups' establishment of goals. A gallons per capita per day figure is calculated for each utility water user as part of the state's water planning process and in the annual conservation reports. These methodologies are documented[17] in the *Guidance and Methodology for Reporting on Water Conservation and Water Use* (TWDB and others, 2012) and are summarized below. Specific water use goals can be found in Chapter 5 or the associated appendix of each regional water plan.

Regional water planning gallons per capita per day – The value reported in the regional water planning process. It is the total volume of water intake minus wholesale volumes to other municipal water users and large industrial facilities and retail volumes to large industrial facilities divided by 365 and then divided by the permanent population of the municipal water user.

Total gallons per capita per day – The value reported in the conservation plans and annual reports. It is the total system input volume of water treated for potable use minus wholesale volumes to other water systems divided by 365 and then divided by the permanent population of the water system. Retail volumes sold to large industrial facilities are included in total gallons per capita per day.

Residential gallons per capita per day – The value reported in the conservation annual reports.[18] Residential gallons per capita per day is calculated as the volume of water metered to single-family and multi-family connections, divided by the total residential population served, divided by 365. Residential water use is collected through the annual Water Use Survey.

8.4 Conservation water management strategies and projects

The types of recommended conservation water management strategies vary between the 16 regions but were generally based on an analysis of a variety of best management practices for various types of water users. These practices either reduce everyday water consumption or increase water use efficiency, allowing more to be done with the same amount of water and resulting in additional available water supplies. Conservation requires a continuous effort, occurs throughout both wet and dry weather cycles, and maintains all normal economic and domestic activities. Best management practices are defined as conservation measures that are useful, proven, cost-effective, and generally accepted among conservation experts. These practices are further described in the water conservation best management practices guides developed by the state's Water Conservation Advisory Council and

[17] www.twdb.texas.gov/waterplanning/waterusesurvey/estimates/GPCD_definitions_051120.pdf

[18] www3.twdb.texas.gov/apps/wcreps/wcreports.aspx

Significant strides in both indoor and outdoor water use efficiency have been made over the past decade

available at www.twdb.texas.gov/conservation/BMPs/index.asp.

8.4.1 Municipal conservation

In a report to the Texas Legislature, the TWDB determined that many utilities do not describe their conservation activities in terms of formalized best management practices (TWDB, 2019). Therefore, many municipal conservation water management strategies in the state water plan are essentially a menu of potential best practices that may be implemented to achieve a specific, estimated amount of water savings. The same report to the legislature also determined that all utilities reviewed included at a minimum the following three best management practices:

- metering of all new connections and retrofit of existing connections
- system water audit and water loss control
- public information

The recommended municipal conservation strategies in this state water plan include all of these and other common best practices, as well as infrastructure-based projects that will address water loss and metering. Municipal conservation was a recommended strategy in every regional water plan and is associated with over 1,200 municipal water user groups statewide (Table 7-4).

Municipal conservation strategies include a variety of activities, such as incentivized installation of water-efficient plumbing fixtures (for example, through rebates, and are included by 9 regions); stronger water conservation pricing structures that discourage waste (included by 11 regions); education programs (included by 13 regions); and year-round landscape irrigation restrictions that continue to allow for maintenance of healthy landscapes (included by 11 regions). Best practices for outdoor landscape watering were included in the municipal conservation strategies in 13 of the 16 regional water plans.

Regional water planning groups recommended about 218,000 acre-feet per year in municipal conservation strategies for 2020 and 977,000 acre-feet per year by 2070 (Table 8-2). These savings are in addition to the estimated volume of additional future passive conservation savings expected to occur as a result of existing plumbing codes and water-efficiency standards discussed earlier in this section (297,000 acre-feet per year in 2020 and 889,000 acre-feet per year in 2070). For municipal water user groups with identified needs, approximately 26 percent of 2020 identified needs and 25 percent of needs in 2070 are addressed by recommended water conservation strategies alone.

Municipal conservation strategies also include activities to detect, measure, and reduce water loss. Planning groups are required to present water loss audit data in Chapter 1 of their plans and to consider this data when developing their plans. Upon considering the information, eight planning groups (Regions A, C, E, F, H, I, J, and N) determined thresholds for recommending water loss audits and leak repair strategies in their plans for entities with significant water loss, and three planning groups established targets for voluntary action (Table 8-3). Regions with thresholds for water loss audit and leak repair

Table 8-2. Annual volume of all recommended conservation strategies by use category in 2020 and 2070 (acre-feet) – continued below

Category	Decade	A	B	C	D	E	F	G	H	I
Irrigation	2020	141,000	7,000	<500	0	34,000	23,000	8,000	94,000	0
Irrigation	2070	565,000	17,000	<500	0	34,000	60,000	19,000	94,000	0
Municipal	2020	5,000	<500	94,000	4,000	5,000	3,000	1,000	40,000	7,000
Municipal	2070	8,000	2,000	192,000	10,000	19,000	4,000	108,000	187,000	22,000
Mining	2020	0	1,000	6,000	0	0	5,000	1,000	0	0
Mining	2070	0	<500	10,000	0	0	1,000	3,000	0	0
Manufacturing	2020	0	0	0	<500	0	0	<500	0	0
Manufacturing	2070	0	0	0	1,000	0	0	1,000	0	0
Steam-electric	2020	0	<500	0	0	0	0	0	0	0
Steam-electric	2070	0	5,000	0	0	0	0	0	0	0
Livestock	2020	0	0	0	0	0	0	0	0	0
Livestock	2070	0	0	0	0	0	0	0	0	0
Total	**2020**	**146,000**	**8,000**	**100,000**	**4,000**	**39,000**	**31,000**	**10,000**	**134,000**	**7,000**
Total	**2070**	**573,000**	**24,000**	**202,000**	**11,000**	**53,000**	**65,000**	**131,000**	**281,000**	**22,000**

Table 8-2. Annual volume of all recommended conservation strategies by use category in 2020 and 2070 (acre-feet) – continued

Category	Decade	J	K	L	M	N	O	P	Texas[a]
Irrigation	2020	<500	51,000	0	67,000	1,000	95,000	15,000	**536,000**
Irrigation	2070	<500	119,000	0	118,000	3,000	153,000	15,000	**1,197,000**
Municipal	2020	<500	13,000	29,000	15,000	0	2,000	0	**218,000**
Municipal	2070	<500	82,000	167,000	155,000	19,000	1,000	1,000	**977,000**
Mining	2020	0	1,000	0	2,000	<500	<500	0	**16,000**
Mining	2070	0	2,000	0	1,000	<500	<500	0	**17,000**
Manufacturing	2020	0	0	0	<500	2,000	<500	0	**2,000**
Manufacturing	2070	0	0	0	1,000	15,000	<500	1,000	**19,000**
Steam-electric	2020	0	1,000	0	2,000	0	0	0	**3,000**
Steam-electric	2070	0	1,000	0	2,000	0	0	0	**8,000**
Livestock	2020	<500	0	0	0	0	0	0	**<500**
Livestock	2070	<500	0	0	0	0	0	0	**<500**
Total	**2020**	**<500**	**66,000**	**29,000**	**86,000**	**3,000**	**97,000**	**15,000**	**775,000**
Total	**2070**	**<500**	**204,000**	**167,000**	**277,000**	**37,000**	**154,000**	**17,000**	**2,218,000**

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

Table 8-3. Planning-group-determined thresholds for water loss audit and leak repair strategies and targets for voluntary action

Region	Threshold for water management strategy[a]	Target for voluntary action
A	Cities: ≥15% total loss WSCs: ≥25% total loss	na
C	Urban/suburban systems: >12% total loss Rural systems: >18% total loss	na
D	na	>15% loss
E	>10% loss	>200 GPCD
F	Cities: ≥15% total loss WSCs: ≥25% total loss	na
H	>10% real loss	na
I	Less than 32 connections per mile: >18% total loss More than 32 connections per mile: >12% total loss	na
J	>10% loss	>200 GPCD
N	>15% real loss (pipeline replacement) >5% apparent loss (meter replacement)	na

[a] Whereas the thresholds used to develop water management strategies by the planning groups include the use of GPCD as well as the use of water loss expressed as a percentage, the water industry does not recognize percentage as a metric or performance indicator for water loss, and the TWDB does not use percentage of water loss in its review and analysis of water loss audits. Type of water loss is specified where known.

> = greater than

≥ = greater than or equal to

% = percent

GPCD = gallons per capita per day

na = not applicable

WSC = water supply corporation

strategies primarily considered total water loss in their evaluations. Total water loss is the sum of real and apparent water loss.[19] Region H specifically considered real water loss in its evaluation. Region N differentiated thresholds for both real and apparent water loss, recommending pipeline replacement for entities above the real water loss threshold and meter replacement for entities above the apparent water loss threshold. Planning groups that did not establish such thresholds or targets still recommended water loss reduction strategies. Replacing leaking lines and installing advanced metering infrastructure are examples of recommended projects that involve capital expenditures to specifically address water loss. About 74,000 acre-feet per year in savings associated specifically with water loss projects is recommended in 2020, and 320,000 acre-feet per year in savings is recommended in 2070. The total capital cost associated with these projects is $3.8 billion.

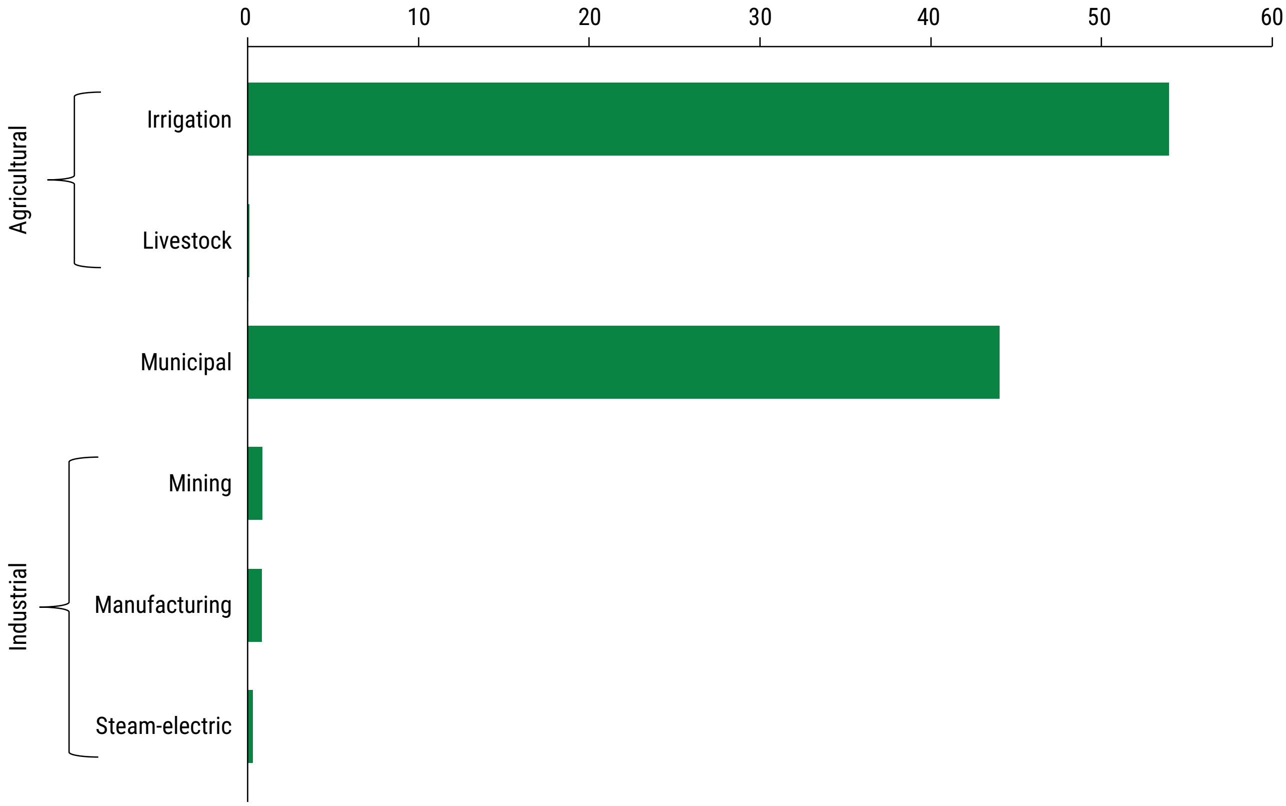
[19] More information on the TWDB's water loss programs can be found at www.twdb.texas.gov/conservation/municipal/index.asp

8.4.2 Agricultural conservation

Irrigation for agricultural production is the largest water demand sector in the state for most of the planning horizon and is projected to account for 40 percent of annual statewide water use in 2070. Identified water supply needs for this sector account for 44 percent of total statewide needs in 2070.

Irrigation conservation strategies include changes to irrigation methods, equipment, and crops. For example, conversion to Low Energy Precision Application systems and irrigation scheduling, as well as other activities associated with irrigation best management practices, can help producers reduce their water use. Like municipal conservation, irrigation conservation strategies tend to be an aggregate of multiple best management practices, any one of or several of which could

Figure 8-1. Share of statewide recommended conservation water management strategies by use sector in 2070 (percent)



be implemented to achieve the estimated water savings of the strategy. About 536,000 acre-feet per year in irrigation conservation strategies is recommended in 2020, and 1.2 million acre-feet per year is recommended in 2070 (Table 8-2).

Implementing all recommended irrigation conservation strategies will cost approximately $1.1 billion, or slightly more than 1 percent of the total capital costs of all recommended water management strategy projects in the plan. Conservation is the primary strategy recommended to address identified irrigation needs in most regions and has an estimated statewide average implementation cost of about $181 per acre-foot in 2070. Irrigation conservation is consistently the largest statewide relative share of recommended conservation and remains so in 2070, even as volumes of municipal needs addressed by conservation increase across the planning horizon (Figure 8-1).

In addition to irrigation water use for agricultural production, livestock water use is another water need identified within the state. However, compared to irrigation water use, livestock accounts for a less significant amount of water use throughout the state. Conservation strategies are also recommended for a small number of livestock water users in Region J, roughly less than 500 acre-feet per year in 2020 and 2070.

8.4.3 Industrial conservation

Conservation is also a recommended strategy for numerous steam-electric, manufacturing, and mining water users. Recommended conservation measures for these users, to be implemented mostly by private interests, are generally based on best management practices appropriate for each facility, which may include evaluating more efficient cooling and process water practices, water audits, or submetering. Although presented individually in this subchapter, these sectors of use are collectively presented as *industrial conservation* elsewhere in this state water plan. In 2020, 21,000 acre-feet per year in industrial conservation strategies is recommended, and about 44,000 acre-feet per year is recommended in 2070 (Table 8-2).

Three regions (Regions B, K, and M) recommend conservation strategies for steam-electric water users. Approximately 3,000 acre-feet per year in steam-electric conservation strategies is recommended in 2020, and 8,000 acre-feet per year is recommended in 2070.

Seven regions (Regions C, D, G, M, N, O, and P) recommend conservation strategies for manufacturing water users. Region N recommends the most manufacturing conservation strategy supplies, accounting for 70 percent of statewide manufacturing conservation strategy supplies in 2020 and more than 80 percent in 2070. Total supplies from recommended manufacturing conservation strategies increase significantly over the planning horizon from about 2,000 acre-feet per year in 2020 to 19,000 acre-feet per year in 2070.

Eight regions (Regions B, C, F, G, K, M, N, and O) recommend conservation strategies for mining water users. Total mining conservation strategy supplies fluctuate slightly but are relatively stable over the planning period. Approximately 16,000 acre-feet per year in mining conservation strategies is recommended in 2020, and 17,000 acre-feet per year is recommended in 2070. More than 65 percent of the 2020 mining conservation supplies are recommended for mining water users in Regions C and F. By 2070, Region C accounts for over half of the recommended mining conservation strategy supplies.

8.5 Conservation implementation

Measuring and tracking conservation implementation can be challenging due to limitations in utilities' data across water use sectors and the large number of factors that can impact water use, such as weather (BBC, 2012; WCAC, 2020; TWDB, 2021). Historical implementation of statewide municipal conservation can be observed in the generally declining trend of the statewide average municipal gallons per capita per day as reported through the TWDB's annual Water Use Survey (Figure 8-2).[20] The 2006 and 2011 peaks in reported use correspond to drought conditions experienced across the state.

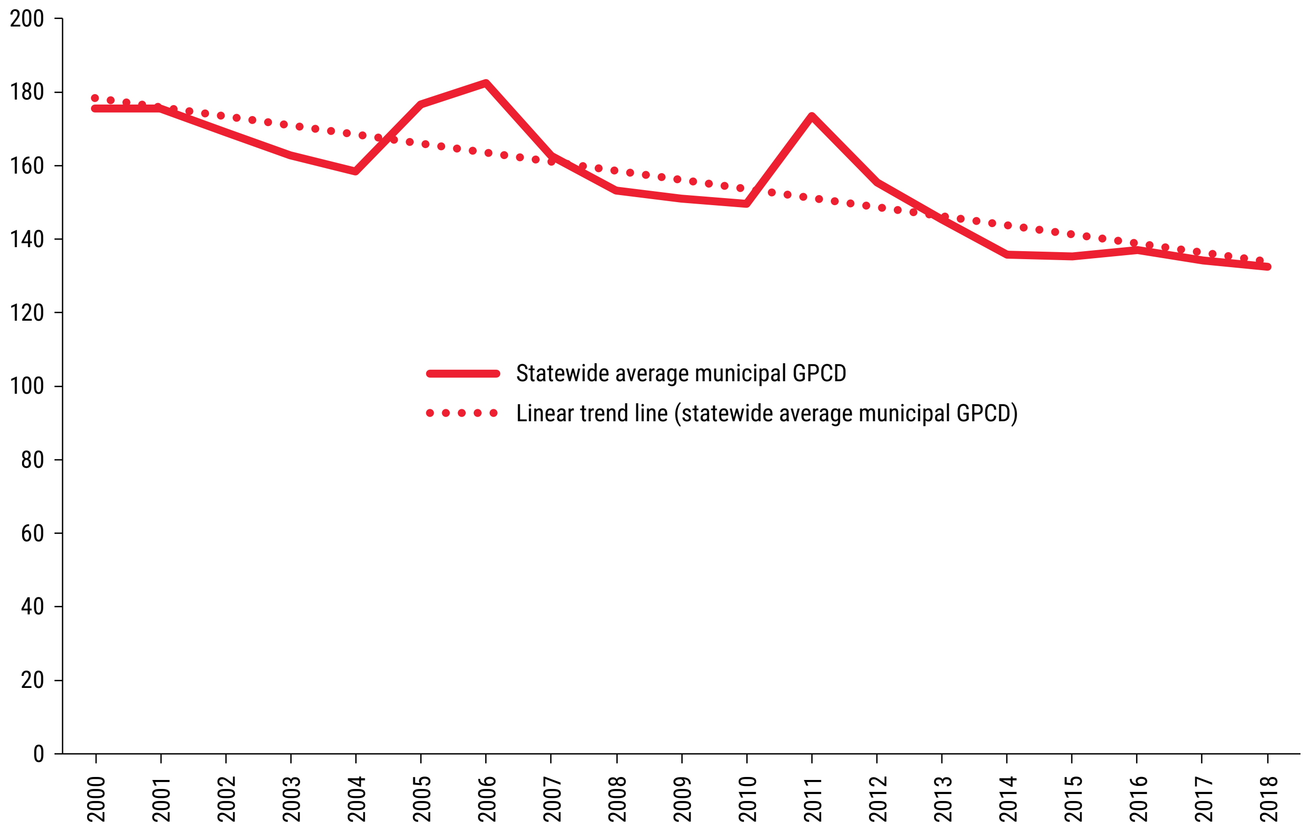
Each regional water plan is required to report on the implementation status of all strategies that they recommended in their previous plan. Gathering the required information is generally accomplished through surveys of entities in the regional water planning area. The surveys differentiated conservation *strategies* from conservation *projects*. *Strategies* do not require infrastructure or capital costs, whereas *projects* do.

Based on survey respondents and as reported by the regional water planning groups, implementation data indicates that of the conservation *strategies* with reported information (55 percent of all recommended conservation *strategies* in the 2017 State Water Plan), 81 percent of respondents reported implementation, and 5 percent reported progress towards implementation. Of the conservation *projects* with reported information (56 percent of all recommended conservation *projects* in the 2017 State Water Plan), 61 percent of respondents reported implementation, and 24 percent reported progress toward implementation.

The TWDB financial programs have supported implementation of certain conservation projects

[20] www.twdb.texas.gov/waterplanning/waterusesurvey/estimates/index.asp

Figure 8-2. Historical statewide average municipal gallons per capita per day (2000–2018)



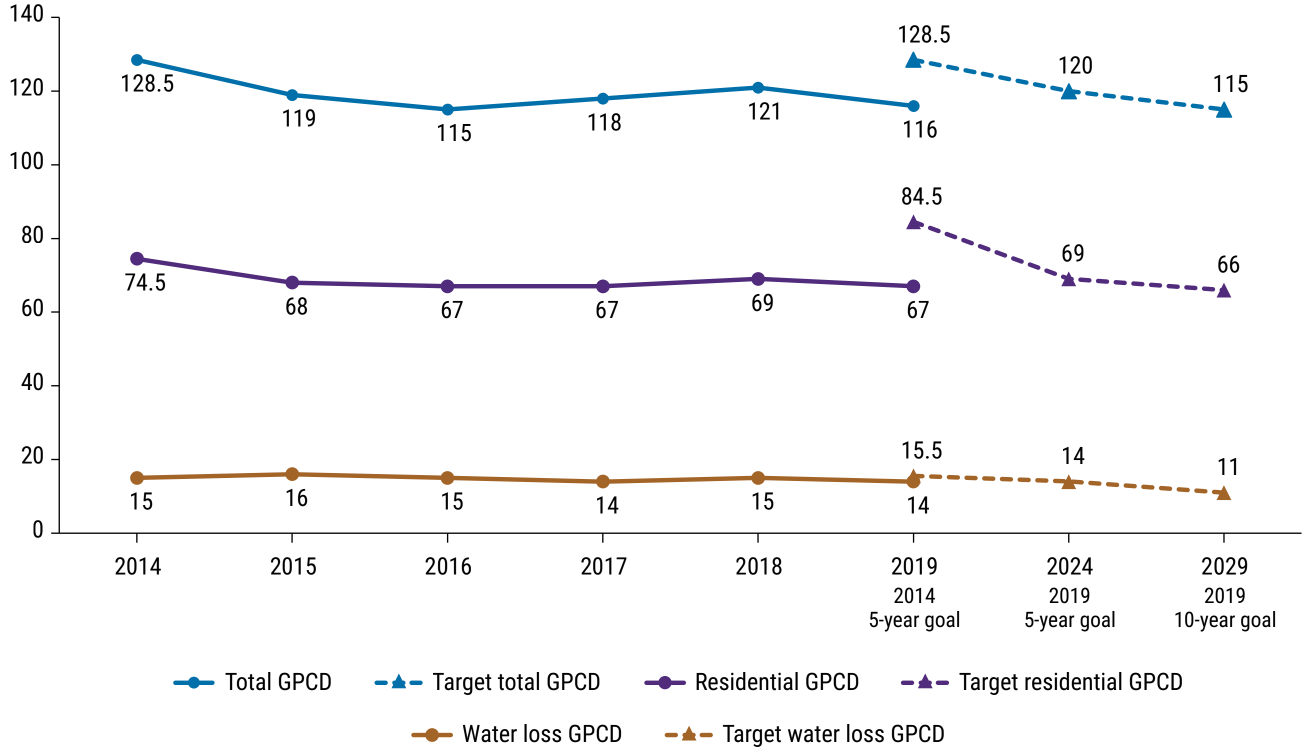
GPCD = gallons per capita per day

statewide, whether recommended in the state water plan or not. Additionally, since the passage of House Bill 3605 in 2013, all retail water utilities applying for financial assistance for a water supply project from the TWDB must be below water loss thresholds established by the agency, thus encouraging conservation. If the water loss of the applicant is above the thresholds, a portion of the financial assistance project must include water loss mitigation activities. However, if the applicant has water loss above the threshold and is addressing that water loss independently of the project that it is seeking to fund, the utility can apply for a waiver from the TWDB.

Ultimately, each utility is best suited to track its own progress on implementing its programs. However, data that is reported to the TWDB for water conservation plans and annual reports provides insight into the implementation of these conservation programs across the state. Data collected through annual conservation reports indicates an overall reduction in water use (Figure 8-3). Utilities are required to establish 5- and 10-year goals for total water use, residential water use, and water loss, expressed in gallons per capita per day in their water conservation plans.

Implementing irrigation conservation strategies is the focus of the Agricultural Water Conservation grant and loan program. Collectively, grant recipients reported more than 537,000 acre-feet of water savings over the past 10 years. Over the same 10-year period, the Agricultural Loans Program saved an estimated additional 85,000 acre-feet. The loans program generally funds large-scale equipment cost-share lending programs that encourage producers to implement more efficient irrigation systems and technologies, such as center-pivot irrigation devices.

Figure 8-3. Statewide historical median gallons per capita per day (GPCD) and 5- and 10-year goals for total water use, residential water use, and water loss



8.6 Conservation policy recommendations from the regional water planning groups

Each regional water plan contains policy recommendations developed by the planning groups for consideration by the legislature and various state agencies, including the TWDB. Every planning group included at least one policy recommendation related to either conservation planning, gallons per capita per day goals and calculations, project funding, program support, or data collection. Five planning groups recommended continued support of the state's Water Conservation Advisory Council and its recommendations. Several planning groups recommended funding additional data collection to support the understanding of conservation implementation in various sectors of water use and to better inform the development of future conservation measures and recommended strategies. A majority of the planning groups recommended that the legislature continue funding conservation initiatives and project development through the TWDB and other state agencies, including infrastructure projects, educational programs, and demonstration projects.

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Spray irrigator in a grapefruit orchard in Hidalgo County, Texas

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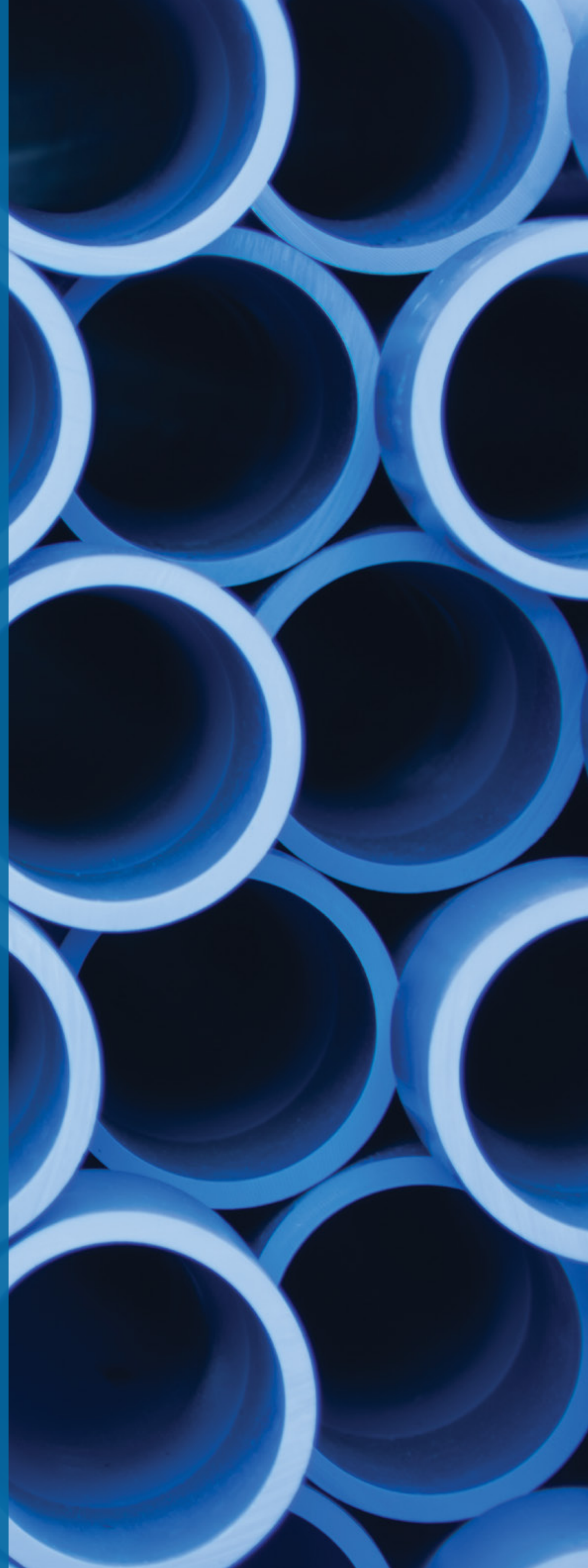
9

Financing needs



QUICK FACTS

Of the $80 billion in capital costs required to implement the state water plan over the next 50 years, approximately $47 billion, or 59 percent, was reported as requiring state financial assistance.

The reported state financial assistance need in the 2022 State Water Plan for municipal water management strategies is approximately $10 billion greater than the 2017 State Water Plan.

The State Water Implementation Fund for Texas (SWIFT) program, created specifically to fund state water plan projects, has already committed almost $8.2 billion toward projects in this state water plan.

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

The TWDB serves as a source of financial assistance for municipalities and rural areas across Texas. It administers loans and grants through several cost-effective state and federal programs to finance water supply development. These programs provide for the planning, design, and construction of water-related infrastructure and other water quality improvements. Through December 2020, the TWDB has committed more than $30.5 billion for water and wastewater projects in Texas via the agency's financial assistance programs.

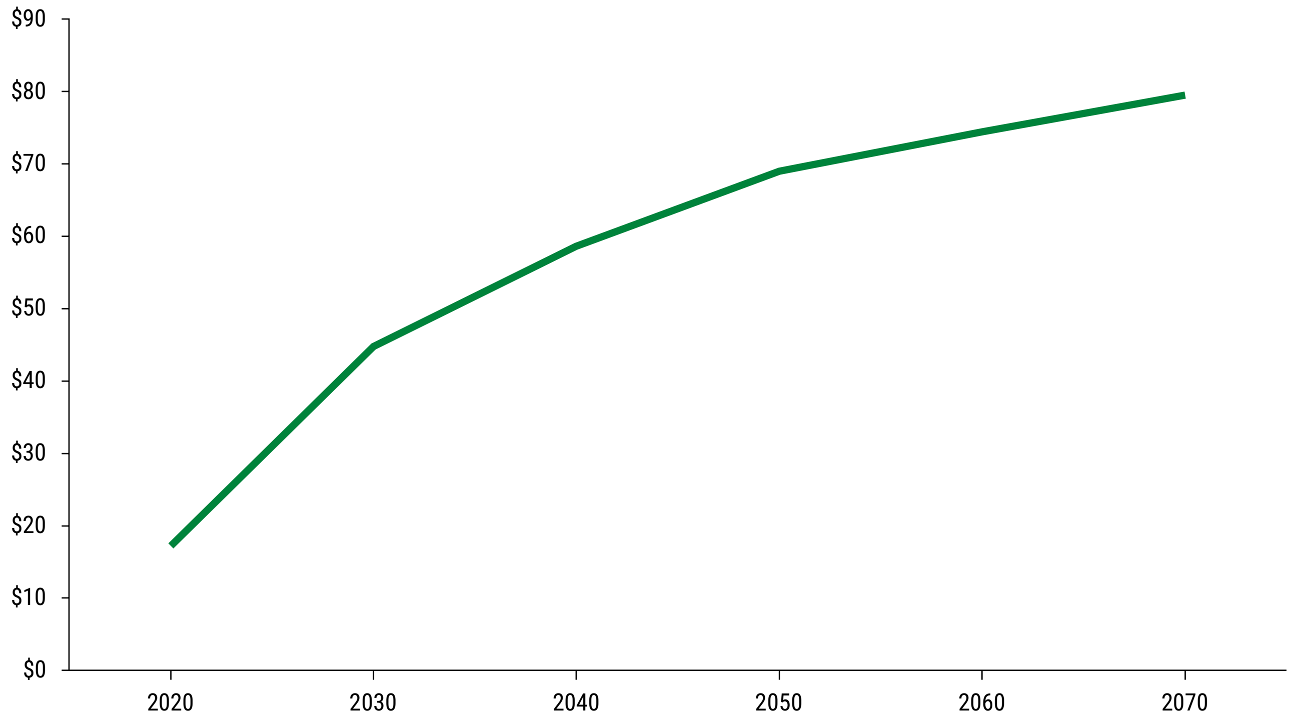
9.1 Costs of implementing the state water plan

The estimated total capital costs of the water management strategy projects recommended by the 16 regional water planning groups in this plan is $80 billion in 2018 dollars, without accounting for future inflation. The total capital costs of all recommended strategies increased by $17 billion, or more than 25 percent, from $63 billion in the previous plan to $80 billion due to many factors, but primarily due to increased costs of construction in general,[21] refinement of projects through the planning phases, increased engagement of water providers and communities in the regional planning process, and a more comprehensive effort by the regional water planning groups to incorporate more projects that will conserve water or increase treated water supply volumes.

The projects in this plan include conservation programs; groundwater development; treating water; and developing additional water sources, new reservoirs, aquifer storage and recovery systems, and desalination projects that would meet the drought needs of their regions during the next 50 years. Many of these projects vary in stages of implementation and are anticipated to be completed at various points in time throughout the next 50 years (Figure 9-1). All strategies and

[21] Over a five-year period between regional water planning cycles, the Engineering News Record Construction Cost Index increased by approximately 17 percent.

Figure 9-1. Cumulative total capital costs of all recommended water management strategy projects by decade (in billions)



projects identify the decade year by which they are projected to be online.

The planning groups estimated the total capital costs of projects and the annual unit costs for each water user group. Direct and indirect capital costs include, but are not limited to

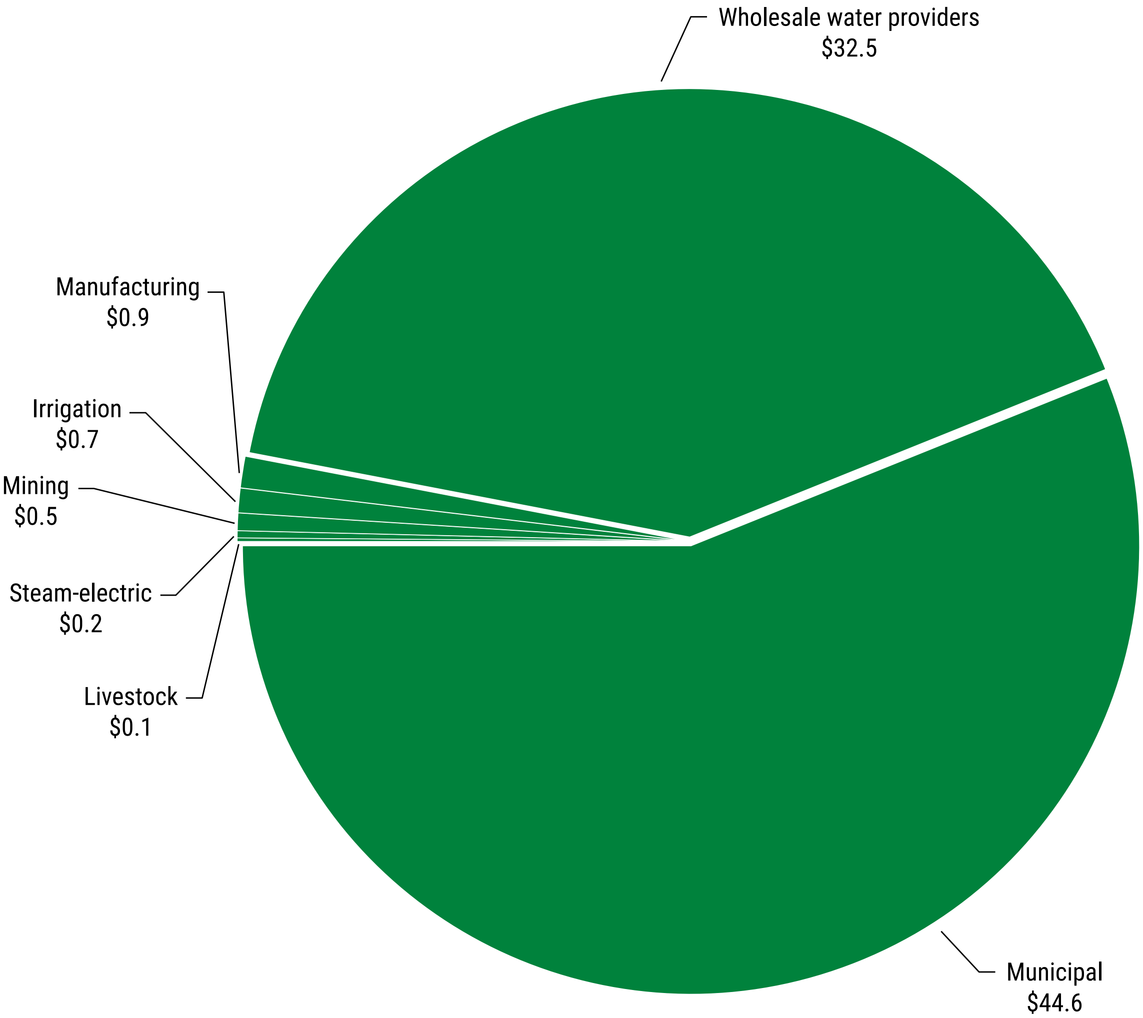
- engineering and feasibility studies, including those for permitting and mitigation;
- construction;
- professional services related to legal assistance and financing costs;
- land and easement acquisition; and
- purchases of water rights.

Unit costs of water supply (dollars per acre-foot supplied in each year) are calculated based on total annual costs divided by the associated water volume and include annual 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 above 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 conservation strategies that reduce water loss through replacement of internal distribution system lines. The TWDB has other financing options that are available to finance rehabilitation and replacement costs, which are summarized at the end of this chapter.

Approximately 97 percent ($77.1 billion) of the $80 billion in anticipated capital costs is associated with recommended water management strategy projects that are sponsored by municipal water user groups and wholesale water providers (Figure 9-2). Region C ($29.9 billion), Region H ($20.1 billion), and Region G ($5.5 billion) have the highest estimated capital costs required to implement the recommended strategy projects in their 2021

Figure 9-2. Total capital costs of all recommended water management strategy projects by wholesale water providers and water user group sponsor type (in billions)



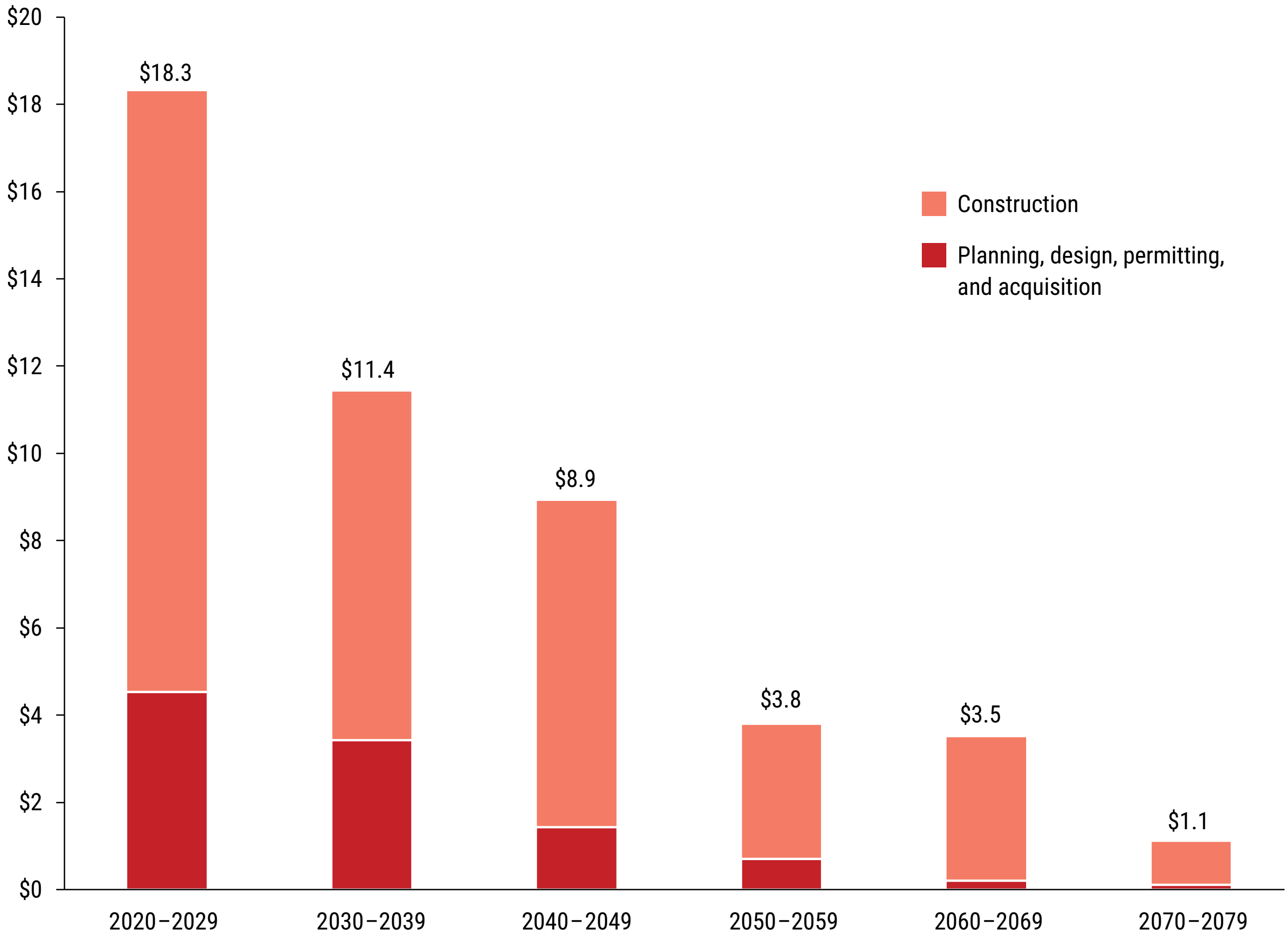
regional water plans (Table 7-2). The costs associated with these three planning areas account for approximately 70 percent of the total capital costs in the 2022 State Water Plan. These regions represent approximately 60 percent of the state's projected population in 2070 (Table 4-1) and more than two-thirds of the total projected municipal water needs for the state by 2070 (Table C-1).

9.2 Funding assistance required to implement the state water plan

The 16 regional water planning groups administer a survey toward the end of each planning cycle to estimate the amount of state financial assistance that local and regional water providers will require to implement the water management strategy projects. The surveys attempt to collect accurate funding needs for projects that may qualify for state funding programs. Survey responses were received for approximately 24 percent of the sponsors associated with recommended projects in the 2022 State Water Plan, capturing 59 percent of the recommended project costs.

As of November 2020, water providers reported an anticipated need of over $47 billion from state financial assistance programs. Of this, $10.4 billion, or approximately 22 percent, was associated with planning, design, permitting, and acquisition activities, with the remaining $36.7 billion, or approximately 78 percent, associated directly with construction activities (Figure 9-3).

Figure 9-3. Reported state financial assistance needs by decade (in billions)*



** State financial assistance may be needed prior to a project's online decade. Reported financial assistance needs for 2020–2029 include costs, including permitting and acquisition, for projects with online decades ranging from 2020 to 2070.*

Of the total required state financial assistance

- approximately $18.3 billion is expected to be required prior to 2030,
- approximately $46.6 billion is required to assist in implementing recommended strategies sponsored by municipal water providers or wholesale water providers, and
- approximately $3.9 billion is required by sponsors seeking state assistance through state ownership of excess capacity of their larger projects.

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

Recognizing the need for affordable financial assistance, the Texas Legislature entrusted the TWDB with a set of financing tools to help public utilities achieve their water infrastructure goals. Due to the high costs of water projects, many water providers seek financial assistance from the state or federal government, which may provide attractive financing and subsidies.

In Texas, political subdivisions have traditionally provided a majority of the financing for water-related infrastructure projects through municipal debt on the open bond market or, 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).

9.3.1 TWDB financial assistance

To accomplish the goals of planning for the state's water resources, the TWDB offers a variety of cost-effective loan and grant programs that provide for the development and implementation of water supply projects. Programs range from addressing the immediate needs of a community in meeting regulatory requirements to providing long-term water supply solutions. The TWDB administers multiple financial programs to provide financial assistance to political subdivisions. These programs include providing financial assistance through the issuance of general obligation and revenue bonds. General obligation bonds, secured by the full faith and credit of the State of Texas, may be issued for all components of water supply, wastewater conveyance and treatment, flood control projects, and water projects that involve conversion from a groundwater supply source to a surface water supply. Revenue bonds, which are secured by repayments from program participants, may be issued to facilitate the provision of wastewater treatment projects through the State Water Pollution Control (Clean Water) Revolving Fund and for the provision of facilities for the treatment of drinking water through the State Safe Drinking Water Revolving Fund, or for the purpose of implementing the state water plan through issuance under the State Water Implementation Revenue Fund for Texas (SWIRFT). With strong credit ratings, the TWDB can offer lower interest rates than many water providers would be able to obtain through traditional financing means.

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 constructing dams, reservoirs, and other water storage projects. Since 1957, the legislature and the voters of the state have approved several constitutional amendments increasing the issuance authority and authorized funding purposes.

9.3.2 State Water Implementation Fund for Texas

SWIFT was established by the Texas Legislature in 2013 to provide affordable, ongoing state financial assistance for recommended projects in the state water plan. The program helps communities develop cost-effective water supplies by providing low-interest loans, extended repayment terms, deferral of loan repayments, and incremental repurchase terms through the Board Participation program that includes financing terms similar to the State Participation program. Since inception, the SWIFT program has committed almost $9 billion to state water plan projects, of which almost $8.2 billion is toward projects included in this state water plan.

Before SWIFT was created, there were limited funding opportunities to finance the sizable costs of all the projects in the state water plan. The **Water Infrastructure Fund**, created by the legislature in 2007, was the predecessor program to SWIFT to provide financial incentives for the implementation of strategies recommended in the state water plan. The program has effectively been replaced by SWIFT, which is generally based on the Water Infrastructure Fund's program structure.

Passed by the legislature and approved by Texas voters through a constitutional amendment, SWIFT—and its associated funding mechanism, SWIRFT (State Water Implementation Revenue Fund for Texas)—were enacted to develop and optimize water supply projects in the state water plan. Accordingly, to be eligible for SWIFT funding, a project and its associated capital costs must be included in the state water plan.

The legislature also put in place a process for prioritizing recommended projects at both the regional and state level. At the regional level, the 16 planning groups prioritize all recommended water management strategy projects in their regional water plans every five-year cycle using uniform standards developed by the stakeholder committee composed of the planning group chairs.

At the state level, the TWDB's administrative rules include a prioritization system for 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 project ranking by the planning group. Other criteria include the local financial contribution, emergency needs for water, and the project's impact on conservation. Typically, the TWDB solicits SWIFT abridged applications once a year, and the projects proposed in each application are prioritized using this system.

9.3.3 Other TWDB state-funded programs

In addition to SWIFT, the TWDB offers other financial assistance programs to fund projects included in or consistent with the state water plan. These low-interest-rate programs encourage municipalities to break ground on projects to ensure an adequate water supply for future generations.

The **Texas Water Development Fund** was created in 1957 with the passage of the agency's first constitutional amendment and is the oldest of the TWDB's programs. The program is a streamlined state loan program that provides financing for various types of infrastructure projects. This program enables the TWDB to fund projects with multiple purposes, like water and wastewater or flood control, in one loan.

The **State Participation Program** allows for the "right sizing" of projects in consideration of future water needs. The program encourages the optimum development of regional projects by funding excess capacity for future use. The TWDB assumes a temporary ownership interest, and the local sponsor repurchases the TWDB's interest as growth is realized and additional customers connect to the system. Projects can include reservoirs, well fields, water rights, wastewater, and flood control. The 86th Texas Legislature passed House Bill 1052 in 2019, which expanded the program's scope to encourage interregional water supply projects and the development of desalination and aquifer storage and recovery facilities.

The **Rural Water Assistance Fund** provides small, rural water utilities with low-cost, long-term financing for water and wastewater projects. The program is designed to offer tax-exempt equivalent financing to water supply corporations or projects ineligible for tax-exempt financing. Eligible applicants are rural political subdivisions and nonprofit water supply corporations serving a population of 10,000 or less, or counties in which no urban area has a population exceeding 50,000.

The **Agricultural Water Conservation Program** provides financial assistance in the form of loans and grants for agricultural water conservation projects in Texas. The program supports the implementation of strategies and practices that improve agricultural irrigation water use efficiency. Some of the projects funded by the program include irrigation equipment upgrades, metering devices, and construction projects that improve infrastructure, equipment, and efficiency of irrigation delivery.

The **Economically Distressed Areas Program** provides financial assistance in the form of grants and loans for water and wastewater projects in economically distressed areas where service is unavailable or inadequate to meet state standards. Funded projects must be located in counties that are enforcing adopted Model Subdivision Rules. The 86th Texas Legislature passed Senate Bill 2452 making some changes to the program, including requiring a prioritization process for future funding cycles. Another change, which was approved by Texas voters in November 2019, allows the TWDB to issue bonds on a continuing basis not to exceed $200 million outstanding for water supply and wastewater services in economically distressed areas. As of January 2021, future funding requires additional legislative action.

The newly established **Flood Infrastructure Fund** became available in 2020 to provide grants and low-cost loans for drainage, flood mitigation, and flood control projects, some of which may have a water supply component. This fund was created during the 86th Texas Legislative Session through the passage of Senate Bill 7 and the accompanying $793 million contained in Senate Bill 500. Texas voters approved a supporting constitutional amendment on November 5, 2019, that directs the TWDB to administer a new statewide flood mitigation plan by 2024.

9.3.4 TWDB federally funded programs

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

The **Clean Water State Revolving Fund (CWSRF)** was authorized by the Clean Water Act to provide low-cost financial assistance for planning, acquisition, design, and construction of wastewater, reuse, and stormwater infrastructure. Recent streamlining of the program provides year-round funding as projects are included in the CWSRF Intended Use Plan. This funding addresses water quality needs by building on state partnerships with the U.S. Environmental Protection Agency. Currently, all 50 states and Puerto Rico operate CWSRF programs. The program is funded by annual capitalization grants from the U.S. Congress through the Environmental Protection Agency, a required 20 percent state funding match, loan repayments, and revenue bonds.

The **Drinking Water State Revolving Fund (DWSRF)** was authorized by the Safe Drinking Water Act to assist communities by providing low-cost financing for a wide range of water projects that facilitate compliance with drinking water standards. Below market interest rate loans are offered for planning, acquisition, design, and construction of water infrastructure projects, such as water treatment facilities, system upgrades, source water protection, and flood resiliency projects. Like the CWSRF, recent streamlining of the program provides year-round funding as projects are included in the DWSRF Intended Use Plan. The 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

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10

Implementation and funding of the 2017 State Water Plan

Photo courtesy of Tarrant Regional Water District

QUICK FACTS

Regional water planning groups reported that 477, or 43 percent, of the water management strategies recommended in the 2017 State Water Plan that do not require a capital project were either partially or fully implemented.

Planning groups reported that 979 projects in the 2017 State Water Plan were either partially or fully implemented. This represents nearly 39 percent of the approximately 2,500 recommended projects.

Of the total estimated $63 billion in project costs in the 2017 State Water Plan, approximately $6.5 billion was funded through the TWDB's financial assistance programs and is associated with 61 projects.

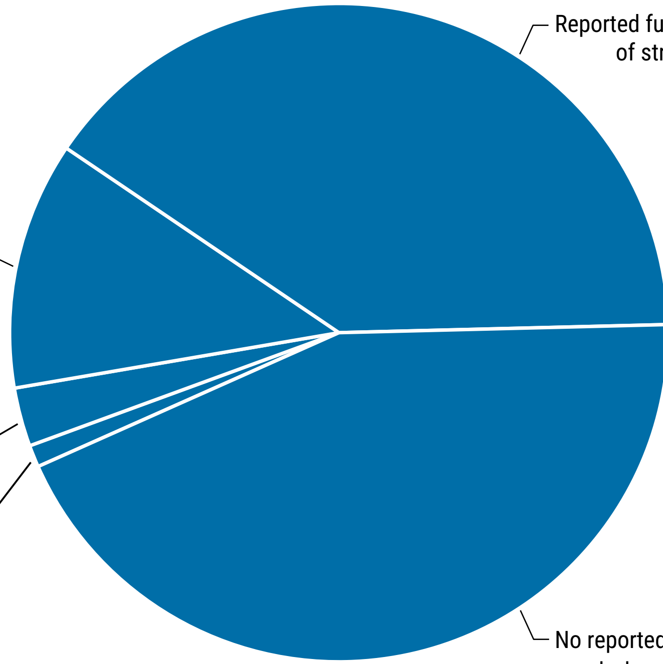
Regional water planning groups assist in evaluating the state's progress in meeting future water needs by assessing the previously recommended water management strategies implemented during the five-year planning cycle. The state water plan also includes information on state water plan projects funded since adoption of the previous state water plan. In 2017, the Texas Legislature passed Senate Bill 1511, which requires an assessment of project implementation in the decade in which projects were needed as well as an analysis of any project implementation impediments. This requirement applies to projects in the previous state water plan that the TWDB prioritized for SWIFT funding. The 2022 State Water Plan is the first plan required to incorporate information on implementation impediments.

10.1 Implementation of the 2017 State Water Plan

Water management *strategies* in the state water plan may or may not require new infrastructure—referred to as water management strategy *projects*—to be developed. The 2017 State Water Plan was the first to clearly differentiate between strategies and infrastructure projects. Not every strategy requires a project, but every project is tied to an associated strategy. Planning groups reported on the implementation of water management strategies and projects from the 2017 State Water Plan in their 2021 regional water plans. To do this, the planning groups surveyed the project sponsors and reported on the extent to which water infrastructure projects had progressed toward planning, design, or construction phases. They also gathered information on strategies that do not require new infrastructure development. Examples include demand reduction strategies (conservation and drought management) and other supply development strategies, such as utilization of unallocated supplies, contract purchases, and voluntary redistributions or transfers that use existing infrastructure. Because water management strategies, particularly those involving infrastructure projects, can require several years to fully implement, strategy (and project) progress was categorized in two ways:

1. Implemented: when a strategy is fully capable of meeting water needs in the manner planned
2. Progress toward implementation: includes any type of implementation step (including start of project construction or pre-implementation

Figure 10-1. Reported implementation of recommended water management strategies not associated with a project from the 2017 State Water Plan by share of total number of strategies not associated with a project



activity, such as negotiating contracts, applying for and securing financing or state and federal permits, or conducting preliminary engineering studies) or achieving a portion of the total anticipated conservation savings from a strategy

Statewide implementation progress is presented as

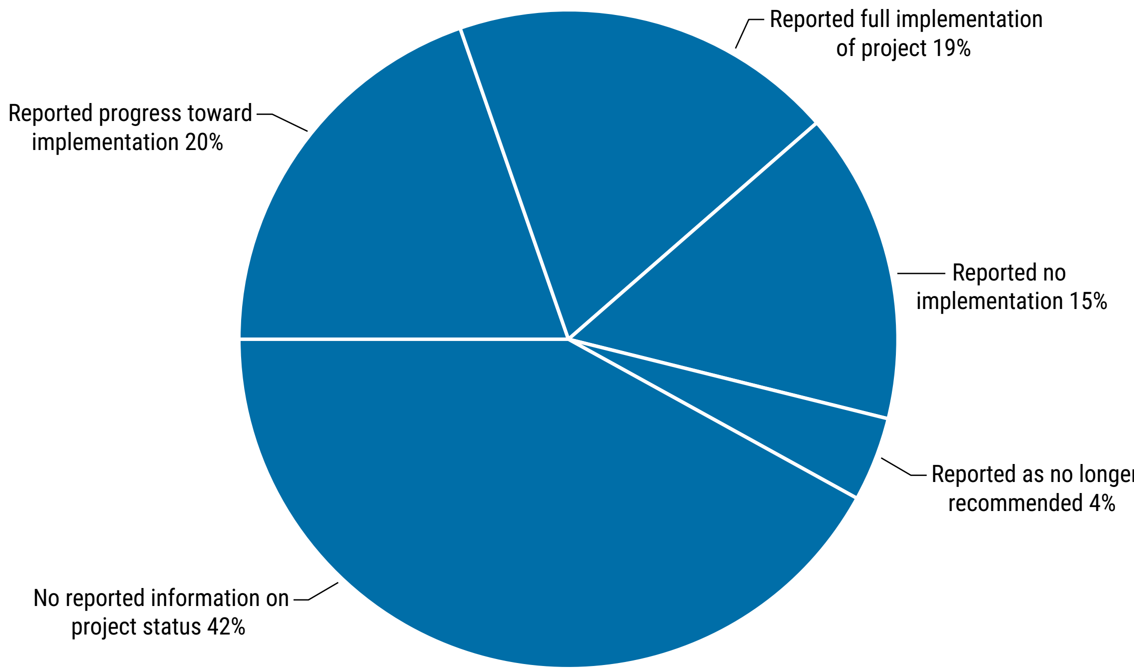
- the relative count of strategies not associated with a project compared to the total number of recommended strategies not associated with a project (approximately 1,100) in the 2017 State Water Plan[22] (Figure 10-1); and
- the relative count of projects compared to the total number of recommended projects (approximately 2,500) in the 2017 State Water Plan (Figure 10-2).

[22] The count of water management strategies and the capital cost of projects associated with the 2017 State Water Plan include amendments to the plan.

The planning groups reported implementation survey information regarding 624 strategies not associated with a project. Of these, about 71 percent were fully implemented and another 5 percent reported some form of implementation progress. Strategies reported as fully implemented represent about 40 percent of the total number of recommended water management strategies without an associated project in the 2017 State Water Plan. The water supplies associated with these fully implemented strategies now appear as existing supply on the supply side of the planning equation in this current water plan. Strategies reported as only partially implemented represent almost 3 percent of the total number of strategies without associated projects in the 2017 State Water Plan.

Planning groups also reported, separately from strategies, implementation status information for the approximately 1,500 projects in the 2017 State Water Plan. Of the approximately 40 percent of projects that were reported on, about half of those were reported as being fully implemented

Figure 10-2. Reported implementation of all recommended water management strategy projects from the 2017 State Water Plan by share of total number of projects



with the other half of those reporting some degree of implementation progress. Fully implemented projects, as reported, represent $3.8 billion, or 6 percent, of the $63 billion in total capital costs associated with the 2017 State Water Plan; the partially implemented projects, as reported, represent $36.6 billion, or 58 percent, of the total capital costs.

New to this round of planning was a requirement from House Bill 807, 86th Legislative Session, directing the regional planning groups to assess their progress in encouraging cooperation between water user groups to develop strategies that achieve economies of scale and benefit the entire region. This assessment is included in Chapter 11 of the 2021 regional water plans. To meet this requirement, some planning groups highlighted the roles of regional water providers, provided examples of water management strategies and projects that involve multiple sponsors or benefit multiple water user groups, or described how the regional water planning process has encouraged cooperation in the region.

Several planning groups noted that regional scale projects are not necessarily practical in areas where needs are already being met or in sparsely populated areas where the costs of transmission may outweigh the cost savings from economies of scale. Planning groups reported that 29 projects recommended in the 2017 State Water Plan to serve multiple water user groups have been fully implemented.

10.2 Impediments to implementation of the 2017 State Water Plan

Because the project evaluations in each five-year planning cycle are expected to consider current, updated conditions and reflect changed circumstances since the previous plan, they are inherently adaptive in reflecting the associated project implementation timelines. In addition to being survey based, which results in limited responses, tracking implementation of all projects across multiple planning cycles is difficult, especially for phased projects. However, certain larger and clearly and consistently defined projects, such as the construction of new reservoirs, that have longer development timelines and more reliable survey responses are easier to consistently track across water plans and are, therefore, more easily assessed over time.

To better understand why some water management strategy projects are not implemented in the decade in which they are needed, the planning groups are required to collect information regarding impediments to implementation and do so via surveys sent to the project sponsors. This is the first time the planning groups have had to address this legislative requirement to identify impediments; the 2020 decade is the only decade for which definitive passage of an identified online decade would have occurred.

Planning groups mentioned several categories of impediments to implementation, including access to funding, the anticipated online date of the project is further in the future, and the permitting process being the most common. Other identified impediments included lack of a project sponsor, land acquisition, and water availability constraints. Because even technically and economically feasible projects, especially large ones, require significant effort to implement, the impediments reported by planning groups do not necessarily indicate a project will not be implemented. Rather, the identified impediments indicate that implementation will take longer than previously anticipated and potentially delay the online date. Right-of-way acquisition is a good example of a process that can create significant delays, even for relatively straightforward projects that simply require conveyance pipelines.

The TWDB is limited in its ability to provide one-to-one assessments of the extent to which projects in the previous plan were not implemented in the decade needed, especially beyond the first decade in the planning cycle. During each planning cycle, the planning groups update their water management strategies, including the names, configuration, beneficiaries, capacity, and when the projects are anticipated to be needed and fully operational. Due to these changes, including schedule updates, the regional and state water plans will rarely reflect a project not being implemented in time for the recommended decade and would only measurably apply to projects due to be online in 2020 but that were not online then. Planning groups reported the implementation status of nearly 1,600 of the approximately 2,700 water management strategies and projects in the 2017 State Water Plan that were due to be online in 2020. Of these, about 55 percent were reported as fully implemented, just over 21 percent as partially implemented, 20 percent as not implemented, and almost 4 percent as no longer recommended.

Of the 2017 State Water Plan projects prioritized for funding through the SWIFT program, no impediments were noted in their implementation. Approximately 53 percent of the projects funded through SWIFT indicated 2020 as the decade of need and received funding for project phases including construction. The remaining 47 percent of the projects received funding prior to their decades of need as reported in the 2017 State Water Plan, with the vast majority having an online decade of 2030.

10.3 Funding of the 2017 State Water Plan

Since adopting the 2017 State Water Plan, the TWDB has closed[23] on approximately $8.8 billion in additional financial assistance and delivered to project sponsors more than $6.5 billion toward the implementation of state water plan projects (Table 10-1). In addition to the SWIFT program, the TWDB also funded recommended water management strategies through several other funding programs, including the Board Participation Program,

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

Table 10-1. 2017 State Water Plan projects funded by the TWDB by project sponsor – continued on next page

Map reference	Region	Project[a]	Entity	Financial assistance features: State water plan funding	Financial assistance features: Board participation	Financial assistance features: Other state and federal funding programs	Closed funding amount	Associated annual water supply (acre-feet per year)[b]
1	C	Main Street Water Line Replacement	Azle	x			$1,350,000	1
2	C	Conservation, Water Loss Control - Boyd	Boyd			x	$720,000	332
3	C	Conservation, Water Loss Control - Dallas	Dallas			x	$132,000,000	5,500
4	C	Conservation, Water Loss Control - Everman	Everman			x	$3,000,000	1
5	C	Krum New Wells in Trinity Aquifer	Greater Texoma Utility Authority			x	$1,225,000	202
6	C	Gunter New Well in Trinity Aquifer (2020)	Greater Texoma Utility Authority			x	$3,415,000	320
7	C	Conservation, Water Loss Control - Lake Kiowa Special Utility District	Greater Texoma Utility Authority			x	$2,125,000	4
8	C	Grayson County Water Supply Project - Additional Texoma Supply from Greater Texoma Utility Authority	Greater Texoma Utility Authority			x	$7,155,000	97
9	C	Enhanced Water Loss Control and Conservation Program	Justin	x			$4,800,000	35
10	C	Keller Enhanced Water Loss Control and Conservation Program	Keller	x			$8,120,000	514
11	C	Conservation, Water Loss Control - Ladonia	Ladonia			x	$3,110,000	1
12	C	Conservation, Water Loss Control - Grayson County	Lake Texoma VFW Post 7873			x	$200,000	15
13	C	Lower Bois d'Arc Creek Reservoir and Drinking Water Treatment Plant	North Texas Municipal Water District	x			$1,476,980,000	120,665
14	C	Conservation, Water Loss Control - River Oaks	River Oaks			x	$8,000,000	750
15	C	Springtown New Wells in Trinity Aquifer	Springtown	x			$1,390,000	81
16	C	Increase Delivery Infrastructure from Fort Worth	Trophy Club Municipal Utility District No. 1	x			$4,635,000	7,398
17	C	Lake Ralph Hall Reservoir	Upper Trinity Regional Water District	x	x		$209,680,000	33,604
18	C	Parallel Pipeline Taylor Regional Water Treatment Plant to Stonehill Pump Station	Upper Trinity Regional Water District	x			$42,070,000	49,846
19	C	Increase Delivery Infrastructure from Fort Worth	Westlake	x			$2,100,000	6,497
20	D	Riverbend Strategy (Texarkana)	Annona			x	$300,000	94
21	D	Riverbend Strategy (Texarkana)	Riverbend Water Resources District			x	$18,000,000	67,209
22	E	Town of Anthony - Arsenic Treatment System	Anthony			x	$980,000	435
23	E	Bone Spring - Victorio Peak Aquifer Land and Water Rights Acquisition	El Paso Public Service Board	x			$200,000,000	20,000

[a] *Project name may vary from 2017 State Water Plan project name.*

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

Table 10-1. 2017 State Water Plan projects funded by the TWDB by project sponsor *– continued on next page*

Map reference	Region	Project[a]	Entity	Financial assistance features: State water plan funding	Financial assistance features: Board participation	Financial assistance features: Other state and federal funding programs	Closed funding amount	Associated annual water supply (acre-feet per year)[b]
24	F	Voluntary Transfer from Clyde - Fort Phantom Hill Supplies	Ballinger			x	$3,393,435	1,250
25	F	Advanced Groundwater Treatment - Brady	Brady			x	$28,905,000	3,500
26	F	Additional Treatment - Mason	Mason			x	$2,659,200	2,242
27	F	Hickory Well Field Expansion in McCulloch County - San Angelo	San Angelo			x	$56,075,000	3,000
28	G	Brushy Creek Regional Utility Authority Water Treatment and Distribution Project	Brushy Creek Regional Utility Authority	x			$32,735,000	14,562
29	G	Aquifer Storage and Recovery (Carrizo-Wilcox)	Bryan	x			$2,345,000	11,900
30	G	Reuse - Cleburne	Cleburne			x	$42,000,000	4,480
31	G	East Williamson County Water Project	Lone Star Regional Water Authority			x	$1,500,000	11,762
32	G	Water Conservation	Waco	x			$12,000,000	1,462
33	H	Central Harris County Regional Water Authority Transmission and Distribution Expansion	Central Harris County Regional Water Authority	x			$12,585,000	5,470
34	H	Houston - Northeast Water Purification Plant Expansion	Central Harris County Regional Water Authority	x			$35,140,000	358,447
			Houston	x			$294,455,000	
			North Fort Bend Water Authority	x			$350,780,000	
			North Harris County Regional Water Authority	x			$727,060,000	
			West Harris County Regional Water Authority	x			$395,810,000	
35	H	Houston - Second Source Phase I	Central Harris County Regional Water Authority	x			$12,365,000	189,396
			Houston	x			$192,825,000	
			North Harris County Regional Water Authority	x			$339,990,000	
36	H	Luce Bayou Interbasin Transfer	Central Harris County Regional Water Authority	x			$1,500,000	358,447

[a] *Project name may vary from 2017 State Water Plan project name.*

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

Table 10-1. 2017 State Water Plan projects funded by the TWDB by project sponsor – continued on next page

Map reference	Region	Project[a]	Entity	Financial assistance features: State water plan funding	Financial assistance features: Board participation	Financial assistance features: Other state and federal funding programs	Closed funding amount	Associated annual water supply (acre-feet per year)[b]
37	H	Groveton Well Development	Groveton			x	$2,164,161	241
38	H	Municipal Conservation, County-Other, Austin County	New Ulm Water Supply Corporation			x	$97,060	5
39	H	Internal Distribution Expansion	North Fort Bend Water Authority	x			$15,110,000	76,730
40	H	Wastewater Reclamation for Municipal Irrigation	North Fort Bend Water Authority			x	$2,421,800	504
41	H	West Harris County Regional Water Authority - Second Source Transmission	North Fort Bend Water Authority	x			$414,485,000	176,736
			West Harris County Regional Water Authority	x			$345,320,000	
42	H	North Harris County Regional Water Authority Internal 2020 Distribution	North Harris County Regional Water Authority	x			$242,980,000	143,360
43	H	Pearland Surface Water Treatment Plant Development	Pearland			x	$159,500,000	11,202
44	H	Municipal Conservation, Shoreacres	Shoreacres			x	$4,500,000	3
45	H	Water User Group Infrastructure Expansion	Spring Valley Village	x			$2,500,000	2,190
46	I	Sabine River Authority Pump Station	Sabine River Authority	x			$75,000,000	254,395
47	K	Conservation Strategy - Smart Meters (Advanced Meter Infrastructure)	Austin	x			$26,195,000	6,105
48	K	Direct Reuse Strategy	Austin	x			$65,605,000	38,429
49	K	Urgent Water Loss Reduction - Creedmoor-Maha Water Supply Corporation	Creedmoor-Maha Water Supply Corporation			x	$4,667,500	134
50	L	Hays-Caldwell Groundwater Project - Phase 1B	Alliance Regional Water Authority	x			$240,410,000	35,690
51	L	Local Carrizo Aquifer Development - Cotulla	Cotulla			x	$8,155,000	450
52	L	Carrizo Groundwater Supply Project	Guadalupe-Blanco River Authority	x	x		$140,705,000	15,000
53	L	Reuse - San Marcos	San Marcos			x	$5,445,839	1,932
54	L	Expanded Carrizo for Schertz-Seguin Local Government Corporation	Schertz-Seguin Local Government Corporation	x	x		$66,500,000	6,500

[a] *Project name may vary from 2017 State Water Plan project name.*

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

Table 10-1. 2017 State Water Plan projects funded by the TWDB by project sponsor – continued

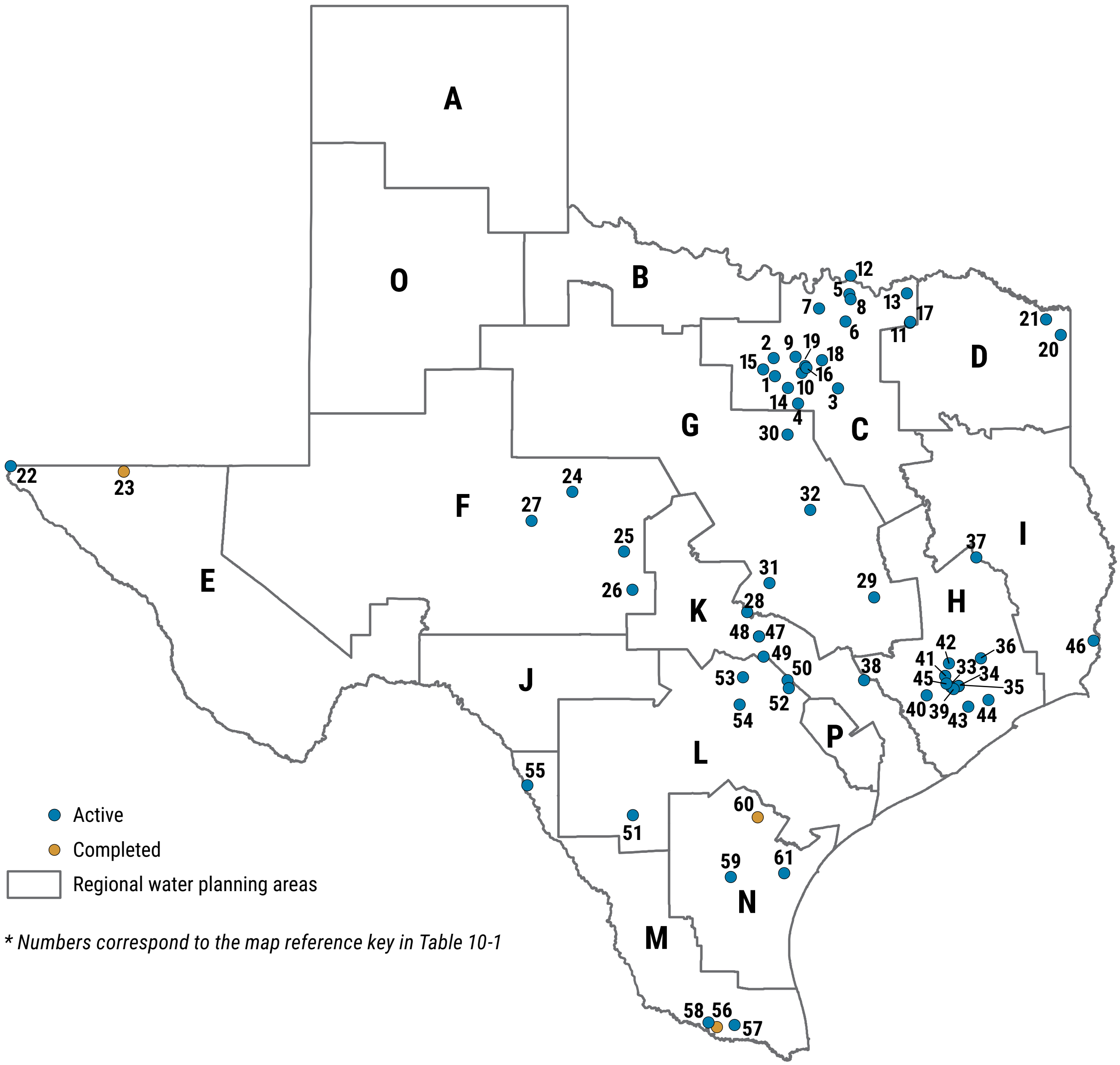
Map reference	Region	Project[a]	Entity	Financial assistance features: State water plan funding	Financial assistance features: Board participation	Financial assistance features: Other state and federal funding programs	Closed funding amount	Associated annual water supply (acre-feet per year)[b]
55	M	Advanced Municipal Conservation - Eagle Pass	Eagle Pass			x	$26,975,000	208
56	M	Water Rights Acquisition	McAllen	x			$6,900,000	3,000
57	M	Delta Area Reverse Osmosis Water Treatment Plant Expansion	North Alamo Water Supply Corporation			x	$6,976,373	1,410
58	M	Off-Channel Storage Facility	United Irrigation District	x			$8,100,000	2,000
59	N	Brackish Groundwater Development - Alice	Alice			x	$5,499,000	1,120
60	N	Chase Field Project	Beeville	x			$4,500,000	1,491
61	N	Seawater Desalination	Corpus Christi	x			$14,175,000	22,420

[a] *Project name may vary from 2017 State Water Plan project name.*

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

Intake structure at Bois d'Arc Lake; photo courtesy of North Texas Municipal Water District

*Figure 10-3. Locations of 2017 State Water Plan projects funded by the TWDB by project sponsor**



** Numbers correspond to the map reference key in Table 10-1*

Texas Water Development Fund, Economically Distressed Areas Program, and the Clean and Drinking Water State Revolving Funds.

A wide variety of water management strategies have received commitments for TWDB funding since the adoption of the 2017 State Water Plan, including seawater desalination, transmission line expansions, new water meters, acquisition of water rights, new groundwater wells, and aquifer storage and recovery projects. Funding commitments, which may be larger than the estimated costs of those projects in the state water plan, were associated with several different project sponsors throughout Texas, including cities and regional water providers (Figure 10-3).

Glossary

Acre-foot
Volume of water needed to cover one acre to a depth of one 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 raw 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 surface water, groundwater, and/or reuse sources that optimizes the beneficial characteristics of each source.

County-other
Aggregation of utilities that provide less than an average of 100 acre-feet per year, as well as rural areas not served by a water utility in a given county.

Desalination
Process of removing salt and other dissolved solids from seawater or brackish water.

Desired future condition
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 historical records indicate that natural hydrological conditions provided the least amount of water supply.

Environmental flows
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
Bay or inlet, often at the mouth of a river and may be bounded by barrier islands, where freshwater and seawater mix providing for economically and ecologically important habitats and species and that also yields essential ecosystem services.

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

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

Groundwater availability model
Regional groundwater flow model approved by the TWDB executive administrator.

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

Industrial conservation
An aggregate presentation of anticipated water savings from conservation activities in the manufacturing, mining, and electric power generation sectors of water use.

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.

Interactive state water plan
TWDB website that lets water users statewide take an up-close look at data in the 2022 State Water Plan. Users can see how water needs change over time by showing projected water demands, existing water supplies, relative severity and projected water needs (potential shortages), water management strategies recommended to address potential shortages, and recommended capital projects and their sponsors. 2022.texasstatewaterplan.org

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.

Major water provider
Water user group or wholesale water provider of particular significance to the region's water supply as determined by the regional water planning group. This may include public or private entities that provide water for any water use category.

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

Modeled available groundwater peak factor
A percentage that is applied to a modeled available groundwater value reflecting the annual groundwater availability that, for planning purposes, is considered temporarily available for pumping consistent with desired future conditions. The modeled available groundwater peak factor is not intended as a limit to permits or as guaranteed approval or pre-approval of any future permit application.

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

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

Regional water planning group
Group designated pursuant to Texas Water Code § 16.053. There are 16 water planning groups in Texas responsible for developing regional water plans that are guided by statute, rules, contracts, members of the planning groups, and the general public. Each group has diverse members with various economic, social, and environmental interests in their areas.

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 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.

Safe yield
Identified annual volume of water held in reserve to account for droughts worse than the drought of record.

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 within each river basin for permitting in the state.

Water management strategy
Plan by a discrete water user group to meet a need for additional water, which can mean increasing the total water supply or maximizing an existing supply, including through reducing demands.

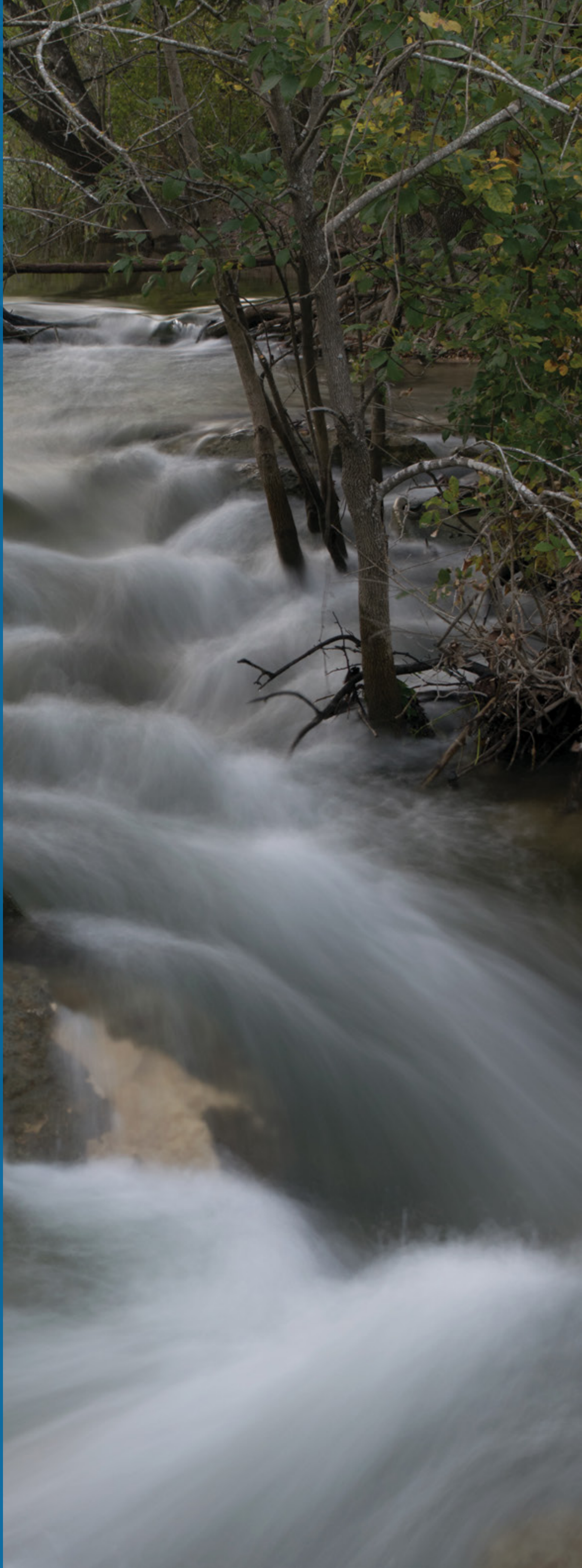
Water Service Boundary Viewer
Statewide public water system service area mapping application used to collect accurate retail water service boundaries to better estimate and project utility population for the regional water plans and the state water plan. The Viewer also helps in estimating the rural population not served by a system and strives to provide the most up-to-date and best data available on the service areas for all community public water systems within Texas. www3.twdb.texas.gov/apps/waterserviceboundaries

Water user group
Identified user or group of users for which water demands and existing water supplies have been identified and analyzed and plans have been developed to meet water needs. These include: privately-owned utilities that provide an average of more than 100 acre-feet per year for municipal use for all owned water systems; water systems serving institutions or facilities owned by the state or federal government that provide more than 100 acre-feet per year for municipal use; all other retail public utilities that provide more than 100 acre-feet per year for municipal use; collective reporting units or groups of retail public utilities that have a common association and are requested for inclusion by the regional water planning group; 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
Person or entity, including river authorities and irrigation districts, that delivers or sells water wholesale (treated or raw) to water user groups or other wholesale water providers or that the regional water planning group expects or recommends to deliver or sell water wholesale to water user groups or other wholesale water providers during the period covered by the plan. The regional water planning groups identify the wholesale water providers within each region to be evaluated for plan development.

Appendices

- Appendix A Background on Texas' water planning history, institutions, and laws
  - A.1 Texas water planning, 1904–1957
  - A.2 State water planning, 1957–1997
  - A.3 Regional and state water planning, 1997–present
  - A.4 State and federal water supply institutions
  - A.5 Management of water in Texas
  - A.6 Key water planning statute and administrative rules
- Appendix B Water availability and existing supplies
  - B.1 Surface water
  - B.2 Groundwater
- Appendix C Annual water needs by region and water use category
- Appendix D Socioeconomic impact regional summary and dashboards



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

A.1 Texas water planning, 1904–1957

While formal statewide water planning did not begin until the 1950s, the Texas Legislature began assigning responsibility for managing and developing the state's water resources in the early 20th century. A series of devastating droughts and floods in the early 1900s magnified the need for water management. In 1904, a constitutional amendment was adopted authorizing the first public development of water resources (Figure A-1). 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 Water Development Board and the Texas Commission on Environmental Quality, 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 developing irrigation and water supply districts, issue water right permits for storing and diverting water, and plan for storing and using floodwater. Later, the legislature authorized the agency to define and designate groundwater aquifers; establish 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.

In 1949, Lyndon Johnson, then a U.S. Senator, wrote to the U.S. Secretary of the Interior requesting federal assistance to help guide Texas in achieving "a comprehensive water program that will take into account the needs of the people of my state." The U.S. Bureau of Reclamation responded by publishing "Water Supply and the Texas Economy: An Appraisal of the Texas Water Problem" (USBR, 1953). The report divided the state into four planning regions and evaluated existing and projected municipal and industrial water requirements up to the year 2000. The study recommended that Texas consider forming a permanent water planning agency to guide state water policy going forward.

In the 1950s, Texas experienced its worst drought in recorded history. The drought began in 1950 and by the end of 1956, all but one of Texas' 254 counties were classified as disaster areas. The drought ended in 1957 with massive rains that resulted in the flooding of 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 the statewide "drought of record" upon which state and regional water supply planning in Texas is based.

The drought of the 1950s was unique in that most Texans felt the impacts of water scarcity at some point. Small and large cities alike faced dire situations. By the fall of 1952, the City of Dallas faced a severe water shortage and prohibited all but necessary household use of water. In 1953, 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 drought reduced the number of communities with shortages during later years of the drought, but many municipalities continued to be forced to haul in water before it was over (TBWE, 1959). The drought also had significant impacts to agriculture and livestock production and led tens of thousands of Texans to resettle from farms to cities. All told, the drought of the 1950s cost the state hundreds of millions of dollars and was

Figure A-1. Texas water planning timeline

Texas Water Planning Timeline, 1904–2019

Pre-State Water Plan Era

1904
A constitutional amendment authorized the first public development of water resources.

The Texas Supreme Court adopted the rule of capture for groundwater.

1913
The Texas Legislature adopted laws for irrigation and created the Board of Water Engineers.

1917
Senate Joint Resolution 12 created conservation and reclamation districts, later known as river authorities, and declared the preservation and conservation of Texas natural resources as public rights and duties.

1949
The Texas Groundwater Act provided for under-ground water conservation districts.

1951
The first groundwater conservation district, the High Plains Underground Conservation District No. 1, was created.

1950s
Texas experienced its worst drought in recorded history from 1950 to 1957. Most water supply planning in Texas is based on this statewide "drought of record."

1957
The Texas Legislature created the TWDB, and voters authorized $200 million in bonds for water project loans.

The Water Planning Act created the Texas Water Resources Planning Division of the Board of Water Engineers, which was assigned the responsibility of water supply planning.

Centralized Water Planning Era

1961
The first state water plan was published, projecting the 1980 municipal, agricultural, and industrial water requirements and providing a plan to meet them.

1968
The Water Rights Adjudication Act consolidated all previously held surface water rights into a unified system of "certificates of adjudication."

The TWDB published a state water plan identifying and planning for needs through 2030.

1984
The TWDB published a state water plan identifying and planning for needs through 2030.

1990
The TWDB published a state water plan that emphasized improved overall management of existing and future water infrastructure systems.

1992
The TWDB published a state water plan formatted as an amendment to the more detailed 1990 plan.

1993
Following the *Sierra Club v. Lujan* decision, the legislature created the Edwards Aquifer Authority to regulate withdrawals from the aquifer.

1997
Senate Bill 1 created 16 RWPGs, updated the laws relating to priority GMAs, and identified GCDs as the preferred method of groundwater management. The TWDB, TPWD, and TCEQ produced the first state water plan that organized the state into 16 regions.

Regionalized Water Planning Era

2001
Senate Bill 2 made significant amend-ments to regional water planning, established the Water Infrastructure Fund, directed the TWDB to delineate groundwater management areas, and empowered TCEQ to recommend groundwater conservation districts.

2002
The TWDB produced the first state water plan based on regional planning.

2005
The Texas Legislature established a requirement that groundwater conservation districts within 16 groundwater management areas conduct joint planning and establish desired future conditions.

2007
Senate Bill 3 established a stakeholder process to develop environmental flow standards for Texas' major river basins and bay systems. The TWDB produced a state water plan.

2012
The TWDB produced a state water plan.

2013
House Bills 4 and 1025 created the State Water Implementation Fund for Texas (SWIFT) and the State Water Implementation Revenue Fund for Texas (SWIRFT) to fund state water plan projects.

2017
The TWDB produced a state water plan and accompanying interactive website.

2019
House Bill 807 created the Interregional Planning Council to report planning process improvements to the TWDB.

RWPG = regional water planning group, GMA = groundwater management area, GCD = groundwater conservation district, TPWD = Texas Parks and Wildlife Department, TCEQ = Texas Commission on Environmental Quality followed by floods that caused an additional $120 million in damages (TBWE, 1958).

A.2 State water planning, 1957–1997

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 the committee's recommendations, the legislature passed a resolution authorizing $200 million in state bonds to fund water supply projects and created the Texas Water Development Board (TWDB) to administer funds from the bond sale. 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 and assigned it the responsibility of statewide water supply planning. Texas voters 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 recommended 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. The plan described historical and present uses of surface water and groundwater by municipalities, industries, and irrigated agriculture; summarized the development of reservoirs; projected 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. The 1961 plan recommended 45 new reservoirs. During this era, reservoirs reigned supreme in water resource management, providing water supply, flood control, and electricity, as well as recreational opportunities.

In 1962, the Board of Water Engineers was reorganized, renamed the Texas Water Commission, and given specific responsibilities for water planning by the 57th Texas Legislature. The Texas Legislature again restructured the state water agencies in 1965 and transferred water resource planning functions to the TWDB and renamed the Texas Water Commission to the Texas Water Rights Commission.

Later plans were developed by the state and adopted in 1968, 1984, 1990, 1992, and 1997. Each of these plans recognized the state's steady population growth and the need to develop additional 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. For example, the 1968 State Water Plan recommended the federal government continue to fund feasibility studies on importing surplus water from the Mississippi River (a later study determined that this proposed idea was not economically feasible). Less than 20 years later, the 1984 State Water Plan was the first to address water quality, water conservation, water use efficiency, and environmental water needs.

The first three plans were organized by river basin, but 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 in coordination with the Texas Parks and Wildlife Department and the Texas Commission on Environmental Quality—was the first to organize the state into 16 water planning regions.

A.3 Regional and state water planning, 1997–present

Drought conditions in the mid-1990s spurred action in Texas water planning efforts, just as 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 short-lived, but its consequences were severe enough to remind Texans of the importance of water planning to ensure dependable water supplies. When the legislature convened in 1997, Lieutenant Governor Bob Bullock declared water the primary issue for the 75th Legislative Session. After lengthy debate and numerous amendments, the Texas Legislature passed Senate Bill 1 to improve the development and management of water resources in the state. Among other provisions relating to water supplies, financial assistance, data collection and dissemination, the bill established the regional water planning process, which directed state water planning to begin at the local (regional) level.

Senate Bill 1 outlined a new planning process in which every five years, local and regional stakeholders would develop consensus-driven regional plans for how to meet their water needs during times of drought. The TWDB would then develop a comprehensive state plan based on the regional water plans. The legislation also specified that the TWDB could only provide financial assistance for water supply projects if they were consistent with the regional water plans and the state water plan. The same provision also applied to the Texas Commission on Environmental Quality's granting of water right permits. The 2022 State Water Plan is the fifth plan completed under the Senate Bill 1 planning process and comprises the 16 regional water plans due to the TWDB January 5, 2021.

A.4 State and federal water supply institutions

Although the TWDB is the state's designated water planning agency, several state and federal agencies in Texas are responsible for managing water resources and participate in the regional planning process. The Texas Parks and Wildlife Department, Texas Department of Agriculture, and Texas State Soil and Water Conservation Board all have non-voting representatives on each regional water planning group. The Texas Parks and Wildlife Department, Texas Department of Agriculture, and Texas Commission on Environmental Quality are also directly involved in developing population and water demand projections and are consulted in developing and amending rules governing the planning process. The water-related responsibilities of these agencies, along with other state and federal entities that indirectly participate in the regional water planning process, are described in the following sections.

State entities

The TWDB is the state's primary water science, planning, and financing agency and is led by three appointed Board members. It supports the development of the 16 regional water plans and is responsible for developing a state water plan every five years. The TWDB provides financial assistance to local governments for projects that support water supply, wastewater treatment, flood mitigation, and agricultural water conservation. The TWDB also collects data annually through the Water Use Survey, Water Loss Audit, and Water Conservation Plan Annual Reports. The TWDB provides scientific information on state water resources by collecting data, developing models, and conducting studies of surface water and groundwater availability and quality, all of which undergirds the state water planning process. The TWDB uses and shares this information through a variety of avenues, including overseeing the joint planning process carried out by groundwater management areas and providing technical support to both the environmental flows process and the regional water planning process. The TWDB also participates in many committees and serves as a member of the Water Conservation Advisory Council, Drought Preparedness Council, and the Emergency Drinking Water Task Force, to name a few. The TWDB houses the **Texas Natural Resources Information System (TNRIS)**, which provides high-quality historic and current geospatial data products. The Deputy Executive Administrator of TNRIS acts as the state's Geographic Information Officer.

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, led by nine commissioners appointed by the governor, 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 stakeholders participating in regional water planning and the environmental flows process, as well as with regulatory agencies to protect and enhance water quality and to ensure adequate environmental flows for rivers and estuaries.

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, led by three commissioners appointed by the governor, is the environmental regulatory agency for the state. Focusing on water quality and quantity through various state and federal programs, the Commission issues permits for the treatment and discharge of industrial and domestic wastewater and stormwater; 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 maintains the water availability modeling programs that are the basis for the state's water rights permitting and water supply planning efforts (see Section A.5). It also administers 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 regulates public drinking water systems, is the primary agency for enforcing the federal Safe Drinking Water Act, 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, an elected official of the state. It supports protection of agricultural crops and livestock from harmful pests and diseases; facilitates trade and market development for agricultural commodities; provides financial assistance to farmers and ranchers; and administers consumer protection, economic development, infrastructure grants to rural communities, and healthy living programs.

The **Public Utility Commission of Texas**, established in 1975, is led by three commissioners appointed by the governor 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, and mergers.

Created in 1939, the **Texas State Soil and Water Conservation Board**, led by seven board members composed of two governor appointees and five elected officials, 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 and maintains flood control structures across the state.

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 16 river authorities in Texas (Figure A-2), 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 relevant aquifers within the groundwater management areas. As of 2020, there are 98 confirmed groundwater conservation districts (excluding the two subsidence districts and the Edwards Aquifer Authority) located partially or fully within 176 of 254 Texas counties (Figure A-3). A map of these districts may also 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.

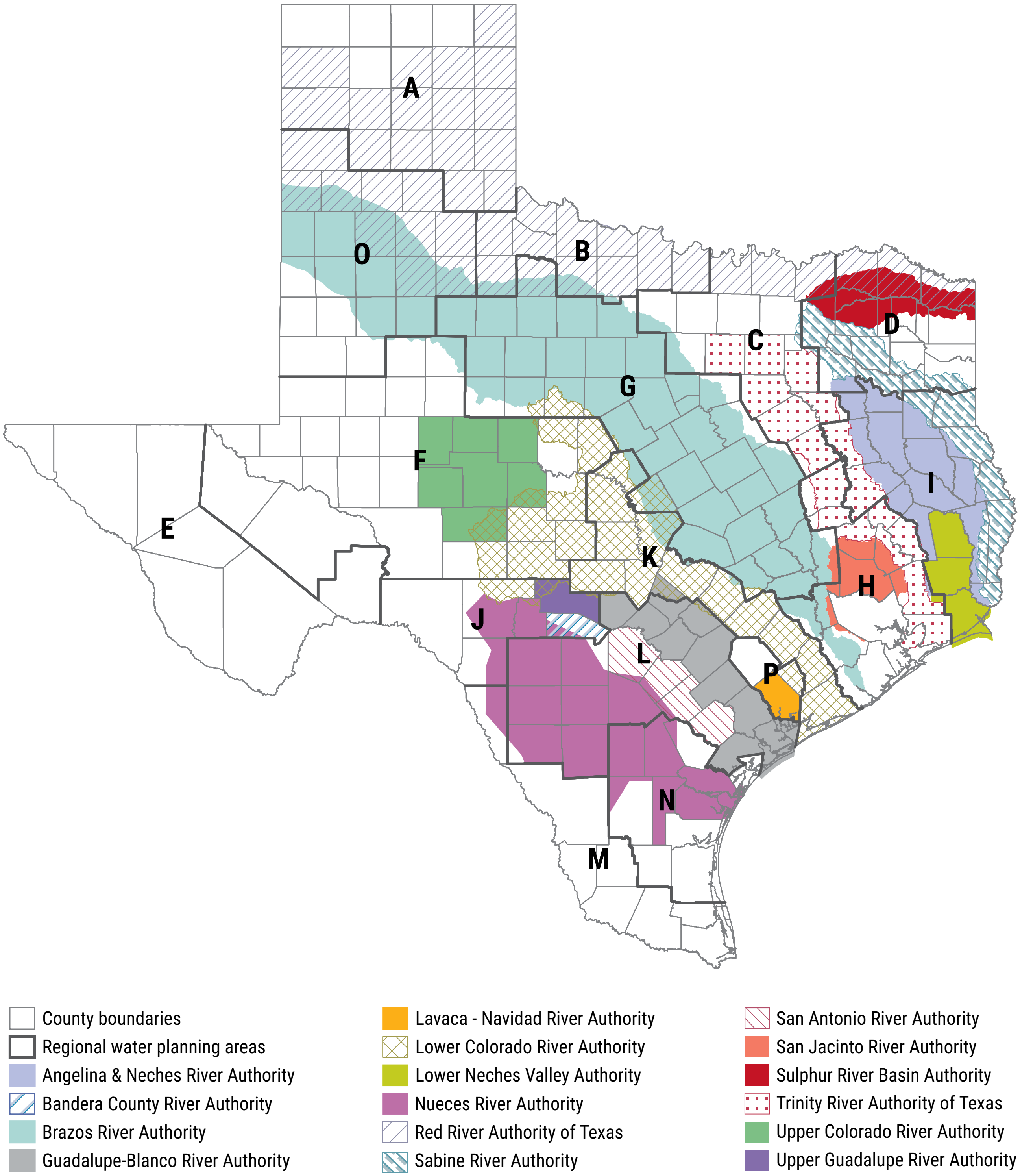
Federal agencies

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 several 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 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 the 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 U.S. Army Corps of Engineers operates a program that regulates construction and other work in the nation's waterways.

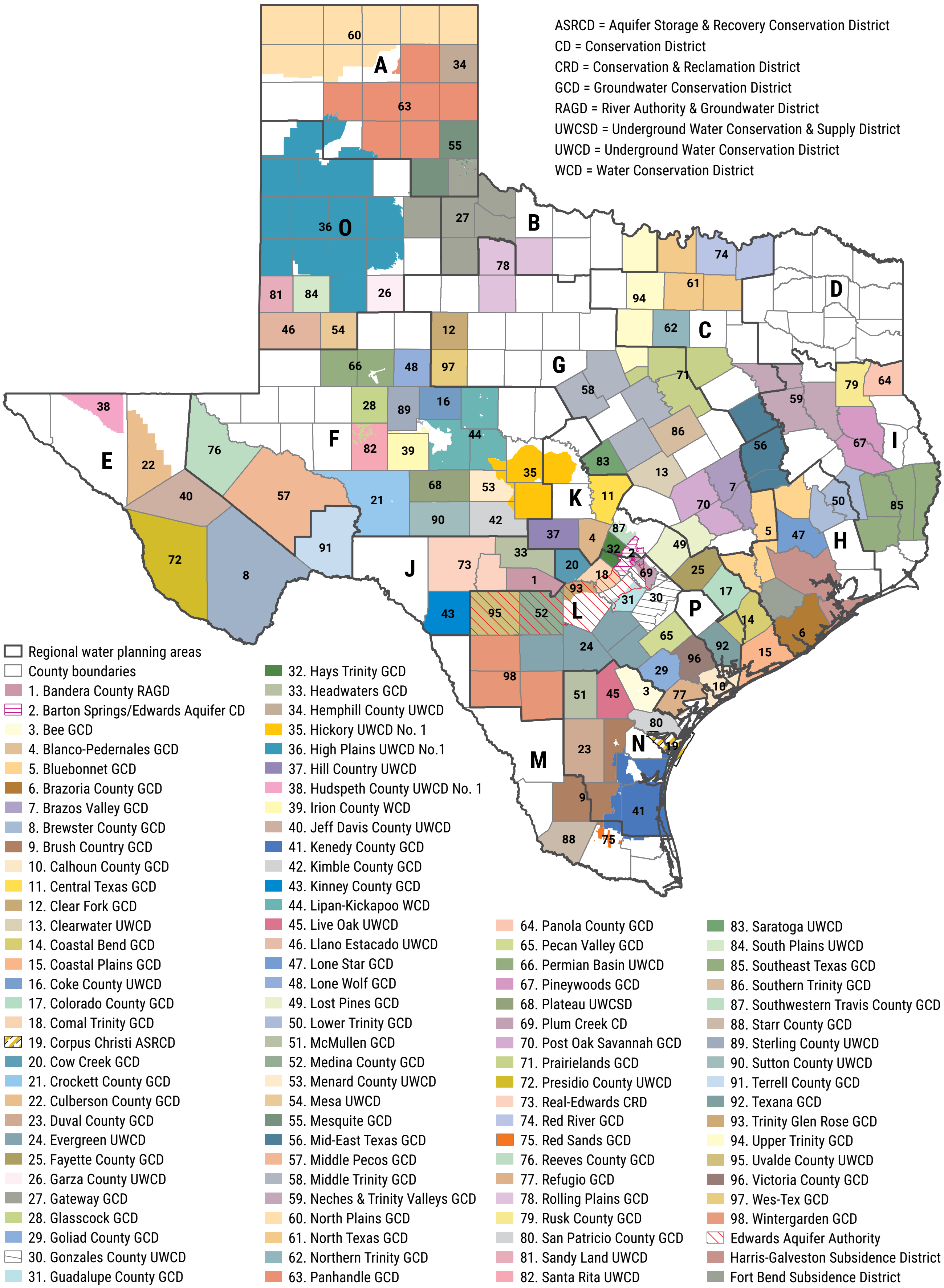
Within the **U.S. Department of the Interior**, the **U.S. Geological Survey** conducts natural resources studies and collects water-related data, and the **U.S. Bureau of Reclamation** conducts

Figure A-2. Locations of river authorities and regional water planning area boundaries



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.

Figure A-3. Locations of groundwater conservation districts and regional water planning area boundaries



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, 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.5 Management of water in Texas

Texas water law divides water into several categories for the purpose of regulation. Different rules apply to surface water and groundwater, determining who is entitled to use the water, in what amount, and for what purpose. This system stems from Spanish and English common laws, the laws of other western states, and state and federal case law and legislation. The following sections briefly describe how the state manages surface water and groundwater resources, water quality, drinking water, and interstate waters, all important considerations when planning for drought.

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, 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 appropriation system recognizes the “priority doctrine,” 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 coordinates releases from the Amistad and Falcon reservoir system; the Brazos Watermaster, who serves the middle and lower portions 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, overseeing 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 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. A 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 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.

Groundwater conservation districts can be created by four possible methods: (1) action of the Texas Legislature, (2) petition by property owners, (3) initiation by the Texas Commission on Environmental Quality, or (4) 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 introduced.

The TWDB and the Texas Commission on Environmental Quality are the primary state agencies involved in supporting groundwater conservation districts to implement 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.

Galveston Island, Texas

In 2015, the 84th Texas Legislature passed House Bill 30, directing the TWDB to conduct studies to identify and designate local or regional brackish groundwater production zones in areas of the state with moderate to high availability and productivity of brackish groundwater. To date, the TWDB has designated a total of 31 such brackish groundwater production zones that meet statutory criteria. In 2019, the 86th Texas Legislature passed House Bill 722, creating a framework for groundwater conservation districts to establish permitting rules for producing brackish groundwater from the TWDB-designated brackish groundwater production zones for municipal drinking water projects or electric generation projects. The statute further directed the TWDB to conduct technical reviews of operating permit applications submitted to groundwater conservation districts and, when requested by a district, investigate the impacts of brackish groundwater production as described in the annual reports of the permitted production.

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.

Seawater (Gulf of Mexico)

The diversion, treatment, and use of marine seawater, as well as the discharge of the treated water and associated waste, is permitted by the Texas Commission on Environmental Quality. State-sponsored studies for seawater desalination plants were initiated in the 2000s, and in 2015 the 84th Texas Legislature passed House Bill 2031, directing the development of seawater desalination permitting rules in Chapter 18 of the Texas Water Code. The overall goal of the bill was to streamline and expedite the regulatory and permitting processes associated with seawater desalination. In addition, the Texas Parks and Wildlife Department and General Land Office have identified zones for both the diversion of marine seawater and discharge of the desalination waste, which are only applicable when using the Texas Commission on Environmental Quality expedited permitting process for seawater desalination. No zones are located within the state's bays and estuaries. The map of zones is available at the General Land Office Coastal Resource Management Viewer (cgis.glo.texas.gov/rmc/index.html).

Surface water quality

The Texas Commission on Environmental Quality is charged with managing the quality of the

Trinity Bay, Texas

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 to determine if the use is being supported. Water quality data is 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 not meeting 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 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 rulemaking. 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.6 Key water planning statute and administrative rules

Texas Water Code §§ 16.012, 16.051, 16.052, 16.053, 16.054, and 16.055.

31 Texas Administrative Code Chapters 355, 356, 357, and 358.

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Appendix B Water availability and existing supplies

B.1 Surface water

As discussed in Chapter 5, hydrologic variances from the use of firm yield determined by the default water availability model (WAM Run 3) may be justified for drought planning purposes. For example, in regions where droughts are more frequent, it is reasonable to plan with a more conservative measure of reliability, such as a one- to two-year safe yield, because some reservoirs in more arid regions of the state have extended periods between filling.

Of the 16 planning regions, six requested and were authorized to use safe yield for the surface water availability analysis in their plan development. Authorization was granted based upon assurances and evidence that the resulting estimates of alternative water availability are reasonable for drought planning purposes and will reflect conditions expected in the event of near-term, actual drought conditions. Additionally, planning groups must also report the standard firm yield value. These authorizations are summarized in Table B-1. For presentation purposes, only approved safe yield hydrologic variance assumptions for reservoir sources are summarized. Run-of-river sources also have hydrologic variance assumptions approved, and the specifics may be reviewed (along with reservoir variance assumptions) in Chapter 3 or the associated appendix in each regional water plan.

Beyond the use of safe yield, other authorized surface water variances included

- extension of the hydrology beyond the water availability model period of record (Regions A, B, C, F, G, H, K, N, and O);
- modifications to water availability models to more accurately reflect operational or contract agreements, subordination agreements, correct known errors in the models, or remove canceled water rights (all regions); and
- modifications to a water availability model to utilize return flows (Regions C, D, G, H, J, K, M, and O).

Playa lake in the Texas Panhandle

Table B-1. Summary of safe yield hydrologic variances used in the 2022 State Water Plan

River basin	Reservoir source	Region(s) utilizing reservoir as current source	Region(s) utilizing reservoir as future source	Safe yield additional period assumption (years)	2020 Firm yield (ac-ft/yr)	2020 Safe yield (ac-ft/yr)	Percent difference between firm and safe yield availability 2020	2070 Firm yield (ac-ft/yr)	2070 Safe yield (ac-ft/yr)	Percent difference between firm and safe yield availability 2070
Brazos	Cisco Lake/ Reservoir	G	None	1	1,300	1,075	-17	1,300	1,075	-17
Brazos	Daniel Lake/ Reservoir	G	None	1	250	175	-30	225	150	-33
Brazos	Fort Phantom Hill Lake/ Reservoir	G	None	2	7,500	4,800	-36	6,900	3,600	-48
Brazos	Graham/ Eddleman Lake/Reservoir	B; C; G	None	1	1,800	1,275	-29	1,125	675	-40
Brazos	Hubbard Creek Lake/Reservoir	G	G	2	26,900	20,000	-26	26,300	19,500	-26
Brazos	McCarty Lake/ Reservoir	G	None	1	100	75	-25	0	0	0
Brazos	Millers Creek Lake/Reservoir	B; G	None	1	125	75	-40	0	0	0
Brazos	Palo Pinto Lake/Reservoir	C; G	C; G	0.5	9,800	7,800	-20	8,950	7,100	-21
Brazos	Stamford Lake/Reservoir	G	None	1	4,400	2,600	-41	4,050	2,200	-46
Canadian	Meredith Lake/ Reservoir	A; O	A	1	28,221	24,669	-13	28,326	24,501	-14
Colorado	Brownwood Lake/Reservoir	F; G; K	F	1	24,000	18,900	-21	23,100	18,200	-21
Colorado	O.H. Ivie Lake/ Reservoir Non-System Portion	F; G	F; G	1	18,314	16,065	-12	15,536	13,491	-13
Nueces	Corpus Christi-Choke Canyon Lake/Reservoir System	N	N	1	173,154	111,560	-36	168,239	100,560	-40
Red	Greenbelt Lake/Reservoir	A; B	None	1	3,964	3,112	-22	3,276	2,256	-31
Red	Kemp-Diversion Lake/Reservoir System	B	None	1	44,000	29,000	-34	22,800	14,500	-36
Red	Little Wichita River Lake/ Reservoir System	B	B	1	31,770	16,900	-47	28,960	11,000	-62
Red	Olney-Cooper Lake/Reservoir System	B; G	None	1	268	194	-28	229	130	-43
Red	Santa Rosa Lake/Reservoir	B	None	1	3,075	50	-98	3,075	50	-98
Rio Grande	Red Bluff Lake/ Reservoir	F	None	1	38,630	30,050	-22	38,220	29,700	-22
Trinity	Amon G. Carter Lake/Reservoir	B	None	1	1,689	1,270	-25	1,185	830	-30
Trinity	TRWD Lake/ Reservoir System	C; D; G	C; D; G; I	1	517,349	451,094	-13	500,647	412,135	-18

ac-ft/yr = acre-feet per year

Table B-2. Annual surface water availability by river and coastal basin (acre-feet)

Surface water basin	2020	2030	2040	2050	2060	2070	Percent change
Brazos	1,457,019	1,452,479	1,447,935	1,443,413	1,438,849	1,433,608	-2
Brazos-Colorado	21,299	21,299	21,299	21,299	21,299	21,299	0
Canadian	41,802	41,726	41,651	41,576	41,500	41,425	-1
Colorado	956,710	954,837	952,913	951,091	949,178	947,235	-1
Colorado-Lavaca	4,852	4,852	4,852	4,852	4,852	4,852	0
Cypress	294,482	293,908	289,372	286,966	283,557	280,417	-5
Guadalupe	179,887	179,743	179,599	179,454	179,310	179,166	0
Lavaca	79,710	79,710	79,710	79,710	79,710	79,710	0
Lavaca-Guadalupe	297	297	297	297	297	297	0
Neches	2,342,466	2,340,310	2,338,353	2,336,570	2,334,215	2,330,521	-1
Neches-Trinity	90,555	90,555	90,555	90,555	90,555	90,555	0
Nueces	121,519	119,619	117,419	115,219	113,019	110,519	-9
Nueces-Rio Grande	8,807	8,807	8,807	8,807	8,807	8,807	0
Red	314,001	309,737	306,050	302,376	298,705	292,707	-7
Rio Grande	1,235,141	1,234,865	1,234,588	1,234,312	1,234,035	1,233,759	0
Sabine	2,013,544	2,009,131	2,003,908	1,999,215	1,994,420	1,989,632	-1
Sabine-Louisiana	343	343	343	343	343	343	0
San Antonio	52,984	52,984	52,984	52,984	52,984	52,984	0
San Antonio-Nueces	993	993	993	993	993	993	0
San Jacinto	269,297	265,297	261,497	257,597	252,997	244,997	-9
San Jacinto-Brazos	38,827	38,827	38,827	38,827	38,827	38,827	0
Sulphur	463,523	450,321	436,374	422,875	409,425	395,669	-15
Trinity	2,674,184	2,648,707	2,634,977	2,563,513	2,543,176	2,521,365	-6
Trinity-San Jacinto	5,537	5,537	5,537	5,537	5,537	5,537	0
Texas	**12,667,779**	**12,604,884**	**12,548,840**	**12,438,381**	**12,376,590**	**12,305,224**	**-3**

Table 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	1,028,398	1,027,522	1,027,471	1,024,880	1,021,226	1,016,537	-1
Brazos-Colorado	18,146	18,146	18,146	18,146	18,146	18,146	0
Canadian	37,884	37,851	37,818	37,784	37,750	37,716	0
Colorado	850,792	849,674	848,806	846,861	847,167	845,952	-1
Colorado-Lavaca	4,289	4,289	4,289	4,289	4,289	4,289	0
Cypress	188,035	183,161	182,029	181,321	180,470	179,575	-5
Guadalupe	172,627	169,329	166,256	166,874	169,350	169,365	-2
Lavaca	78,055	78,136	78,136	78,136	78,136	78,136	0
Lavaca-Guadalupe	297	297	297	297	297	297	0
Neches	495,915	500,538	503,810	506,896	510,377	514,747	4
Neches-Trinity	88,962	88,962	88,962	88,962	88,962	88,962	0
Nueces	118,408	116,486	114,285	112,076	109,878	107,379	-9
Nueces-Rio Grande	926	926	926	926	926	926	0
Red	170,041	166,889	164,581	162,546	160,859	154,978	-9
Rio Grande	943,633	944,086	941,201	941,050	941,819	941,943	0
Sabine	591,377	573,717	573,540	573,113	572,665	576,570	-3
Sabine-Louisiana	343	343	343	343	343	343	0
San Antonio	52,444	52,445	52,445	52,446	52,455	52,455	0
San Antonio-Nueces	444	444	444	444	444	444	0
San Jacinto	187,038	187,816	188,218	187,201	187,441	187,646	0
San Jacinto-Brazos	35,989	35,989	35,989	35,989	35,989	35,989	0
Sulphur	121,575	121,149	121,323	121,616	121,803	121,938	0
Trinity	2,041,046	2,019,985	1,998,152	1,978,278	1,960,409	1,940,465	-5
Trinity-San Jacinto	5,537	5,537	5,537	5,537	5,537	5,537	0
Texas[a]	**7,232,201**	**7,183,717**	**7,153,004**	**7,126,011**	**7,106,738**	**7,080,335**	**-2**

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

B.2 Groundwater

As discussed in Chapter 5, the joint groundwater planning process is the basis for most groundwater availability in this plan. Desired future conditions for this plan were adopted by March 2018; however, the majority were adopted in 2016 and 2017. Desired future conditions by groundwater management area are available on the TWDB website: www.twdb.texas.gov/groundwater/dfc/2016jointplanning.asp.

The modeled available groundwater peak factor option discussed in Chapter 5 was utilized for this state water plan by Regions G and H. A modest modeled available groundwater reallocation was also approved for use by Region F, which allowed for the reallocation of modeled available groundwater values across river basins within a county.

During development of this state water plan, the reasonableness of the desired future condition adopted in 2016 for the Gulf Coast Aquifer in the Lone Star Groundwater Conservation District was challenged and determined to be no longer reasonable. Due to this decision, the modeled available groundwater volume used in this plan for Montgomery County is based on the desired future condition adopted in 2010.

Based on a policy recommendation in the 2017 State Water Plan, the timing of adopting desired future conditions was revised by House Bill 2215 from the 85th Legislative Session to set a statutory deadline for adopting desired future conditions and to better synchronize the joint planning and regional water planning cycles. For the 2026 regional water plans and 2027 State Water Plan, modeled available groundwater values will be based on desired future conditions in effect as of January 5, 2022. Where available during development of the 2027 State Water Plan, modeled available groundwater values will be utilized in developing draft irrigation demand projections in counties in which the total groundwater availability over the planning period is projected to be less than the groundwater portion of the baseline water demand projections (see Chapter 4 for methodological details). Steps in the groundwater joint planning process are outlined on the following flowchart: www.twdb.texas.gov/groundwater/docs/DFCFlowchart_May2020.pdf.

Texas windmill at sunrise

Table B-4. Annual groundwater availability by aquifer (acre-feet) – continued on next page

Aquifer	2020	2030	2040	2050	2060	2070	Percent change
Austin Chalk	5,704	5,704	5,704	5,704	5,704	5,704	0
Blaine	85,832	82,524	82,719	82,524	82,719	82,524	-4
Blossom	2,273	2,273	2,273	2,273	2,273	2,273	0
Bone Spring-Victorio Peak	101,400	101,400	101,400	101,400	101,400	101,400	0
Brazos River Alluvium	283,054	278,495	277,929	277,731	277,625	277,558	-2
Buda Limestone	758	758	758	758	758	758	0
Capitan Reef Complex	44,410	44,410	44,410	44,410	44,410	44,410	0
Carrizo-Wilcox	1,214,959	1,185,373	1,189,014	1,207,269	1,205,152	1,204,940	-1
Cross Timbers	13,127	13,127	13,127	13,127	13,127	13,127	0
Dockum	342,240	346,708	337,468	325,948	312,528	312,427	-9
Edwards (Balcones Fault Zone)	320,285	320,285	320,285	320,285	320,285	320,285	0
Edwards-Trinity (Plateau)/Pecos Valley[a]	420,915	420,915	420,915	420,915	420,915	420,915	0
Edwards-Trinity (Plateau)	7,390	7,390	7,390	7,390	7,390	7,390	0
Edwards-Trinity (Plateau)/Pecos Valley/Trinity[a]	479,060	479,060	479,060	479,060	479,060	479,060	0
Ellenburger-San Saba	41,141	41,095	41,141	41,095	41,141	41,095	0
Frio River Alluvium	2,145	2,145	2,145	2,145	2,145	2,145	0
Gulf Coast	1,998,403	1,880,722	1,826,411	1,874,886	1,919,628	1,947,314	-3
Hickory	56,572	56,554	56,572	56,554	56,572	56,554	0
Hueco-Mesilla Bolsons	480,000	480,000	480,000	480,000	480,000	480,000	0
Igneous	11,713	11,713	11,712	11,709	11,709	11,708	0
Leona Gravel	31,402	31,402	31,402	31,402	31,402	31,402	0
Lipan	46,539	46,539	46,539	46,539	46,539	46,539	0
Marathon	7,327	7,327	7,327	7,327	7,327	7,327	0
Marble Falls	10,443	10,415	10,443	10,415	10,443	10,415	0
Nacatoch	15,652	15,651	15,672	16,027	16,506	17,211	10
Navasota River Alluvium	2,216	2,216	2,216	2,216	2,216	2,216	0
Nueces River Alluvium	3,574	3,574	3,574	3,574	3,574	3,574	0
Ogallala/Edwards-Trinity (High Plains)[a]	3,115,814	2,086,599	1,534,371	1,246,995	1,092,489	1,002,728	-68
Ogallala/Rita Blanca[a]	804,584	576,367	452,421	332,470	221,287	221,287	-73
Ogallala	2,804,827	2,717,750	2,529,481	2,322,725	2,118,890	2,118,657	-25

[a] Noted aquifer combinations reflect specific groundwater management policy decisions based on aquifer properties. In these cases, the modeled available groundwater and existing supply values have likewise been developed to honor these aquifer combinations.

Table B-4. Annual groundwater availability by aquifer (acre-feet) – continued

Aquifer	2020	2030	2040	2050	2060	2070	Percent change
Other	258,668	258,668	258,668	258,668	258,668	258,668	0
Pecos Valley	150	150	150	150	150	150	0
Queen City	276,339	273,543	272,856	272,408	271,562	270,669	-2
Rustler	11,183	11,183	11,183	11,183	11,183	11,183	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
San Marcos River Alluvium	271	271	271	271	271	271	0
Seymour	219,785	196,032	199,985	203,240	205,495	211,223	-4
Sparta	30,710	33,049	35,487	37,505	37,426	37,348	22
Trinity	385,697	384,923	385,302	384,288	384,924	384,243	0
Trinity River Alluvium	3,913	3,913	3,913	3,913	3,913	3,913	0
West Texas Bolsons	80,603	80,402	80,111	79,907	79,661	79,424	-2
Woodbine	30,656	30,575	30,656	30,575	30,656	30,575	0
Yegua-Jackson	113,891	111,921	111,909	111,823	111,287	111,287	-2
Texas	**14,167,595**	**12,645,091**	**11,726,340**	**11,170,774**	**10,732,380**	**10,673,867**	**-25**

Table B-5. Annual groundwater existing supplies by aquifer (acre-feet) *– continued on next page*

Aquifer	2020	2030	2040	2050	2060	2070	Percent change
Austin Chalk	3,618	3,618	3,618	3,618	3,618	3,618	0
Blaine	30,692	30,793	30,807	30,831	30,873	30,931	1
Blossom	723	723	722	722	722	722	0
Bone Spring-Victorio Peak	68,642	68,642	68,642	68,642	68,642	68,642	0
Brazos River Alluvium	148,920	145,718	145,392	145,303	145,262	145,239	-3
Buda Limestone	50	50	114	168	229	289	478
Capitan Reef Complex	13,629	13,629	8,104	8,104	8,104	8,104	-41
Carrizo-Wilcox	672,841	681,209	687,886	693,615	694,922	694,693	3
Cross Timbers	9,184	9,348	8,201	7,808	7,812	7,820	-15
Dockum	67,779	67,183	66,880	66,805	66,873	66,816	-1
Edwards (Balcones Fault Zone)	265,040	265,281	265,854	266,261	266,442	266,618	1
Edwards-Trinity (Plateau)/Pecos Valley[a]	175,622	168,286	172,014	170,072	167,656	164,760	-6
Edwards-Trinity (Plateau)	3,857	3,857	3,857	3,857	3,857	3,857	0
Edwards-Trinity (Plateau)/Pecos Valley/Trinity[a]	227,299	228,437	221,056	211,168	205,130	204,366	-10
Ellenburger-San Saba	21,386	21,349	20,476	19,938	19,492	19,175	-10
Frio River Alluvium	609	609	609	609	609	609	0
Gulf Coast	1,395,614	1,251,219	1,179,114	1,202,922	1,227,311	1,252,253	-10
Hickory	28,708	28,164	27,070	26,421	25,917	25,508	-11
Hueco-Mesilla Bolsons	167,028	167,028	167,028	167,028	167,028	167,028	0
Igneous	8,756	8,756	8,756	8,756	8,756	8,756	0
Leona Gravel	9,854	10,086	10,236	10,412	10,634	10,877	10
Lipan	45,696	45,703	45,702	45,702	45,701	45,701	0
Marathon	566	566	566	566	566	566	0
Marble Falls	1,826	1,826	1,826	1,826	1,826	1,826	0
Nacatoch	6,637	6,670	6,661	6,580	6,501	6,485	-2
Navasota River Alluvium	58	58	58	58	58	58	0
Nueces River Alluvium	13	13	13	13	13	13	0
Ogallala/Edwards-Trinity (High Plains)[a]	2,877,633	1,995,757	1,466,426	1,180,748	1,025,520	933,924	-68

[a] Noted aquifer combinations reflect specific groundwater management policy decisions based on aquifer properties. In these cases, the modeled available groundwater and existing supply values have likewise been developed to honor these aquifer combinations

Table B-5. Annual groundwater existing supplies by aquifer (acre-feet) – continued

Aquifer	2020	2030	2040	2050	2060	2070	Percent change
Ogallala/Rita Blanca[a]	626,332	432,477	337,860	252,457	176,937	177,993	-72
Ogallala	1,266,282	1,223,996	1,156,231	1,047,358	943,288	945,346	-25
Other	178,613	178,741	178,389	177,794	177,362	177,139	-1
Pecos Valley	150	150	150	150	150	150	0
Queen City	29,053	29,758	30,181	30,350	30,422	30,551	5
Rustler	4,719	4,719	4,719	4,719	4,719	4,719	0
San Bernard River Alluvium	-	-	-	-	-	-	na
San Jacinto River Alluvium	-	-	-	-	-	-	na
San Marcos River Alluvium	-	-	-	-	-	-	na
Seymour	179,391	170,041	170,638	172,210	173,061	170,176	-5
Sparta	19,058	20,218	20,414	20,527	20,655	20,806	9
Trinity	266,544	264,284	263,868	264,586	266,517	268,473	1
Trinity River Alluvium	-	-	-	-	-	-	na
West Texas Bolsons	43,620	43,620	43,620	43,620	43,620	43,620	0
Woodbine	21,740	21,221	21,224	21,206	21,210	21,202	-3
Yegua-Jackson	23,862	23,898	23,865	23,883	23,560	23,619	-1
Texas	**8,911,644**	**7,637,701**	**6,868,847**	**6,407,413**	**6,091,575**	**6,023,048**	**-32**

[a] Noted aquifer combinations reflect specific groundwater management policy decisions based on aquifer properties. In these cases, the modeled available groundwater and existing supply values have likewise been developed to honor these aquifer combinations

na = not applicable

Appendix C Annual water needs by region and water use category

Table C-1. Annual water needs by region and water use category (acre-feet) *– continued on next page*

Region	Water use category	2020	2030	2040	2050	2060	2070
A	Irrigation	146,064	381,557	385,041	351,667	309,784	310,602
	Manufacturing	1,008	2,585	4,015	6,932	9,372	9,684
	Municipal	1,387	9,961	21,873	35,686	49,380	58,136
A total		**148,459**	**394,103**	**410,929**	**394,285**	**368,536**	**378,422**
B	Irrigation	21,165	22,979	24,793	26,606	28,419	30,233
	Manufacturing	0	0	0	0	13	145
	Mining	1,616	678	556	201	137	137
	Municipal	263	532	1,298	2,135	3,149	6,028
	Steam-electric	1,701	2,303	2,905	3,506	4,109	4,713
B total		**24,745**	**26,492**	**29,552**	**32,448**	**35,827**	**41,256**
C	Irrigation	4,584	4,654	4,712	4,757	5,042	5,395
	Livestock	478	478	478	478	478	478
	Manufacturing	402	5,350	9,072	12,148	14,601	17,532
	Mining	11,005	11,350	12,545	14,852	17,334	21,425
	Municipal	42,659	274,237	489,855	723,029	963,130	1,217,573
	Steam-electric	6,824	10,569	12,957	14,233	15,195	16,023
C total		**65,952**	**306,638**	**529,619**	**769,497**	**1,015,780**	**1,278,426**
D	Irrigation	13,188	13,206	13,208	13,209	13,211	13,213
	Livestock	14,542	14,552	14,540	14,455	14,477	14,491
	Manufacturing	2,914	5,578	5,455	5,465	5,735	5,865
	Mining	2,390	2,278	1,916	1,534	1,224	1,039
	Municipal	17,488	20,418	24,510	30,368	38,414	49,331
	Steam-electric	30,066	30,866	31,766	32,566	32,814	33,083
D total		**80,588**	**86,898**	**91,395**	**97,597**	**105,875**	**117,022**
E	Irrigation	46,737	46,737	52,262	52,262	52,262	52,262
	Manufacturing	0	860	860	860	860	860
	Mining	2,530	3,223	3,840	4,407	5,038	5,796
	Municipal	4,102	8,061	11,815	24,605	38,953	52,666
	Steam-electric	7,260	7,260	7,260	7,260	7,260	7,260
E total		**60,629**	**66,141**	**76,037**	**89,394**	**104,373**	**118,844**
F	Irrigation	13,529	17,957	19,544	21,240	24,585	27,060
	Livestock	9	17	25	39	50	60
	Manufacturing	951	1,065	1,108	1,327	1,527	1,710
	Mining	21,261	21,357	17,834	12,088	7,677	5,407
	Municipal	14,048	18,792	23,899	33,706	44,212	55,512
	Steam-electric	12,794	12,678	12,678	12,800	12,923	13,039
F total		**62,592**	**71,866**	**75,088**	**81,200**	**90,974**	**102,788**

Table C-1. Annual water needs by region and water use category (acre-feet) – continued on next page

Region	Water use category	2020	2030	2040	2050	2060	2070
G	Irrigation	75,658	81,687	76,700	75,374	76,180	78,660
	Manufacturing	1,024	3,458	3,088	2,718	2,379	1,916
	Mining	30,305	31,798	28,925	29,692	30,753	33,008
	Municipal	31,099	65,413	109,496	163,766	221,873	290,966
	Steam-electric	72,721	72,816	72,912	73,008	73,104	73,200
G total		**210,807**	**255,172**	**291,121**	**344,558**	**404,289**	**477,750**
H	Irrigation	84,455	84,455	84,455	84,455	84,455	84,538
	Livestock	1,259	1,642	1,898	1,898	1,898	1,906
	Manufacturing	32,615	63,357	64,445	65,239	64,442	63,506
	Mining	3,293	4,193	4,004	4,024	4,228	4,565
	Municipal	18,532	246,828	418,544	506,533	609,134	723,653
	Steam-electric	4,968	4,968	4,968	4,968	4,968	4,968
H total		**145,122**	**405,443**	**578,314**	**667,117**	**769,125**	**883,136**
I	Irrigation	526	526	526	526	556	576
	Livestock	23,708	26,613	30,128	34,381	39,483	40,666
	Manufacturing	102,587	145,222	145,206	145,188	145,171	145,155
	Mining	8,413	5,281	903	468	308	207
	Municipal	501	877	2,551	5,832	10,120	15,540
	Steam-electric	3,494	3,494	3,494	3,494	3,494	3,494
I total		**139,229**	**182,013**	**182,808**	**189,889**	**199,132**	**205,638**
J	Irrigation	75	75	75	75	75	75
	Livestock	357	357	357	357	357	357
	Mining	221	281	294	259	229	210
	Municipal	5,082	5,735	6,366	7,016	7,641	8,607
J total		**5,735**	**6,448**	**7,092**	**7,707**	**8,302**	**9,249**
K	Irrigation	254,364	239,922	225,869	212,193	198,886	185,938
	Manufacturing	0	40	40	40	40	40
	Mining	2,677	6,937	8,264	7,708	5,472	6,860
	Municipal	4,927	13,378	34,037	50,170	72,550	105,401
	Steam-electric	20,546	20,546	20,546	20,546	20,546	20,546
K total		**282,514**	**280,823**	**288,756**	**290,657**	**297,494**	**318,785**
L	Irrigation	131,184	131,915	134,104	136,099	137,596	140,812
	Manufacturing	10,427	12,940	13,041	13,073	13,073	13,073
	Mining	15,921	16,809	15,105	12,334	10,454	9,180
	Municipal	24,468	48,817	83,667	121,804	167,216	216,255
	Steam-electric	21,707	21,707	21,707	21,707	21,707	21,707
L total		**203,707**	**232,188**	**267,624**	**305,017**	**350,046**	**401,027**
M	Irrigation	888,896	843,532	798,075	753,082	707,399	662,060
	Manufacturing	632	851	851	851	851	851
	Mining	6,662	6,007	4,834	4,386	4,566	5,318
	Municipal	35,487	69,080	117,113	174,131	235,515	296,472
	Steam-electric	5,217	5,028	4,928	4,928	4,928	4,928
M total		**936,894**	**924,498**	**925,801**	**937,378**	**953,259**	**969,629**

Table C-1. Annual water needs by region and water use category (acre-feet) – continued

Region	Water use category	2020	2030	2040	2050	2060	2070
N	Irrigation	1,283	1,474	1,474	1,474	1,474	1,474
	Manufacturing	1,479	16,617	21,509	25,741	30,222	34,441
	Mining	2,203	2,430	2,327	2,185	2,158	2,216
	Municipal	10,235	10,571	10,769	10,931	11,107	11,233
N total		**15,200**	**31,092**	**36,079**	**40,331**	**44,961**	**49,364**
O	Irrigation	705,992	1,440,091	1,450,917	1,446,461	1,445,719	1,445,026
	Livestock	112	122	844	2,041	3,689	5,442
	Manufacturing	5,454	6,482	6,482	6,482	6,482	6,482
	Mining	10,118	10,503	9,517	8,145	6,908	6,016
	Municipal	4,345	9,345	15,418	21,861	30,062	36,931
O total		**726,021**	**1,466,543**	**1,483,178**	**1,484,990**	**1,492,860**	**1,499,897**
P	Irrigation	8,067	8,067	8,067	8,067	8,067	8,067
P total		**8,067**	**8,067**	**8,067**	**8,067**	**8,067**	**8,067**
Texas	Irrigation	2,395,767	3,318,834	3,279,822	3,187,547	3,093,710	3,045,991
	Livestock	40,465	43,781	48,270	53,649	60,432	63,400
	Manufacturing	159,493	264,405	275,172	286,064	294,768	301,260
	Mining	118,615	123,125	110,864	102,283	96,486	101,384
	Municipal	214,623	802,045	1,371,211	1,911,573	2,502,456	3,144,304
	Steam-electric	187,298	192,235	196,121	199,016	201,048	202,961
Texas total		**3,116,261**	**4,744,425**	**5,281,460**	**5,740,132**	**6,248,900**	**6,859,300**

Appendix D Socioeconomic impact regional summary and dashboards

The TWDB assists the regional water planning groups in evaluating the social and economic impacts of not meeting identified water needs for a single year drought of record. The TWDB calculated all estimates using a variety of data sources and tools, including the use of a region-specific Impact for Planning Analysis model. This appendix presents regional summaries of socioeconomic impact reports for all regions.

The regional water plan impact estimates presented in Table D-1 and the online dashboards vary from the results included in Chapter 6. This is primarily due to a difference in the quantity of water needs used to estimate the impacts.

The results presented here and included in the regional water plans and online dashboards were from the analysis conducted in September 2019 to allow for public comment in the draft regional plans. The final regional water plans included updated water need estimates, and the statewide impact estimates included in Chapter 6 were performed based upon the final needs data in November 2020.

Full socioeconomic impact reports for all 16 planning regions are available on the TWDB website, www.twdb.texas.gov/waterplanning/data/analysis/index.asp.

Table D-1. Socioeconomic impact regional summary *–* *continued on next page*

Region	Impact measures	2020	2030	2040	2050	2060	2070
A	Income losses (millions)*	$80	$432	$867	$2,262	$3,225	$3,511
A	Job losses	770	4,380	9,535	23,417	33,968	37,964
A	Tax losses on production and imports (millions)*	$4	$23	$58	$171	$249	$272
A	Population losses	141	804	1,751	4,299	6,236	6,970
B	Income losses (millions)*	$1,423	$505	$460	$320	$284	$339
B	Job losses	5,249	1,703	1,460	863	699	1,316
B	Tax losses on production and imports (millions)*	$164	$51	$43	$23	$16	$19
B	Population losses	964	313	268	158	128	242
C	Income losses (millions)*	$3,505	$8,361	$16,791	$27,127	$37,499	$48,071
C	Job losses	20,437	73,315	158,102	260,573	366,762	472,979
C	Tax losses on production and imports (millions)*	$279	$582	$1,123	$1,777	$2,461	$3,221
C	Population losses	3,752	13,461	29,027	47,841	67,338	86,839
D	Income losses (millions)*	$5,868	$7,000	$6,602	$6,211	$6,068	$6,148
D	Job losses	46,069	57,405	55,266	54,160	56,434	59,710
D	Tax losses on production and imports (millions)*	$445	$548	$500	$454	$440	$450
D	Population losses	8,458	10,540	10,147	9,944	10,361	10,963
E	Income losses (millions)*	$883	$1,143	$1,287	$1,386	$1,538	$1,753
E	Job losses	3,635	5,443	6,606	7,592	9,422	11,989
E	Tax losses on production and imports (millions)*	$58	$80	$93	$103	$118	$139
E	Population losses	667	999	1,213	1,394	1,730	2,201

** Year 2018 dollars, rounded.*

Table D-1. Socioeconomic impact regional summary – *continued on next page*

Region	Impact measures	2020	2030	2040	2050	2060	2070
F	Income losses (millions)*	$19,624	$19,720	$17,058	$13,443	$7,750	$6,356
F	Job losses	98,208	100,186	88,685	71,444	43,995	38,833
F	Tax losses on production and imports (millions)*	$2,644	$2,647	$2,266	$1,749	$937	$725
F	Population losses	18,031	18,394	16,283	13,117	8,078	7,130
G	Income losses (millions)*	$13,299	$15,465	$13,353	$12,695	$12,154	$12,080
G	Job losses	65,131	86,060	80,693	86,373	91,113	98,141
G	Tax losses on production and imports (millions)*	$967	$1,152	$932	$836	$749	$712
G	Population losses	11,958	15,801	14,815	15,858	16,728	18,019
H	Income losses (millions)*	$4,600	$8,521	$10,313	$11,301	$12,437	$13,784
H	Job losses	28,805	66,183	95,862	110,604	127,869	148,164
H	Tax losses on production and imports (millions)*	$507	$815	$944	$1,021	$1,115	$1,226
H	Population losses	5,289	12,151	17,600	20,307	23,477	27,203
I	Income losses (millions)*	$9,314	$6,786	$3,515	$3,651	$3,892	$3,920
I	Job losses	68,468	57,221	42,058	45,480	50,164	51,585
I	Tax losses on production and imports (millions)*	$1,061	$704	$248	$242	$243	$239
I	Population losses	12,571	10,506	7,722	8,350	9,210	9,471
J	Income losses (millions)*	$233	$298	$316	$289	$268	$257
J	Job losses	2,272	2,597	2,780	2,850	2,935	3,064
J	Tax losses on production and imports (millions)*	$26	$33	$35	$32	$29	$28
J	Population losses	417	477	510	523	539	563
K	Income losses (millions)*	$1,282	$1,363	$1,702	$1,986	$2,168	$2,609
K	Job losses	5,018	6,859	12,154	16,898	21,398	27,413
K	Tax losses on production and imports (millions)*	$73	$49	$67	$93	$117	$151
K	Population losses	921	1,259	2,231	3,102	3,929	5,033
L	Income losses (millions)*	$16,571	$17,246	$14,600	$11,679	$9,674	$9,384
L	Job losses	100,514	107,453	96,710	86,976	85,393	94,978
L	Tax losses on production and imports (millions)*	$1,775	$1,794	$1,433	$1,032	$740	$663
L	Population losses	18,454	19,728	17,756	15,969	15,678	17,438
M	Income losses (millions)*	$8,004	$7,273	$6,468	$6,523	$6,581	$7,355
M	Job losses	56,165	61,242	66,154	76,308	87,917	104,162
M	Tax losses on production and imports (millions)*	$771	$650	$538	$531	$522	$600
M	Population losses	10,312	11,244	12,146	14,010	16,142	19,124
N	Income losses (millions)*	$732	$1,930	$3,178	$4,662	$5,998	$6,914
N	Job losses	5,955	13,686	22,208	32,324	41,429	47,613
N	Tax losses on production and imports (millions)*	$80	$170	$259	$366	$462	$529
N	Population losses	1,093	2,513	4,077	5,935	7,606	8,742
O	Income losses (millions)*	$12,745	$15,091	$14,621	$14,075	$13,806	$13,596

** Year 2018 dollars, rounded.*

Table D-1. Socioeconomic impact regional summary – continued

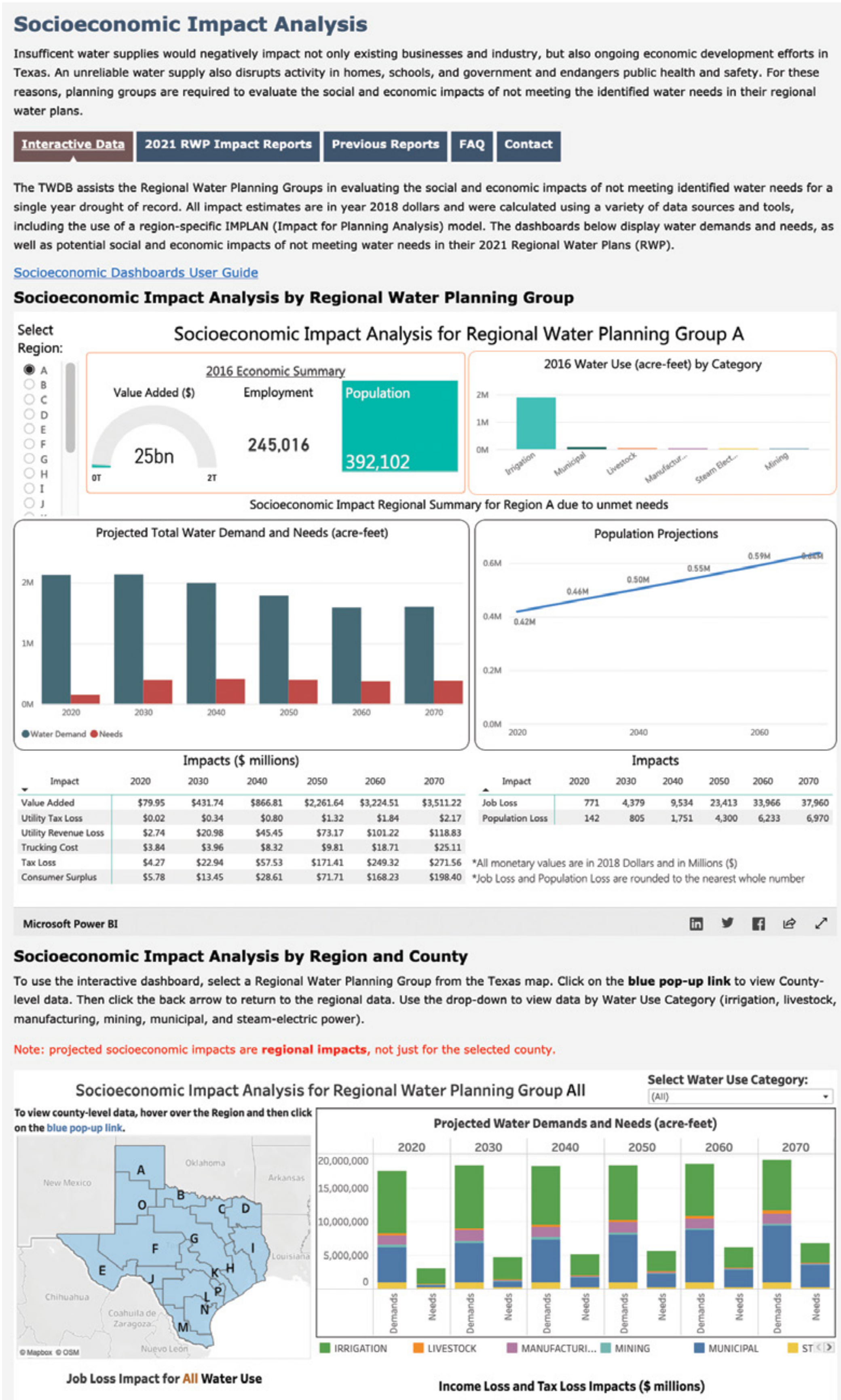
Region	Impact measures	2020	2030	2040	2050	2060	2070
O	Job losses	91,473	112,867	112,166	112,158	114,484	115,546
O	Tax losses on production and imports (millions)*	$1,076	$1,221	$1,171	$1,109	$1,076	$1,051
O	Population losses	16,794	20,722	20,594	20,592	21,019	21,214
P	Income losses (millions)*	$2	$2	$2	$2	$2	$1
P	Job losses	39	37	35	33	32	30
P	Tax losses on production and imports (millions)*	$0	$0	$0	$0	$0	$0
P	Population losses	7	7	6	6	6	5

** Year 2018 dollars, rounded.*

Interactive dashboards

The detailed socioeconomic impact data behind the summaries included in Chapter 6 are provided at the region and county level and can be explored via the TWDB's new, interactive dashboards (Figure D-1) at www.twdb.texas.gov/waterplanning/data/analysis/index.asp. The dashboards display water demands and needs, as well as potential social and economic impacts of not meeting water needs in the 2021 regional water plans.

Figure D-1. Interactive dashboards



Socioeconomic Impact Analysis

Insufficent 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.

Interactive Data | 2021 RWP Impact Reports | Previous Reports | FAQ | Contact

The TWDB assists the Regional Water Planning Groups in evaluating the social and economic impacts of not meeting identified water needs for a single year drought of record. All impact estimates are in year 2018 dollars and were calculated using a variety of data sources and tools, including the use of a region-specific IMPLAN (Impact for Planning Analysis) model. The dashboards below display water demands and needs, as well as potential social and economic impacts of not meeting water needs in their 2021 Regional Water Plans (RWP).

Socioeconomic Dashboards User Guide

Socioeconomic Impact Analysis by Regional Water Planning Group

Impacts ($ millions)

Impact	2020	2030	2040	2050	2060	2070
Value Added	$79.95	$431.74	$866.81	$2,261.64	$3,224.51	$3,511.22
Utility Tax Loss	$0.02	$0.34	$0.80	$1.32	$1.84	$2.17
Utility Revenue Loss	$2.74	$20.98	$45.45	$73.17	$101.22	$118.83
Trucking Cost	$3.84	$3.96	$8.32	$9.81	$18.71	$25.11
Tax Loss	$4.27	$22.94	$57.53	$171.41	$249.32	$271.56
Consumer Surplus	$5.78	$13.45	$28.61	$71.71	$168.23	$198.40

Impacts

Impact	2020	2030	2040	2050	2060	2070
Job Loss	771	4,379	9,534	23,413	33,966	37,960
Population Loss	142	805	1,751	4,300	6,233	6,970

*All monetary values are in 2018 Dollars and in Millions ($)
*Job Loss and Population Loss are rounded to the nearest whole number

Microsoft Power BI

Socioeconomic Impact Analysis by Region and County

To use the interactive dashboard, select a Regional Water Planning Group from the Texas map. Click on the **blue pop-up link** to view County-level data. Then click the back arrow to return to the regional data. Use the drop-down to view data by Water Use Category (irrigation, livestock, manufacturing, mining, municipal, and steam-electric power).

Note: projected socioeconomic impacts are **regional impacts**, not just for the selected county.

Texas Water Development Board

www.twdb.texas.gov

www.twdb.texas.gov/waterplanning/swp/2022

texasstatewaterplan.org