Quick Facts

Municipal conservation strategies are expected to result in about 650,000 acre-feet of supply by 2060, with irrigation and other conservation strategies totaling another 1.5 million acre-feet per year.

The planning groups recommended 26 new major reservoirs projected to generate approximately 1.5 million acre-feet per year by 2060. Other surface water strategies would result in about 3 million acre-feet per year.

Recommended strategies relying on groundwater are projected to result in about 800,000 additional acre-feet per year by 2060.

7 Water Management Strategies

The regional planning groups recommended 562 unique water supply projects designed to meet needs for additional water supplies for Texas during drought, resulting in a total, if implemented, of 9.0 million acre-feet per year in additional water supplies by 2060. Some recommended strategies are associated with demand reduction or making supplies physically or legally available to users.

After identifying surpluses and needs for water in their regions, regional water planning groups evaluate and recommend water management strategies to meet the needs for water during a severe drought. Planning groups must address the needs of all water users, if feasible. If existing supplies do not meet future demand, they recommend specific water management strategies to meet water supply needs, such as conservation of existing water supplies, new surface water and groundwater development, conveyance facilities to move available or newly developed water supplies to areas of need, water reuse, and others.

TWDB may provide financial assistance for water supply projects only if the needs to be addressed by the project will be addressed in a manner that is consistent with the regional water plans and the state water plan. This same provision applies to the granting of water right permits by the Texas Commission on Environmental Quality, although the governing bodies of these agencies may grant a waiver to the consistency requirement. TWDB funding programs that are targeted at the implementation of state water plan projects, such as the Water Infrastructure Fund, further require that projects must be recommended water management strategies in the regional water plans and the state water plan to be eligible for financial assistance.

TABLE 7.1. RECOMMENDED WATER MANAGEMENT STRATEGY SUPPLY VOLUMES BY REGION (ACRE-FEET PER YEAR)

Region	2010	2020	2030	2040	2050	2060
A	2,718	332,468	545,207	617,843	631,629	648,221
B	15,373	40,312	40,289	49,294	76,252	77,003
C	79,898	674,664	1,131,057	1,303,003	2,045,260	2,360,302
D	11,330	16,160	20,180	33,977	62,092	98,466
E	3,376	66,225	79,866	98,816	112,382	130,526
F	90,944	157,243	218,705	236,087	235,400	235,198
G	137,858	405,581	436,895	496,528	562,803	587,084
H	378,759	622,426	863,980	1,040,504	1,202,010	1,501,180
I	53,418	363,106	399,517	427,199	607,272	638,076
J	13,713	16,501	20,360	20,862	20,888	23,010
K	350,583	576,795	554,504	571,085	565,296	646,167
L	188,297	376,003	542,606	571,553	631,476	765,738
M	90,934	182,911	275,692	389,319	526,225	673,846
N	46,954	81,020	130,539	130,017	133,430	156,326
O	517,459	503,886	504,643	464,588	429,136	395,957
P	67,739	67,739	67,739	67,740	67,739	67,739
Total	**2,049,353**	**4,483,040**	**5,831,779**	**6,518,415**	**7,909,290**	**9,004,839**

7.1 EVALUATION AND SELECTION OF WATER MANAGEMENT STRATEGIES

After the water demand and supply comparisons and needs analyses were completed, planning groups evaluated potentially feasible water management strategies to meet the needs for water within their regions. A water management strategy is a plan or a specific project to meet a need for additional water by a discrete user group, which can mean increasing the total water supply or maximizing an existing supply. Strategies can include development of new groundwater or surface water supplies; conservation; reuse; demand management; expansion of the use of existing supplies such as improved operations or conveying water from one location to another; or less conventional methods like weather modification, brush control, and desalination.

Factors used in the water management strategy assessment process include

- the quantity of water the strategy could produce;
- capital and annual costs;
- potential impacts the strategy could have on the state's water quality, water supply, and agricultural and natural resources (Chapter 8, Impacts of Plans); and
- reliability of the strategy during time of drought.

Calculating the costs of water management strategies is done using uniform procedures to compare costs between regions and over time, since some strategies are recommended for immediate implementation, while others are needed decades into the future. Cost assumptions include expressing costs in 2008 dollars, using a 20-year debt service schedule, using capital costs of construction as well as annual operation and maintenance costs, and providing unit costs per acre-foot of water produced.

Reliability is an evaluation of the continued availability of an amount of water to the users over time, but particularly during drought. A water management strategy's reliability is considered high if water is determined to be available to the user all the time, but

TABLE 7.2. RECOMMENDED WATER MANAGEMENT STRATEGY SUPPLY VOLUMES BY TYPE OF STRATEGY (ACRE-FEET PER YEAR)

Type of Water Management Strategy	2010	2020	2030	2040	2050	2060
Municipal Conservation	137,847	264,885	353,620	436,632	538,997	647,361
Irrigation Conservation	624,151	1,125,494	1,351,175	1,415,814	1,463,846	1,505,465
Other Conservation *	4,660	9,242	15,977	18,469	21,371	23,432
New Major Reservoir	19,672	432,291	918,391	948,355	1,230,573	1,499,671
Other Surface Water	742,447	1,510,997	1,815,624	2,031,532	2,700,690	3,050,049
Groundwater	254,057	443,614	599,151	668,690	738,484	800,795
Reuse	100,592	428,263	487,795	637,089	766,402	915,589
Groundwater Desalination	56,553	81,156	103,435	133,278	163,083	181,568
Conjunctive Use	26,505	88,001	87,496	113,035	136,351	135,846
Aquifer Storage and Recovery	22,181	61,743	61,743	72,243	72,243	80,869
Weather Modification	0	15,206	15,206	15,206	15,206	15,206
Drought Management	41,701	461	461	461	461	1,912
Brush Control	18,862	18,862	18,862	18,862	18,862	18,862
Seawater Desalination	125	125	143	6,049	40,021	125,514
Surface Water Desalination	0	2,700	2,700	2,700	2,700	2,700
Total Supply Volumes	**2,049,353**	**4,483,040**	**5,831,779**	**6,518,415**	**7,909,290**	**9,004,839**

*Other conservation is associated with manufacturing, mining, and steam-electric power industries.

it is considered low or moderate if the availability is contingent on other factors.

The water management strategy evaluation process also considered other factors applicable to individual regions including difficulty of implementation, regulatory issues, regional or local political issues, impacts to recreation, and socioeconomic benefits or impacts.

Upon conclusion of a thorough evaluation process, planning groups recommended a combination of water management strategies to meet specific needs in their regions during a repeat of the drought of record. In this planning cycle, planning groups could also include alternative water management strategies in their plans. An alternative strategy may be substituted for a strategy that is no longer recommended, under certain conditions and with the approval of the TWDB executive administrator. All recommended and alternative water management strategies included in the 2011 regional water plans are presented in Appendix A.

7.2 SUMMARY OF RECOMMENDED WATER MANAGEMENT STRATEGIES

To meet the needs for water during a repeat of the drought of record, regional water planning groups evaluated and recommended water management strategies that would account for an additional 9.0 million acre-feet per year of water by 2060 if all are implemented (Tables 7.1 and 7.2). These strategies included 562 unique water supply projects designed to meet needs for additional water supplies for Texas during drought (this figure is lower than presented in previous plans because it does not separately count each entity participating in a given project).

7.2.1 WATER CONSERVATION

Conservation focuses on efficiency of use and the reduction of demands on existing water supplies. In 2010, almost 767,000 acre-feet per year of water conservation savings is recommended, increasing to nearly 2.2 million acre-feet per year by 2060 from all forms of conservation strategies (Table 7.3). Some of the savings from water conservation practices are achieved

TABLE 7.3. SUPPLY VOLUMES FROM RECOMMENDED CONSERVATION STRATEGIES BY REGION (ACRE-FEET PER YEAR)

Region	2010	2020	2030	2040	2050	2060
A	0	299,077	488,721	544,840	553,661	556,914
B	13,231	13,798	13,833	13,875	13,891	14,702
C	46,780	107,975	154,950	197,288	240,912	290,709
D	0	0	0	0	0	0
E	0	33,275	37,275	41,275	46,275	52,275
F	3,197	43,113	80,551	81,141	81,769	82,423
G	10,857	24,873	31,473	33,757	38,011	41,758
H	116,880	137,151	147,529	156,336	172,831	183,933
I	20,111	30,480	33,811	36,085	41,381	41,701
J	579	622	641	643	669	681
K	18,498	169,207	179,630	192,541	221,622	241,544
L	33,843	41,032	47,818	53,944	64,761	82,297
M	15,743	54,469	102,047	154,932	217,882	286,629
N	1,664	2,449	3,398	4,466	5,766	7,150
O	485,275	442,100	399,095	359,792	324,783	293,542
P	0	0	0	0	0	0
Total	**766,658**	**1,399,621**	**1,720,772**	**1,870,915**	**2,024,214**	**2,176,258**

passively in the normal course of daily activities, such as flushing a low-flow toilet or showering with a low-flow showerhead. Other savings are achieved through education and programs designed specifically to reduce water usage. Conservation includes water savings from municipal, irrigation, and "other" (mining, manufacturing, and power generation) water users. Water conservation is being recommended in greater quantities over time. Comparing the 2007 State Water Plan with the 2012 plan, there is an additional 129,400 acre-feet of water conservation recommended in the current plan.

7.2.2 SURFACE WATER STRATEGIES

Surface water strategies include stream diversions, new reservoirs, other surface water strategies such as new or expanded contracts or connection of developed supplies, and operational changes.

One long-term trend in Texas is the relative shift from reliance on groundwater to surface water. The volume of water produced by surface water strategies recommended in 2060 is five times greater than that produced by recommended groundwater strategies. Surface water strategies, excluding desalination and non-traditional strategies, compose about 51 percent of the recommended volume of new water, compared to 9 percent from groundwater strategies in the 2012 State Water Plan. Surface water management strategies recommended by the regional planning groups total in excess of 4.5 million acre-feet per year by 2060.

In the 2012 State Water Plan, 26 new major reservoirs are recommended to meet water needs in several regions (Figure 7.1). A major reservoir is defined as one having 5,000 or more acre-feet of conservation storage. These new reservoirs would produce 1.5 million acre-feet per year in 2060 if all are built, representing 16.7 percent of the total volume of all recommended strategies for 2060 combined (Figure 7.2). Not surprisingly, the majority of these projects would be located east of the Interstate Highway-35 corridor where rainfall and resulting runoff are more plentiful than in the western portion of the state.

FIGURE 7.1. RECOMMENDED NEW MAJOR RESERVOIRS.

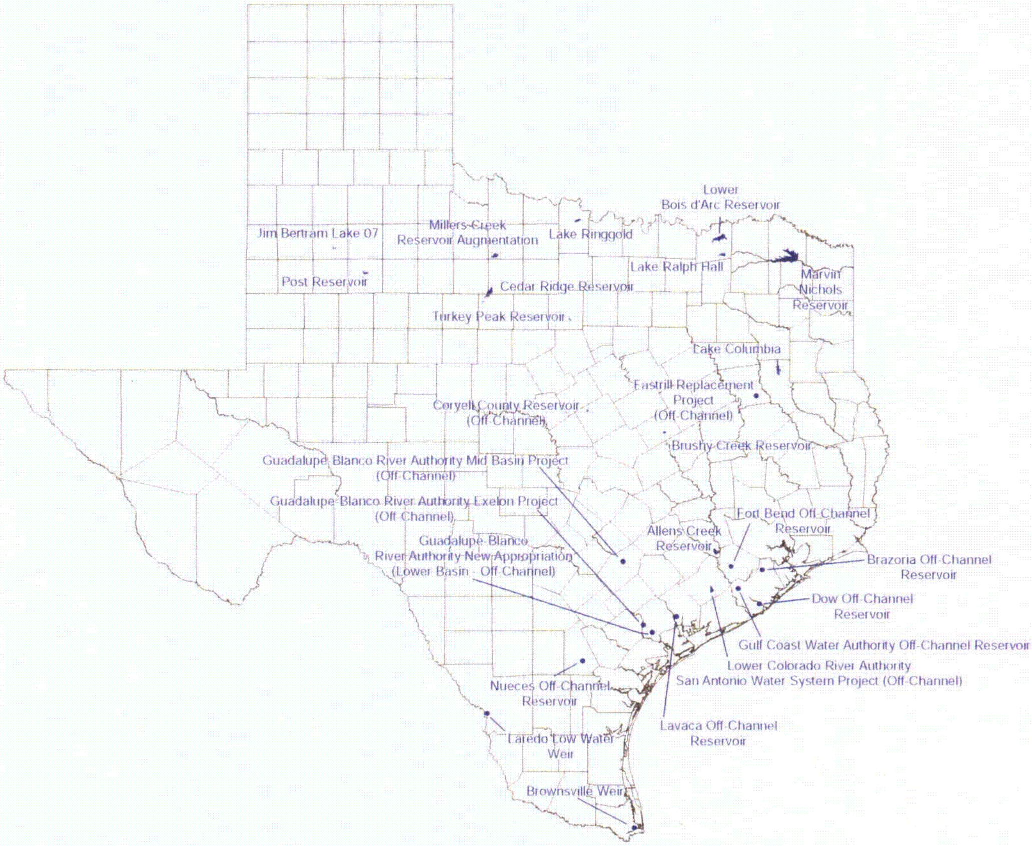


FIGURE 7.2. RELATIVE VOLUMES OF RECOMMENDED WATER MANAGEMENT STRATEGIES IN 2060.

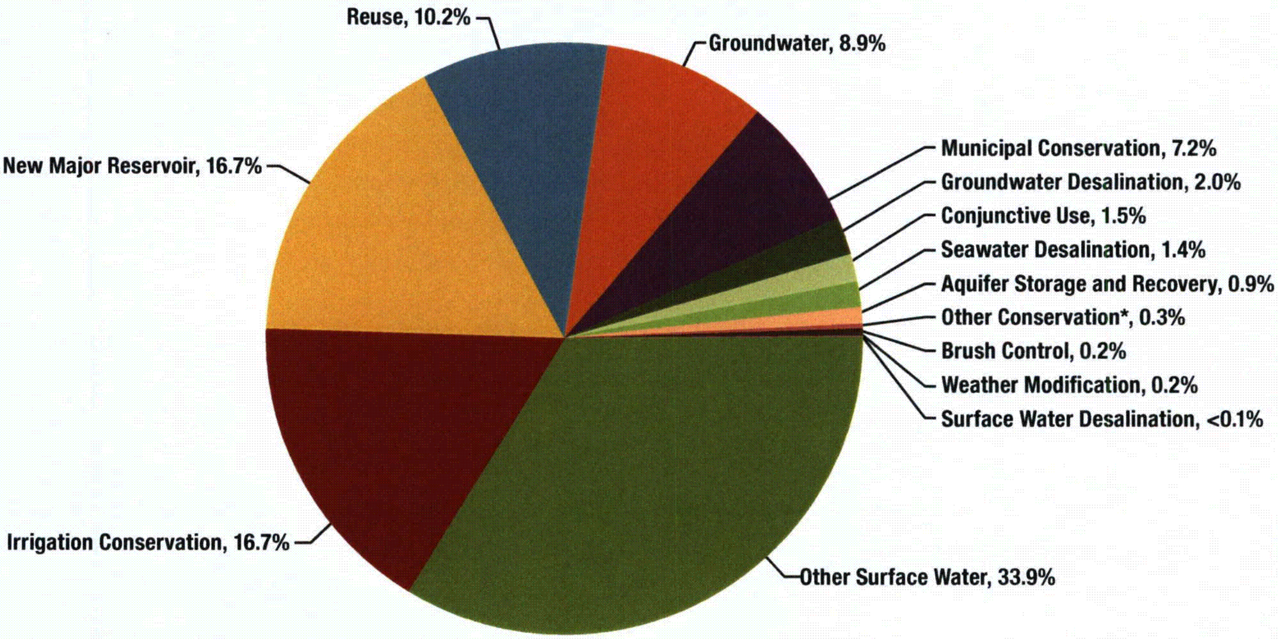
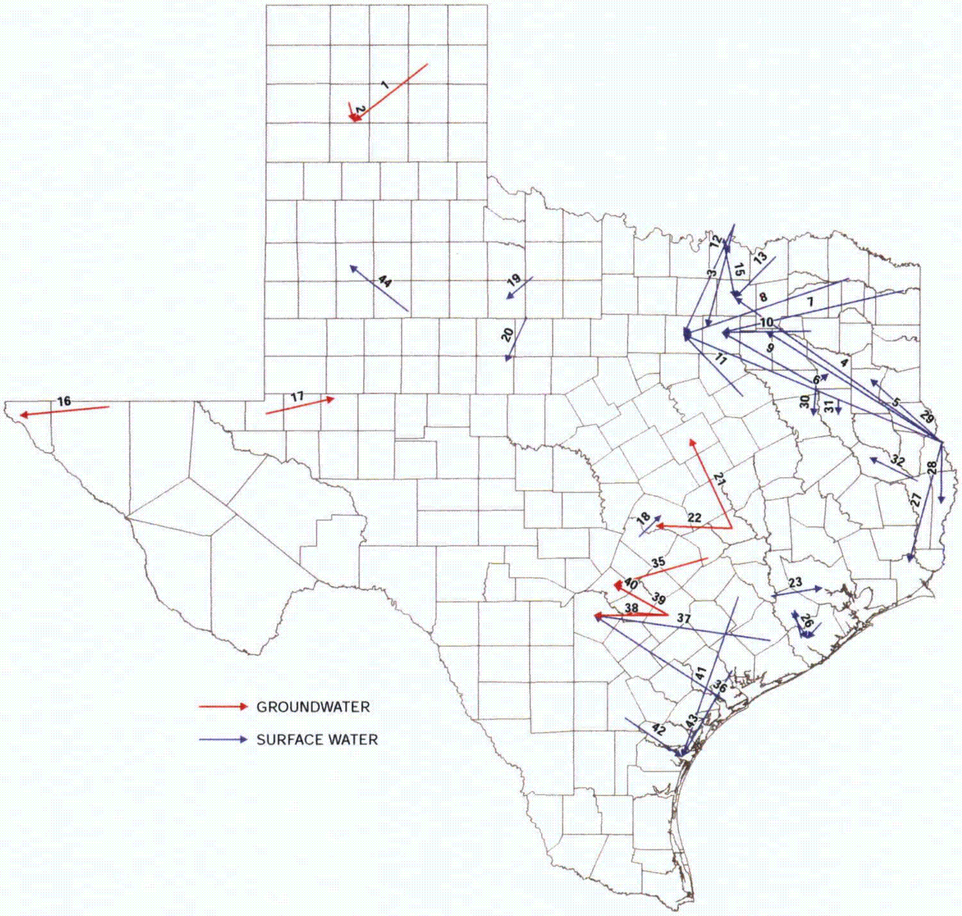


FIGURE 7.3. RECOMMENDED GROUND AND SURFACE WATER CONVEYANCE AND TRANSFER PROJECTS.



"Other surface water" strategies include existing supplies that are not physically or legally available at the present time. Examples include an existing reservoir that has no pipeline to convey water to some or all users, a water user that does not have a water supply contract with the appropriate water supplier, or an entity that has no "run-of-river" water right to divert water for use.

Other surface water strategies are recommended to provide in excess of 742,400 acre-feet per year of supply in 2010, and about 3 million acre-feet per year by 2060. Other surface water is the largest water management strategy category recommended, and usually requires additional infrastructure such as new pipelines to divert and convey water from an existing source to a new point of use. Transporting water from existing, developed sources such as reservoirs, to a new point of use many miles away, is very common in Texas and will become more prevalent in the future. An example is the current project to construct a joint pipeline from Lake Palestine to transport water to Dallas and water from Tarrant Regional Water District's lakes to Fort Worth. Figure 7.3 and Table 7.4 depict recommended major groundwater and surface water conveyance and transfer projects.

TABLE 7.4. RECOMMENDED GROUND AND SURFACE WATER CONVEYANCE AND TRANSFER PROJECTS

ID	Project	Conveyance From	To
1	Roberts County Well Field	Roberts County	Amarillo
2	Potter County Well Field	Potter County	Amarillo
3	Oklahoma Water to Irving	Oklahoma Lake/Reservoir	Irving
4	Toledo Bend Project	Toledo Bend Reservoir	Collin County
5	Toledo Bend Project	Toledo Bend Reservoir	Kaufman County
6	Toledo Bend Project	Toledo Bend Reservoir	Tarrant County
7	Wright Patman - Reallocation of Flood Pool	Wright Patman Lake	Dallas
8	Marvin Nichols Reservoir	Marvin Nichols Reservoir	Colin, Denton, Tarrant Counties
9	Lake Palestine Connection (Integrated Pipeline with Tarrant Regional Water District)	Lake Palestine	Dallas
10	Additional Pipeline From Lake Tawakoni (More Lake Fork Supply)	Lake Fork	Dallas
11	Tarrant Regional Water District Third Pipeline and Reuse	Navarro County	Tarrant County
12	Oklahoma Water to North Texas Municipal Water District, Tarrant Regional Water District, Upper Trinity Regional Water District	Oklahoma Lake/Reservoir	Colin, Denton, Tarrant Counties
13	Lower Bois D'Arc Creek Reservoir	Lower Bois D'Arc Reservoir	Collin County
14	Grayson County Project	Lake Texoma Non-System Portion	Collin, Grayson Counties
15	Lake Texoma - Authorized (Blend)	Lake Texoma North Texas Municipal Water District System	Collin County
16	Integrated Water Management Strategy - Import From Dell Valley	Dell City	El Paso
17	Develop Cenozoic Aquifer Supplies	Winkler County	Midland
18	Regional Surface Water Supply	Lake Travis	Williamson County
19	Millers Creek Augmentation	Millers Creek Reservoir	Haskell County
20	Cedar Ridge Reservoir	Cedar Ridge Reservoir	Abilene
21	Conjunctive Use (Lake Granger Augmentation)	Burleson County	Mclennan
22	Conjunctive Use (Lake Granger Augmentation)	Burleson County	Round Rock
23	Allens Creek Reservoir	Allens Creek Lake/Reservoir	Houston
24	Gulf Coast Water Authority Off-Channel Reservoir	Gulf Coast Water Authority Off-Channel Reservoir	Fort Bend County
25	Brazoria Off-Channel Reservoir	Brazoria Off-Channel Reservoir	Brazoria County
26	Fort Bend Off-Channel Reservoir	Fort Bend Off-Channel Lake/Reservoir	Brazoria County
27	Purchased Water	Toledo Bend Reservoir	Jefferson County
28	Purchased Water	Toledo Bend Reservoir	Newton County
29	Purchased Water	Toledo Bend Reservoir	Rusk County
30	Purchased Water	Lake Palestine	Anderson County
31	Lake Columbia	Lake Columbia	Cherokee County
32	Angelina County Regional Project	Sam Rayburn-Steinhagen Reservoir System	Lufkin
33	Lake Palestine Infrastructure	Lake Palestine	Tyler
34	Regional Carrizo For Schertz-Seguin Local Government Corporation Project Expansion	Gonzales County	Guadalupe County
35	Guadalupe-Blanco River Authority Simsboro Project	Lee County	Comal County
36	Seawater Desalination	Gulf Of Mexico Sea Water	Bexar County
37	Off-Channel Reservoir - Lower Colorado River Authority/ San Antonio Water System Project (Region L Component)	Colorado, Matagorda, Wharton Counties	Bexar County
38	Regional Carrizo For Saws (Including Gonzales County)	Gonzales County	Bexar County
39	Guadalupe-Blanco River Authority Mid-Basin (Surface Water)	Gonzales County	Comal County
40	Texas Water Alliance Regional Carrizo (Including Gonzales County)	Carrizo-Wilcox Aquifer	Comal County
41	Garwood Pipeline And Off-Channel Reservoir Storage	Colorado River	Corpus Christi
42	Off-Channel Reservoir Near Lake Corpus Christi	Nueces Off-Channel Reservoir	Corpus Christi
43	Lavaca River Off-Channel Reservoir Diversion Project	Lavaca Off-Channel Reservoir	Corpus Christi
44	Lake Alan Henry Pipeline	Lake Alan Henry	Lubbock

Some regions recommended operational improvement strategies for existing reservoirs to increase their efficiency by working in tandem with one or more other reservoirs as a system. "System operations" involves operating multiple reservoirs as a system to gain the maximum amount of water supply from them.

Reallocation of reservoir storage from one approved purpose to another is a strategy that was recommended by some regions to meet needs from existing reservoirs. This reallocation requires formal changes in the way reservoirs are operated and shifts more of the storage space from flood control or hydro-electric power generation to water supply. If the operational change involves a federal agency such as the U.S. Army Corps of Engineers, congressional approval is required if the reallocation involves more than 50,000 acre-feet. These operational changes may come at a cost, however. Compensation for lost electrical generation will likely be required for hydro-electric storage reallocation, and additional property damages from flooding are possible if flood storage capacity is reduced.

7.2.3 GROUNDWATER STRATEGIES

Groundwater management strategies recommended in the regional water plans total 254,057 acre-feet in 2010 and increasing to 800,795 acre-feet in 2060. Additional recommendations for groundwater desalination of 56,553 acre-feet in 2010 and 181,568 acre-feet in 2060 result in a total of 310,610 acre-feet of groundwater in 2010 and 982,363 acre-feet in 2060. Desalination of brackish groundwater and other groundwater management strategies compose about 11 percent of the total volume of water from recommended strategies in 2060. Not including desalination, the recommended groundwater strategies involve some combination of the following: 1) installing new wells; 2) increasing production from existing wells; 3) installing supplemental wells; 4) temporarily over-drafting aquifers to supplement supplies; 5) building, expanding, or replacing treatment plants to make groundwater meet water quality standards; and 6) reallocating or transferring groundwater supplies from areas where projections indicate that surplus groundwater will exist to areas with needs.

7.2.4 WATER REUSE STRATEGIES

Water management strategies involving reuse are recommended to provide roughly 100,600 acre-feet per year of water in 2010, increasing to approximately 915,600 acre-feet per year in 2060. This represents slightly more than 10 percent of the volume of water produced by all strategies in 2060. Reuse projects in the 2012 State Water Plan produce approximately 348,000 thousand acre-feet less water than those recommended in 2007. This is directly related to several recommended wastewater effluent reuse projects that were funded through TWDB's Water Infrastructure Fund and have been implemented in the intervening five-year period.

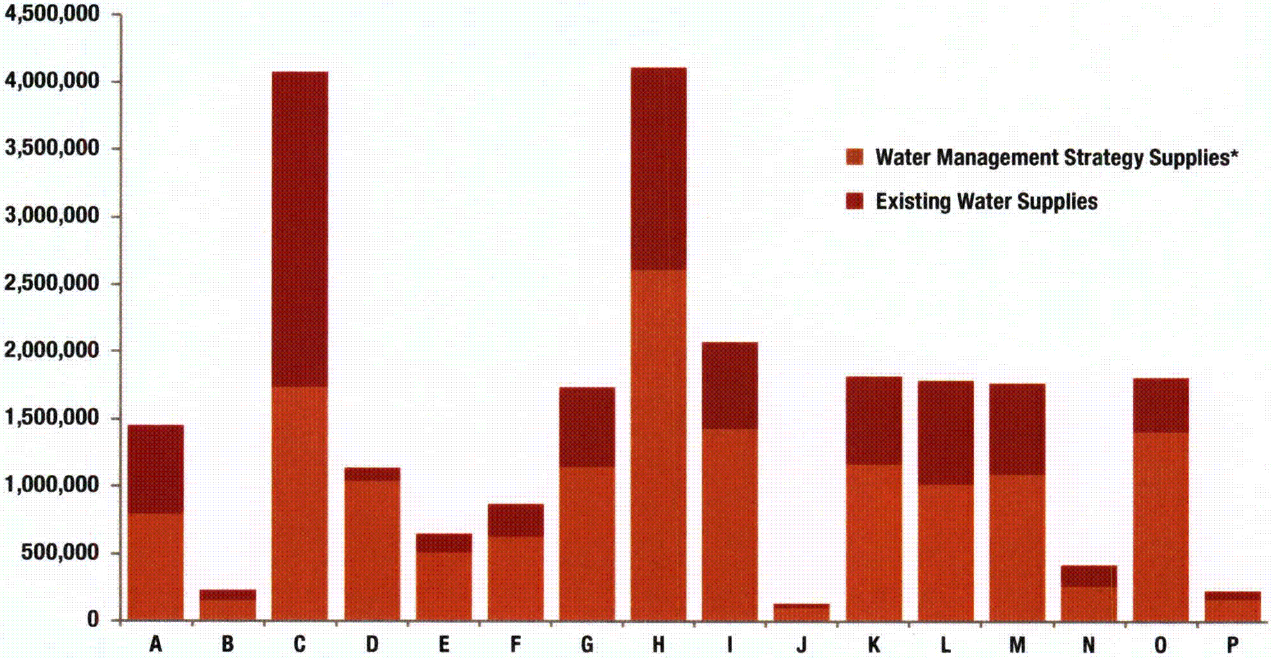
Direct reuse projects in which the wastewater never leaves the treatment system until it is conveyed through a pipeline to the point of use do not require an additional conveyance permit. These projects are commonly used to provide water for landscapes, parks, and other irrigation in many Texas communities.

Indirect reuse involves discharge of wastewater into a stream and later routing or diverting it for treatment as water supply. Since the wastewater is discharged into state water for conveyance downstream, it requires authorization known as a "bed and banks permit" from the Texas Commission on Environmental Quality.

TABLE 7.5. RECOMMENDED WATER MANAGEMENT STRATEGY CAPITAL COSTS BY REGION (MILLIONS OF DOLLARS)

Region	2010	2020	2030	2040	2050	2060	Total
A	$187	$129	$137	$287	—	—	$739
B	$110	—	—	$7	$383	—	$499
C	$9,922	$3,976	$3,891	$928	$17	$2,747	$21,482
D	$39	—	—	—	—	—	$39
E	—	$382	—	$246	$214	—	$842
F	$223	$439	$252	—	—	—	$915
G	$2,064	$745	$94	$273	$10	—	$3,186
H	$4,710	$4,922	$287	$1,135	$458	$506	$12,019
I	$363	$350	$79	$80	—	$12	$885
J	$11	$44	—	—	—	—	$55
K	$663	$67	$4	$169	—	$4	$907
L	$1,022	$2,973	$2,321	$2	$12	$1,294	$7,623
M	$2,070	$124	—	—	—	—	$2,195
N	$45	$113	$360	—	—	$139	$656
O	$669	$273	$167	—	—	—	$1,108
P	—	—	—	—	—	—	—
Total	**$22,097**	**$14,537**	**$7,592**	**$3,127**	**$1,095**	**$4,702**	**$53,150**

FIGURE 7.4. EXISTING SUPPLIES AND RECOMMENDED WATER MANAGEMENT STRATEGY SUPPLIES BY REGION (ACRE-FEET PER YEAR).



* Some water management strategies include demand reduction or shifts of existing supplies to other users.

Using artificially created wetlands to provide biological treatment such as nutrient uptake, the Tarrant Regional Water District was the first wholesale water provider in Texas to discharge treated wastewater through a natural filtering system before returning the water to its water supply lakes. This provides an additional source of water, which then can be diverted to water treatment plants for potable use. Similar indirect reuse projects are being implemented by other water suppliers in north Texas, and additional projects are in the planning stages.

7.2.5 OTHER STRATEGIES

Conjunctive use is the combined use of multiple sources that optimizes the beneficial characteristics of each source. Approximately 136,000 acre-feet of water per year is recommended by 2060 from this strategy.

Weather modification, sometimes referred to as cloud seeding, is the application of scientific technology that can enhance a cloud's ability to produce precipitation. More than 15,000 acre-feet per year of new supply is recommended from this strategy for all decades between 2020 and 2060 in Region A.

Drought management is a temporary demand reduction technique based on groundwater or surface water supply levels of a particular utility. Unlike conservation, which can be practiced most or all of the time, drought management is temporary and is usually associated with summer weather conditions. Drought management is recommended to supply nearly 2,000 acre-feet per year by 2060.

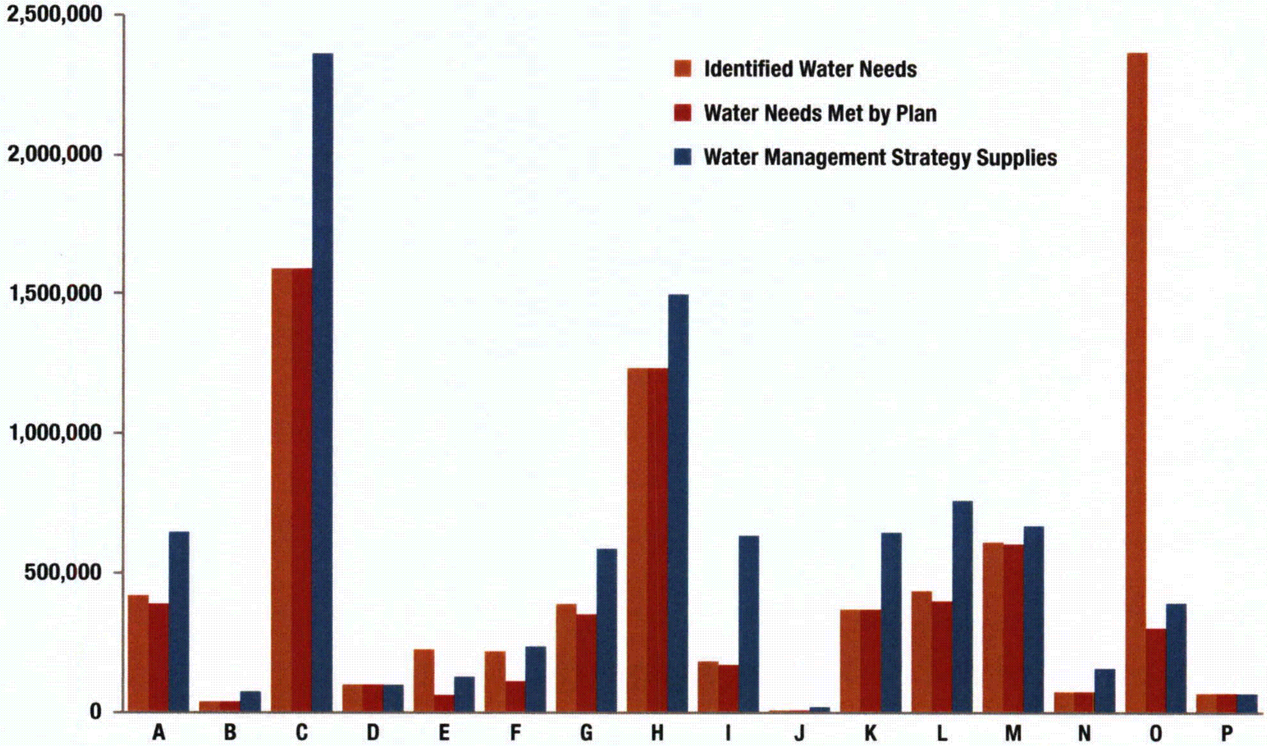
Aquifer storage and recovery refers to the practice of injecting potable water into an aquifer where it is stored for later use, often to meet summer peak usage demands. This strategy is feasible only in certain formations and in areas where only the utility owning the water can access it. It is recommended to provide almost 81,000 acre-feet per year by 2060.

Brush control and other land stewardship techniques have been recommended for many areas in the western half of the state. Removing ash juniper and other water consuming species has been shown in studies to restore springflow and improve surface water runoff in some cases. However, since water produced by this strategy during a drought when little rainfall occurs is difficult to quantify, it is not often recommended as a strategy to meet municipal needs. Brush control is recommended to supply approximately 19,000 acre-feet per year in all decades between 2010 and 2060.

Desalination, the process of removing salt from seawater or brackish water, is expected to produce nearly 310,000 acre-feet of potable water by 2060. Improvements in membrane technology, new variations on evaporative-condensation techniques, and other more recent changes have made desalination more cost-competitive than before. However, it is a very energy-intensive process and power costs have a significant effect on the price of produced water.

Rainwater harvesting is the capture, diversion, and storage of rainwater for landscape irrigation, drinking and domestic use, aquifer recharge, and stormwater abatement. Rainwater harvesting helps reduce outdoor irrigation demands on potable water systems. While it is often a component of municipal water conservation programs, rainwater harvesting was not recommended as a water management strategy to meet needs since, like brush control, the volume of water may not be available during drought conditions.

FIGURE 7.5. WATER NEEDS, NEEDS MET BY PLANS, AND STRATEGY SUPPLY BY REGION (ACRE-FEET PER YEAR).



DROUGHT MANAGEMENT

On April Fool's Day in 1911, legendary Texas cattleman and oil pioneer, W.T. "Tom" Waggoner, discovered oil on his family's ranch near Electra. In the midst of one of the worst droughts on record, he exclaimed, "Damn the oil, I need water for my cattle." (Time Magazine US, 2011).

Though his perspective may have changed with the expansion of the Waggoner ranching and oil empire, water has remained scarce in the region, particularly during times of drought. Nearly a century later, the town of Electra—named after Tom Waggoner's daughter—faced a desperate situation during the drought of 2000. With a mere 45-day water supply, the town imposed severe water restrictions. Residents were limited to 1,000 gallons of water per person per month, about a third of an average American's typical water use. All outdoor watering was banned and people were asked to use their toilets five times before flushing (CNN, 2000).

Drought management strategies, such as those used in Electra in 2000, are temporary measures that are used to reduce water demand during a drought. All wholesale and retail public water suppliers and irrigation districts in Texas must include these measures in drought contingency plans as required by the Texas Water Code. In Region B and many areas of Texas, water conservation and drought management are a way of life.

7.3 WATER MANAGEMENT STRATEGY TOTALS AND COSTS

As discussed further in Chapter 9 (Financing Needs), the total capital costs of the 2012 State Water Plan—representing all of the water management strategies recommended by the regional water planning groups—is $53 billion. The estimated capital costs of strategy implementation has increased significantly from the 2007 estimate of $31 billion, and it does not include annual costs such as operational and maintenance costs (Table 7.5). The increase in costs is attributable to several factors, including an increased volume of strategies in areas of high population growth, increased construction costs, increased costs of purchasing water rights, increased land and mitigation costs, and the addition of new projects to address uncertainty and other considerations.

In general, recommended water management strategy supply volumes increased significantly over the 50-year planning period due to the anticipated increase in population and water demands, coupled with a reduction of current supplies over time. In Figure 7.4, the total water supply volume from all recommended water management strategies for each region is shown in addition to the current water supplies. The total in this figure is not the total water available to the region because water management strategies include redistribution of existing supplies and water conservation, which are reductions in demands.

Some regions recommended water management strategies that would provide water in excess of their identified needs. This was done for various reasons including uncertainty in the ability of a strategy to be implemented; recommending the ultimate capacity of the strategy such as a reservoir in a decade before the entire firm yield is needed; potential acceleration of population and demand growth; and uncertainty related to demand and supply projections, due to various factors such as climate variability or the possibility of a drought worse than the drought of record (Figure 7.5).

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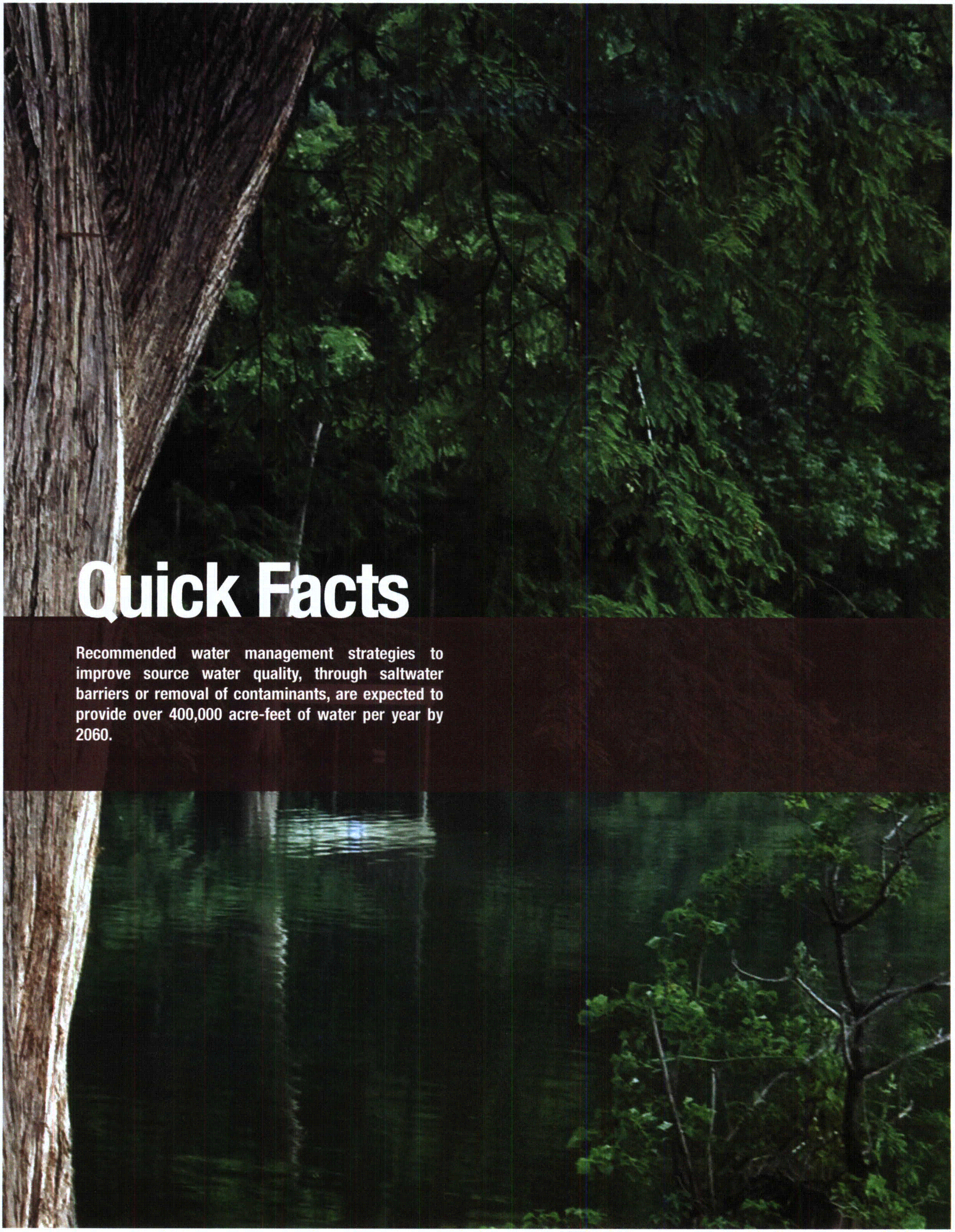


Quick Facts

Recommended water management strategies to improve source water quality, through saltwater barriers or removal of contaminants, are expected to provide over 400,000 acre-feet of water per year by 2060.

8 Impacts of Plans

Regional water plans take into account potential impacts on water quality and consistency with long-term protection of the state's water, agricultural, and natural resources.

During preparation of their plans, regional water planning groups evaluate how the implementation of recommended and alternative water management strategies could affect water quality in Texas. Each regional water plan includes a description of the potential major impacts of recommended strategies on key parameters of water quality, as identified by the planning group as important to the use of the water resource within their regions. The plans compare current conditions to future conditions with the recommended water management strategies in place.

Each regional water plan must also describe how it is consistent with long-term protection of the state's water, agricultural, and natural resources. To accomplish this task, planning groups estimate the environmental impacts of water management strategies and identify specific resources important to their planning areas, along with how these resources are protected through the regional water planning process.

8.1 WATER QUALITY

Water quality is an important consideration in water supply planning. Water quality affects the suitability of water for drinking, agriculture, industry, or other uses. Water quality concerns may determine how much water can be withdrawn from a river or stream without causing significant damage to the environment. These issues are important to planners and water providers because of the impact existing water quality can have on the cost of treating water to drinking water standards. The quality of surface water and groundwater is affected by its natural environment as well as by contamination through human activity.

The implementation of recommended water management strategies can potentially improve or degrade water quality. In their evaluation and choices of water management strategies, each planning group must consider water quality in the region. This includes identifying current water quality concerns, as well as the impacts that recommended water management strategies may have on water quality parameters or criteria.

8.1.1 SURFACE WATER QUALITY

Water quality is an integral component of the overall health of surface water bodies and impacts the treatment requirements for the state's water supply. The state surface water quality programs are based on the federal Clean Water Act and the Texas Water Code, with the Texas Commission on Environmental Quality having jurisdiction over the state's surface water quality programs, as delegated by the U.S. Environmental Protection Agency.

The Texas Commission on Environmental Quality sets surface water quality standards as goals to maintain the quality of water in the state. A water quality standard is composed of two parts: a designated use and the criteria necessary to attain and maintain that use. The three basic designated water uses for site-specific water quality standards are

- domestic water supply (including fish consumption),
- recreation, and
- aquatic life.

Surface Water Quality Parameters

The regional water planning groups use parameters from the Texas Surface Water Quality Standards to evaluate water quality impacts of the recommended water management strategies. These standards include general criteria for pollutants that apply to all surface waters in the state, site-specific standards, and additional protection for classified water bodies that are defined in the standards as being of intermediate, high, or exceptional quality. The following parameters are used for evaluating the support of designated uses:

- **Total Dissolved Solids (Salinity):** For most purposes, salinity is considered equivalent to total dissolved solids content. Salinity concentration determines whether water is acceptable for drinking water, livestock, or irrigation. Low salinity is considered 'fresh' water and is generally usable for all applications. Slightly saline water may be used to irrigate crops, as well as to water livestock, depending on the type of crop and the levels of solids in the water. Several river segments in the state have relatively moderate concentrations of salts including the upper portions of the Red and Wichita rivers in Region B; the Colorado River in Region F; and the Brazos River in Regions G and O. These regions have recommended water management strategies to address salinity issues.
- **Nutrients:** A nutrient is classified as a chemical constituent, most commonly a form of nitrogen or phosphorus, that can contribute to the overgrowth of aquatic vegetation and impact water uses in high

concentrations. Nutrients from permitted point source discharges must not impair an existing, designated, presumed, or attainable use. Site-specific numeric criteria for nutrients are related to the concentration of chlorophyll *a* in water and are a measure of the density of phytoplankton.

- **Dissolved Oxygen:** Dissolved oxygen concentrations must be sufficient to support existing, designated, presumed, and attainable aquatic life uses in classified water body segments. For intermittent streams with seasonal aquatic life uses, dissolved oxygen concentrations proportional to the aquatic life uses must be maintained during the seasons when the aquatic life uses occur. Unclassified intermittent streams with perennial pools are presumed to have a limited aquatic life use and correspondingly lower dissolved oxygen criteria.
- **Bacteria:** Some bacteria, although not generally harmful themselves, are indicative of potential contamination by feces of warm-blooded animals. Water quality criteria are based on these indicator bacteria rather than direct measurements of pathogens primarily because of cost, convenience, and safety. An applicable surface water use designation is not a guarantee that the water so designated is completely free of disease-causing organisms. Even where the concentration of indicator bacteria is less than the criteria for primary or secondary contact recreation, there is still some risk of contracting waterborne diseases from the source water without treatment.
- **Toxicity:** Toxicity is the occurrence of adverse effects to living organisms due to exposure to a wide range of toxic materials. Concentrations of chemicals in Texas surface waters must be maintained at sufficiently low levels to preclude adverse toxic effects on aquatic life, terrestrial life, livestock/domestic animals, and human health resulting from contact recreation, consumption of aquatic organisms, consumption of drinking water, or any combination of the three. Surface waters with sustainable fisheries or public drinking water supply uses must not exceed applicable human health toxic criteria, and those waters used for domestic water supply must not exceed toxic material concentrations that prevent them from being treated by conventional methods to meet federal and state drinking water standards.

Surface Water Quality Monitoring and Restoration Programs

The Texas Commission on Environmental Quality coordinates the cooperative multi-stakeholder monitoring of surface water quality throughout the state, regulates and permits wastewater discharges, and works to improve the quality of water body segments that do not meet state standards.

To manage the more than 11,000 named surface water bodies in the state, the Texas Commission on Environmental Quality has subdivided the most significant rivers, lakes, wetlands, and estuaries into classified segments. A segment is that portion of a water body that has been identified as having homogenous physical, chemical, and hydrological characteristics. As displayed in the *Atlas of Texas Surface Waters* (TCEQ, 2004) classified segments are water bodies (or a portion of a water body) that are individually defined in the state surface water quality standards.

Water body segments that exceed one or more water quality standards are considered to be impaired. A list of these impaired segments is submitted to the U.S. Environmental Protection Agency, as required under Section 303(d) of the Clean Water Act. The *2008 Texas Water Quality Inventory and 303(d) List* (TCEQ, 2011) identifies 386 impaired water body segments in Texas (Figure 8.1).

Several state programs have been developed by the Texas Commission on Environmental Quality in partnership with stakeholders to determine whether water quality standards have been attained in individual water bodies and to plan and implement best management practices in an effort to restore impaired water resources. These include the Surface Water Quality Monitoring program, the Clean Rivers program, the Total Maximum Daily Load program, and the Nonpoint Source Pollution program. The regional water planning groups use information and data from these programs during their water management strategy evaluation processes.

8.1.2 GROUNDWATER QUALITY

Groundwater accounts for almost 60 percent of the water used in Texas. In its natural environment, groundwater slowly dissolves minerals as it recharges and flows through an aquifer. In many cases, these dissolved minerals are harmless at the levels in which they are naturally present in the groundwater. However, in some cases, groundwater may dissolve excessive amounts of certain minerals, making it unsuitable for some uses.

Other groundwater contamination may also result from human activities, such as leakage from petroleum storage tank systems, salt water disposal pits, pipelines, landfills, and abandoned wells, as well as infiltration of pesticides and fertilizers. These types of contamination are often localized but can also be widespread, covering large areas that are used for agriculture or oil and gas production.

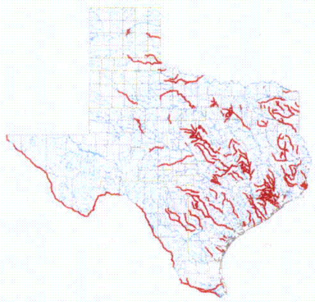
Although there are no equivalent water quality standards for groundwater as exists for surface water, the Texas Water Code provides general powers to groundwater conservation districts to make and enforce rules to prevent degradation of water quality.

Common Groundwater Quality Parameters

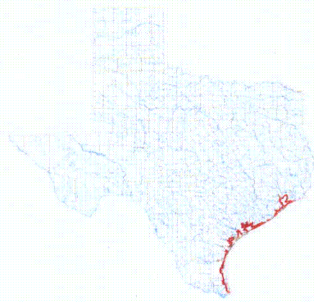
Below are a few of the more common drinking water parameters used in assessment of public water supplies that are applicable to groundwater quality:

- **Total Dissolved Solids (Salinity):** As was noted with surface water, total dissolved solids are a measure of the salinity of water and represent the amount of minerals dissolved in water. Moderately saline groundwater is defined as 'brackish' and is a viable potential water source for desalination treatment to make it suitable for public consumption. Much of the groundwater in the state's aquifers is fresh; however, brackish groundwater is more common than fresh in the southern Gulf Coast Aquifer and in aquifers in many parts of west Texas.
- **Nitrates:** Although nitrates exist naturally in groundwater, elevated levels generally result from human activities, such as overuse of fertilizer and improper disposal of human and animal waste. High levels of nitrates in groundwater often coexist with other contaminants. Human and animal waste sources of nitrates will often contain bacteria, viruses, and protozoa; fertilizer sources of nitrates usually contain herbicides and pesticides. Groundwater in Texas that exceeds this drinking water standard for nitrates is located mostly in the Ogallala and Seymour aquifers, although parts of the Edwards-Trinity (High Plains), Dockum, and Trinity aquifers are also affected.
- **Arsenic:** Although arsenic can occur both naturally and through human contamination, most of the arsenic in Texas groundwater is naturally occurring. Most of the groundwater supplies in Texas that exceed standards occur in the southern half of the Ogallala Aquifer, the Hueco-Mesilla

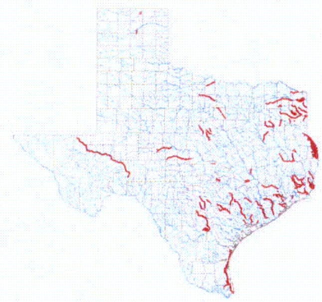
BACTERIA IMPAIRMENT



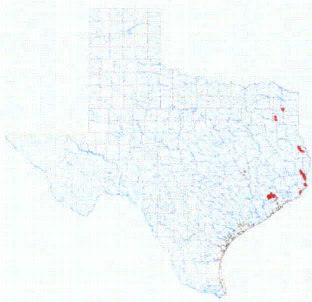
BACTERIA IMPAIRMENT FOR OYSTERS



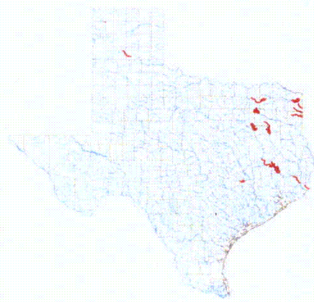
DISSOLVED OXYGEN IMPAIRMENT



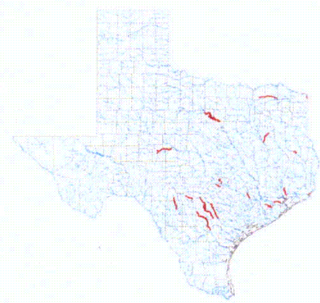
TOXICITY IMPAIRMENT



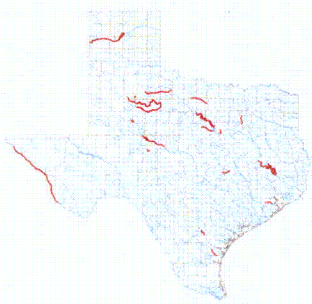
PH IMPAIRMENT



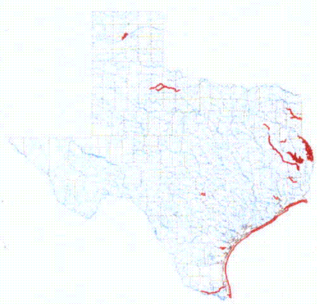
BIOLOGICAL INTEGRITY IMPAIRMENT



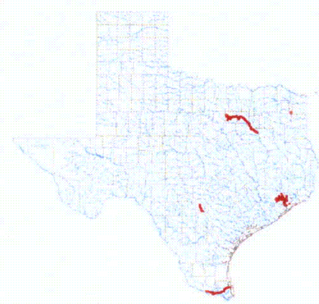
DISSOLVED SOLIDS IMPAIRMENT



METALS IMPAIRMENT



ORGANICS IMPAIRMENT



NITRATE AND NITRITE IMPAIRMENT

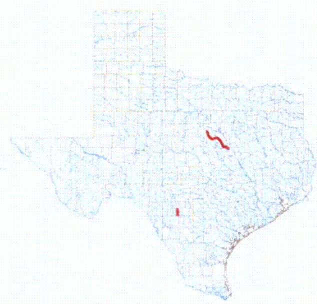


FIGURE 8.1. IMPAIRED RIVER SEGMENTS AS DEFINED BY SECTION 303(D) OF THE CLEAN WATER ACT (TCEQ, 2008).

Bolsons, and the West Texas Bolsons located in the western portions of Texas, as well as in the Gulf Coast Aquifer in southeast Texas (Figure 8.2).

- **Radionuclides:** A radionuclide is an atom with an unstable nucleus that emits radiation. Most groundwater in Texas with gross alpha radiation greater than the maximum acceptable level is found in the Hickory Aquifer in central Texas and the Dockum Aquifer of west Texas (Figure 8.3). The Edwards-Trinity (Plateau), Gulf Coast, and Ogallala aquifers also have significant numbers of wells with high levels of gross alpha radiation. Although contamination from human activity can be a source of radionuclides, most of the radionuclides in Texas groundwater occur naturally. Where radionuclides are found in drinking water supplies, communities and water providers must provide additional levels of water treatment to remove the radionuclides, blend the groundwater with surface water to dilute the radionuclide concentration, or find an alternative source of drinking water.

Groundwater Quality Monitoring and Restoration Programs

The Texas Groundwater Protection program, administered by the Texas Commission on Environmental Quality, supports and coordinates the groundwater monitoring, assessment, and research activities of the interagency Texas Groundwater Protection Committee, made up of nine state agencies as well as the Texas Alliance of Groundwater Districts. The Texas Groundwater Protection Committee publishes an annual report describing the status of current groundwater monitoring programs to assess ambient groundwater quality and also contains current documented regulatory groundwater contamination cases within the state and the enforcement status of each case. As part of its efforts to monitor groundwater quality, TWDB is currently funding research on the effects of natural and human influences on groundwater quantity.

8.1.3 POTENTIAL IMPACTS OF RECOMMENDED WATER MANAGEMENT STRATEGIES ON WATER QUALITY

To assess how the implementation of 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.

Regional water planning groups presented high-level assessments of how the implementation of strategies could potentially affect the water quality of surface water and groundwater sources. Regions used different approaches, including categorical assessments (such as "low" "moderate," or "high"), or numerical impact classifications such as "1-5." Statewide, about a third of the recommended water management strategies were designated by the regional water planning groups to have no adverse impacts, while more than half were estimated to only have low or minimum impacts. Approximately 10 percent were classified as having medium or moderate impacts to water quality. No water management strategies recommended by the regional water planning groups were expected to have a high impact on water quality.

Although many recommended water management strategies include water treatment as part of the project implementation, seven regional water planning areas recommended water management strategies whose primary goal is to improve the quality of the source water. These include saltwater barriers to reduce

FIGURE 8.2. IMPAIRED GROUNDWATER WELLS/AQUIFERS FOR ARSENIC.

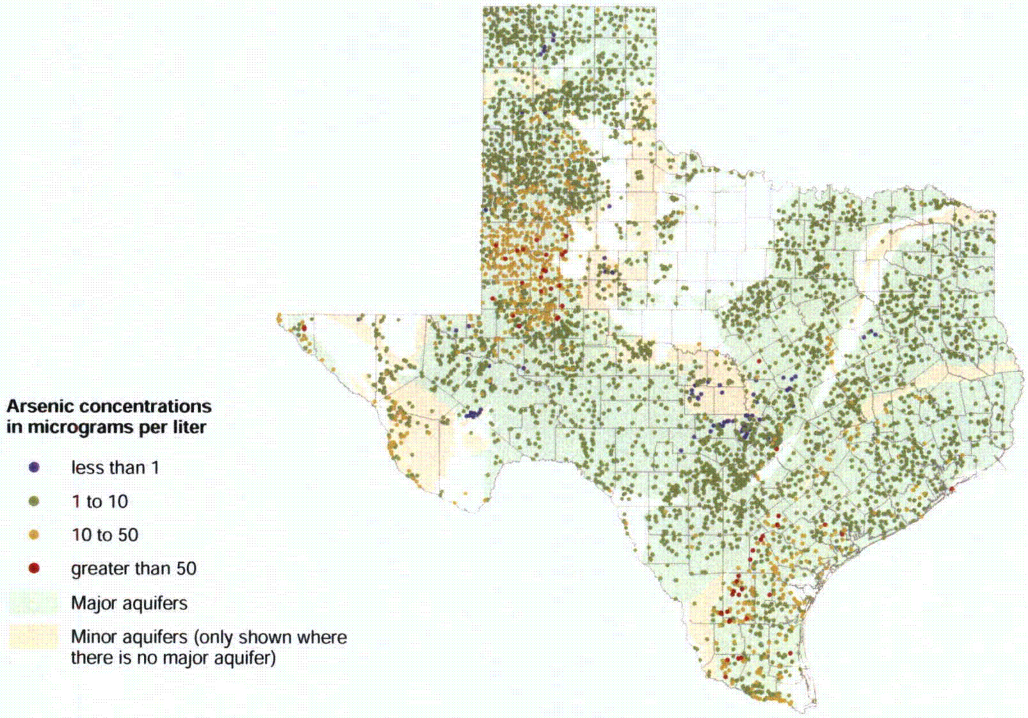
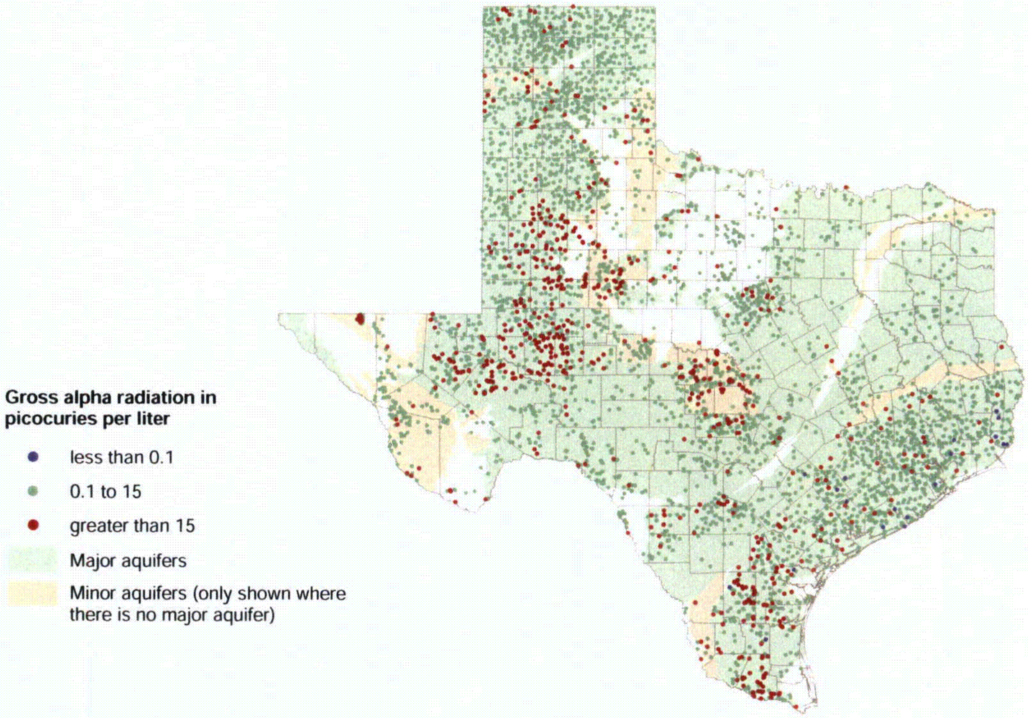


FIGURE 8.3. IMPAIRED GROUNDWATER WELLS/AQUIFERS FOR RADIONUCLIDES.



inflow of saline waters into receiving streams as well as removal of contaminants such as nitrates, arsenic, and radionuclides from surface water and groundwater. Statewide, these strategies will improve over 400,000 acre-feet of water per year by 2060 (Table 8.1).

Several other recommended water management strategies are anticipated to have a secondary benefit of improving the quality of the source water, primarily by reducing the volume of high total dissolved solids effluent flows and contaminants into receiving waters. Examples of these strategies include on-farm reuse, irrigation scheduling, and direct and indirect reuse.

8.2 POTENTIAL IMPACTS TO THE STATE'S WATER, AGRICULTURAL, AND NATURAL RESOURCES

In addition to considering the potential impact of strategies on water quality, planning groups also evaluated the potential impacts of each water management strategy on the state's water, agricultural, and natural resources. In analyzing the impact of water management strategies on the state's water resources, the planning groups honored all existing water rights and contracts and considered conservation strategies for all municipal water user groups with a water supply need. They also based their analyses of environmental flow needs for specific water management strategies on Consensus Criteria for Environmental Flow Needs or site-specific studies (Chapter 5, Water Supplies). In addition, planning groups were required to consider water management strategies to meet the water supply needs of irrigated agriculture and livestock production.

Planning groups determined mitigation costs and quantified the potential of impacts for all water management strategies considered. Some used categorical assessments describing impacts as "high," "moderate," and "low." These ratings were based on existing data and the potential to avoid or mitigate impacts to agricultural and natural resources. For example, a "low" rating implied that impacts could be avoided or mitigated relatively easily. In contrast, a "high" rating implied that impacts would be significant and mitigation requirements would be substantial. Other planning groups used a numerical rating that indicated the level of impact. Many planning groups based their ratings on factors such as the volume of discharges a strategy would produce or the number of irrigated acres lost. Another approach relied on identifying the number of endangered or threatened species listed in a county with a proposed water source.

In general, most planning groups relied on existing information for evaluating the impacts of water management strategies on agricultural and natural resources. However, some regions performed region-wide impact analyses to evaluate potential cumulative impacts. For example, because of the close connection between the Edwards Aquifer, spring and river flows, and bay and estuary inflows, Region L developed an overall impact analysis that took into account many factors including draw-down of aquifers, impacts on spring flows, ecologically significant stream segments, bay and estuary inflows, vegetation and habitat, cultural resources, as well as endangered and threatened species.

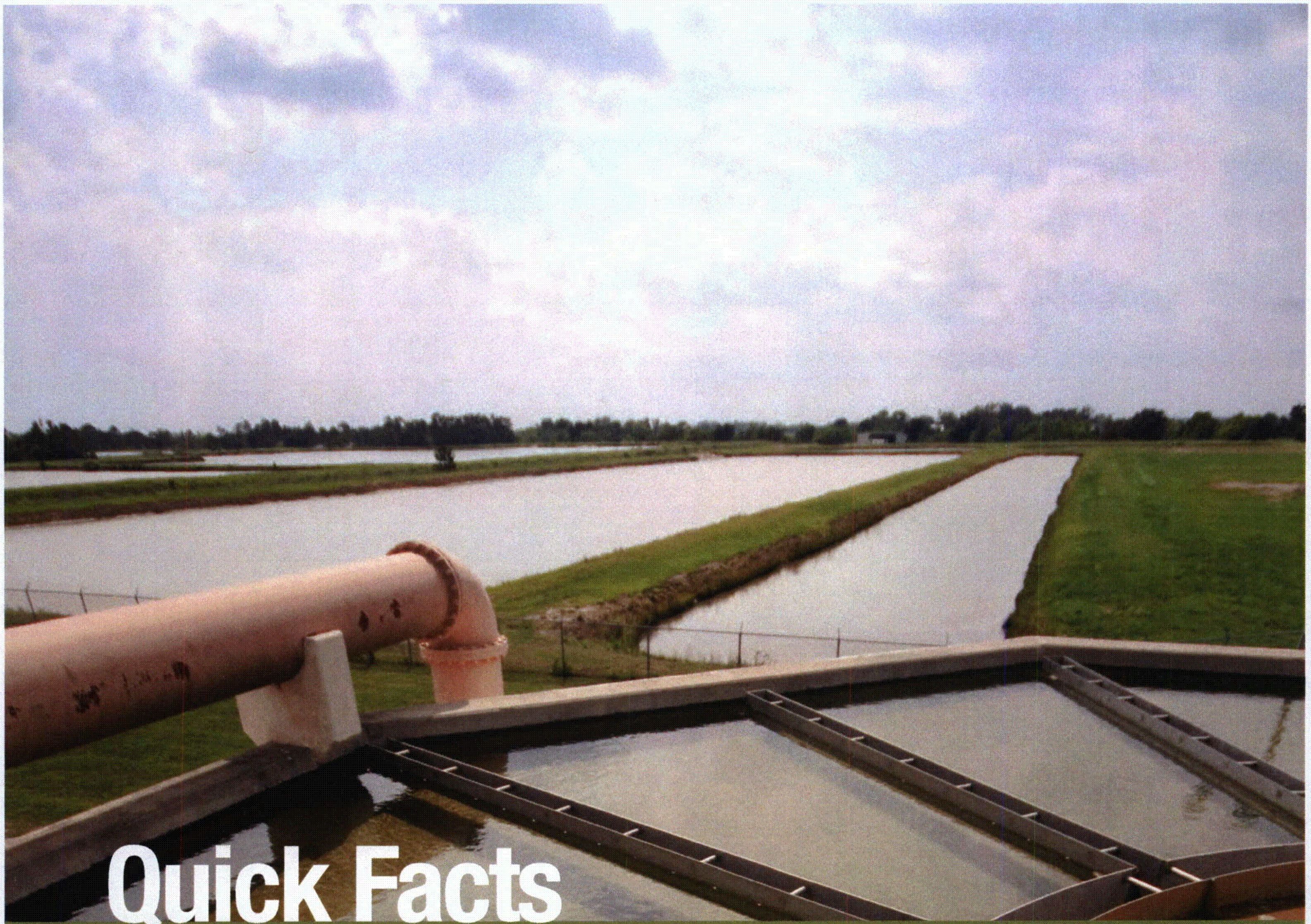
REFERENCES

TCEQ (Texas Commission on Environmental Quality), 2004, Atlas of Texas Surface Waters: Texas Commission on Environmental Quality Publication Number GI-316, http://www.tceq.texas.gov/publications/gi/gi-316/gi-316_intro.html/at_download/file.

TABLE 8.1. WATER MANAGEMENT STRATEGIES DESIGNED TO IMPROVE SOURCE WATER QUALITY

Region	Water Management Strategy Name	Description	Annual Volume in 2060 (acre-feet)
B	Nitrate removal plant	Removal of moderate to high levels of nitrate from the Seymour Aquifer	50
B	Wichita Basin chloride control project	Designed to reduce the amount of salt contamination from eight of the Red River Basin's natural salt sources; three of which lie within the Wichita River Basin.	26,500
C	Lake Texoma - authorized (blend)	Blending groundwater with surface water to decrease total dissolved solids concentration.	113,000
C	Tarrant Regional Water District Wetlands Project	Additional teriary treatment via wetlands for conventionally treated wastewater prior to release into receiving reservoir (Richland-Chambers and Cedar Creek Reservoir)	105,500
E	Arsenic removal facility	Removes naturally occurring arsenic from groundwater that exceeds newly revised drinking water standards	276
E	Integrated water management strategy for the City and County of El Paso - desalination of agricultural drain water	Surface water quality improvement (new this planning cycle): will treat agricultural drain water at the end of the irrigation season, when the level of dissolved salts becomes too high for conventional treatment	2,700
F	Bottled water program	Water quality improvement - no cost effective resolution for current poor quality groundwater source	1
F	Develop Ellenburger Aquifer supplies	Blending groundwater with surface water to decrease concentration of naturally occurring radionuclides	200
F	Develop Hickory Aquifer supplies	Blending groundwater with surface water to decrease concentration of naturally occurring radionuclides	12,160
G	Groundwater-Surface Water Conjunctive Use (Lake Granger Augmentation)	Blending groundwater with surface water to decrease concentration of contaminants	70,246
G	Stonewall, Kent, and Garza Chloride Control Project	Improve surface water quality by using brine recovery wellfields for saline aquifers; this will decrease amount of salt leaching into tributaries to the Brazos River; market brine products to cover annual costs; volume of water with improved water quality undetermined at this time	n/a
H	Brazos Saltwater Barrier	Improve surface water quality in the lower Brazos Basin during low flow periods, by preventing seawater intrusion at raw water intake structures; volume of water with improved water quality undetermined at this time	n/a
I	Saltwater Barrier Conjunctive Operation with Rayburn/Steinhagen	Improve surface water quality by impeding salt water intrusion into the Neches River downstream of reservoirs so released water remains salt free for downstream diversion.	111,000
	Total		**441,663**

TCEQ (Texas Commission on Environmental Quality), 2011, 2008 Texas Water Quality Inventory and 303(d) List; Texas Commission on Environmental Quality, http://www.tceq.texas.gov/waterquality/assessment/08twqi/twqi08.html.



Quick Facts

The capital cost of the 2012 State Water Plan is about 23 percent of the $231 billion in the total costs for water supplies, water treatment and distribution, wastewater treatment and collection, and flood control required for the state of Texas in the next 50 years.

The 80th and 81st Texas Legislatures provided funding to implement recommended water management strategies to meet the needs for additional water supply needs during times of drought, enabling the issuance of over $1.47 billion in bonds to finance state water plan projects at below market rates. This funding is expected to have an economic impact resulting in the generation of $2.6 billion in additional sales revenue and over 19 thousand jobs.

In addition to dedicated appropriations for State Water Plan financial assistance, TWDB has provided over $530 million in additional funding to implement strategies recommended in the 2007 State Water Plan through Economically Distressed Areas Program, Texas Water Development Fund, Water Assistance Fund, Rural Water Assistance Fund, and the Drinking Water State Revolving Fund.

9 Financing Needs

The capital cost to design, construct, or implement the strategies and projects is $53 billion and represents about only about a quarter of the total needs for water supplies, water treatment and distribution, wastewater treatment and collection, and flood control required for the state of Texas in the next 50 years.

During the regional water planning process, planning groups estimated the costs of potentially feasible water management strategies. The total estimated capital cost of the 2012 State Water Plan, representing all of the strategies recommended by the regional water planning groups, is $53 billion. This amount is about 23 percent of the $231 billion in the total costs for water supplies, water treatment and distribution, wastewater treatment and collection, and flood control required for the state of Texas in the next 50 years. Water providers reported an anticipated need of $26.9 billion from state financial assistance programs to help implement recommended strategies for municipal water user groups in the 2012 State Water Plan. A number of state and federal financial assistance programs are available to aid in implementation of water supply projects; however, there is still a need for a long-term, affordable, and sustainable method to provide financial assistance for the implementation of state water plan projects.

9.1 COSTS OF IMPLEMENTING THE STATE WATER PLAN

As part of their evaluations, regional water planning groups estimate the costs of potentially feasible water management strategies that are under consideration during the planning process. These include the costs to develop a new source of water needed during times of drought, the costs of infrastructure needed to convey the water from the source to treatment facilities, and the costs to treat the water for end users. Water management strategies in the regional water plans do not include costs associated with internal system distribution facilities or aging infrastructure needs, unless the strategy increases available supply through water conservation or reduction of water loss in a system.

Water management strategy cost estimates include direct and indirect capital costs, debt service, and annual operating and maintenance expenses each decade over the planning horizon, as follows:

Capital Costs: Capital costs include engineering and feasibility studies, including those for permitting and mitigation, construction, legal assistance, financing, bond counsel, land and easements costs, and purchases of water rights. Construction costs include expenses for infrastructure such as pump stations, pipelines, water intakes, water treatment and storage facilities, well fields, and relocation of existing infrastructure such as roads and utilities. All costs are reported in constant September 2008 U.S. dollars per the Engineering News-Record Construction Cost Index, which is used throughout the U.S. construction industry to calculate building material prices and construction labor costs.

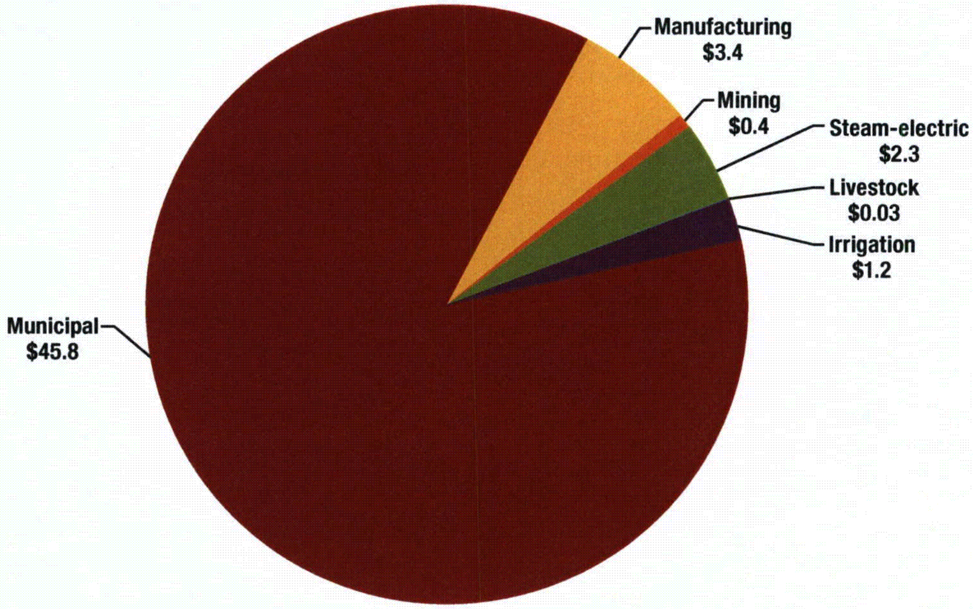
Interest and Debt Service: Interest during construction is based on total project costs drawn down at a constant rate per month during the construction period. Planning groups assume level debt service and an annual interest rate of 6.0 percent for project financing. The length of debt service is based on an estimated 20 years for most water management strategies and 40 years for reservoirs.

Annual Operating and Maintenance Costs: Operations and maintenance costs are based on the quantity of water supplied. Planning groups calculate annual operating and maintenance costs as 1.0 percent of the total estimated construction costs for pipelines, 2.5 percent of the estimated construction costs for pump stations, and 1.5 percent of the estimated construction costs for dams. Costs include labor and materials required to maintain projects such as regular repair and replacement of equipment. Power costs are calculated on an annual basis using calculated horsepower input and a power purchase cost of $0.09 per kilowatt hour.

The majority of the $53 billion costs are for water management strategies recommended for municipal water user groups (Figure 9.1). While the identified water needs of 8.3 million acre-feet per year in 2060 are less than the 8.9 million acre-feet per year identified in the 2007 State Water Plan, the costs of implementing the strategies have increased significantly from the $31.0 billion estimated in the 2007 State Water Plan. The increase was due to several factors:

- an increased volume of strategies in areas of high population growth;
- increased construction costs;
- increased costs of purchasing water rights;
- increased land and mitigation costs;
- the addition of new infrastructure projects to deliver treated water from existing and new water sources;

FIGURE 9.1. TOTAL CAPITAL COSTS OF RECOMMENDED WATER MANAGEMENT STRATEGIES BY WATER USE CATEGORY (BILLIONS OF DOLLARS).



- the addition of new projects to address uncertainty in the ability to implement projects;
- inclusion, at a greater level of detail, of additional infrastructure that will be required to deliver and treat water to water users; and
- the addition of new projects to address the uncertainty that could result from climate change or a drought worse than the drought of record.

The decrease in the amount of needs from the 2007 plan to the 2012 plan is attributed to the successful implementation of previously recommended water management strategies, including those funded by the 80th and 81st Texas Legislatures (see Implementation of State Water Plan Projects, 9.4.1).

Region C ($21.5 billion), Region H ($12.0 billion), and Region L ($7.6 billion) have the highest estimated capital costs for implementation of their 2011 regional water plans. The costs associated with these three planning areas account for approximately 77 percent of the total capital costs in the 2012 State Water Plan. Their combined populations represent over 62 percent of the total projected population for the state by 2060.

The total estimated costs for implementing the 2012 State Water Plan are consistent with a general trend of increasing costs. The total estimated capital cost of the 2007 State Water Plan, $31.0 billion, was substantially higher than the $17.9 billion estimated in the 2002 State Water Plan. The 1997 State Water Plan, developed by TWDB prior to regional water planning, estimated $4.7 billion in costs for recommended major water supply and conveyance systems through 2050. These trends indicate that delays in the implementation of projects will likely result in continued cost increases.

9.2 COSTS OF ALL WATER INFRASTRUCTURE NEEDS

While the capital costs to implement the state water plan may seem staggering, the amount of funding needed to implement all water-related infrastructure in Texas is far greater. The estimated costs to implement water management strategies in the regional water plans do not include costs associated with internal system distribution facilities or aging infrastructure needs, nor do the plans include needs for wastewater infrastructure or flood control projects. Since 1984, TWDB has estimated the costs for implementing various types of water infrastructure—including those that go above and beyond water supply strategies. These estimates demonstrate the need for federal revolving fund financial assistance programs and help put the costs of the state water plan in perspective.

Estimated costs for water supply facilities, major water conveyances, major raw water treatment, wells and facilities, reservoirs, chloride control, and wastewater treatment were first provided in the 1984 State Water Plan. The 1990 State Water Plan expanded these estimates to include flood protection. All subsequent plans have provided cost estimates for all water-related infrastructure in Texas, divided into four categories:

- Water supplies (water management strategies recommended in the regional water plans, including costs of major conveyances to points of distribution)
- Water treatment and distribution not included in the regional water plans and state water plan
- Wastewater treatment and collection
- Flood control

The estimated capital costs included in the 2012 State Water Plan for water supply infrastructure represent the total capital costs of the 16 regional water plans. Estimates of capital costs for other water treatment and distribution and for wastewater facilities were developed using information gathered by TWDB with federal infrastructure needs surveys mandated by the Safe Drinking Water Act and the Clean Water Act. Estimates of the capital costs for current and planned flood control projects were obtained from the "Flood Funding Needs Database Research Project" funded by TWDB (Halff Associates, Inc., 2011).

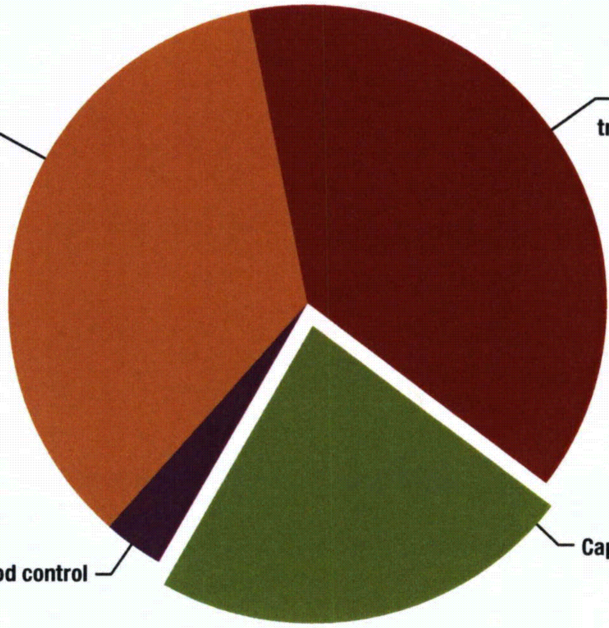
Current TWDB estimates indicate that Texas will need to invest about $231 billion by 2060 to meet the state's needs for water supply, water and wastewater infrastructure, and flood control. The 2012 State Water Plan recommends water management strategies that represent an estimated $53 billion, or 23 percent, of these total needs (Figure 9.2).

9.3 FUNDING NEEDED TO IMPLEMENT THE STATE WATER PLAN

Each planning cycle, regional water planning groups assess the amount of state financial support that local and regional water providers will need to implement municipal water management strategies recommended in their plans for times of drought. During development of the 2011 regional water plans, planning groups surveyed every water provider that had a municipal water management strategy with an associated capital cost to determine if they needed financial assistance from the state.

Of 694 water providers contacted, 269 responded to the survey and reported an anticipated need of $26.9 billion from state financial assistance programs to help implement recommended strategies. This amount represents about 58 percent of the total capital costs for water management strategies recommended for

FIGURE 9.2. TOTAL CAPITAL COSTS FOR WATER SUPPLIES, WATER TREATMENT AND DISTRIBUTION, WASTEWATER TREATMENT AND COLLECTION, AND FLOOD CONTROL (BILLIONS OF DOLLARS).



municipal water user groups in the 2011 regional water plans (Table 9.1). Of the total reported need for state financial assistance, nearly $15.7 billion is expected to occur between the years 2010 and 2020; $4.2 billion will occur between 2020 and 2030; $4.1 billion between 2030 and 2040; and $1.9 billion between 2040 and 2050 (Figure 9.3).

Water providers reported that over $20 billion (75 percent) of the requested funds would target construction activities and land acquisition; $3.3 billion (12 percent) would finance project permitting, planning, and design activities; $3.1 billion would finance excess storage capacity; and approximately $440 million is needed for projects in rural and economically distressed areas of the state.

Not only are the costs to implement strategies significantly higher now than in previous state water plans, the needs for state assistance to help implement projects represent a much larger portion of the plan's total costs. Of the $31.0 billion total presented in the 2007 State Water Plan, only about $2.1 billion or 6.8 percent of the total was needed in the form of state assistance. However, later events indicated that the need for state assistance was underestimated, and a new financing survey was completed in 2008. At the request of the legislative Joint Committee on State Water Funding, TWDB surveyed 570 entities, with 212 water providers (37 percent) reporting an anticipated need for $17.1 billion in funds from TWDB financial assistance programs. The increases in requests for funding can be attributed in part to higher survey

TABLE 9.1. 2060 WATER MANAGEMENT STRATEGY SUPPLIES (ACRE-FEET PER YEAR), CAPITAL COST, AND REPORTED FINANCIAL ASSISTANCE NEEDED

Region	Water Management Strategy Supplies	Water Management Strategy Capital Cost (millions $)	Financial Assistance Needed (millions $)
A	648,221	$739	$624
B	77,003	$499	$384
C	2,360,302	$21,482	$11,743
D	98,466	$39	$5
E	130,526	$842	$500
F	235,198	$915	$593
G	587,084	$3,186	$1,153
H	1,501,180	$12,019	$7,142
I	638,076	$885	$500
J	23,010	$55	$20
K	646,167	$907	$154
L	765,738	$7,623	$3,517
M	673,846	$2,195	$445
N	156,326	$656	$0
O	395,957	$1,108	$78
P	67,739	$0	$0
Total	**9,004,839**	**$53,150**	**$26,857**

response rates and to an increased awareness of the availability of attractive state financial assistance programs targeted at state water plan projects.

9.4 IMPLEMENTATION OF STATE WATER PLAN PROJECTS

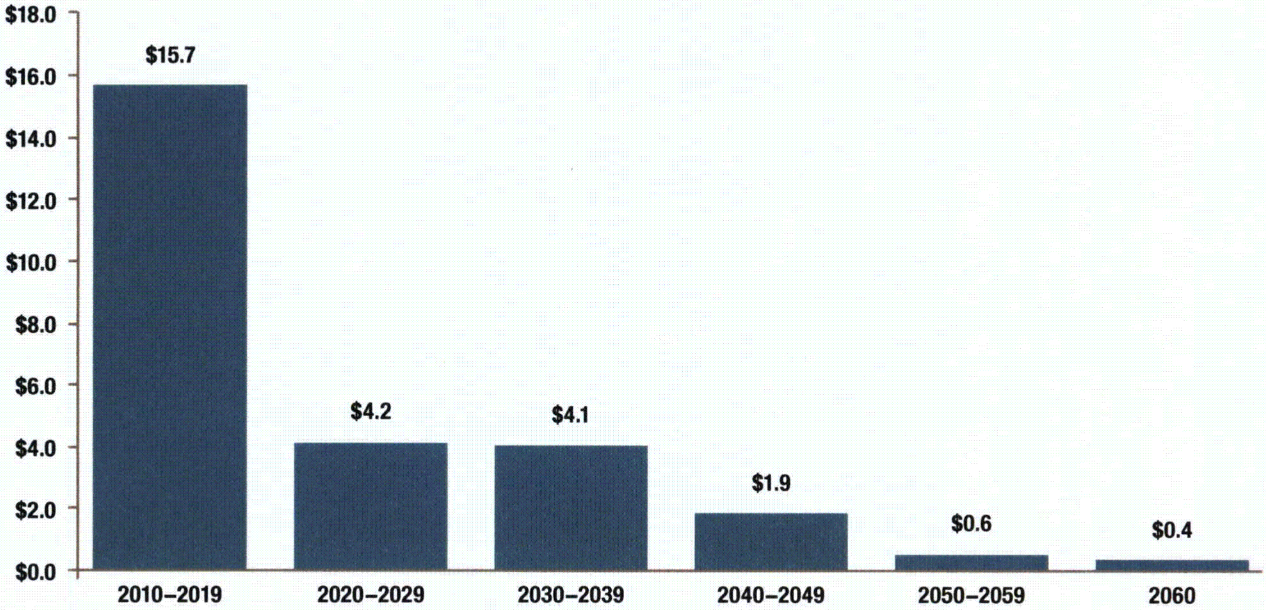
9.4.1 STATE WATER PLAN FUNDING

In response to the 2007 State Water Plan, the 80th and 81st Texas Legislatures provided funding to implement recommended water management strategies to meet the needs for additional water supply during times of drought. In 2007 and 2009, the Texas Legislature appropriated funds that enabled the issuance of over $1.47 billion in bonds to finance state water plan projects at below market rates. These projects were recommended water management strategies in the 2006 regional water plans and the 2007 State Water Plan. Funding was distributed through three TWDB programs: the Water Infrastructure Fund, the State Participation Program, and the Economically Distressed Areas Program.

As a result of these appropriations, TWDB has committed over $1 billion in financial assistance for 46 projects across the state, including projects in 11 of the 16 regional water planning areas (Figure 9.4). A variety of water management strategies have been funded, including groundwater desalination; new groundwater wells; wetlands that treat water for reuse; transmission and treatment facilities; and planning, design, and permitting of new reservoirs. Once implemented, these projects will generate over 1.5 million acre-feet of water that will help meet millions of Texans' needs for water during drought (Table 9.2).

The Water Infrastructure Fund, TWDB's financial assistance program designed specifically for state water plan projects, has been "oversubscribed," meaning that the demands for financial assistance have far exceeded what the program has been able to provide. Over $1.5 billion in requests was submitted for funding through the Water Infrastructure Fund, but

FIGURE 9.3. DEMAND FOR TWDB FINANCIAL ASSISTANCE PROGRAMS BY DECADE OF ANTICIPATED NEED (BILLIONS OF DOLLARS).



there was not sufficient funding available to provide assistance to all projects that were eligible. In 2011, the 82nd Texas Legislature authorized additional funding to finance approximately $100 million in state water plan projects; these funds will be available during state fiscal years 2012 and 2013.

TWDB also funds recommended water management strategies through other loan programs. In addition to dedicated appropriations for state water plan financial assistance, TWDB has provided over $530 million in additional funding to implement strategies recommended in the 2007 State Water Plan through the Economically Distressed Areas Program, the Texas Water Development Fund, the Water Assistance Fund, the Rural Water Assistance Fund, and the Drinking Water State Revolving Fund.

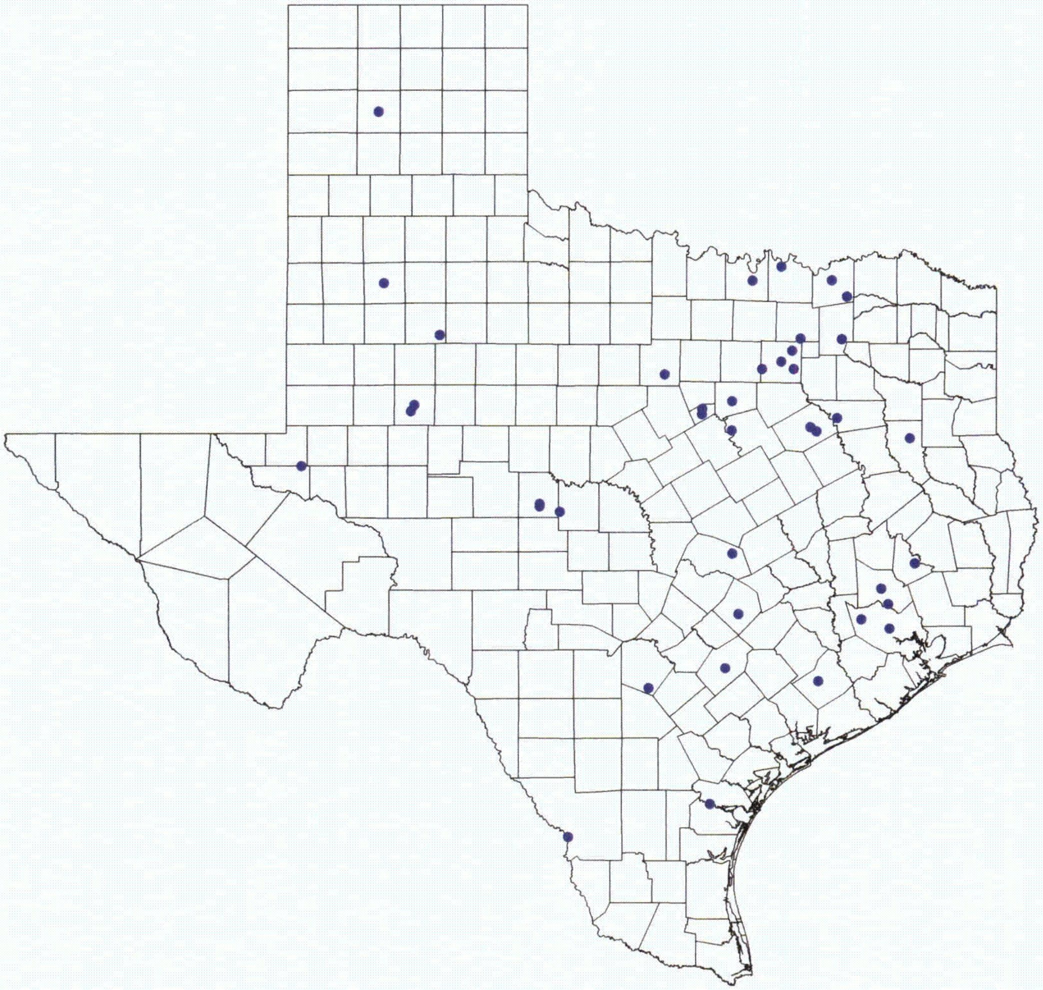
9.4.2 ECONOMIC BENEFITS OF IMPLEMENTATION

The implementation of water management strategies can often have a significant positive economic impact within a particular region and also on the state's economy as a whole. In the short term, construction projects provide a temporary boost to a local economy through employment and earnings. Expenditures on materials and labor as well as planning, design, and construction services result in increased local income. After construction is complete, permanent employment is supported by the operation and maintenance of water supply facilities.

It is estimated that every billion dollars in financial assistance provided for state water plan projects, over the course of project implementation, will

- generate $1.75 billion in sales revenues in the construction, engineering, and materials sectors and supporting businesses;
- create $888.8 million in state gross domestic product;
- add $43.9 million in state and local tax receipts; and
- create or support nearly 13,077 jobs in the state.

FIGURE 9.4. LOCATIONS OF STATE WATER PLAN PROJECTS FUNDED BY TWDB.



9.4.3 IMPLEMENTATION SURVEY

Although TWDB does not have a formal mechanism in place to track implementation of all water management strategies, regardless of funding sources, the agency has undertaken efforts to assess the implementation progress of strategies from the 2007 State Water Plan. In the summer of 2011, TWDB contacted cities and water utilities with recommended water management strategies in the 2007 State Water Plan to evaluate implementation progress. Since water projects, particularly those that involve infrastructure, can require several years or more to put into place, progress was defined as any type of project construction or any form of pre-implementation activity, such as negotiating contracts, applying for and securing financing, state and federal permits, or conducting preliminary engineering studies.

Of the 497 projects for which the sponsoring entities responded, 139 of them (28 percent) reported some form of progress on strategy implementation. Of these, 65 (13 percent) reported that strategies had been

TABLE 9.2. STATE WATER PLAN PROJECTS FUNDED BY TWDB PROGRAMS

Entity	Funding Program						Population Served		Supply Generated	
	Water Infrastructure Fund Deferred	Water Infrastructure Fund Construction	Water Infrastructure Fund Rural	Economically Distressed Areas Program - State Water Plan Rural	Economically Distressed Areas Program - State Water Plan	State Participation	2010	2060	2010	2060
Central Harris Co. Regional Water Authority		$22,050,000					29,950	41,550	2,375	4,806
Coastal Water Authority	$28,000,000						2,240,974	3,626,591	-	394,266
Dallas, City of		$15,100,000					2,050,026	3,208,230	-	20,458
*Dallas, City of	$8,280,000						-	-	-	29,924
Lubbock, City of		$22,615,000					216,974	248,622	21,880	21,880
Tarrant Regional Water District	$3,135,000						2,417,419	4,942,954	-	105,500
*Tarrant Regional Water District	$6,755,000						-	-	-	-
Upper Trinity Regional Water District	$10,400,000						131,129	576,237	-	34,050
*Dallas, City of		$94,723,000					-	-	-	-
Brazos River Authority		$22,000,000					151,729	524,852	26,505	70,246
Corsicana, City of	$1,935,000						29,940	37,894	-	2,268
North Texas Municipal Water District		$26,155,000					1,546,195	3,256,816	50,000	10,000
*North Texas Municipal Water District		$17,825,000					-	-	-	-
San Jacinto River Authority	$21,500,000						-	-	-	52,534
Somervell County Water District		$9,367,000	$9,494,000	$9,494,000	$2,680,000		7,542	9,804	840	840
Amarillo, City of		$38,885,000					223,607	336,060	-	10,831
Cleburne, City of	$1,180,000						30,572	52,812	680	680
*Cleburne, City of	$4,750,000						-	-	2,128	2,128
*North Texas Municipal Water District	$9,930,000						-	-	-	108,487
Palo Pinto County Municipal Water District No. 1	$3,200,000				$4,800,000		37,026	48,513	-	7,600
*Lubbock, City of		$19,945,000					-	-	-	-
Angelina and Neches River Authority						$48,530,000	98,078	142,311	-	75,700
*Coastal Water Authority	$5,115,000						-	-	-	-
San Antonio Water System	$35,000,000						1,354,381	2,116,782	-	26,400
Laredo, City of					$7,500,000		234,423	650,317	1,425	49,863
*Amarillo, City of		$47,400,000					-	-	-	-
Colorado River Municipal Water District		$11,685,000				$45,315,000	121,434	148,673	-	6,000
*Cleburne, City of		$14,500,000					-	-	-	-
Corpus Christi, City of	$8,000,000						-	-	-	35,000
Grand Prairie, City of		$4,995,000					-	-	-	6,726
Greater Texoma Utility Authority		$21,230,000					2,000	18,000	-	113,000
*Lubbock, City of		$41,000,000					-	-	-	-
*Tarrant Regional Water District	$17,835,000	$83,785,000					-	-	-	107,347
*Colorado River Municipal Water District		$11,970,000					-	-	-	1,855
Greater Texoma Utility Authority/ City of Gainesville		$7,235,000					37,326	67,289	-	4,480
*San Antonio Water System		$24,550,000					-	-	-	-
Corpus Christi, City of	$2,395,000						-	-	42,329	32,996
Guadalupe Blanco River Authority	$4,400,000						96,521	287,647	-	25,000
*Guadalupe Blanco River Authority	$2,500,000						-	-	-	49,777
Montgomery County Municipal Utility District Nos. 8 and 9	$1,290,000						6,900	12,445	-	1,120
San Angelo, City of		$120,000,000					94,261	105,445	-	12,000
West Harris County Regional Water Authority	$11,195,000						334,247	484,587	21,678	78,839
West Harris County Regional Water Authority	$2,465,000						-	-	-	-
Eden, City of				$995,000	$1,000,000		2,885	2,988	-	-
Eden, City of					$2,680,000		-	-	-	-
*Somervell County Water District				$700,000	$700,000		-	-	-	960
	$189,260,000	$677,015,000	$9,494,000	$11,189,000	$19,360,000	$93,845,000	11,495,539	20,947,419	169,840	1,503,561

* denotes water user groups with projects that are related and therefore the population and/or strategy supply may only be listed once to prevent double counting as the population and strategy supply are the same for both projects.

fully implemented. Of the 74 projects (15 percent) that reported incomplete progress, 13 (3 percent) reported that project construction had begun.

In comparison to the implementation results reported in the 2007 State Water Plan, a significantly larger number of projects are reported to have been implemented (65 projects, up from 21 in the 2002 State Water Plan). The percentage of projects reporting at least some progress is lower than reported in the 2007 plan, largely because more responses were submitted that reported no progress. It should also be noted that Senate Bill 660, passed by the 82nd Legislature in 2011, included a requirement for the state water plan to include an evaluation of the implementation progress of water management strategies in the previous plan, and allows TWDB to obtain implementation data from the regional planning groups. The 2016 regional water plans will be required to include an implementation progress report, which will be included in the 2017 State Water Plan.

9.5 FINANCING WATER MANAGEMENT STRATEGIES

In Texas, local governments have traditionally provided the majority of the financing for water infrastructure projects. Water and wastewater providers finance projects primarily through municipal debt on the open bond market and less frequently with cash or private equity sources such as banks. The federal government has also historically implemented water projects, and earlier state water plans relied heavily on the federal government for financial assistance. Federal agencies such as the U.S. Natural Resources Conservation Service (formerly the Soil Conservation Service), the U.S. Bureau of Reclamation, and the U.S. Army Corps of Engineers have 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. 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 water supply to local users (USACE, 1999).

9.5.1 FINANCIAL ASSISTANCE PROGRAMS

Traditional funding mechanisms will continue to assist with financing water projects, but they are not enough to meet the needs for water that Texans face during drought. Meeting these needs is particularly challenging for rural and disadvantaged communities where citizens cannot afford higher water rates to repay the cost of traditional project financing. Because of the difficulty in financing projects on their own, many water providers seek financial assistance from the state or federal government.

TWDB Financial Assistance

TWDB provides financial assistance to water providers for implementation of projects through several state and federally funded TWDB programs. These programs provide loans and some grants for projects that range from serving the immediate needs of a community to meeting regulatory requirements to providing long-term water supply. While not all programs target state water plan projects, water management strategies recommended in the regional water plans and state water plan have been funded from many of TWDB's major financial assistance programs. In accordance with state statute, TWDB may provide financial assistance for water supply projects only if the needs to be addressed by the project will be addressed in a manner that is consistent with the regional water plans and the state water plan.

TWDB's state programs are primarily funded by the sale of general obligation bonds that are secured by the "full faith and credit" of the state of Texas. Because of the state's good credit rating, TWDB is able to offer a lower interest rate than many providers can obtain through traditional financing. Under the supervision and approval of the Texas Legislature, TWDB issues bonds and uses the proceeds to make loans to political subdivisions of the state such as cities, counties, and river authorities, as well as non-profit water supply and wastewater service corporations. The recipients make payments of principal and interest to TWDB, which then uses the proceeds to pay debt service on the general obligation bonds. Some programs receive subsidization by the state through reduced interest rates or deferred repayments. Such programs require legislative authorization and appropriations to cover the debt service associated with the authorized subsidy. Through subsidization by the state, some programs are able to offer grants and low-cost loans to communities and provide a significant incentive to implement state water plan projects.

TWDB's authority to issue general obligation bonds to provide financial assistance programs was first approved by the Texas Legislature and the state's electorate in 1957. The 1957 constitutional amendment approved by voters created TWDB and authorized the agency to issue $200 million in general obligation bonds for the construction of dams, reservoirs, and other water storage projects. Further amendments to the Texas Constitution and additional statutory authority expanded the types of facilities eligible for TWDB financial assistance to include

- all components of water supply;
- wastewater collection, treatment, and disposal;
- flood control;
- municipal solid waste management; and
- agricultural water conservation projects.

TWDB's federal programs—the Clean Water and Drinking Water State Revolving Funds—are capitalized by federal grants, with state matching funds provided primarily by the sale of general obligation bonds along with a smaller amount of appropriations by the legislature. The Clean Water State Revolving Fund program is also leveraged with revenue bonds, a type of municipal bond that is secured by revenue from the recipient's loan repayments. These revenue bonds allow TWDB to increase the amount of funding offered through the Clean Water State Revolving Fund without the guarantee of the full faith and credit of the state.

With its original and expanded authority, TWDB has provided financing for over $12.6 billion of water and wastewater projects. TWDB has delivered an average of over $694 million per year in state assistance in the previous five years.

State-Funded Programs

The **Texas Water Development Fund** is the oldest of TWDB's programs. It was originally created in 1957, with the passage of the agency's first constitutional amendment, for the purpose of helping communities develop water supplies and drinking water infrastructure. Over time, further constitutional amendments have provided additional authority to fund wastewater and flood control projects. TWDB issues general obligation bonds to support the program.

The **State Participation Program** was created in 1962 to encourage regional water supply, wastewater, and flood control projects. The program enables TWDB to assume a temporary ownership in a regional project when the local sponsors are unable to assume debt for the optimally sized facility, thus allowing for the "right sizing" of projects to accommodate future growth. To support the program, TWDB issues general obligation bonds. General revenue appropriations pay a portion of the related debt service until the local participants are able to begin purchasing the state's interest.

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

The **Agricultural Water Conservation Program** was created in 1989 to provide loans to political subdivisions either to fund conservation programs or projects. TWDB may also provide grants to state agencies and political subdivisions for agricultural water conservation programs, including demonstration projects, technology transfers, and educational programs. The program is funded by assets in the Agricultural Water Conservation Fund as well as general obligation bonds.

The **Economically Distressed Areas Program** provides grants and loans for water and wastewater services in economically distressed areas where services do not exist or existing systems do not meet state standards. Created in 1989, the program is focused on delivering water and wastewater services to meet immediate health and safety concerns, and to stop the proliferation of sub-standard water and wastewater services through the development and enforcement of minimum standards. The program is funded by general obligation bonds. Debt service on the general obligation bonds is paid first by the principal and interest payments received from loans, with general revenue appropriations from the legislature paying the remaining debt service.

The **Water Infrastructure Fund** was created in 2001 to provide financial incentives for the implementation of strategies recommended in the state water plan. The program was first funded in 2008 to offer loans at discounted interest rates for the planning, design, and construction of state water plan projects. Other incentives previously provided were deferral of payments for up to 10 years for projects with significant planning, design, and permitting requirements and zero percent interest loans for rural providers. Applications are prioritized based on the demonstration of significant future or prior water conservation savings and the date of need for the proposed project. The program is funded with general obligation bonds, with debt service paid primarily by principal and interest repayments from borrowers, as well as general revenue appropriations from the legislature.

Federally Funded TWDB Programs

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

The program is funded by annual "capitalization" grants by the U.S. Congress, through the U.S. Environmental Protection Agency. TWDB provides a 20 percent match from state Development Fund general obligation bonds, which are repaid by interest received on Clean Water State Revolving Fund loans.

The Safe Drinking Water Act, as amended in 1996, established the **Drinking Water State Revolving Fund** to finance infrastructure improvements to the nation's drinking water systems. The fund provides low-cost loans and loan forgiveness for drinking water projects and special assistance for disadvantaged communities.

Like the Clean Water State Revolving Fund, the program is funded by annual capitalization grants by the U.S. Congress, through the U.S. Environmental Protection Agency. The program also has a 20 percent state match requirement, which TWDB provides primarily through Texas Water Development Fund general obligation bonds, with a portion provided by state appropriations to subsidize disadvantaged communities.

The **American Recovery and Reinvestment Act of 2009** provided additional funding for TWDB's Clean Water and Drinking Water State Revolving Fund programs. The state received an additional grant of $326 million from the U.S. Environmental Protection Agency to assist communities in improving their water and wastewater infrastructure through both grants and loans. The program required that at least 50 percent of the funding be for disadvantaged communities and at least 20 percent for "green" projects that demonstrated water or energy efficiency or environmental innovation. The program resulted in the funding of 20 Clean Water State Revolving Fund and 25 Drinking Water State Revolving Fund projects across the state. These projects are completing construction and the program has not been renewed by the U.S. Congress.

Other Federal Funding for Water Projects

Other federal programs administer financial assistance for agricultural and rural and disadvantaged communities through grants and low-interest loans. The North American Development Bank Border Environment Infrastructure Fund administers grants provided by the U.S. Environmental Protection Agency to help finance the construction of water and wastewater projects within 100 kilometers (62 miles) of the U.S.-Mexico border. The U.S. Department of Agriculture Rural Development offers financial assistance to rural areas to support public facilities and services such as water and sewer systems, housing, health clinics, emergency service facilities, and electric and telephone service. While the U.S. Army Corps of Engineers does not provide funding for the construction of single-purpose water supply projects, they still play an important role in meeting the state's water supply needs by contracting with local and regional providers for municipal and industrial water use.

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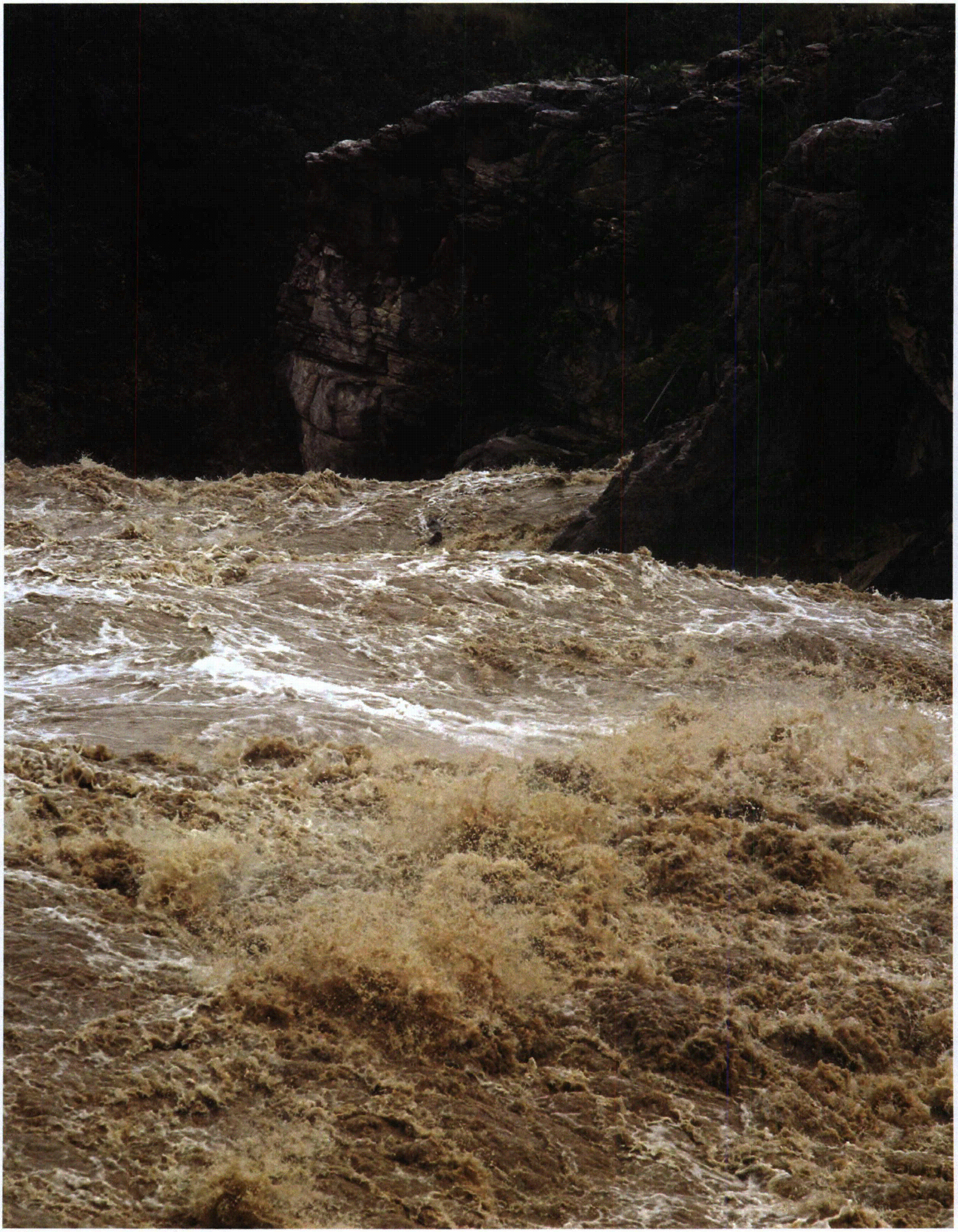


10 Challenges and Uncertainty

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

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

10.1 RISK AND UNCERTAINTY

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

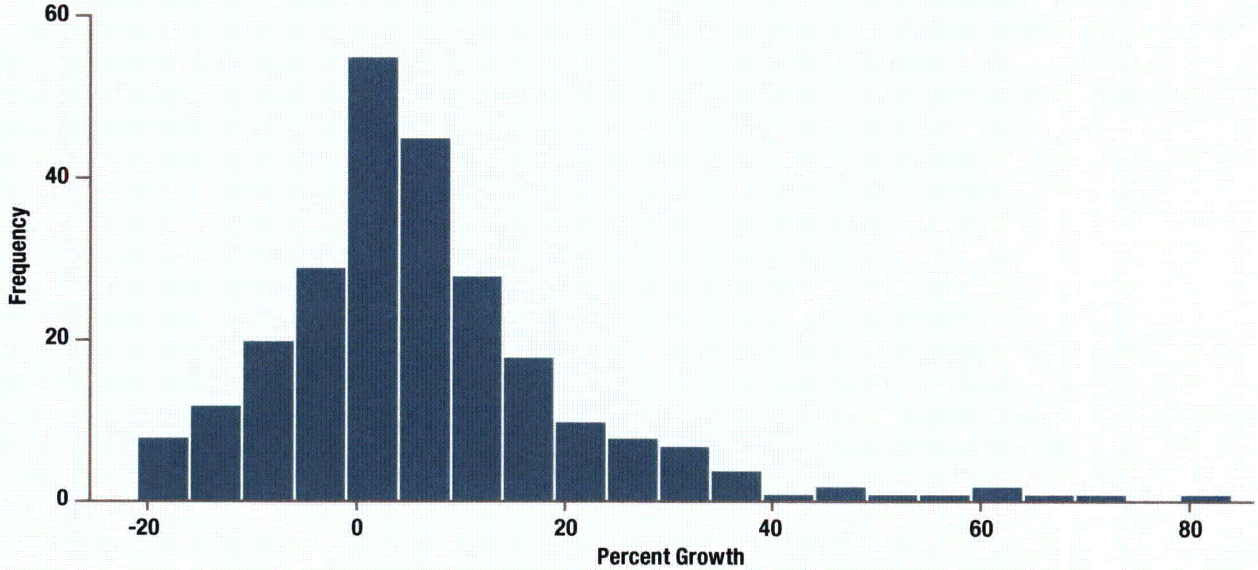
The National Research Council (a nonprofit institution that provides science, technology, and health policy advice to improve government decision making) recommends responding to risk with a cycle of analysis and deliberation, where analysis is the gathering and assessment of technical facts and deliberation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

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

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

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

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



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

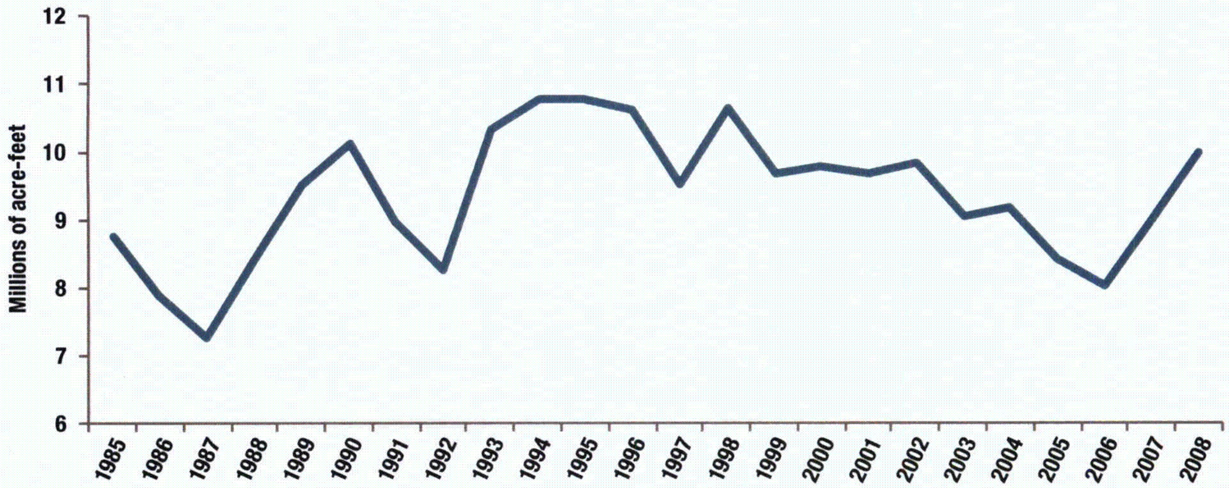
10.2 UNCERTAINTY OF DEMAND

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

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

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

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



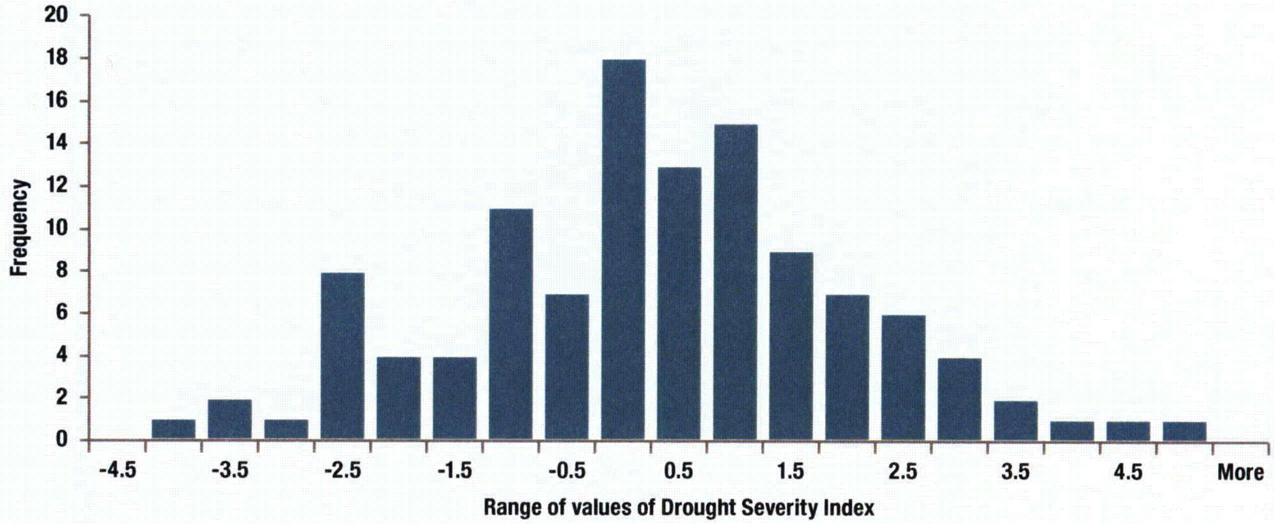
For example, population projections for some water user groups in the 2007 State Water Plan were revised upward for the next planning cycle, based on information from the State Data Center that indicated growth in excess of the original projections. The state population projected for 2010 in the 2007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

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

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

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

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



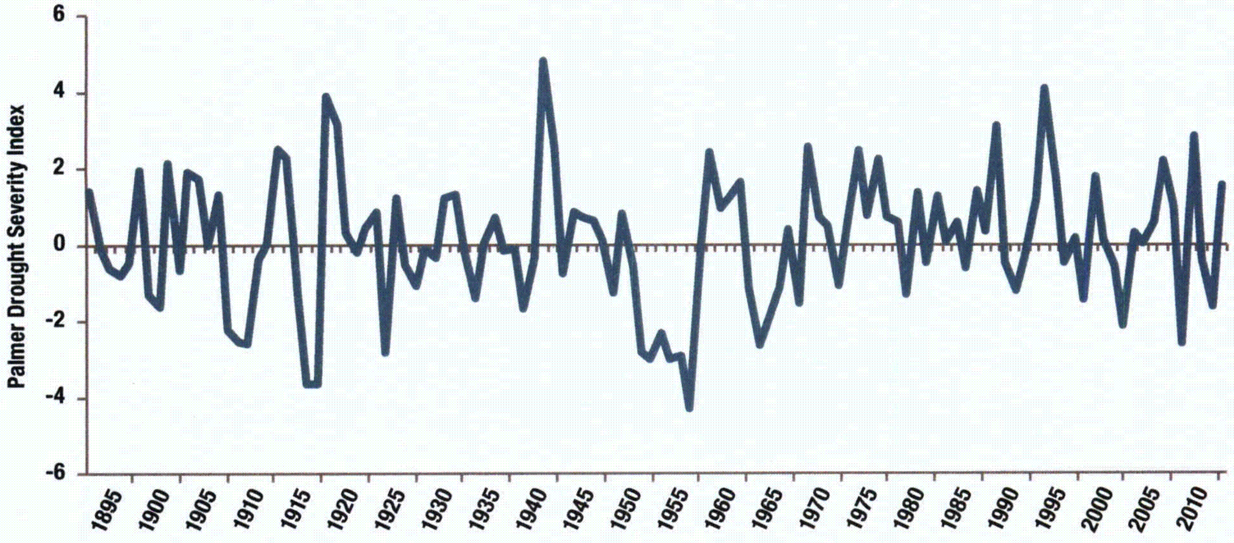
Manufacturing, mining, and power production also depend on price levels of their inputs and outputs, or the resources needed for production and the products or results of that production. Because practically all industrial processes are energy intensive, the prices of energy sources such as gasoline,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

10.3 UNCERTAINTY OF SUPPLY AND NEED

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

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

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



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

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

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

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

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

10.4 UNCERTAIN POTENTIAL FUTURE CHALLENGES

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

10.4.1 NATURAL DISASTERS

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

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

10.4.2 CLIMATE VARIABILITY

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

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

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

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

10.5 WATER AND SOCIETY

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

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

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

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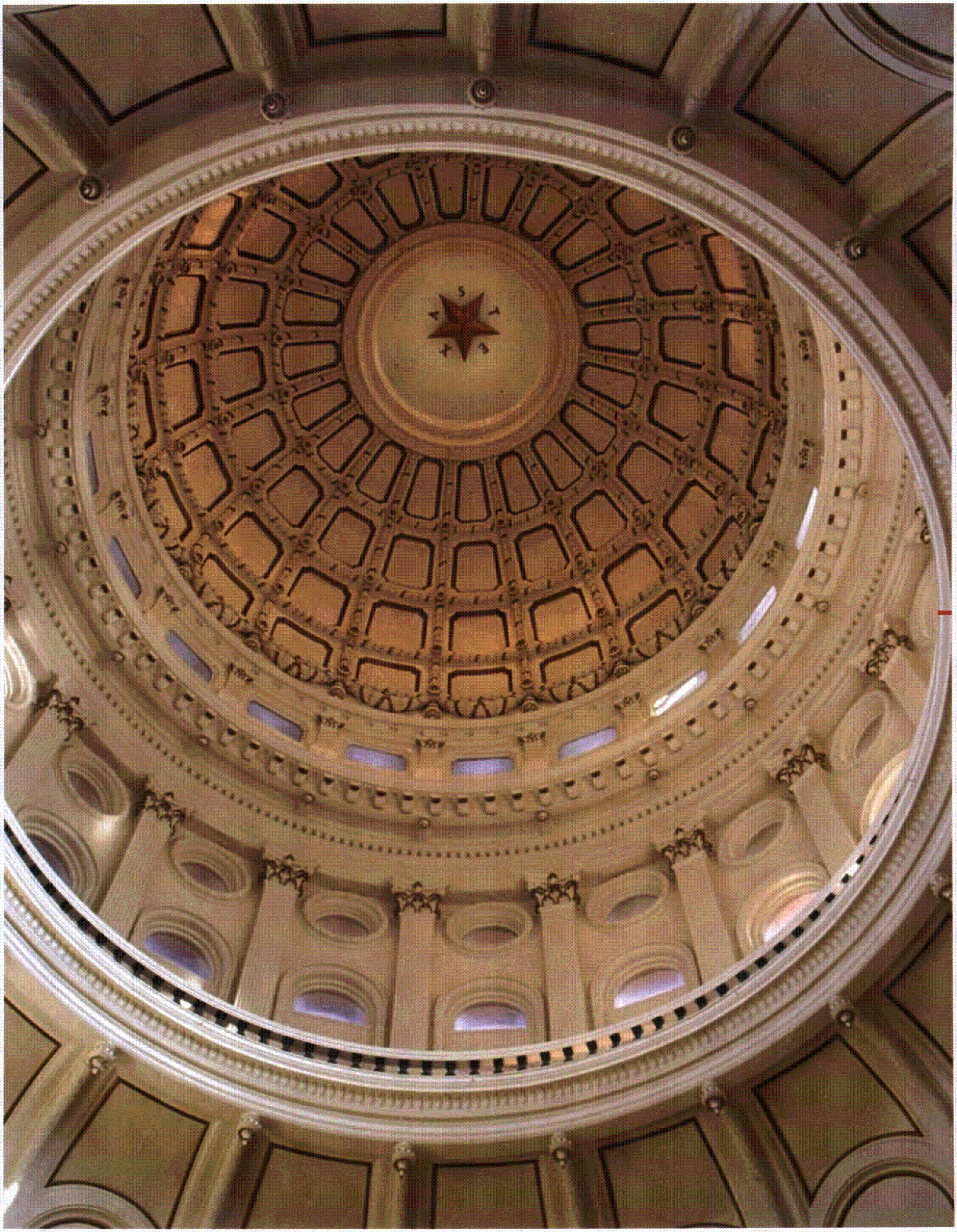
UNCERTAINTY IN THE WEATHER

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

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

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



11 Policy Recommendations

TWDB's statutory requirement to develop a state water plan every five years includes provisions that the plan should be a guide to state water policy that includes legislative recommendations that TWDB believes are needed and desirable to facilitate more voluntary water transfers. TWDB based the following recommendations, in part, on recommendations from the regional water planning process.

During the development of their regional water plans, planning groups made regulatory, administrative, and legislative recommendations (Appendix D) that they believe are needed and desirable 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 for designating unique reservoir sites and stream segments of unique ecological value; however, the Texas Legislature is responsible for making the official designations of these sites.

Planning groups may recommend the designation of sites of unique value for construction of reservoirs within their planning areas. The recommendations include descriptions of the sites, reasons for the unique designation, and expected beneficiaries of the water supply to be developed at the site. A planning group may 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; or
- 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.

Planning groups may also recommend the designation of all or parts of river and stream segments of unique ecological value located within their planning areas. A planning group may recommend a river or stream segment as being of unique ecological value based upon several criteria:

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

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

Based on planning groups' recommendations and other policy considerations, TWDB makes the following recommendations that are needed to facilitate the implementation of the 2012 State Water Plan:

ISSUE 1: RESERVOIR SITE AND STREAM SEGMENT DESIGNATION

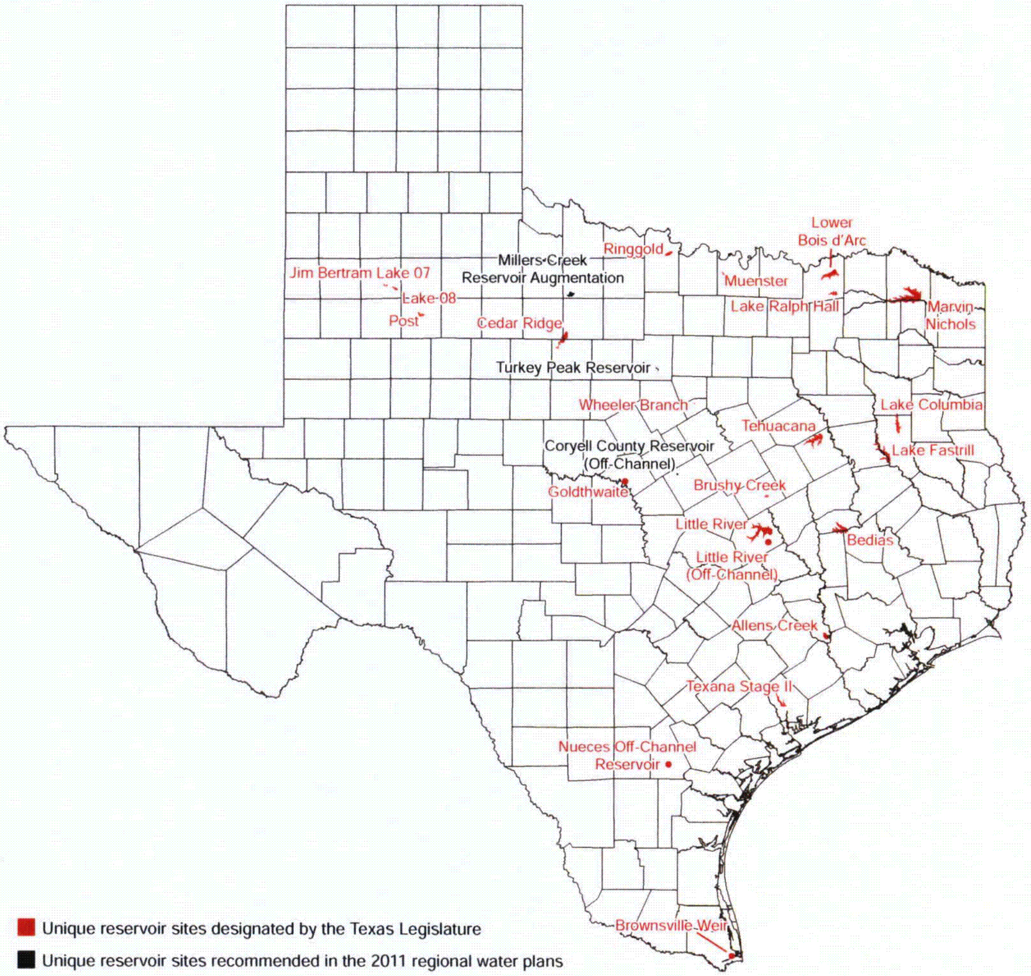
The legislature should designate the three additional sites of unique value for the construction of reservoirs recommended in the 2011 regional water plans (Turkey Peak Reservoir, Millers Creek Reservoir Augmentation, and Coryell County Reservoir) for protection under Texas Water Code, Section 16.051(g) (Figure 11.1).

The legislature should designate the nine river stream segments of unique ecological value recommended in the 2011 regional water plans (Pecan Bayou, Black Cypress Creek, Black Cypress Bayou, Alamito Creek, Nueces River, Frio River, Sabinal River, Comal River, and San Marcos River) for protection under Texas Water Code, Section 16.051(f) (Figure 11.2).

SUMMARY OF THE RECOMMENDATION

Recent regional water plans reflect the recognition that major reservoir projects absolutely must remain a strong and viable tool in our water supply development toolbox if the state is to meet its future water supply needs. The 2011 regional water plans include recommendations to develop 26 major reservoirs, which by 2060 would provide nearly 1.5 million acre-feet of water annually (16.7 percent of the total water management strategy volume).

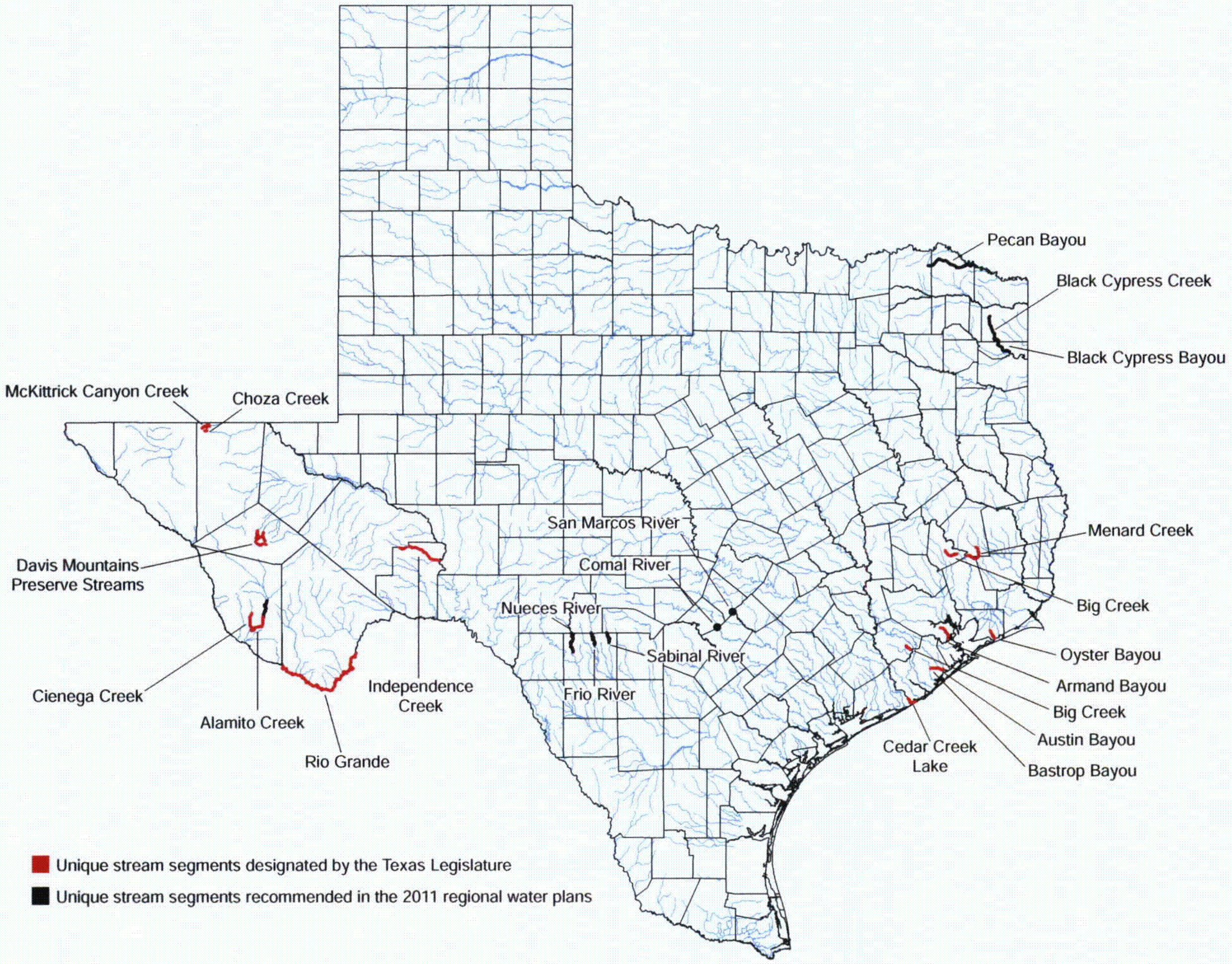
FIGURE 11.1. DESIGNATED AND RECOMMENDED UNIQUE RESERVOIR SITES.



In response to the drought of record of the 1950s, Texas embarked on a significant program of reservoir construction. In 1950, Texas had about 53 major water supply reservoirs, with conservation storage amounting to less than one-half acre-foot per resident of the state. By 1980, the state had 179 major reservoirs, and conservation storage per capita (Chapter 1, Introduction) had increased to nearly 2.5 acre-feet. However, reservoir construction and storage capacity have slowed considerably. Texas currently has 188 major water supply reservoirs, storing just over 1.5 acre-feet per capita. If nothing is done to implement the strategies in the regional water plans, population growth will result in per capita storage declining to less than 1 acre-foot per resident, the lowest since immediately following the drought of record.

A number of factors have contributed to the slowdown in reservoir development. The earlier period of construction captured many of the most logical and prolific sites for reservoirs. However, increased costs and more stringent requirements for obtaining state and federal permits for reservoir construction have

FIGURE 11.2. DESIGNATED AND RECOMMENDED UNIQUE STREAM SEGMENTS.



also been major factors. A significant factor in whether or not the major reservoirs recommended in the 2011 regional water plans can actually be developed involves the reservoir site itself and the manner in which the state addresses issues associated with preserving the viability of the reservoir site for future reservoir construction purposes.

Actions by federal, state, or local governments to protect natural ecosystems located within the reservoir footprint can significantly impact the viability of a site for future construction of a proposed reservoir. Development of Waters Bluff Reservoir on the main stem of the Sabine River was prevented in 1986 by the establishment of a private conservation easement. In addition, the proposed Lake Fastrill, which was included in the 2007 State Water Plan as a recommended water management strategy to meet the future water supply needs of the City of Dallas, was effectively precluded from development by the U.S. Fish and Wildlife Service's designation of the Neches River National Wildlife Refuge on the basis of a 1-acre conservation easement. Lack of action by the state legislature in protecting reservoir sites has been cited as a problem in precluding federal actions that could otherwise be considered to be in contravention of the state's primacy over water of the state.

Texas Water Code, Sections 16.051(e) and 16.053(e)(6), provide that state and regional water plans shall identify any sites of unique value for the construction of reservoirs that the planning groups or TWDB recommend for protection. Texas Water Code, Section 16.051(g) provides for legislative designation of sites of unique value for the construction of a reservoir. By statute, this designation means that 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 on a designated site.

Designation by the Texas Legislature provides a limited but important measure of protection of proposed reservoir sites for future development and provides a demonstration of the legislature's support for protection of potential sites.

The 80th Texas Legislature in 2007 designated all reservoir sites recommended in the 2007 State Water Plan as sites of unique value for the construction of a reservoir (Senate Bill 3, Section 4.01, codified at Texas Water Code Section 16.051 [g-1]). Senate Bill 3 (Section 3.02, codified at Texas Water Code Section 16.143) also added provisions providing certain protections to owners of land within a designated reservoir site. A former owner of land used for agricultural purposes within a designated reservoir site whose property is acquired either voluntarily or through condemnation is entitled to lease back the property and continue to use it for agricultural purposes until such time that the use must be terminated to allow for physical construction of the reservoir. In addition, a sunset provision was included that terminates the unique reservoir site designation on September 1, 2015, unless there is an affirmative vote by a project sponsor to make expenditures necessary to construct or file applications for permits required in connection with construction of the reservoir under federal or state law.

Texas Water Code, Sections 16.051(e) and 16.053(e)(6), also provide that state and regional water plans shall identify river and stream segments of unique ecological value that the planning groups or TWDB recommend for protection. Texas Water Code Section 16.051(f) also provides for legislative designation of river or stream segments of unique ecological value. By statute, this designation means that a state agency or political subdivision of the state may not finance the actual construction of a reservoir in a specific river or stream segment that the legislature has designated as having unique ecological value. Senate Bill 3, passed by the 80th Texas Legislature, also provided that all river or stream segment sites recommended in the 2007 State Water Plan were designated as being of unique ecological value.

ISSUE 2: RESERVOIR SITE ACQUISITION

The legislature should provide a mechanism to acquire feasible reservoir sites so they are available for development of additional surface water supplies to meet the future water supply needs of Texas identified in the 2011 regional water plans and also water supply needs that will occur beyond the 50-year regional and state water planning horizon.

SUMMARY OF THE RECOMMENDATION

If the major reservoir sites recommended for construction in the 2011 regional water plans are not developed, the state will be short 1.5 million acre-feet of water in 2060, about 16.7 percent of the total water supply needed. Without additional water supplies, the state is facing a total water deficit of 8.3 million acre-feet in 2060. Failure to meet the state's water supply needs in drought conditions could cost Texas businesses and workers up to $115.7 billion in 2060.

The cost of acquiring the remaining sites recommended as water management strategies is estimated to be $558.2 million, based on 2011 regional water planning data. The advantages of acquiring these reservoir sites include the following:

- Provides for more efficient and economical long-term infrastructure planning
- Provides certainty to project sponsors that recommended reservoirs could be constructed on designated sites for future water supplies
- Provides some protection from actions by federal agencies that could prohibit the development of reservoirs
- Ensures these sites would be available to meet future water supply needs
- Demonstrates the state's commitment to provide sufficient water supply for Texas citizens to ensure public health, safety, and welfare and to further economic development
- Allows the state to lease sites, prior to reservoir construction, to existing landowners or others for land use activities, such as crops and livestock, wildlife, or recreation, thereby also generating income for the state through lease revenue

Although prior legislative designation helps with preserving reservoir sites, purchasing future sites would provide significant additional protection, including much better protection from unilateral actions by federal agencies that could preempt major water supply projects. If the state owned the sites, it would be highly unlikely that a federal agency could take an action related to those sites, such as the U.S. Fish and Wildlife Service action establishing the Neches Wildlife Refuge at the location of the proposed Fastrill Reservoir.

ISSUE 3: INTERBASIN TRANSFERS OF SURFACE WATER

The legislature should enact statutory provisions that eliminate unreasonable restrictions on the voluntary transfer of surface water from one basin to another.

SUMMARY OF THE RECOMMENDATION

Interbasin transfers of surface water have been an important, efficient, and effective means of meeting the diverse water supply needs of an ever-increasing population in Texas. Interbasin transfers that have already been permitted are or will be used to meet a wide variety of water demands, including municipal, manufacturing, steam-electric power generation, and irrigated agriculture demands.

Prior to the passage of Senate Bill 1, 75th Legislative Session (1997), Texas Water Code, Section 11.085, was entitled Interwatershed Transfers and contained the following provisions:

- Prohibited transfers of water from one watershed to another to the prejudice of any person or property within the watershed from which the water is taken.
- Required a permit from the Texas Commission on Environmental Quality to move water from one watershed to another.
- Required the Texas Commission on Environmental Quality to hold hearings to determine any rights that might be affected by a proposed interwatershed transfer.
- Prescribed civil penalties for violations of these statutory requirements.

In Senate Bill 1, 75th Texas Legislative Session, Texas Water Code, Section 11.085, was amended to replace the above provisions with significantly expanded administrative and technical requirements for obtaining an interbasin transfer authorization. Since the amendments to the Texas Water Code requirements for interbasin transfers in 1997, there has been a significant drop in the amount of interbasin transfer authorizations issued and a significant amount of public discussion about whether the 1997 amendments to Texas Water Code, Section 11.085, have had a negative effect on issuing interbasin transfer authorizations.

Any impediments to obtaining interbasin transfer permits will severely impact the implementation of the projects included in the 2011 regional water plans. There are 15 recommended water management strategies which would rely on an interbasin transfer and will still require a permit to be granted.

ISSUE 4: THE PETITION PROCESS ON THE REASONABLENESS OF DESIRED FUTURE CONDITIONS

The legislature should remove TWDB from the petition process concerning the reasonableness of a desired future condition except for technical review and comment.

SUMMARY OF THE RECOMMENDATION

Prior to the passage of House Bill 1763 in 2005, regional water planning groups decided how much groundwater was available for use in the water planning process after considering groundwater conservation districts' management plans and rules. Groundwater conservation districts also decided how much groundwater was available for use for purposes of their management plans and permitting rules but with the requirement that their number not be inconsistent with the implementation of the state water plan. The passage of House Bill 1763 granted groundwater conservation districts the sole role of deciding how much groundwater was available for use for both regional water planning and groundwater conservation districts' purposes. Regional water planning groups are now required to use numbers called modeled available groundwater, known as managed available groundwater before statutory changes effective September 1, 2011 (Chapter 5, Supplies). These availability numbers are determined by TWDB on the basis of the specific desired future conditions adopted by the groundwater districts.

Current statute allows a petition to be filed with TWDB challenging the reasonableness of a desired future condition. A person with a legally defined interest in a groundwater management area, a groundwater conservation district in or adjacent to a groundwater management area, or regional water planning group with territory in a groundwater management area can file the petition.

If TWDB finds that a desired future condition is not reasonable, it recommends changes to the desired future condition. The groundwater conservation districts then must prepare a revised plan in accordance with the recommendations and hold another public hearing, but at the conclusion of the hearing the districts may adopt whatever desired future condition they deem appropriate. The final decision by the districts is not reviewable by TWDB, and at the conclusion of the process districts are free to retain the same desired future condition that existed before a petition was filed.

TWDB's Legislative Priorities Report for the 82nd Texas Legislative Session (TWDB, 2011) recommended that the legislature repeal the petition process concerning the reasonableness of desired future conditions or modify the process to provide a judicial remedy exclusive of TWDB, except for the agency's technical review and comment. This recommendation was made because the process, as is, allows districts to make the final decision on their desired future condition regardless of TWDB's determination of reasonableness. TWDB recommended a judicial remedy exclusive of TWDB because the agency is not regulatory and is therefore ill-suited for a regulatory process.

The Sunset Advisory Commission (2010) recommended that the petition process with TWDB be repealed and that district adoption of a desired future condition be appealed to district court in the same manner as any challenge to a district rule under substantial evidence review. Although the petition process was discussed and debated during the 82nd Texas Legislative Session, the legislature ultimately did not pass legislation to change the process. Because the same concerns remain on the petition process, TWDB continues to recommend that the legislature should remove TWDB from the petition process except for technical review and comment.

ISSUE 5: WATER LOSS

The legislature should require all retail public utilities to conduct water loss audits on an annual basis, rather than every five years.

SUMMARY OF THE RECOMMENDATION

System water loss refers to the difference between how much water is put into a water distribution system and how much water is verified to be used for consumption. Water loss includes theft, under-registering meters, billing adjustments and waivers, main breaks and leaks, storage tank overflows, and customer service line breaks and leaks. High values of water loss impact utility revenues and unnecessarily increase the use of water resources, especially during drought. During reviews of loan applications, TWDB has seen water losses as high as 50 percent for some water systems. Smaller municipal water systems tend to have higher percentage water losses than larger systems. Based on information collected in 2005, statewide water losses were estimated at 250,000 to 460,000 acre-feet per year (Alan Plummer Associates, Inc. and Water Prospecting and Resource Consulting, LLC, 2007).

The first step toward addressing high water losses is measuring where the water is going in a system with a water loss audit. An audit shows a utility how much of its water is lost and where they may need to focus efforts to reduce those losses. Water loss audits done over time help a utility identify progress with minimizing water losses as well as identifying any new water loss issues.

Currently, the Texas Water Code requires all retail public utilities (about 3,600 in all) to submit a water loss audit to TWDB every five years. During the 82nd Legislative Session, based, in part, on TWDB's Legislative Priorities report for the 81st Legislative Session, the legislature required annual reporting for retail public utilities that receive financial assistance from TWDB (about 200). While this is a step in the right direction, TWDB believes that all retail public utilities would benefit from annual water loss surveys. Municipal water conservation is expected to account for about 7 percent of new water supplies (about 650,000 acre-feet per year) by 2060 in the state water plan. Measuring—and ultimately addressing—water loss will help achieve those conservation goals.

DROUGHT AND PUBLIC POLICY

Droughts and other natural disasters have often served as the impetus behind significant changes in public policy. A severe drought in the mid-1880s resulted in the state's first disaster relief bill and set off a public policy debate on how the federal government should respond to disasters.

Many of the settlers that arrived in Texas in the mid-1800s had little knowledge of the variability of the state's climate. As a result, they were often ill-prepared to respond to droughts. While struggling to survive the effects of a drought that began in 1885, local leaders in Albany, Texas, selected John Brown, a local minister, to solicit donations of wheat for farmers in nearby counties. Believing it was just as appropriate to ask for drought relief as it was to seek aid following hurricanes, Brown appealed to financial institutions and churches throughout the eastern United States. He persisted despite attacks from Texas newspaper editors and land promoters, who feared that the negative publicity would harm the state's economic development (Caldwell, 2002).

In response to Brown's efforts and those of Clara Barton, founder and first president of the American Red Cross, Congress passed the Texas Seed Bill of 1887. The bill appropriated $10,000 for the purchase of seed grain for distribution to farmers in Texas counties that had suffered from the drought. The legislation was quickly vetoed by President Grover Cleveland, citing his belief that the government should not provide assistance, "to individual suffering which is in no manner properly related to the public service or benefit" (Bill of Rights Institute, 2011). It is still widely known as the most famous of President Cleveland's many vetoes.

Despite the defeat of federal aid, the Texas Legislature appropriated $100,000 for drought relief, providing a little over $3 to each needy person. The Red Cross and other donors also sent clothing, household goods, tools, and seed to drought-stricken areas. This type of response to disasters—government aid, combined with private charitable donations—is a template that is still in use today (Caldwell, 2002).

ISSUE 6: FINANCING THE STATE WATER PLAN

The legislature should develop a long-term, affordable, and sustainable method to provide financing assistance for the implementation of the state water plan.

SUMMARY OF THE RECOMMENDATION

Following publication of the 2007 State Water Plan, TWDB conducted an Infrastructure Finance Survey to evaluate the amount of funding needed from state financial assistance programs to support local and regional water providers in implementing water management strategies recommended in the 2007 State Water Plan. The survey reported an anticipated need of $17.1 billion in funds from TWDB financial assistance programs. Steps toward meeting these needs were made in the form of subsidized funding for state water plan projects provided during each of the previous two biennia to provide incentives for state water plan projects to be implemented. The 80th Legislature appropriated funds to subsidize the debt service for $762.8 million in bonds, and the 81st Legislature appropriated funds to subsidize the debt service for $707.8 million in bonds. The 82nd Legislature approved the issuance of up to $200 million in Water Infrastructure Funds bonds for state water plan projects; however, the funds appropriated to subsidize the debt service will provide for approximately $100 million to be issued.

To date, incentives for state water plan projects have included reduced interest rates and deferral of payments and some grants, depending on the program. While these incentives have proven successful, they are a steady draw on general revenues of the state as long as there is debt outstanding.

During the 82nd Legislative session a new model of funding state water plan projects was discussed. This model would involve a deposit of funding, either from general revenue, a fee, or another appropriate source designated by the legislature. This funding, one-time or ongoing over a period of time, could be utilized to make loans to entities for state water plan projects. As the loan payments are received by TWDB, these funds would be available to be lent out again. In this way, the original funding would provide "capital" for the fund. Once established, this model could be expanded to include bond funding and reduced interest rates without being a draw on general revenue.

The latest estimate of funding needed to implement the 2012 State Water Plan is $53 billion, with financial assistance needed from the state estimated to be $26.9 billion, based on the planning groups' financing survey. With a need of this size identified, it is imperative that the state determine a sustainable, long-term methodology to provide funding necessary to implement state water plan projects.

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