Appendix I

Water Conservation Savings

Appendix I Conservation Measures and GPCD Goals

This appendix presents information on water conservation strategies (costs and savings) and per capita water use goals. The *2021 Region C Water Plan* recommends Water Conservation measures for municipal, irrigation, and mining water user groups (WUGs). The purpose of this appendix is to document the criteria for recommending strategies in the Water Conservation Package for a WUG, and to document assumptions made in projecting water savings and opinions of probable costs for these strategies. **Sections I.2** to **I.4** describe conservation measures mandated by state or federal law and already included within demand projections. **Sections I.4** to **I.16** describe conservation measures chosen for Region C WUGs and recommended as strategies. The last section of this appendix contains the goals for per capita water use by water user group as required by TWDB.

Section Outline

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Section I.16 – Mining Water Conservation

Section I.17 – GPCD Goals by WUG

Related Chapters:

Chapter 2 Population and Water Demand Projections

Chapter 5B Conservation and Reuse

I.1 Relationship of Water Conservation and Water Demand Projections

Water demand projections for regional water planning are based on per capita water usage during the base year, which is the most recent very dry year with high water usage. For most Region C WUGs, the base year is 2011. To obtain the initial water demand projection for a given decade, the base year per capita water use is multiplied by the projected population for that decade.

I.1.1 Passive Water Conservation

Passive water conservation measures do not require actions from a WUG to realize the savings. The Texas Water Development Board (TWDB) has projected water savings that are expected to result from passive water conservation measures, including low-flow plumbing fixture rules, efficient new residential clothes washer standards, and efficient new residential dishwasher standards. The final water demand projections presented in **Chapter 2** are the initial water demand projections minus the projected water savings from passive measures. Therefore, the projected water savings from passive measures are built into the Region C water demand projections.

The projected passive water savings are presented in **Table I.1** as "Water Savings Implicit in Water Demand Projections."

I.1.2 Active Water Conservation Through the Base Year

Active water conservation measures require actions from a WUG to realize the savings. Although significant water conservation occurred from active measures in Region C prior to and during the base year, the associated water savings have not been enumerated. Instead, all water conservation savings that occurred through the base year are assumed to be implicit in the base year per capita water use and are therefore built into the water demand projections.

I.1.3 Active Water Conservation Since the Base Year

Region C WUGs have continued to implement active water conservation measures since the base year. The associated water savings has reduced water demand in Region C, but this demand reduction is not reflected in the Region C water demand projections. For measures with sufficient available data, this demand reduction is quantified in **Table I.1** as "Demand Reduction Since Base Year (Already Implemented)." No future costs are shown in **Table I.2** for this demand reduction, because the costs have already been incurred. This is analogous to how existing water supplies are handled in the Region C Water Plan.

The Statewide Water Conservation Quantification Project (SWCQP) interviewed representative of 63 Region C WUGs and estimated water savings from recently implemented water conservation measures. (1)

I.1.4 Active Water Conservation During the Planning Period

Recommended water management strategies include active water conservation measures that are projected to save water during the planning period. The projected water savings from active water conservation measures are presented in

Table I.1 as "Water Savings from Recommended Water Management Strategies," and projected costs are projected in **Table I.2**.

Table I.1 Summary of Projected Municipal Water Savings by Conservation Measure

WUG Name	2020	2030	2040	2050	2060	2070
Water Savings Implicit in Water Demand Projections						
Low Flow Plumbing Fixture Rules [a]	75,085	119,881	160,677	193,278	221,329	249,646
Efficient New Residential Clothes Washer Standards [a]						
Efficient New Residential Dishwasher Standards [a]						
Water Savings Implicit in Water Demand Projections	***75,085***	***119,881***	***160,677***	***193,278***	***221,329***	***249,646***
Demand Reduction Since Base Year (Already Implemented, but not reflected in demand projections)						
Enhanced Public and School Education [b]	0	0	0	0	0	0
Price Elasticity/Rate Structure Impacts	8,958	9,755	10,567	11,202	11,702	12,165
Enhanced Water Loss Control Program	4,751	4,969	1,293	1,325	1,328	1,328
Water Waste Prohibition	75	255	319	373	462	551
Time-of-Day Irrigation Restriction	43	62	76	89	98	110
Twice Weekly Irrigation Restriction	29,448	32,887	36,803	40,136	43,165	45,403
Water Conservation Coordinator	947	2,145	2,393	2,678	2,994	3,289
Other [c]	6,617	5,067	1,539	1,101	1,107	1,112
Water Savings from Demand Reduction Since Base Year	***50,839***	***55,140***	***52,990***	***56,904***	***60,856***	***63,958***
Water Savings from Recommended Water Management Strategies						
Enhanced Public and School Education	6,358	9,467	10,721	12,624	14,830	16,951
Price Elasticity/Rate Structure Impacts	5,043	11,443	19,384	28,979	40,354	53,476
Enhanced Water Loss Control Program	24,302	29,165	11,418	10,196	8,577	6,645
Water Waste Prohibition	246	635	787	906	1,013	1,163
Time-of-Day Irrigation Restriction	75	167	208	237	267	300
Twice Weekly Irrigation Restriction	7,006	13,357	15,746	18,285	21,366	24,376
Water Conservation Coordinator	0	36	127	246	373	545
Other [d]	195	7,519	23,231	26,063	26,249	25,813
Water Savings from Recommended Water Management Strategies	***43,225***	***71,789***	***81,622***	***97,536***	***113,029***	***129,269***
Total Projected Water Savings	**169,149**	**246,810**	**295,289**	**347,718**	**395,214**	**442,873**

a. Water savings estimated by Texas Water Development Board.

b. Little information is available regarding WUGs that implemented enhanced public and school education programs during this time. In addition, it is very difficult to accurately measure water savings from these programs. For these reasons, no estimate of water savings since the base year was made.

c. For demand reduction since the base year, "other" water conservation includes water savings from two sources:

i. Rebates, direct installation, and other methods of implementing low flow plumbing fixtures and efficient appliances before they would otherwise be naturally replaced. This accelerates the savings from low flow plumbing fixture and efficient appliance rules.

ii. Miscellaneous water conservation measures that have been implemented since the base year.

d. For recommended water management strategies, "other" water conservation includes water savings from two sources:

i. According to their water conservation plans, 15 WUGs have implemented significant measures in addition to the Water Conservation Package. These conservation measures have been implemented recently and were not reflected in the historical water data that were used to project water demands. These measures were evaluated on a WUG-specific basis.

ii. Conservation water savings estimates over and above the Water Conservation Package that were submitted by WUGs or their consultants.

Table I.2 Summary of Projected Unit Cost by Municipal Conservation Measure

WUG Name	2020	2030	2040	2050	2060	2070
Future Costs Implicit in Water Demand Projections						
Low Flow Plumbing Fixture Rules	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Efficient New Residential Clothes Washer Standards						
Efficient New Residential Dishwasher Standards						
Future Savings Implicit in Water Demand Projections	***$0.00***	***$0.00***	***$0.00***	***$0.00***	***$0.00***	***$0.00***
Future Cost for Demand Reduction Since Base Year (Already Implemented, but not reflected in demand projections) [a]						
Enhanced Public and School Education	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Price Elasticity/Rate Structure Impacts	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Enhanced Water Loss Control Program	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Water Waste Prohibition	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Time-of-Day Irrigation Restriction	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Twice Weekly Irrigation Restriction	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Water Conservation Coordinator	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Other	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Future Cost for Demand Reduction Since Base Year	***$0.00***	***$0.00***	***$0.00***	***$0.00***	***$0.00***	***$0.00***
Future Cost for Recommended Water Management Strategies						
Enhanced Public and School Education	$1.14	$1.19	$1.15	$1.13	$1.12	$1.10
Price Elasticity/Rate Structure Impacts	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Enhanced Water Loss Control Program	$4.20	$3.56	$0.58	$0.80	$1.15	$1.76
Water Waste Prohibition	$1.46	$1.09	$0.89	$0.84	$0.87	$0.90
Time-of-Day Irrigation Restriction	$5.12	$3.78	$3.24	$3.08	$3.09	$3.06
Twice Weekly Irrigation Restriction	$0.24	$0.23	$0.22	$0.21	$0.22	$0.22
Water Conservation Coordinator	$0.00	$1.00	$1.00	$1.00	$1.00	$1.00
Other [b]	$12.31	$1.27	$0.79	$0.82	$0.87	$0.92
Future Cost for Recommended Water Management Strategies	**$2.64**	**$1.80**	**$0.52**	**$0.51**	**$0.50**	**$0.48**
Total Projected Future Water Costs	***$0.67***	***$0.52***	***$0.14***	***$0.14***	***$0.14***	***$0.14***

a. No costs are included in the Region C Water Plan for demand reduction due to measures that have already been implemented. This is analogous to how existing supplies are handled in the Region C Water Plan.

b. These measures are typically pay-as-you-go measures (e.g., rebates), and the costs are not financed. For these measures, the costs are incurred when the measure is implemented, but savings continue for the life of the measure. The unit costs shown in this table are the cost incurred in a given year divided by the projected savings for that year only. This makes measures with front-loaded costs appear to be expensive in the first year of implementation. However, they are cost-effective when the ongoing savings are considered.

I.2 Low Flow Plumbing Fixture Rules

I.2.1 Applicability

Potential savings from state low flow plumbing fixture rules were evaluated for all municipal WUGs. The Water Saving Performance Standards for Plumbing Act, implemented by Texas in 1992, restricted flowrates of plumbing fixtures manufactured after January 1, 1994 to 1.6 gallons per flush (gpf) for toilets and 2.5 gallons per minute for showerheads. House Bill 2667, implemented September 1, 2009, further restricted toilet flowrates to 1.28 gpf by January 1, 2014.

I.2.2 Projected Water Savings

The TWDB projected water savings from the gradual conversion to 1.6 gpf toilets and 2.5 gpm showerheads at 10.5 gallons per capita per day (gpcd) for toilets and 5.5 gpcd for showerheads [(2)]. The TWDB projected the additional water savings from conversion to 1.28 gpf toilets at 1.63 gpcd.

For a given WUG, the initial number of inefficient toilets is based on the 1995 population. The TWDB assumes that 2 percent of this initial number will be replaced each year. Some of the projected water savings has already occurred as residents and businesses replace toilets and showerheads. For a given WUG, the percentage of the population that has installed low-flow plumbing fixtures depends on the 1995 population, the natural fixture replacement rate, and population growth since 1995 [(2)]. Based on these factors the TWDB estimated future water savings for each municipal WUG from the low flow plumbing fixture rules.

To project future water demands, the TWDB started with a dry-year per capita water use estimate (typically based on 2011 usage) and subtracted projected water savings from three state/federal regulatory measures:

- Low-flow plumbing fixture rules (this section),
- Efficient new residential clothes washer rules (**Section I.3**), and
- Efficient new residential dishwasher rules (**Section I.4**).

Although the savings from each measure are not broken out separately, the savings from all three measures in a given decade is presented in **Table I.2**. The projected 2020 regional municipal water demand is reduced by 4.7 percent from what it would be without these three regulatory measures, and the projected 2070 regional municipal water demand is reduced by 8.5 percent.

I.2.3 Additional Data Requirements

No additional data are needed to project water savings from low flow plumbing fixture rules.

I.2.4 Reliability

The projected water savings will be realized without action by the WUG. Therefore, the reliability of the potential water savings is relatively high.

I.2.5 Opinion of Probably Cost

The projected water savings will be realized at no cost to the WUGs.

I.3 Efficient New Residential Clothes Water Standards

I.3.1 Applicability

Potential savings from federal residential clothes washer standards were evaluated for all municipal WUGs. The federal Department of Energy has set water usage requirements for residential clothes washers by manufacture date (**Table I.3**).

I.3.2 Projected Water Savings

The TWDB projected water savings from the gradual conversion to more efficient residential clothes washers using the per capita savings projections (**Table I.3**), the useful life of clothes washers, the regulatory deadlines, and projected populations for each WUG.

Table I.3 Federal New Residential Clothes Washer Standards

Type of Clothes Washer	Manufacture Date (on or after)	Water Use Standard [a] (gal/ft^3)	TWDB Projected Water Savings [b] (gpcd)
Front-Loading	January 1, 2011	WF = 9.5	5.23
	March 7, 2015	MIWF = 4.5	6.67
Top-Loading	January 1, 2011	WF = 9.5	5.23
	March 7, 2015	MIWF = 8.4	5.56
	January 1, 2018	MIWF = 6.5	6.13
Front-Loading	January 1, 2011	WF = 9.5	5.23

a. For 2011, the water use standard is expressed in terms of water factor (WF). The WF is the total weighted per-cycle water consumption for the cold wash/cold rinse cycle divided by the clothes container capacity. Other water use standards are expressed in terms of maximum integrated water factor (MIWF). The MIWF is the total weighted per-cycle water consumption for all wash cycles divided by the clothes container capacity. The listed standards apply to "standard" sized clothes washers of 1.6 cubic feet and larger.

b. Water savings projections depend on the number of people per household (2.75), the number of loads washed per household per year (300), the proportion of households with clothes washers (75 percent), the percentage of new construction installing a clothes washer (91 percent), the proportion of top-loading machines to front-loading machines (40 percent/60 percent), and the useful life of clothes washers (11 years for a front-loading machine and 14 years for a top-loading machine) [(2)].

As described in **Section I.1.1**, the projected water savings from efficient new residential clothes washer standards are implicit in the TWDB's future water demand projections and comprise a portion of the water savings shown in **Table I.1.**

I.3.3 Additional Data Requirements

No additional data are needed to project water savings from federal residential clothes washer standards.

I.3.4 Reliability

The projected water savings will be realized without action by the WUG, as residents gradually replace inefficient clothes washers. Therefore, the reliability of the potential water savings is relatively high.

I.3.5 Opinion of Probably Cost

The projected water savings will be realized at no cost to the WUGs.

I.4 Efficient New Residential Dishwasher Standards

I.4.1 Applicability

Potential savings from federal residential dishwasher standards were evaluated for all municipal WUGs. The federal Department of Energy has set a requirement that "standard" sized residential dishwashers (capacity for 8 place settings) manufactured on or after January 1, 2010, must achieve a water consumption of 6.5 gallons per cycle. This requirement decreases to 5.0 gallons per cycle for dishwashers manufactured on or after May 30, 2013.

I.4.2 Projected Water Savings

The TWDB projected water savings of 1.83 gpcd from dishwashers that use 6.5 gallons per cycle and 1.93 gpcd from dishwashers that use 5.0 gallons per cycle [(2)]. As described in **Section I.1.1**, the projected water savings from efficient new residential dishwasher standards are implicit in the TWDB's future water demand projections and comprise a portion of the water savings shown in **Table I.1**.

I.4.3 Additional Data Requirements

No additional data are needed to project water savings from federal residential dishwasher standards.

I.4.4 Reliability

The projected water savings will be realized without action by the WUG, as residents gradually replace inefficient dishwashers. Therefore, the reliability of the potential water savings is relatively high.

I.4.5 Opinion of Probably Cost

The projected water savings will be realized at no cost to the WUGs.

I.5 Enhanced Public and School Education

Most utilities in Region C have some kind of public and school education program. However, the levels of effort put into these programs, the budgets for these programs, and the water savings from these programs are highly variable. Although this measure does not define how a utility should conduct its public and school education program, it assumes that participating utilities will operate their programs at a high (or "enhanced") level, committing resources as necessary to achieve significant water savings.

This measure incorporates elements of Best Management Practices (BMPs) 6.1 Public Information, 6.2 School Education, and 6.3 Public Outreach & Education [3].

I.5.1 Applicability

The enhanced public and school education program measure was evaluated for municipal WUGs with the following characteristics:

- Existing or projected total water usage of more than 140 gpcd,
- A projected water need,
- An identified sponsor for the public and school education program.

I.5.2 Projected Water Savings

Water savings from public and school education are difficult to measure. Public and school education results in indirect savings through enhancement of other water conservation measures and direct savings from changes in customer behavior. In this memorandum, the indirect savings from public education will be attributed to the other water conservation measures with which they are associated. Therefore, the potential water savings from public and school education will be the direct savings from changes in customer behavior.

Water Savings Through the Base Year

Tarrant Regional Water District (TRWD), North Texas Municipal Water District (NTMWD), and Dallas Water Utilities (DWU) began operating enhanced public education programs before the base year. Water savings from enhanced public and school education through the base year are built into the water demand projections.

Water Savings Since the Base Year

Little information is available regarding WUGs that implemented enhanced public and school education programs during this time. In addition, it is very difficult to accurately measure water savings from these programs. For these reasons, no estimate of water savings since the base year was made.

Projected Water Savings During the Planning Period

It has been assumed that the direct customers of TRWD, NTMWD, and DWU will achieve an additional savings of 0.5 percent of municipal water demand during the planning period (**Table I.4**). For other WUGs, the projected water savings in a given decade is estimated to be from 1 to 2 percent of municipal water demand, with savings increasing according to **Table I.4.** WUGs that implement this program by 2020 are projected to achieve 2 percent water savings by 2030.

Table I.4 Projected Percentage Savings by Decade for Enhanced Public and School Education

WUGs	2020	2030	2040	2050	2060	2070
Customers of TRWD, NTWMD, and/or DWU	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%
Other WUGs	1.5%	2.0%	2.0%	2.0%	2.0%	2.0%

It is assumed that the savings from public and school education last one year [(4)] and that the program must be renewed each year to maintain and increase the estimated savings.

I.5.3 Additional Data Requirements

WUGs that have implemented enhanced public and school education programs since the base year need to be identified. No additional data are needed to project water savings from enhanced public and school education during the planning period.

I.5.4 Reliability

Water savings from enhanced public and school education are difficult to measure and depend on customer behavior. For these reasons, the reliability of the estimated water savings is low. Enhanced public and school education reinforces and builds on previously delivered conservation messages; therefore, it is important that the enhanced public and school education program be continued from year to year in order to increase the reliability of the savings.

I.5.5 Opinion of Probably Cost

Actual spending per resident can be difficult to track, because media markets overlap many cities. For example, Dallas Water Utilities planned to budget about $1.38 million in fiscal year 2018-2019 for its public awareness program and its environmental education initiative [(5)]. Based on the retail customer population, this corresponds to $1.07 per resident. However, the associated media buys also reached wholesale customers. When the wholesale customer population is taken into account, the per capita spending was $0.58.

Based on this information, the cost of enhanced public and school education is expected to be about $1.00 per resident for the largest WUGs. It is anticipated that smaller cities would have to spend up to $3.00 per resident per year to deliver effective water conservation messages [(3)].

The opinion of probable annual cost for each WUG to which this measure applies was derived using population projections. For a given WUG and given year, the probable unit cost was calculated as the probable annual cost divided by projected water savings.

These costs have been associated with the WUGs that benefit from the programs, regardless of whether the funding comes from the WUG itself or from a wholesale supplier.

I.6 Price Elasticity/Rate Structure Impact

Price increases or changes in rate structure impact water consumption. This measure incorporates elements of BMP 3.1 Water Conservation Pricing [3].

I.6.1 Applicability

The impact of real increases in water prices was evaluated for all municipal WUGs. Although many WUGs in Region C already have conservation-oriented rate structures, this measure is also assumed to account for rate structure changes.

I.6.2 Projected Water Savings

The change in water demand due to a real increase in the water price is called the price elasticity of water demand. A price elasticity of -0.20 indicates that a 1.0 percent increase in water rates will cause a -0.2 percent change in water usage.

Water Savings Through the Base Year

Water savings from price elasticity/rate structure impacts through the base year are built into the water demand projections.

Water Savings Since the Base Year

The SWCQP identified recent price increases and estimated water savings using projected municipal water demands and a price elasticity of -0.20. However, water demand is also sensitive to changes in income, and the change in water demand due to an increase in income is called the income elasticity of water demand. Income elasticity may range from 0.20 to 0.60 [6]. Recent historical Texas income data were obtained from the Federal Reserve [7]. Assuming an income elasticity of 0.20, it is estimated that rising incomes offset from 38 percent to 107 percent of the SWCQP-estimated water savings for the six largest Region C WUGs.

Based on this information, the SWCQP-estimated water savings were updated based on the current projected water demands and multiplied by 50 percent to represent the impact of rising incomes.

Projected Water Savings During the Planning Period

Unfortunately, historical price elasticities depend upon economic and other conditions that may not persist in the future, and no projections of future price elasticities were identified. Therefore, a long-term price elasticity of -0.20 is recommended for projecting the impact of increasing water prices in Region C [3]. It has also been assumed that real water prices will increase by 20 percent over the planning period and that half of the potential impact of increasing water prices will be offset by increasing income.

The projected water savings for each WUG is one half of the long-term price elasticity multiplied by the change in real water price multiplied by the municipal water demand. It was assumed that real water prices will increase linearly during planning period, for a total 20 percent increase by 2070 (**Table I.5**). By the end of the planning period, increasing water prices are projected to cause a 2 percent reduction in total water demand.

Table I.5 Projected Real Water Price Increases During Planning Period

2020	2030	2040	2050	2060	2070
3.3%	6.7%	10.0%	13.3%	16.6%	20%

I.6.3 Additional Data Requirements and Reliability

Customer participation is highly reliable for this measure, since changes in water prices automatically affect all water customers. However, the projected water savings are based on broad, general assumptions, and the reliability of the above projections is medium.

The reliability of the above projections could be increased if detailed projections of real treated water prices and real income were available. This would require projections of raw water costs, treatment costs, distribution costs, and administrative costs for each WUG.

I.6.4 Opinion of Probable Cost

The projected water savings due to real increases in water price will be realized at no cost to the WUGs.

I.7 Enhanced Water Loss Control Program

Most utilities in Region C have some kind of water loss control program. However, the levels of effort put into these programs, the budgets for these programs, and the water savings from these programs are highly variable. Although this measure does not define how a utility should conduct its water loss control program, it assumes that participating utilities will operate their programs at a high (or "enhanced") level, committing resources as necessary to achieve significant water savings.

The enhanced water loss control program consists of:

- Water audits, pressure control, and leak detection and repair (including Automated Metering Infrastructure), and
- Water main replacement

This measure incorporates elements of BMP 4.2 System Water Audit and Water Loss Control [3].

I.7.1 Applicability

Retail public utilities that supply potable water to more than 3,300 connections or receive financial assistance from the TWDB must file a system water loss audit with the TWDB by May 1 each year. Other retail public utilities that supply potable water must file a system water loss audit with the TWDB every five years (the next due date is May 1, 2021) [8]. In addition, the feasibility of water audits, pressure control, and leak detection and repair was evaluated for publicly-owned municipal WUGs with the following characteristics:

- Existing or projected total water usage of more than 140 gpcd,
- Total water loss in excess of the target level.
- A projected water need, and
- An identified sponsor for this measure.

Water main replacement was evaluated for every WUG.

I.7.2 Projected Water Savings

Water Savings Through the Base Year

Water savings from enhanced water loss control through the base year are built into the water demand projections.

Water Savings Since the Base Year

The SWCQP identified three WUGs that have implemented advanced metering infrastructure (AMI) with a customer portal and estimated water savings from these improvements.

In addition, several WUGs have obtained TWDB funding for water loss improvements, including main replacement, AMI, and automated meter reading (AMR). Associated water savings were assumed to be 0.5 percent of municipal water demand for each WUG or were estimated based on information provided by the TWDB or the WUG.

Projected Water Savings During the Planning Period

For a given WUG, the projected water savings associated with water audits, pressure control, and leak detection and repair is the difference between the WUG's actual water loss percentage and the target water loss percentage multiplied by the municipal water demand multiplied by an implementation schedule percentage. The

target water loss is 12 percent for urban/suburban WUGs and 18 percent for WUGs with widespread, rural systems. It has been assumed this measure will be 33 percent complete in the first decade of implementation and 100 percent complete by the second decade of implementation. The program should be continued indefinitely to maintain the target water loss. No water savings were projected from these measures for WUGs that have not reported their water loss.

Water savings from main replacement was estimated to be 0.5 percent of total water demand for each WUG. For each WUG, main replacement was assumed to take place in 2020, and the main replacements are projected to save water for 20 years.

In recent years, Fort Worth and Bedford have both applied for and received TWDB funding for enhanced water loss control projections. Based on funding disbursements to date, it is estimated that Fort Worth has completed approximately 15 percent of its AMI project and that Bedford has completed approximately 50 percent of its main replacement/AMI project. The remainder of the projected savings for each of these projects is included in the recommended water conservation strategy for these WUGs.

I.7.3 Additional Data Requirements

Some WUGs did not report their water loss to the TWDB. In addition, some water loss accounting quantities are difficult to estimate (e.g., fire fighting, main flushing, etc.). As more utilities report and refine their system water audit data, the overall estimate of potential water savings from this measure should be refined.

I.7.4 Reliability

The projected water savings are based on reported water loss data, which increases the reliability of the estimates. However, water loss as a percentage of total produced and/or purchased water can vary widely from year to year, even if the total system water loss does not change. Therefore, the reliability of the potential water savings is medium.

I.7.5 Opinion of Probable Cost

The cost for a system water audit is highly variable and depends on the size of the water system and the degree of uncertainty present in the estimated losses. The opinion of probable cost for a “desktop” audit, conducted by assembling readily available data and estimating losses for which data are not available, may range from $5,000 to $50,000. The opinion of probable cost for an “intensive” audit, where field investigations are conducted to generate additional data with which to refine the desktop audit, may range from $50,000 to $500,000 or more. It has been assumed that WUGs will implement the desktop audit.

In addition, a cost for leak detection and repair of $686 per mile of main per year has been assumed. This unit cost was derived from the typical leak detection and repair cost of $400 per mile of main per year used in the 2006 Region C Water Plan, with adjustment for inflation. Using estimates of the number of miles per main for different populations, an opinion of the probable annual cost for leak detection and repair was generated.

Since small diameter pipes are prevalent in a water distribution system, the large majority of the main replacements will be small diameter pipes. Costs were calculated

assuming an 8-inch diameter for each main replacement, using pipe installation costs from the TWDB's Unified Costing Model, assuming a multiplier of 1.5 to account for other costs involved in pipe replacement, and assuming a multiplier of 1.21 to inflate the cost from the Unified Costing Model basis (March 2012) to the 2021 Region C Water Plan basis (September 2018).

In some instances, water user groups provided their own estimate of cost to replace mains that are a significant source of measurable water loss.

For a given WUG and given year, the probable unit cost was calculated as the probable annual cost divided by projected water savings.

For Fort Worth and Bedford, the remainder of the projected costs for the projects described in **Section I.7.2** is included in the recommended water conservation strategy for these WUGs.

I.8 Water Waste Prohibition

Many Region C WUGs have prohibited water waste. This measure incorporates elements of BMP 9.1 Prohibition on Wasting Water [3].

I.8.1 Applicability

Water waste prohibition was evaluated for municipal WUGs with the following characteristics:

- Existing or projected total water usage of more than 140 gpcd,
- A projected water need, and
- No current water waste prohibition/ordinance.

It has been assumed that WUGs that lack ordinance-making authority will be able to implement a water waste prohibition through other means, such as including it in the terms of service.

I.8.2 Projected Water Savings

The projected water savings for each WUG is the product of the following parameters:

- Potential water savings (as a percentage of irrigation water demand)
- Municipal water demand
- Percent seasonal water demand
- Percent automatic irrigation
- Compliance rate
- Implementation schedule percentage

The projected savings are based on use of rain sensors that shut off automatic irrigation systems when it is raining or when it has rained recently (depending on the type of sensor). It is estimated that the percentage of watering cycles missed during a drought year is approximately equal to the minimum annual percentage of days with ½-inch rainfall events. The projected water savings from an irrigation water waste prohibition is 3.3 percent of irrigation water use for accounts that have automatic irrigation systems.

The percentage of customers that have automatic irrigation systems varies considerably across the region and is unknown in most cases. In the July 2004 RCWPG survey, 52 out of 129 total responses provided an estimate of the percentage of customers that have automatic irrigation systems.

In cases where no information was available, assumptions were made based on the whether the WUG is located in a rural, suburban, or urban area, the pace of recent development and the degree of projected growth. Based on these factors, the current percentages of customers with automatic irrigation systems were assumed to be 5, 20, or 50 percent, and the percentages of future connections with automatic irrigation systems were assumed to be 5, 50, or 80 percent.

It is anticipated that it will take ten years of implementation to realize full compliance with the water waste prohibition. However, anecdotal evidence indicates that there is some fraction of rain sensors that will be out of order. Therefore, “full compliance” is projected to be 90 percent participation.

The estimated potential water savings has been based on a requirement for rain sensors for automatic irrigation systems. As discussed previously, a water waste prohibition may address numerous other sources of waste, but it is not possible to predict what the ordinance for an individual WUG might prohibit. The potential water

savings from other sources of water waste have not been estimated.

It is anticipated that the customer will replace the rain sensor at the end of its useful life at his or her own expense to maintain compliance with the water waste prohibition and that the projected water savings will be permanent.

Water Savings Through the Base Year

Water savings from water waste prohibition through the base year are built into the water demand projections.

Water Savings Since the Base Year

WUGs that have implemented a water waste prohibition since the base year were identified through previous surveys and comparison of historical and current water conservation plans. For these WUGs, water savings since the base year were estimated as described above.

Projected Water Savings During the Planning Period

For WUGs that have not implemented a water waste prohibition, projected water savings were estimated as described above. Where no implementation information was available, it was assumed that the WUG will implement a water waste prohibition in the future.

I.8.3 Additional Data Requirements

The status of whether a WUG has implemented a water waste prohibition is known for WUGs that comprise 85 percent of 2070 municipal water demand. Additional information is necessary to refine the projected water savings for the remainder of the WUGs.

In addition, the percentage of customer accounts that have automatic irrigation systems is unknown for most WUGs. Additional data would improve the reliability of the assumptions stated in **Section I.8.2**.

I.8.4 Reliability

For an individual automatic irrigation system with a rain sensor in working order, the reliability of the potential water savings should be high. However, for an entire WUG to realize its projected savings, there must be enforcement of the water waste prohibition to ensure that the projected number of rain sensors are installed, and automatic irrigation system owners must keep the rain sensor in working order. In addition, there are uncertainties associated with the estimates of the market penetration of automatic irrigation systems. Due to uncertainties described above, the reliability of the projected savings is medium.

I.8.5 Opinion of Probable Cost

The primary costs for this measure include adoption of an ordinance and enforcement of the prohibition. For a given WUG and given year, the probable unit cost was calculated as the probable annual cost divided by projected water savings.

It has been assumed that the probable cost to pass an ordinance in a city of up to 25,000 people is $8,576 and that the cost to pass an ordinance in a city of more than 50,000 people is $17,153. To obtain an opinion of probable annual costs, probable capital costs were amortized at a 3.5 percent interest rate for a term of 20 years, and enforcement costs were assumed to be $0.43 per resident per year. For a given WUG and given year, the probable unit cost

was calculated as the probable annual cost divided by projected water savings.

I.9 Time-Of-Day Irrigation Restriction

Time-of-day irrigation restriction ordinances have been passed for a number of WUGs in Region C, although in varying forms. Some ordinances specify time-of-day restrictions (no automatic irrigation watering from 10am through 6pm) throughout the year, while some choose only the warmer months (e.g., April through October). The exact times allowed throughout a day also vary across the Region. Almost all WUGs allow hand irrigation regardless of time of day or year.

I.9.1 Applicability

The time-of-day irrigation restriction was evaluated for municipal WUGs with the following characteristics:

- Existing or projected total water usage of more than 140 gpcd,
- A projected water need, and
- No existing time-of-day irrigation restriction.

It has been assumed that WUGs that lack ordinance-making authority will be able to implement a time-of-day irrigation restriction through other means, such as including it in the terms of service.

I.9.2 Projected Water Savings

Sprinkler evaporation losses depend on relative humidity, air temperature, wind speed, nozzle diameter, and nozzle pressure [9]. Using long-term, monthly average weather data from the Dallas-Fort Worth International Airport weather station and assuming 5/16-inch nozzle diameter and 50 psi nozzle pressure, annual sprinkler evaporation losses were estimated to be 6.9 percent of irrigation water applied for irrigation between 10am and 6 pm and 4.0 percent if irrigation is restricted to 6pm to 10am. For each WUG, it was assumed that one-third of customers that have automatic irrigation systems would have to change their irrigation time in response to this restriction. For these customers, the estimated water savings is 2.9 percent of seasonal water demands. Seasonal water demands are calculated as the difference between monthly water usage and winter usage. Seasonal water demands are attributable largely to landscape irrigation, although cooling water usage and other factors may also contribute.

It is anticipated that it will take ten years of implementation to realize full compliance with the time-of-day irrigation restriction. However, some customers will continue to irrigate from 10am to 6pm. Therefore, "full compliance" is projected to be 90 percent participation.

Water Savings Through the Base Year

Water savings from a time-of-day irrigation restriction through the base year are built into the water demand projections.

Water Savings Since the Base Year

WUGs that have implemented a time-of-day irrigation restriction since the base year were identified through previous surveys and comparison of historical and current water conservation plans. For these WUGs, water savings since the base year were estimated as described above.

Projected Water Savings During the Planning Period

For WUGs that have not implemented a time-of-day irrigation restriction, projected water savings were estimated as described above. Where no implementation information was available, it was assumed that the WUG will implement a time-of-day irrigation restriction in the future.

I.9.3 Additional Data Requirements

Additional WUG surveys would help refine the number and type of ordinances currently enforced and the percentages of customers that have automatic irrigation systems.

I.9.4 Reliability

Customer participation is related to knowledge of the restriction and enforcement, which varies by WUG. It is also not possible to predict the exact irrigation restrictions that each WUG would adopt. In addition, amounts of water used in irrigation are dependent on weather patterns which cannot be predicted throughout the planning periods. Due to these unknowns the reliability of the savings estimate is medium.

I.9.5 Opinion of Probable Cost

The primary costs for this measure include adoption of an ordinance and enforcement of the ordinance similar to **Section I.8.5**. For a given WUG and given year, the probable unit cost was calculated as the probable annual cost divided by projected water savings.

I.10 Twice Weekly Irrigation Restriction

Historically, twice weekly irrigation restrictions have been used as drought response measures in Region C. In recent years, however, a number of WUGs in Region C have implemented permanent twice weekly irrigation restrictions, although in varying forms. Some ordinances limit irrigation to two times per week year-round, while others also restrict irrigation to once per week during the winter months.

I.10.1 Applicability

The twice weekly irrigation restriction was evaluated as a water management strategy for municipal WUGs with the following characteristics:

- Existing or projected total water usage of more than 140 gpcd,
- A projected water need, and
- No existing twice weekly irrigation restriction.

It has been assumed that WUGs that lack ordinance-making authority will be able to implement a twice weekly irrigation restriction through other means, such as including it in the terms of service.

I.10.2 Projected Water Savings

Water savings from a twice weekly irrigation restriction are difficult to measure and typically require statistical analysis to account for changes in weather and other factors that influence water use. Although this restriction has been used as a drought response measure in Region C for many years, the corresponding water savings have not been widely studied. In addition, a permanent restriction of this type is relatively new in Texas and the U.S., so there are limited data available regarding permanent water savings.

Tarrant Regional Water District implemented Stage 1 drought response measures, primarily consisting of twice-weekly irrigation limits, from August 29, 2011 through May 3, 2012. An analysis of water use in the service area of their four major customers indicated that the water savings during this period were about 8.5 percent of the water that would have been delivered without the Stage 1 drought response measures [(10)].

For a permanent twice weekly irrigation restriction, reported savings for Texas cities as a percentage of municipal water demand are [(11)]:

- 1 to 9 percent (Fort Worth, 2013-2016)
- 7 percent (Dallas, 2012)
- 7 percent (Austin, 2009)

More recent unpublished data for major water providers in Region C indicate water savings of 1 to 4 percent of municipal water demand for permanent twice weekly irrigation restriction. Two major water providers submitted water conservation plans that project water savings from twice weekly watering restrictions at 1.5 to 2 percent of municipal water demand.

The effectiveness of a twice weekly irrigation restriction depends on public education and customer behavior. Customers have apparently been willing to comply with a twice weekly irrigation restriction as a drought measure, although the water savings data are limited. As a permanent measure, water savings may have eroded somewhat in recent years. Also, it is not clear what impact

implementing a twice weekly irrigation restriction as a permanent measure will have on water savings during drought conditions.

Due to the limited data, it has been assumed that a permanent twice weekly irrigation restriction will result in savings of 3 percent of municipal water demand. It is anticipated that it will take ten years of implementation to realize the full water savings.

Water Savings Through the Base Year

No water savings from this measure are built into the water demand projections, because no Region C WUGs had implemented this measure by the base year.

Water Savings Since the Base Year

WUGs that have implemented a time-of-day irrigation restriction since the base year were identified from current water conservation plans and from the SWCQP. For these WUGs, water savings since the base year were estimated as described above.

Projected Water Savings During the Planning Period

For WUGs that have not implemented a twice weekly irrigation restriction, projected water savings were estimated as described above. Where no implementation information was available, it was assumed that the WUG will implement a time-of-day irrigation restriction in the future.

I.10.3 Additional Data Requirements

Additional data should be collected on water savings realized from implementation of a permanent twice weekly irrigation restriction, particularly during drought periods. This will help refine the water savings estimate.

I.10.4 Reliability

Customer participation is related to knowledge of the restriction and enforcement, which varies by WUG. It is also not possible to predict the exact irrigation restrictions that each WUG would adopt. In addition, amounts of water used in irrigation are dependent on weather patterns which cannot be predicted throughout the planning periods. Due to these unknowns the reliability of the savings estimate is medium.

I.10.5 Opinion of Probable Cost

The primary costs for this measure include adoption of an ordinance and enforcement of the ordinance similar to **Section I.8.5**. For a given WUG and given year, the probable unit cost was calculated as the probable annual cost divided by projected water savings.

I.11 Water Conservation Coordinator

A water conservation coordinator "coordinates water utility staff, data from various departments, and other resources as necessary for the purpose of developing, implementing, and evaluating the effectiveness of the utility's water conservation plan [3]." Coordination will make other water conservation measures more effective.

I.11.1 Applicability

Beginning September 1, 2017, House Bill 1648 required all retail public utilities with 3,300 service connection or more to designate a water conservation coordinator that is responsible for implementing the water conservation plan.

The water conservation coordinator measure was evaluated for municipal WUGs based on the projected number of connections during the planning period.

I.11.2 Projected Water Savings

Water Savings Through the Base Year

Water savings for WUGs that had a water conservation coordinator prior to or during the base year are built into the water demand projections.

Water Savings Since the Base Year

It was assumed that other WUGs that currently have 3,300 connections or more have already appointed a water conservation coordinator, as required by HB 1648. Savings from coordination of the water conservation program are projected to be 0.25 percent of municipal water demand.

Projected Water Savings During the Planning Period

It was assumed that WUGs that currently have fewer than 3,300 connections will appoint a water conservation coordinator as they meet this threshold. Savings from coordination of the water conservation program are projected to be 0.25 percent of municipal water demand.

No savings were projected for the County Other WUGs, since these are comprised of multiple utilities for which the number of connections is unknown and likely to be small.

I.11.3 Additional Data Requirements

Additional WUG surveys would help identify WUGs that have and have not appointed water conservation coordinators.

I.11.4 Reliability

The savings from this measure are uncertain and difficult to measure, since they result from improved effectiveness of the overall water conservation program. In addition, the savings depend on the level of effort by the water conservation coordinator. Due to these unknowns the reliability of the savings estimate is low.

I.11.5 Opinion of Probable Cost

Since the level of effort required of a water conservation coordinator is undefined and will likely vary among the various WUGs, a unit cost of $1.00 per thousand gallons of water savings was assigned to this measure. This cost was judged to be reasonably reflective of general water conservation savings, but it should be refined as more information becomes available.

I.12 Reuse of Treated Wastewater Effluent

Reuse is a significant water conservation measure in Region C. Reuse strategies were evaluated on a case-by-case basis, and reuse water supplies are described in **Chapter 5B.**

I.13 Accelerated Low-Flow Plumbing Fixtures

The SWCQP identified Region C WUGs that have implemented measures to accelerate the water savings from the low-flow plumbing fixture rules. These measures encourage the retrofitting of efficient toilets, showerheads, and clothes washers, whether by rebates, direct installation, or other implementation methods.

All of the water savings associated with these measures would have been realized eventually by natural replacement due to the low-flow plumbing fixture rules. For each low-flow plumbing fixture installed as a result of these measures, accelerated water savings will be realized for a few years until the water savings would have been realized anyway by natural replacement. The natural replacement savings are already built into the water demand projections. Therefore, to avoid double-counting of the water savings, only the accelerated water savings are attributed to these measures.

I.13.1 Applicability

Water savings were included for all WUGs identified by the SWCQP as having implemented accelerated low-flow plumbing fixture measures.

I.13.2 Projected Water Savings

Water Savings Through the Base Year

Water savings for accelerated low-flow plumbing fixture measures implemented prior to or during the base year are built into the water demand projections

Water Savings Since the Base Year

The SWCQP findings were used to estimate water savings for measures implemented since the base year. However, the SWCQP water savings estimates were adjusted to exclude savings beyond the natural life of the fixtures installed as part of these measures, since these future savings are already accounted for and built into the water demand projections.

Projected Water Savings During the Planning Period

The SWCQP focused on measures that have already been implemented and did not report planned future implementation. Therefore, with exceptions described in **Section I.13**, no water savings from accelerated low-flow plumbing fixtures were estimated.

I.13.3 Additional Data Requirements

To estimate future water savings, information about planned future implementation is required.

I.13.4 Reliability

The savings from these measures are relatively well-defined, so the reliability of the savings estimate is high.

I.13.5 Opinion of Probable Cost

No costs have been estimated for these measures, because planned future

implementation information was not available from the SWCQP.

I.14 Other

I.14.1 Applicability

The SWCQP identified a few Region C WUGs, most notably Allen and Dallas, that have implemented miscellaneous water conservation measures that are not described in other sections of this technical memorandum. These measures include irrigation system surveys, other irrigation measures, and measures directed toward industrial, commercial, and institutional customers.

In addition, some Region C WUGs provided sufficient information about their planned implementation of miscellaneous water conservation measures to allow projection of water savings and costs.

I.14.2 Projected Water Savings

Water Savings Through the Base Year

Water savings for miscellaneous water conservation measures implemented prior to or during the base year are built into the water demand projections

Water Savings Since the Base Year

The SWCQP findings were used to estimate water savings for measures implemented since the base year.

Projected Water Savings During the Planning Period

Some WUGs provided planned future implementation information in their water conservation plans, and water savings from these measures were estimated using generally accepted methods.

Projected water savings for Dallas were taken from their most recent Long Range Water Supply Plan [12].

I.14.3 Additional Data Requirements

Additional data on planned future implementation is needed for many WUGs.

I.14.4 Reliability

The savings from this measure are somewhat uncertain, and they depend upon ongoing maintenance by the customer. The reliability of the savings estimate is medium.

I.14.5 Opinion of Probable Cost

Some WUGs provided planned future implementation information in their water conservation plans, and costs for these measures were estimated using generally accepted methods.

Projected costs for Dallas were taken from their most recent Long Range Water Supply Plan [12].

I.15 Golf Course Conservation Program

I.15.1 Applicability

The golf course conservation measure was evaluated for irrigation WUGs that have a projected water need.

I.15.2 Potential Water Savings

It has been assumed that where the measure is implemented, the potential water savings for the golf course conservation program is 15 percent of golf course water demand and that the potential water savings will last indefinitely (the golf course will continue to maintain and implement the conservation program at its own expense). Assumed participation rates for implementation by 2020 are shown in **Table I.6.**

Table I.6 Participation Rates in Golf Course Conservation Program

2020	2030	2040	2050	2060	2070
20%	40%	50%	60%	70%	80%

I.15.3 Additional Data Requirements

No additional data are required to estimate potential water savings from a golf course conservation program.

I.15.4 Reliability

The effectiveness of this measure depends on the degree of participation of golf courses. In addition, the estimate of potential water savings is not based on course-specific data. Therefore, the reliability of the potential water savings for the golf course conservation program is low.

I.15.5 Opinion of Probable Cost

Implementation alternatives include voluntary implementation for self-supplied golf courses, rebates for courses supplied by a municipal WUG, and ordinances if supplied by a city. The opinion of probable cost assumes that a municipal WUG offers a rebate to a golf course to implement a conservation program.

The opinion of probable cost for rebates is $306 per acre-foot of savings, including the rebate, marketing, and overhead. The cost for a single rebate is amortized at 3.5 percent interest over 15 years, the expected life of the associated measure. The opinion of probable annual cost is the sum of amortized costs for all rebates given in the previous 15 years. For a given WUG and given year, the probable unit cost was calculated as the probable annual cost divided by projected water savings.

I.16 Mining Conservation

I.16.1 Applicability

Mining water conservation was evaluated for the Wise County Mining WUG.

I.16.2 Potential Water Savings

Water savings for Wise County Mining was assumed to be 90 percent of the water demand for sand and gravel mining in the county. Savings would be achieved through on-site recycling of process water. The water demand for sand and gravel mining was estimated as the difference between the overall mining water demand for Wise County and water demand for oil and gas well drilling (from the Bureau of Economic Geology [13].

I.16.3 Additional Data Requirements

To better estimate the potential water savings and costs for mining conservation methods, data are needed on the types of mining activities in each county, their relative water uses, and their water quality needs.

I.16.4 Reliability

Since few data are available on types of mining activities in each county, their relative water uses, and their water quality needs, the reliability of the potential water savings for mining conservation is low.

I.16.5 Opinion of Probable Cost

The opinion of probable cost for Wise County Mining is based on the cost from the 2016 Region C Water Plan adjusted to September 2018 dollars.

I.17 GPCD Goals by WUG

As required by TWDB, gpcd goals for each WUG in included below in **Table I.7**. These calculations are based on the formula:

GPCD Goals = (Water Demand Projections - Recommended Conservation Water Management Strategies - Demand Reduction Since Base Year)/WUG Population

Table I.7 GPCD Goals for Municipal Water User Groups

WUG Name	2020	2030	2040	2050	2060	2070
ABLES SPRINGS WSC	59	59	59	59	59	59
ADDISON	349	342	340	337	335	333
ALEDO	137	134	133	132	131	131
ALLEN	174	172	172	171	170	169
ALVORD	124	124	124	123	123	123
ANNA	128	112	138	137	136	136
ANNETTA	103	99	97	96	96	95
ARGYLE WSC	175	162	158	157	156	156
ARLEDGE RIDGE WSC	104	100	97	96	96	95
ARLINGTON	148	139	137	135	134	134
ATHENS	180	167	164	162	160	160
AUBREY	105	103	102	101	100	100
AVALON WATER SUPPLY & SEWER SERVICE	112	108	106	105	104	104
AZLE	138	133	131	130	129	128
B AND B WSC	122	118	115	114	113	113
B B S WSC	92	89	89	89	89	89
B H P WSC	67	62	60	59	59	58
BALCH SPRINGS	90	86	83	82	81	81
BEAR CREEK SUD	101	98	96	95	95	94
BECKER JIBA WSC	81	77	75	74	74	73
BEDFORD	151	141	154	152	152	151
BELLS	94	90	88	87	86	86
BENBROOK WATER AUTHORITY	195	188	185	183	182	181
BETHEL ASH WSC	90	86	85	84	83	83
BETHESDA WSC	179	174	172	170	169	169
BLACK ROCK WSC	167	164	163	155	153	153
BLACKLAND WSC	171	166	164	162	161	161
BLOOMING GROVE	148	144	141	133	131	130
BLUE RIDGE	144	137	135	150	149	149
BOIS D ARC MUD	104	100	97	96	96	95
BOLIVAR WSC	79	75	73	72	71	71
BONHAM	142	138	136	135	134	133
BOYD	147	133	123	138	137	136
BRANDON IRENE WSC	115	112	111	107	107	106
BRIDGEPORT	154	143	140	139	138	137
BUENA VISTA-BETHEL SUD	246	242	231	227	226	224
BURLESON	130	126	125	124	123	122
BUTLER WSC	136	132	128	126	126	126
CADDO BASIN SUD	99	94	92	91	90	90
CALLISBURG WSC	80	76	74	72	72	72

WUG Name	2020	2030	2040	2050	2060	2070
CARROLLTON	158	153	151	149	148	148
CASH SUD	99	95	93	93	92	92
CEDAR HILL	166	162	160	159	158	157
CELINA	176	172	172	171	171	170
CHATFIELD WSC	96	93	91	89	89	88
CHICO	175	163	159	156	155	154
COCKRELL HILL	72	68	69	68	67	66
COLLEGE MOUND WSC	59	59	59	59	59	59
COLLEYVILLE	340	321	318	315	314	313
COLLINSVILLE	97	94	92	91	90	90
COMBINE WSC	84	80	78	77	76	76
COMMUNITY WSC	87	83	80	79	79	78
COPEVILLE SUD	72	68	65	64	64	63
COPPELL	220	216	214	212	211	210
CORBET WSC	79	76	73	72	72	71
CORINTH	151	141	139	138	137	137
CORSICANA	202	196	194	183	181	180
CRANDALL	154	149	147	146	145	145
CRESCENT HEIGHTS WSC	76	73	71	70	69	69
CROSS TIMBERS WSC	194	183	180	179	178	177
CROWLEY	127	124	122	121	120	120
CULLEOKA WSC	96	91	91	91	90	90
DALLAS	185	177	169	166	166	166
DALWORTHINGTON GARDENS	350	332	328	325	324	323
DAWSON	148	142	140	138	137	137
DECATUR	231	224	223	221	220	219
DELTA COUNTY MUD	60	60	58	58	57	55
DENISON	219	204	202	200	199	198
DENTON	152	147	145	144	144	143
DENTON COUNTY FWSD 10	167	156	154	153	153	152
DENTON COUNTY FWSD 1-A	221	217	217	216	215	214
DENTON COUNTY FWSD 7	224	210	208	207	206	205
DESERT WSC	112	109	107	106	105	105
DESOTO	146	140	138	136	135	135
DOGWOOD ESTATES WATER	134	131	129	127	126	126
DORCHESTER	67	63	61	60	59	59
DUNCANVILLE	121	117	115	114	113	113
EAST CEDAR CREEK FWSD	59	59	59	59	59	59
EAST FORK SUD	104	99	97	96	95	94
EAST GARRETT WSC	146	136	133	133	131	131
EDGECLIFF	152	143	140	137	136	136
ELMO WSC	74	71	70	68	68	68
ENNIS	167	152	142	141	140	139
EULESS	141	131	129	133	132	131
EUSTACE	95	91	90	87	87	86
EVERMAN	74	69	67	65	64	64
FAIRFIELD	184	179	176	167	164	163
FAIRVIEW	306	301	301	300	298	297
FARMERS BRANCH	244	238	237	235	234	233
FARMERSVILLE	106	102	101	101	100	100

WUG Name	2020	2030	2040	2050	2060	2070
FATE	150	147	147	146	145	144
FERRIS	138	134	131	130	129	128
FILES VALLEY WSC	136	131	129	127	126	126
FLO COMMUNITY WSC	114	110	106	104	105	105
FLOWER MOUND	216	211	210	209	208	207
FOREST HILL	93	88	85	83	82	82
FORNEY	125	123	122	121	120	120
FORNEY LAKE WSC	138	135	134	133	132	131
FORT WORTH	151	149	157	158	159	160
FRISCO	205	202	202	201	200	200
FROGNOT WSC	93	90	88	87	86	86
GAINESVILLE	127	122	120	118	117	116
GARLAND	134	130	129	127	126	126
GASTONIA SCURRY SUD	59	59	59	59	59	59
GLENN HEIGHTS	97	94	93	92	91	91
GRAND PRAIRIE	136	132	132	131	130	130
GRAPEVINE	297	291	290	288	286	285
GUNTER	132	118	138	137	136	135
HACKBERRY	203	198	197	197	196	194
HALTOM CITY	101	97	95	93	92	92
HASLET	288	270	267	265	263	262
HEATH	275	269	269	267	266	265
HICKORY CREEK SUD	89	84	83	81	81	81
HIGH POINT WSC	80	76	74	73	72	72
HIGHLAND PARK	381	376	373	371	369	368
HIGHLAND VILLAGE	186	174	171	169	169	168
HILCO UNITED SERVICES	126	123	118	117	116	110
HONEY GROVE	142	137	134	132	131	131
HORSESHOE BEND WATER SYSTEM	84	80	78	77	76	76
HOWE	85	80	78	76	76	76
HUDSON OAKS	290	283	282	281	280	279
HURST	145	140	138	137	136	135
HUTCHINS	188	184	183	182	182	181
IRVING	180	177	175	173	173	172
ITALY	116	111	109	108	107	107
JACKSBORO	124	120	118	116	115	115
JOHNSON COUNTY SUD	114	110	108	107	106	106
JOSEPHINE	183	180	179	178	177	176
JUSTIN	131	128	127	127	126	126
KAUFMAN	141	136	138	136	136	135
KAUFMAN COUNTY DEVELOPMENT DISTRICT 1	202	197	195	194	193	192
KAUFMAN COUNTY MUD 11	139	135	133	132	131	131
KELLER	214	210	210	208	207	207
KEMP	147	137	135	134	133	132
KENNEDALE	156	147	144	142	141	141
KENTUCKYTOWN WSC	110	106	103	102	101	101
KERENS	105	99	97	95	95	95
KRUM	188	184	183	181	180	179
LADONIA	137	133	134	132	132	132

WUG Name	2020	2030	2040	2050	2060	2070
LAKE CITIES MUNICIPAL UTILITY AUTHORITY	124	121	120	119	119	118
LAKE KIOWA SUD	359	353	353	351	350	348
LAKE WORTH	194	182	179	177	176	175
LAKESIDE	231	224	223	221	219	218
LANCASTER	144	139	138	137	136	135
LEONARD	132	128	125	123	122	122
LEWISVILLE	160	156	154	153	152	151
LINDSAY	115	112	109	107	107	106
LITTLE ELM	117	115	115	114	114	113
LUCAS	246	232	231	229	228	227
LUELLA SUD	93	89	87	86	85	85
M E N WSC	125	121	119	118	117	117
MABANK	167	162	160	158	157	157
MACBEE SUD	60	59	60	61	58	59
MALAKOFF	100	96	92	90	90	89
MANSFIELD	234	230	230	228	227	226
MARILEE SUD	130	128	127	126	125	125
MARKOUT WSC	147	142	141	140	139	138
MCKINNEY	183	179	177	176	176	176
MELISSA	188	185	185	183	183	182
MESQUITE	125	121	119	117	116	116
MIDLOTHIAN	194	189	187	186	185	184
MILLIGAN WSC	107	104	102	101	100	100
MINERAL WELLS	138	133	138	135	135	134
MOUNT ZION WSC	170	165	163	161	161	160
MOUNTAIN PEAK SUD	253	226	224	223	222	221
MOUNTAIN SPRINGS WSC	148	145	143	142	135	133
MUENSTER	152	147	144	142	141	140
MURPHY	195	192	192	191	190	189
MUSTANG SUD	133	130	129	129	128	128
NAVARRO MILLS WSC	94	90	88	86	86	85
NEVADA SUD	86	83	82	80	80	79
NEWARK	97	94	92	91	91	90
NORTH COLLIN SUD	130	126	124	123	122	121
NORTH FARMERSVILLE WSC	188	178	177	177	176	175
NORTH HUNT SUD	60	60	59	59	59	59
NORTH KAUFMAN WSC	60	59	59	59	59	59
NORTH RICHLAND HILLS	151	146	144	142	141	141
NORTH RURAL WSC	87	82	80	77	78	76
NORTHLAKE	179	171	170	169	169	168
NORTHWEST GRAYSON COUNTY WCID 1	90	86	84	82	82	82
OAK RIDGE SOUTH GALE WSC	77	73	71	69	69	69
OVILLA	197	179	177	175	174	173
PALMER	100	95	93	92	91	90
PALOMA CREEK NORTH	184	172	170	169	169	168
PALOMA CREEK SOUTH	182	171	170	169	169	168
PANTEGO	229	224	221	218	217	217
PARKER	359	353	353	352	350	348

WUG Name	2020	2030	2040	2050	2060	2070
PARKER COUNTY SUD	94	91	90	89	88	88
PELICAN BAY	59	59	59	59	59	59
PILOT POINT	121	118	116	115	114	114
PINK HILL WSC	101	98	96	94	93	93
PLANO	219	214	211	211	210	209
PLEASANT GROVE WSC	88	84	81	80	79	79
POETRY WSC	97	94	92	91	90	90
POINT ENTERPRISE WSC	97	93	90	89	87	87
PONDER	110	107	107	106	105	105
POST OAK SUD	66	63	59	59	59	59
POTTSBORO	143	139	137	136	135	134
PRINCETON	95	92	90	89	89	88
PROSPER	219	216	216	215	214	214
PROVIDENCE VILLAGE WCID	115	113	114	113	112	112
R C H WSC	179	174	172	171	170	169
RED OAK	132	129	128	126	126	125
RED RIVER AUTHORITY OF TEXAS	218	213	210	208	207	207
RENO (Parker)	59	59	59	59	59	59
RHOME	146	142	141	140	140	139
RICE WATER SUPPLY AND SEWER SERVICE	106	102	100	99	99	98
RICHARDSON	213	208	206	204	203	202
RICHLAND HILLS	121	116	113	111	110	110
RIVER OAKS	100	96	93	91	90	90
ROANOKE	251	237	235	234	233	232
ROCKETT SUD	101	97	95	94	93	93
ROCKWALL	157	154	154	153	152	151
ROSE HILL SUD	77	73	71	70	70	69
ROWLETT	131	128	126	125	124	124
ROYSE CITY	102	99	98	97	97	96
RUNAWAY BAY	308	301	299	297	296	295
SACHSE	150	148	147	146	145	145
SAGINAW	114	111	110	109	109	108
SANGER	119	116	114	113	112	112
SANSOM PARK	98	94	91	90	89	89
SANTO SUD	114	105	107	102	103	105
SARDIS LONE ELM WSC	220	216	214	213	212	211
SEAGOVILLE	94	90	89	88	87	87
SEIS LAGOS UD	242	239	238	237	236	235
SHERMAN	216	212	209	207	197	195
SOUTH ELLIS COUNTY WSC	227	223	221	181	120	119
SOUTH FREESTONE COUNTY WSC	88	84	81	79	79	78
SOUTH GRAYSON SUD	108	105	104	103	102	102
SOUTHLAKE	353	346	346	344	342	341
SOUTHMAYD	99	95	92	91	90	90
SOUTHWEST FANNIN COUNTY SUD	88	85	83	82	82	81
SPRINGTOWN	173	146	145	144	143	142
STARR WSC	91	87	85	83	83	82
SUNNYVALE	289	284	282	281	279	278
TALTY SUD	139	135	135	134	133	133

WUG Name	2020	2030	2040	2050	2060	2070
TEAGUE	140	126	123	121	120	120
TERRELL	145	140	139	138	137	136
THE COLONY	134	130	129	127	127	126
TIOGA	109	107	103	102	95	95
TOM BEAN	167	144	117	116	115	114
TRENTON	164	151	146	145	144	144
TRINIDAD	90	85	83	83	81	80
TROPHY CLUB MUD 1	324	318	317	316	314	313
TWO WAY SUD	98	95	93	92	92	91
UNIVERSITY PARK	252	248	245	243	242	241
VAN ALSTYNE	118	114	112	111	110	109
VENUS	165	158	153	151	150	152
VERONA SUD	89	86	84	83	83	82
VIRGINIA HILL WSC	85	81	79	77	77	77
WALNUT CREEK SUD	66	63	62	61	60	60
WATAUGA	99	95	92	91	90	90
WAXAHACHIE	161	157	149	146	145	145
WEATHERFORD	150	143	139	137	136	136
WEST CEDAR CREEK MUD	59	59	59	59	59	59
WEST LEONARD WSC	118	114	112	111	109	109
WEST WISE SUD	109	105	102	100	99	99
WESTLAKE	1,024	973	969	966	962	958
WESTMINSTER WSC	120	117	115	114	114	113
WESTOVER HILLS	1,206	1,121	1,078	1,072	1,069	1,065
WESTWORTH VILLAGE	130	125	122	121	120	119
WHITE SETTLEMENT	109	104	101	99	98	97
WHITE SHED WSC	96	92	90	88	88	87
WHITESBORO	108	104	101	99	98	98
WHITEWRIGHT	121	117	113	112	111	110
WILLOW PARK	137	133	132	130	130	129
WILMER	91	87	85	83	82	82
WOLFE CITY	89	80	82	78	81	76
WOODBINE WSC	94	90	87	86	85	85
WORTHAM	126	122	118	117	115	115
WYLIE	127	125	124	123	123	122
WYLIE NORTHEAST SUD	120	117	116	115	114	114
COUNTY OTHER, COLLIN	139	136	134	131	130	130
COUNTY OTHER, COOKE	117	113	110	108	107	106
COUNTY OTHER, DALLAS	1,759	2,325	2,168	2,041	1,468	1,225
COUNTY OTHER, DENTON	111	109	109	107	107	106
COUNTY OTHER, ELLIS	108	103	100	97	97	96
COUNTY OTHER, FANNIN	99	94	91	89	88	88
COUNTY OTHER, FREESTONE	91	88	85	83	82	81
COUNTY OTHER, GRAYSON	112	108	104	103	102	101
COUNTY OTHER, HENDERSON	81	76	72	72	71	71
COUNTY OTHER, JACK	99	95	92	91	90	90
COUNTY OTHER, KAUFMAN	97	95	93	91	91	91
COUNTY OTHER, NAVARRO	101	97	96	94	93	92
COUNTY OTHER, PARKER	115	112	110	108	107	106
COUNTY OTHER, ROCKWALL	139	137	136	135	134	133

WUG Name	2020	2030	2040	2050	2060	2070
COUNTY OTHER, TARRANT	199	197	200	168	157	150
COUNTY OTHER, WISE	106	103	101	99	98	97
REGION C	**166**	**160**	**159**	**156**	**154**	**151**

Appendix I List of References

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