



TRANS-TEXAS WATER PROGRAM

SOUTHEAST AREA

Draft Memorandum

Water Conservation

January 30, 1998

**Sabine River Authority of Texas
Lower Neches Valley Authority
San Jacinto River Authority
City of Houston
Brazos River Authority
Texas Water Development Board**

This document is a product of the Trans-Texas Water Program: Southeast Area. The program's mission is to propose the best economically and environmentally beneficial methods to meet water needs in Texas for the long term. The program's three planning areas are the Southeast Area, which includes the Houston-Galveston metropolitan area, the South-Central Area (including Corpus Christi), North-Central Area (including Austin) and the West-Central Area (including San Antonio).

The Southeast Area of the Trans-Texas Water Program draws perspectives from many organizations and citizens. The Policy Management Committee and its Southeast Area subcommittee guide the program; the Southeast Area Technical Advisory Committee serves as program advisor. Local sponsors are the Sabine River Authority of Texas, the Lower Neches Valley Authority, the San Jacinto River Authority, the City of Houston and the Brazos River Authority.

The Texas Water Development Board is the lead Texas agency for the Trans-Texas Water Program. The Board, along with the Texas Natural Resource Conservation Commission, the Texas Parks & Wildlife Department and the Texas General Land Office, set goals and policies for the program pertaining to water resources management and are members of the Policy Management Committee.

This is a draft of this document.

Brown & Root and Freese & Nichols are consulting engineers for the Trans-Texas Water Program: Southeast Area. Blackburn & Carter and Ekistics provide technical support. This document was written by:

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Memorandum

TO: Southeast Technical Advisory Committee
FROM: Jeff Taylor
Brown & Root, Inc.
DATE: February 6, 1998
SUBJECT: Water Conservation

Enclosed is a draft copy of *Water Conservation*. Please review and send your comments to me by mail, e-mail or fax at:

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The following is a revised schedule of publication and distribution for the remaining TTWP Technical Study Memoranda. Shown below is the date of report issuance to both the PMC and TAC.

Technical Memoranda	PMC Review	TAC Review
Reservoir Operations	January 16, 1998	January 23, 1998
Equity Analysis	January 23, 1998	January 30, 1998
Water Conservation	January 30, 1998	February 6, 1998
Desalination	February 6, 1998	February 13, 1998
Interbasin Transfer (Env.)	February 13, 1998	February 20, 1998
Neches Salt Water Barrier	February 20, 1998	February 27, 1998
Sabine Lake Salinity	February 27, 1998	March 6, 1998
Wastewater Reclamation	February 27, 1998	March 6, 1998
Contractual Transfers	March 6, 1998	March 13, 1998
Interbasin Transfer (Eng.)	March 6, 1998	March 13, 1998

Due to this program schedule, the time allowed for PMC review has been shortened to one week per report. TAC comments can be submitted in writing up to the time of a final TAC meeting. A final TAC meeting at which all reports will be discussed will be scheduled late in the week of March 16, 1998. Allowing an additional week to receive TAC comments, the final PMC meeting will be scheduled for March 30 or 31, 1998.

Thank you for your cooperation.

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1. Introduction

The Trans-Texas Water Program (TTWP) Southeast Area *Phase I Report* identified seven water management alternatives for possible inclusion in its TTWP Southeast Water Management Plan. This current memorandum analyzes the viability of implementing one of these alternatives, water conservation.

In traditional water supply planning, projections of future water needs are used to determine the size of future water supply development options such as new reservoirs or groundwater well fields. Demand management analyses techniques are intended to manipulate water usage characteristics that alter the computed water need projections. Successful demand management strategies facilitate more efficient use of existing water supplies, allow existing supply sources to serve demands for a longer period of time, and delay the need to develop new supply options.

The specific management technique under consideration in this study is water conservation. The analysis develops assumptions about the implementation of specific conservation measures on total water demand and on specific water use types. The anticipated demand reduction associated with these measures is calculated as the volume of conservation "savings". The revised water demand projections reflecting conservation efforts are then evaluated against the originally projected water demand defined within the TTWP *Planning Information Update*. The value of advanced conservation as a demand management strategy in the

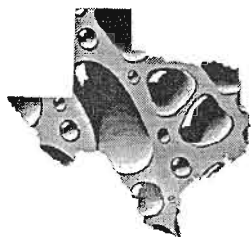
Southeast Area is illustrated through an analysis of its impact on the area's future demand projections.

It should be noted that the water demand projections in the *Planning Information Update* are derived from a demand scenario that contains an "expected" amount of water conservation. These projections assume a per capita reduction in long-term water demand resulting from the implementation of the 1991 State of Texas Water Efficiency Plumbing Act. This Act mandates the exclusive use of low-flow plumbing fixtures in all new construction.

The water conservation management strategy defined in this study assesses the viability of an "advanced" degree of water conservation. "Advanced" water conservation is defined as the implementation of conservation measures sooner and in addition to the "expected" conservation scenarios. These measures are intended to strive aggressively for increased levels of water use reduction. Advanced conservation produces a larger quantity of water savings than the expected water conservation scenarios used in the Consensus State Water Plan and in the TTWP Phase II *Planning Information Update* document.

The Water Conservation memorandum is structured to discuss the following:

- Expected Conservation
- Advanced Conservation
- Water supply and availability with Advanced Conservation
- Environmental impacts
- Implementation costs



2. Expected Conservation

To assess the potential opportunity for advanced levels of conservation, we must review the analytical basis of the existing TTWP water demand projections. The TTWP *Planning Information Update* (September 1997) presented future water demand projections for the Southeast Area of the TTWP. Six water use classifications were defined for planning purposes: municipal, manufacturing, irrigation, livestock, mining, and power. Each category has specific variables affecting its demand projections.

2.1 Water Use Projections

The municipal water use projections are based upon assumptions regarding three components: population projections, per capita (or unit) water use, and forecasts of the efficiency of conservation measures. Municipal demands include both residential and commercial sector uses. A "Most Likely" municipal water use scenario was created for planning purposes. This scenario reflects the following parameters:

- "Most Likely" Population Migration,
- Per Capita Water Use associated with Below Normal Rainfall, and
- Expected or Advanced Conservation Savings.

The current TTWP municipal projections are based on an "expected" level of conservation. "Expected" conservation proj-

ects the potential water savings anticipated from both market forces and regulatory requirements, particularly the 1991 State of Texas Water Efficiency Plumbing Act. Table 1 defines the "expected" conservation factors embedded within the municipal use projections. A more detailed description of expected conservation scenarios and on the computation of the base level of conservation incorporated in TTWP water demand projections is included in both the *Planning Information Update* and the Texas Water Development Board's Consensus Planning documents.

Future demand projections for the manufacturing and irrigation use categories also have expected levels of water conservation defined. Conservation in these categories is a function of industry type, industry specific water use efficiencies, and the potential for improved efficiencies in irrigation. The remaining water use categories, steam power, livestock, and mining, do not have an associated quantity of conservation included within the projections.

2.2 Projected Water Demands

Demand projections within the *Planning Information Update* grow from 2,555,300 acre-feet per year in 1990 to 3,839,600 acre-feet per year in year 2050. The eight-county Houston region represents over 70

Table 1: Components of Municipal Water Conservation Savings

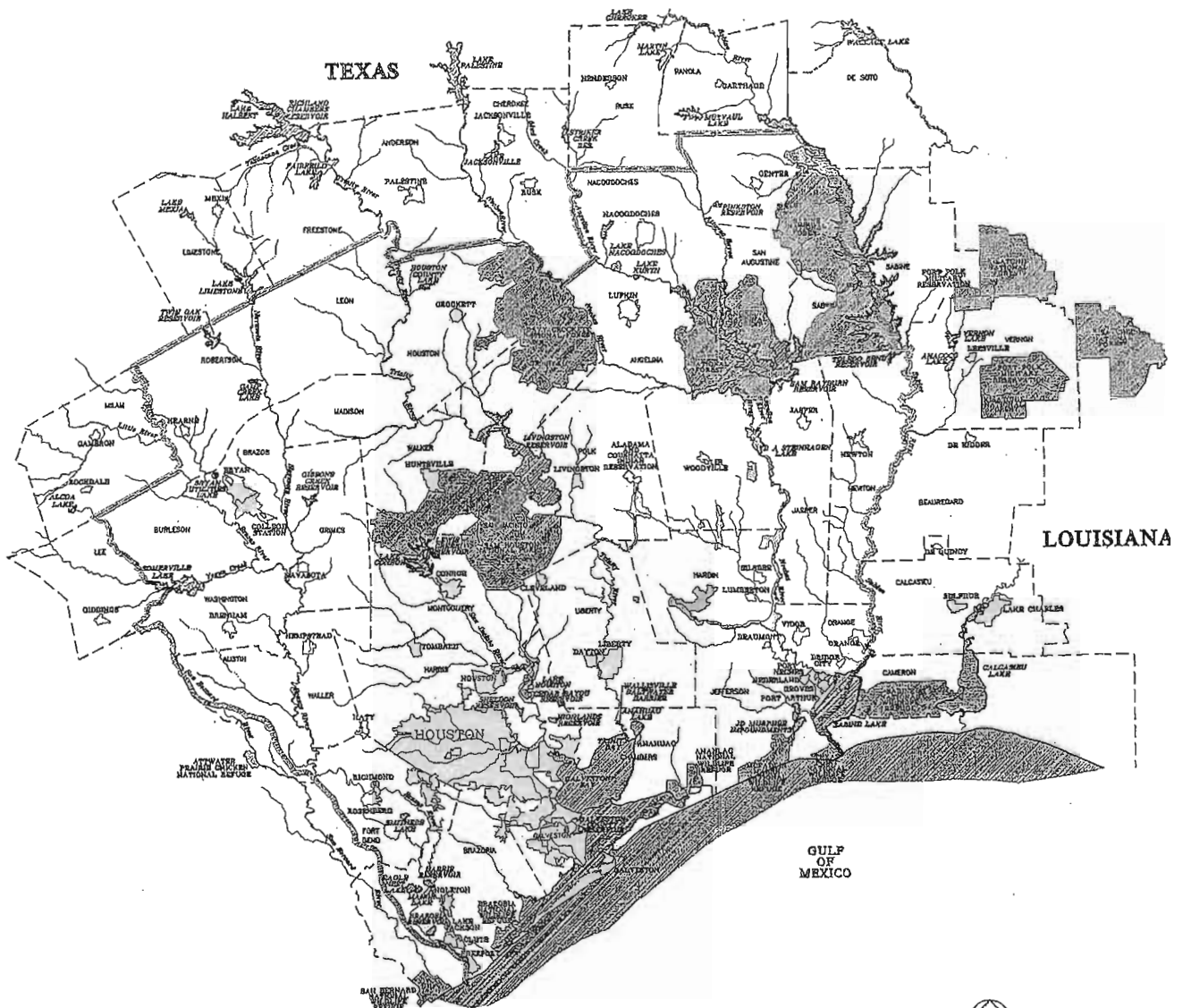
Area of Savings Potential	Expected Conservation Savings
Indoor Plumbing Savings	20.5 gal./capita/day
Seasonal Water Savings	7% of total seasonal use
Dry-Year Irrigation Savings	10.5% of dry-year seasonal use

percent of the total water demand for the entire 32 county TTWP Southeast study area. The eight counties of the Houston region are Brazoria, Chambers, Fort Bend, Galveston, Harris, Liberty, Montgomery, and Waller. These counties occupy all or part of the Trinity, San Jacinto and Brazos River basins as well as the Neches-Trinity, Trinity-San Jacinto and San Jacinto-Brazos coastal basins. The San Jacinto River basin, which includes Harris and Montgomery counties, represents over 30 percent of the total study area demand. The TTWP Southeast Area boundary divides Brazoria and Fort Bend Counties, therefore only the data corresponding to the TTWP region within those two counties is considered in this analysis. Figure 1 shows the TTWP Southeast Area and the eight-county Houston region. Within the Southeast Area, the counties with the largest total demand projections are Harris, Montgomery and Fort Bend.

Appendix A has further detail on population and water demand projections for counties within the TTWP Southeast Area.



LOCATION MAP



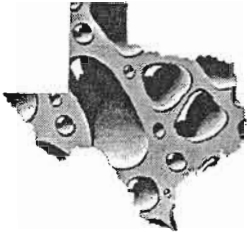
APPROXIMATE SCALE IN MILES
SCALE 1:500,000

LEGEND

- CITY
- MAJOR RIVER
- STREAM
- RESERVOIR
- COUNTY OR PARISH LINE
- STATE LINE
- STUDY BOUNDARY
- FEDERAL LANDS
- BIG THICKET NATIONAL PRESERVE

SOUTHEAST
STUDY AREA

FIGURE 1.



3. Advanced Conservation

An "Advanced" water conservation strategy is designed to produce reductions in water use greater than those produced under the "expected conservation" scenarios. The existing TTWP water demand projections, as defined in the *Planning Information Update*, do not incorporate any of the "advanced" conservation scenarios developed by TWDB in the Consensus Planning process. Developing a strategy for advanced conservation for the Southeast Area requires an analysis of the current water demand patterns and the potential impacts on demand as a result of implementing additional conservation measures.

3.1 Defining a Water Conservation Strategy

Water demand patterns in TTWP Southeast Area are characterized by a number of factors that help define an appropriate water conservation management strategy. These factors include the area's total water demand, the percentage of each type of water use demand within the total, the growth of specific water use demands, the ability of local governments to control water use, the cost of implementing conservation measures, and other locally specific issues. In the Southeast Area the following conditions must be considered.

- Less than 15 percent of total Southeast Area demand is used for irrigation, livestock, steam power generation and mining uses. In addition to the relatively low projected water use, these uses predominately occur in the water-rich, eastern part of the study area. A conservation strategy aimed at these

use categories would yield very low levels of water savings.

- Irrigation demands in the Southeast Area are projected to decrease from 721,092 acre-feet per year in year 1990 to 469,917 acre-feet per year in year 2050. This represents a 35 percent decline in irrigation water use principally brought about by market forces reducing agriculture in southeast Texas. Even within the highly urbanized Houston Metro Area, water use in the irrigation category is projected to decrease. With irrigation uses declining in the area there is little impetus to implement conservation measures within this use category. Table 3 from the *Planning Information Update* (included in Appendix A) provides detail on the declining irrigation demand in the Southeast Area.
- Increases in the manufacturing use demands across the Southeast Area indicate an opportunity for demand savings through conservation. The implementation of conservation measures within the manufacturing category, while warranted, are more difficult to mandate. In addition, developing effective manufacturing conservation measures requires detailed knowledge of specific industrial processes and the technological opportunities for water efficiencies within each industry. Public water suppliers and regulatory agencies establish conservation guidelines for the manufacturing industry but it is market forces associated with reduced cost of production that provide the greatest in-

centive for industrial conservation nation-wide.

The "expected" level of conservation included in the current demand projections is based on industry's implementation of more water efficient processes as a reaction to cost competitive forces. This "expected" level of conservation is realistic for the Southeast Area and is recommended as the appropriate manufacturing use projection for TTWP.

- The greatest potential for water savings from advanced conservation lies within the municipal use category. This category includes water uses, generally within cities, that include residential, commercial, retail, institutional, and light manufacturing. State and local governments and regional water suppliers have a wide range of alternative approaches available to implement advanced levels of conservation within this water use category. These approaches include legislation, pricing policies, building code requirement, and landscaping ordinances.

Conservation savings resulting from the implementation of the 1991 State of Texas water-efficient plumbing fixture legislation vary across the Southeast Area. In general, rural areas with lower commercial retail institutions, and manufacturing demand, use less municipal water than urban areas and will not therefore realize the same levels of "expected" conservation savings. Anticipated water savings will also not accrue as quickly in rural areas.

Based on the distribution of total demand throughout the study area, an Advanced Conservation demand management strategy should be targeted to address those portions of the Southeast study area which exhibit the largest municipal water demands, and the greatest rates of growth. The implementation of advanced conservation measures in these areas has the greatest potential to yield significant water savings where they are most needed. The levels of savings produced under the "expected" conservation scenarios in low water demand areas, such as the East Texas regions within the Sabine and Neches River basins, are appropriate. These regions are projected to have a large quantity of surplus available water supply throughout the 60-year planning period as shown in the *Planning Information Update* data.

An advanced conservation management strategy designed to reduce water use in the high demand section of the study area is indicated. **Therefore, an advanced water conservation strategy consisting of water reduction measures specific to the municipal uses in the Houston Metro area is recommended.**

3.2 Expected vs. Advanced Conservation

The primary differences between the *expected* and *advanced* conservation savings scenarios are timing and the selection of appropriate conservation measures. The majority of additional savings reflected in the advanced conservation cases developed in the TWDB Consensus Planning program result from accelerating the implementation of the Texas Water Efficiency Plumbing Act and from water suppliers implementing other programs which

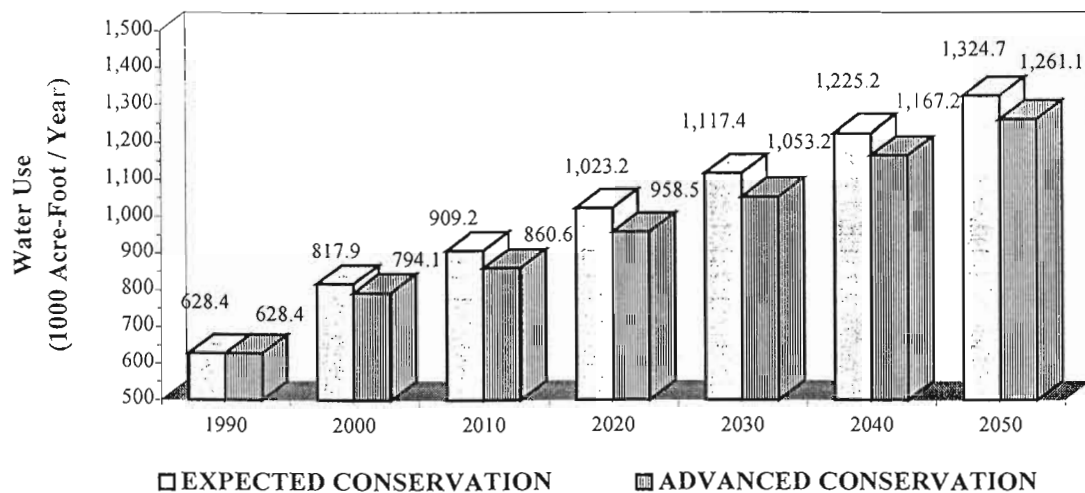


Figure 2: Comparison of Projected Municipal Water Demand with Conservation

encourage or require increased water efficiency from end-users.

The Consensus Planning process developed independent forecasts of unique advanced conservation patterns for each county in the Houston Metro area. These conservation patterns are incorporated into the advanced conservation scenario projections of municipal water use at the county level for each decade in the planning time frame.

To determine the amount of water demand specifically related to advanced water conservation, a comparison of water use projections between the expected and advanced conservation demand scenarios was made. The reduction in total water demand resulting from advanced conservation measures is computed by subtracting the projected municipal demand from the Advanced Conservation Scenario from the "Most Likely" municipal demand for each projected decade. Figure 2 illustrates the relationship of the expected versus the advanced conservation municipal demand projections for the Houston Metro Area.

Appendix B contains several tables that detail the difference between the expected and advanced scenarios for each Houston Metro county and river basin. Table 2 contains the projected conservation savings resulting from an advanced level of conservation for counties within the Houston Metro area by basin.

The total quantity of conservation savings directly attributable to the advanced conservation measures varies from 23,880 acre-feet per year in year 2000 to a maximum level of 64,773 acre-feet per year in year 2020. The quantity of conserved savings decreases slightly from year 2020 to 63,626 acre-feet per year in year 2050. The total quantity of water savings for the entire planning period is approximately 2,657,000 acre-feet. The rate of conservation savings follows the same pattern with the maximum percentage of water savings from advanced conservation occurring around year 2020 and the rate of maximum of about 6.3 percent in year 2020. Advanced level savings as a percentage of total demand decrease from

Table 2: Houston Metro Advanced Conservation Savings on Municipal Demand

COUNTY	WATER SAVINGS (acre-foot / year)						
	1990	2000	2010	2020	2030	2040	2050
BRAZORIA	n/a	972	1,945	2,551	2,415	2,139	2,616
CHAMBERS	n/a	123	259	339	337	307	325
FORT BEND	n/a	1,841	3,801	6,181	7,058	7,717	9,381
GALVESTON	n/a	1,312	2,737	3,447	3,406	3,133	3,353
HARRIS	n/a	17,887	36,150	46,891	45,209	38,805	41,031
LIBERTY	n/a	274	605	736	712	599	663
MONTGOMERY	n/a	1,309	2,664	4,054	4,454	4,677	5,539
WALLER	n/a	162	398	574	591	611	718
TOTAL	0	23,880	48,559	64,773	64,182	57,988	63,626

year 2020 to approximately 4.7 percent of water demand in year 2050.

Table 3 defines the projected water demand for the Advanced Conservation Scenario by basin, in the Houston Metro area.

3.3 Advanced Water Conservation Measures

The City of Houston recently completed their water conservation program. The final report, *City of Houston Water Conservation Plan, March 1997*, projected an annual average net water savings reduction of approximately 22 million gallons per day (24,700 acre-feet per year) through the year 2050 planning period. This represents an annual reduction in projected water demand of approximately 7 percent. This would represent approximately 40 percent of the amount projected in TTWP's advanced conservation scenario for the total Houston Metro area water conservation savings.

The City of Houston program savings are projected to result from implementation of a set of 12 specific conservation measures. These measures affect several water usage categories including: residential, commercial, public, and other programs.

The Other category includes unaccounted-for water leak detection, rehabilitation, and educational programs for both the public and in schools. In general, the identified measures consist of water audits, appliance labeling, institutional water facility rehabilitation, and educational programs. Appendix C contains a listing of these measures.

These 12 programs were selected from an initial list of over 200 potential conservation measures using the computer simulation program, *Water Plan 2.0*. Determination of the most suitable measures was based on criteria including an acceptable benefit-cost ratio, reasonable cost, significance of water savings, and acceptable non-quantifiable impacts.

Based on the level of projected water savings, each measure was evaluated on its viability for achieving the TTWP advanced conservation goals. The measures selected for the City of Houston program should be considered typical of the types of measures necessary to achieve the TTWP advanced conservation goals for total Houston Metro area's water demands.

Table 3: Projected Metro Area Municipal Water Demand with Advanced Conservation

BASIN / COUNTY	1990	2000	2010	2020	2030	2040	2050
Brazos Basin	15,590	19,595	22,728	26,730	32,858	39,682	47,067
Brazoria	1,678	2,160	2,142	2,205	2,461	2,657	3,012
Fort Bend	9,937	12,953	15,558	18,860	23,911	29,597	35,467
Waller	3,975	4,482	5,028	5,665	6,486	7,428	8,588
NechesBasin/ Liberty Co.	287	280	280	286	308	336	355
Neches-Trinity Basin	1,883	1,787	2,001	2,334	2,572	2,702	2,703
Chambers	925	1,180	1,402	1,680	1,875	2,015	2,131
Galveston	935	596	588	642	684	673	557
Liberty	23	11	11	12	13	14	15
San Jacinto Basin	483,803	606,032	653,300	724,062	783,659	859,433	917,765
Fort Bend	12,117	12,855	16,097	20,159	25,817	32,249	40,327
Harris	441,790	552,559	589,858	648,252	690,348	747,024	783,369
Liberty	2,133	2,284	2,403	2,550	2,873	3,028	3,195
Montgomery	26,851	37,086	43,457	51,420	62,642	74,831	88,164
Waller	912	1,248	1,485	1,681	1,979	2,301	2,710
San Jacinto - Brazos Basin	106,896	140,936	155,509	175,874	202,454	230,743	256,562
Brazoria	22,046	25,131	26,723	29,022	33,599	37,432	42,749
Fort Bend	14,987	26,546	32,965	40,873	52,331	65,329	79,082
Galveston	32,752	38,716	40,572	44,079	49,436	53,464	56,651
Harris	37,111	50,543	55,249	61,900	67,088	74,518	78,080
Trinity Basin	5,671	5,929	6,040	6,476	7,212	7,791	8,403
Chambers	656	644	728	877	991	1,074	1,132
Liberty	5,015	5,285	5,312	5,599	6,221	6,717	7,271
Trinity-San Jacinto Basin	14,292	19,510	20,744	22,697	24,173	26,516	28,195
Chambers	1,264	1,620	1,699	1,871	2,010	2,142	2,232
Harris	12,951	17,806	18,962	20,739	22,067	24,269	25,849
Liberty	77	84	83	87	96	105	114
Metro Area Total	628,422	794,069	860,602	958,459	1,053,236	1,167,203	1,261,050



4. Water Supply and Availability

The TTWP *Planning Information Update* determined the period of time for which existing water supplies (groundwater and surface water) within the Southeast Area can satisfy future projected water demands. This analysis was conducted for each river basin and shown in Table 12 of that report. Table 13 of that report then assessed the availability of existing Southeast Area water supplies to meet the future projected water demands for the state-wide TTWP region. These tables are included in Appendix D. Tables 12 and 13 support the following general conclusions:

- Current existing Southeast Area water supplies can meet all projected Southeast Area demands through year 2010.
- The Brazos river basin will experience the earliest water supply shortfalls within the Southeast Area by year 2020.
- The San Jacinto River basins (San Jacinto, San Jacinto-Brazos and Trinity-San Jacinto) within the Houston Metro area will experience initial water supply shortages by year 2030 and these shortfalls will become increasingly significant thereafter.
- East Texas river basins retain significant quantities of available supply through the 2050 planning period.
- The Southeast Area has sufficient existing water supplies to serve the state-wide TTWP region.

The value of the advanced water conservation strategy can be measured by assessing its ability to extend the length of

time that existing available water supplies can serve projected demands. The advanced water conservation strategy is evaluated by inserting basin level reduced water demands, as determined in Section 3, into the above referenced water supply availability tables. The revised tables reflect the reduced demands associated with an Advanced Conservation Scenario for the municipal demand of counties in the Houston Metro area. Table 4 and Table 5 illustrate the impact of accelerated conservation in the Houston Metro region on the Southeast Area and state-wide TTWP water availability.

A comparison of Table 12 and Table 4 indicates that many of the conclusions supported by Table 12 of the *Planning Information Update* remain valid in the Advanced Conservation Scenario. The exception is with regard to supply shortfalls in the San Jacinto River and Coastal basins. Conservation savings are dispersed throughout the Houston Metro area. Existing supply can satisfy projected demand in the San Jacinto River basin through 2030 and meet demand in the coastal basins through 2040.

Table 5 computes the impact of the advanced conservation water demands for the entire TTWP region. It indicates that under Scenario 1, the worst case scenario, an excess of 134,000 acre-feet per year will be available in year 2050. This is approximately 63,600 acre-feet per year more than was available in year 2050 under the Expected Conservation Scenario.

Table 4: Southeast Area Water Availability with Advanced Conservation Strategy¹

Category	Amount (Thousands of Acre/Feet-Year)								Total Southeast
	Sabine	Neches	Neches- Trinity	Trinity	Trinity- San Jacinto	San Jacinto	San Jacinto- Brazos	Brazos	
2000									
In-Basin Demands	86.0	261.4	329.8	138.3	142.5	932.1	459.5	426.6	2776.3
In-Basin Supplies									
Groundwater	23.3	110.5	7.5	34.3	26.6	451.7	74.9	130.5	859.3
Surface Water	1190.4	846.9	0.0	1356.4	0.0	257.7	57.8	488.2	4197.4
TOTAL	1213.7	957.4	7.5	1390.7	26.6	709.4	132.7	618.7	5056.7
Surface Water Transfers									
Imported Supplies	0.9	1.4	322.3	0.0	115.9	282.7	326.8	0.0	1050.1
Export Demands	1.4	280.7	0.0	559.2	0.0	60.0	0.0	148.694	1050.0
In-Basin Reserves	282.9	209.1	0.0	0.0	0.0	0.0	0.0	0.0	492.0
Net Surface Water Availability	844.3	207.6	0.0	693.2	0.0	0.0	0.0	43.4	1788.5
2010									
In-Basin Demands	93.9	275.4	316.5	140.5	146.6	995.4	488.0	462.0	2918.3
In-Basin Supplies									
Supplied by Groundwater	23.3	111.6	7.9	36.6	25.7	292.3	80.9	141.9	720.2
Supplied by Surface Water	1190.4	846.9	0.0	1356.4	0.0	257.7	57.8	487.6	4196.8
TOTAL	1213.7	958.5	7.9	1393.0	25.7	550.0	138.7	629.5	4917.0
Surface Water Transfers									
Imported Supplies	1.0	2.0	308.6	0.0	120.9	505.4	349.3	0.0	1287.2
Export Demands	2.0	279.6	0.0	792.4	0.0	60.0	0.0	153.2	1287.1
In-Basin Reserves	282.9	209.1	0.0	0.0	0.0	0.0	0.0	0.0	492.0
Net Surface Water Availability	835.9	196.4	0.0	460.1	0.0	0.0	0.0	14.3	1506.7
2020									
In-Basin Demands	102.4	287.3	304.3	143.4	150.9	1081.9	516.2	490.6	3077.0
In-Basin Supplies									
Groundwater	23.3	112.8	8.3	38.7	31.1	251.1	87.1	156.1	708.5
Surface Water	1190.4	846.9	0.0	1356.4	0.0	257.7	57.8	487.1	4196.3
TOTAL	1213.7	959.7	8.3	1395.1	31.1	508.8	144.9	643.2	4904.8
Surface Water Transfers									
Imported Supplies	1.0	2.6	296.0	0.0	119.8	633.1	371.3	0.0	1423.9
Export Demands	2.6	267.0	0.0	931.9	0.0	60.0	0.0	162.3	1423.8
In-Basin Reserves	282.9	209.1	0.0	0.0	0.0	0.0	0.0	0.0	492.0
Net Surface Water Availability	826.8	199.0	0.0	319.8	0.0	0.0	0.0	-9.7	1335.8

¹ Adapted from Trans-Texas Water Program
Southeast Area Planning Information Report.
Table 12: Southeast Area Water Supply
Availability: 2000-2050. Brown & Root, Inc.
September 1996.

Table 4: Southeast Area Water Availability with Advanced Conservation Strategy Continued

Category	Amount (Thousands of Acre/Feet-Year)								Total Southeast
	Sabine	Neches	Neches- Trinity	Trinity	Trinity- San Jacinto	San Jacinto	San Jacinto- Brazos	Brazos	
2030									
In-Basin Demands	111.0	299.4	302.9	147.6	155.3	1155.6	554.0	526.8	3252.5
In-Basin Supplies									
Groundwater	23.4	114.6	8.7	41.2	27.9	266.3	87.8	169.4	739.3
Surface Water	1190.4	846.9	0.0	1356.4	0.0	257.7	57.8	486.6	4195.8
TOTAL	1213.8	961.5	8.7	1397.6	27.9	524.0	145.6	656.0	4935.1
Surface Water Transfers									
Imported Supplies	1.0	4.1	294.2	0.0	127.4	691.6	408.4	0.0	1526.7
Export Demands	4.1	265.2	0.0	1023.7	0.0	60.0	0.0	173.7	1526.7
In-Basin Reserves	282.9	209.1	0.0	0.0	0.0	0.0	0.0	0.0	492.0
Net Surface Water Availability	816.8	191.9	0.0	226.3	0.0	0.0	0.0	-44.5	1190.5
2040									
In-Basin Demands	123.1	321.7	306.6	158.8	165.6	1258.2	604.5	580.7	3519.2
In-Basin Supplies									
Groundwater	23.5	116.3	8.8	43.8	29.6	280.5	88.8	181.1	772.4
Surface Water	1190.4	846.9	0.0	1356.4	0.0	257.7	57.8	486.0	4195.2
TOTAL	1213.9	963.2	8.8	1400.2	29.6	538.2	146.6	667.1	4967.6
Surface Water Transfers									
Imported Supplies	1.0	4.6	297.8	0.0	136.0	698.0	457.9	0.0	1595.3
Export Demands	4.6	268.8	0.0	1072.6	0.0	60.0	0.0	189.3	1595.3
In-Basin Reserves	282.9	209.1	0.0	0.0	0.0	0.0	0.0	0.0	492.0
Net Surface Water Availability	804.3	168.3	0.0	168.8	0.0	-82.0	0.0	-103.0	956.4
2050									
In-Basin Demands	135.8	344.8	310.5	174.0	178.3	1343.2	653.2	636.2	3776.0
In-Basin Supplies									
Groundwater	23.6	118.3	9.0	46.7	31.0	291.8	89.7	197.3	807.4
Surface Water	1190.4	846.9	0.0	1356.4	0.0	257.7	57.8	485.4	4194.6
TOTAL	1214.0	965.2	9.0	1403.1	31.0	549.5	147.5	682.7	5002.0
Surface Water Transfers									
Imported Supplies	1.1	4.9	301.5	0.0	136.0	698.0	473.1	0.0	1614.6
Export Demands	4.9	272.6	0.0	1072.6	0.0	60.0	0.0	204.5	1614.5
In-Basin Reserves	282.9	209.1	0.0	0.0	0.0	0.0	0.0	0.0	492.0
Net Surface Water Availability	791.5	143.7	0.0	156.5	-11.3	-155.7	-32.6	-158.0	734.0

Table 5: Trans-Texas Water Program Supply Availability with Advanced Conservation Strategy²

Scenario	Amount (Thousands of Acre-Feet/Year)					
	2000	2010	2020	2030	2040	2050
Scenario 1						
Available Southeast Supply	1788.5	1506.7	1335.8	1190.5	956.4	734
West-Central Demand			150	300	450	600
Net Surface Water Availability	1788.5	1506.7	1185.8	890.5	506.4	134
Scenario 2						
Available Southeast Supply	1788.5	1506.7	1335.8	1190.5	956.4	734
West-Central Demand				100	200	300
Net Surface Water Availability	1788.5	1506.7	1335.8	1090.5	756.4	434
Scenario 3						
Available Southeast Supply	1788.5	1506.7	1335.8	1190.5	956.4	734
West-Central Demand	0	0	0	0	0	0
Net Surface Water Availability	1788.5	1506.7	1335.8	1190.5	956.4	734

² Adapted from Trans-Texas Water Program Southeast Area Planning Information Report. Table 13: Trans-Texas Water Program Supply Availability: 2000 - 2050. Brown & Root, Inc. September 1996.



5. Environmental Impacts

Demand management strategies are designed to affect the patterns and characteristics of water use. These types of water resource management strategies generally require little or no construction and are not associated with the environmental disruption brought about by traditional supply development activities. There are however potential environmental impacts as a result of conservation activities.

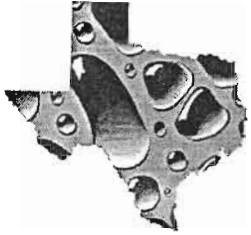
The types of anticipated environmental impacts resulting from a water conservation strategy can be seen by using the City of Houston Water Conservation Program as a model. The City of Houston program contains 12 conservation measures. Only three of the measures, Public Fountain/Pool Audit and Repair, Standards for New Fountains/ Pools, and Unaccounted-For Water, involve structural rehabilitation of water system facilities. Construction related activities associated with these types of measures will be limited to existing public rights-of-way and utility easements, generally located within the urban environment of the city. Compliance with current construction related environmental protection regulations (i.e. National Pollutant Discharge Elimination System (NPDES) stormwater, etc.) will limit the potential for environmental disruption.

Other potential types of environmental impacts relate to water quantity reduction within rivers, streams, bays and estuaries. While conservation reduces the quantity of flow entering receiving streams, the relative rate of reduction is minimal. The quantity of conserved water is small rela-

tive to the total amounts of flow within the Houston Metro water systems. As such, the anticipated impact to flow volumes within receiving streams will be very minor.

A potential social impact is related to the cost of water to residents. Water conservation has the potential to increase water rates to compensate for a loss of revenue from water sales by the utility. The *City of Houston Water Conservation Plan* discussed this issue and concluded that the rate of reduced water use from water conservation would have a minimal impact (1.5 percent) on the price of water to the customer. That report documented that the price impact from reduced water sales is offset from the positive impact of deferred capital cost expenditures of water and wastewater treatment facilities that would have been required at a sooner date without water conservation³. See Sections 6 and 7 from that report for a complete discussion of this issue.

³*City of Houston Final Draft Water Conservation Plan*. March 1997.



6. Implementation Costs

The cost of implementing the recommended advanced conservation strategy is based on the cost of implementing each of the various conservation measures. A detailed cost analysis of the City of Houston conservation measures was used as a basis to develop an advanced conservation strategy program cost for the Houston Metro area of the TTWP.

The cost of implementing the various conservation measures varies significantly. *Appendix D of the City of Houston Conservation Plan*, contains projected implementation costs and resultant quantities of water savings for each of the recommended conservation measures for each year through the planning period. This TTWP analysis uses the same cost basis for each measure as was used within the City of Houston study. As shown, many of the measures require a short-term initial cost investment that then produces a long-term water savings. This data is shown in Appendix E of this report. To determine the cost of implementing the advanced conservation management strategy for the entire Houston Metro area, the total annual program cost was applied to the projected conservation savings for the entire region.

Table 6 shows that the total cost of implementing an advanced conservation strategy for the TTWP Southeast Area for the 50 year planning period is approximately \$319 million. This equates to an average water cost of approximately \$120 per acre-foot of water. As shown, the annual cost varies from \$3.5 million during the decade from year 2000 through year

2009, to \$7.6 million during the decade from year 2030 through year 2039.

A life cycle cost analysis was performed to illustrate the present worth cost of this strategy. The following financial factors were used in the life cycle cost analysis:

- Program implementation was assumed to begin in year 2000 and to continue through the planning period until year 2050.
- Capital costs were assumed to be financed over 50 years at an interest rate of 8.5 percent per year.
- The discount rate was set at 4.5 percent.
- The inflation rate was set at 4.5 percent.

Table 6 shows that the total present worth of the entire 50-year conservation program is approximately \$97 million. As shown, the computed annual present worth cost ranges from \$3.1 million in year 2000 to \$686,000 in year 2049. Financing of a conservation program however functions differently than most of the other potential TTWP water management strategies. Water conservation can be implemented on an annual basis with resultant costs financed at the time of implementation of each measure. Other management strategies require the total financing of the capital improvement at the time of construction of that improvement. A conservation strategy allows more flexibility concerning the use of available funds. An additional benefit occurs with water conservation should the entire 50-year program be financed in year one of

the program. The total cost of the program is significantly reduced.

Table 6: Houston Metro Area - Advanced Conservation Savings Life Cycle Cost Analysis

<i>Year</i>	<i>Savings Acre-feet per year</i>	<i>Annual Conservation Implementation Cost</i>	<i>Present Value of A.C.I.C. (1997 \$)</i>
2000	23,880	3,505,508	3,071,865
2001	23,880	3,505,508	2,939,584
2002	23,880	3,505,508	2,812,999
2003	23,880	3,505,508	2,691,865
2004	23,880	3,505,508	2,575,947
2005	23,880	3,505,508	2,465,021
2006	23,880	3,505,508	2,358,872
2007	23,880	3,505,508	2,257,294
2008	23,880	3,505,508	2,160,090
2009	23,880	3,505,508	2,067,072
2010	48,559	5,482,441	3,093,586
2011	48,559	5,482,441	2,960,369
2012	48,559	5,482,441	2,832,889
2013	48,559	5,482,441	2,710,899
2014	48,559	5,482,441	2,594,162
2015	48,559	5,482,441	2,482,451
2016	48,559	5,482,441	2,375,552
2017	48,559	5,482,441	2,273,255
2018	48,559	5,482,441	2,175,364
2019	48,559	5,482,441	2,081,688
2020	64,773	7,500,524	2,725,316
2021	64,773	7,500,524	2,607,958
2022	64,773	7,500,524	2,495,654
2023	64,773	7,500,524	2,388,186
2024	64,773	7,500,524	2,285,345
2025	64,773	7,500,524	2,186,933
2026	64,773	7,500,524	2,092,759
2027	64,773	7,500,524	2,002,640
2028	64,773	7,500,524	1,916,402

Table 6: Houston Metro Area - Advanced Conservation Savings Life Cycle Cost Analysis - Continued

<i>Year</i>	<i>Savings Acre-feet per year</i>	<i>Annual Conservation Implementation Cost</i>	<i>Present Value of A.C.I.C. (1997 \$)</i>
2029	64,773	7,500,524	1,833,877
2030	64,182	7,572,345	1,771,711
2031	64,182	7,572,345	1,695,417
2032	64,182	7,572,345	1,622,409
2033	64,182	7,572,345	1,552,544
2034	64,182	7,572,345	1,485,688
2035	64,182	7,572,345	1,421,711
2036	64,182	7,572,345	1,360,489
2037	64,182	7,572,345	1,301,903
2038	64,182	7,572,345	1,245,841
2039	64,182	7,572,345	1,192,192
2040	57,988	7,072,640	1,019,682
2041	57,988	7,072,640	975,772
2042	57,988	7,072,640	933,753
2043	57,988	7,072,640	893,544
2044	57,988	7,072,640	855,066
2045	57,988	7,072,640	818,245
2046	57,988	7,072,640	783,009
2047	57,988	7,072,640	749,291
2048	57,988	7,072,640	717,025
2049	57,988	7,072,640	686,149
2050	63,626	7,760,291	720,441
TOTAL	2,657,446	319,094,875	97,317,777



7. Conclusion

The key findings of the water conservation management strategy analysis consist of the following:

- The recommended “advanced” water conservation strategy consists of an aggressive program of conservation measures focused on the municipal water use category for the eight county Houston Metro area.
- The proposed City of Houston water conservation measures will produce water reductions compatible with the level of reductions defined within this TTWP water conservation management strategy. Potential conservation measures include education, water audits, unaccounted-for water system rehabilitation, and appliance labeling.
- The projected level of reduced municipal water demand for the entire Houston Metro area ranges from 23,880 to 64,773 acre-feet per year. This represents a savings of approximately 2.9 to 6.3 percent of the total projected Houston Metro water demand. The total quantity of water savings for the 50-year planning period is approximately 2,657,000 acre-feet.
- The recommended conservation management strategy will reduce the short-term water demand shortfalls projected within the Brazos basin in decades 2020 and 2030, and will meet the San Jacinto basin shortfall in year 2030. Existing water supplies and the recommended conservation management strategy will satisfy long-term Southeast Area water demand projections in all other basins through approximately year 2040.
- Existing water supplies coupled with the conservation management strategy can theoretically satisfy all of the water demands for the state-wide TTWP study area through year 2050 and retain an excess of over 134,000 acre-feet per year within the Southeast Area river basins.
- The environmental impacts associated with a water conservation strategy appear to be minimal. Construction related impacts will be limited to locations within the interiors of buildings and within the existing urban streetscape. Social impacts may result in the form of potential short-term price increases, but the rate of introduction of conservation water use change appears small enough to minimize customer rate impacts.
- The total capital cost of implementing the advanced water conservation strategy for the entire Houston Metro area is approximately \$319 million. This equates to a per unit water cost of approximately \$120 per acre-foot.



8. Appendices

- Appendix A Population and Water Requirements
- Appendix B Houston Metro Conservation Data
- Appendix C Expected Conservation Alternatives
- Appendix D Water Supply Availability
- Appendix E City of Houston's Recommended Conservation Plan

APPENDIX A: Population and Water Requirements

Population Projections for the Southeast Study Area, 1990 - 2050

<i>River Basin</i>	Population (Thousands)						
	1990	2000	2010	2020	2030	2040	2050
Sabine	107	116	124	130	137	142	148
Neches	315	354	384	414	447	478	509
Neches-Trinity	194	210	220	231	238	244	249
Trinity	153	180	201	225	250	270	289
Trinity-San Jacinto	96	118	136	159	173	191	206
San Jacinto	2,771	3,208	3,737	4,389	4,839	5,365	5,783
San Jacinto-Brazos	705	857	1,034	1,247	1,459	1,675	1,874
Brazos	304	347	408	473	544	617	697
Total, Southeast Area	4,646	5,390	6,244	7,267	8,086	8,983	9,755

Population Projections for the Houston Metro Region

<i>BASIN</i>	1990	2000	2010	2020	2030	2040	2050
San Jacinto	2744.4	3176.3	3700.2	4346.7	4791.1	5313.3	5727.4
San Jacinto - Brazos	705.4	857.3	1033.6	1246.7	1458.9	1674.6	1873.9
Brazos	94.1	112.2	142.7	180.1	224.7	273.9	327.6
Neches	1.9	2.1	2.3	2.5	2.8	3.1	3.3
Neches-Trinity	10.8	11.6	15.0	19.1	21.8	23.2	23.1
Trinity	39.4	44.3	50.1	58.0	65.8	72.2	78.7
Trinity-San Jacinto	95.8	118.0	136.4	159.3	172.6	191.3	206.3
METRO TOTAL	3691.7	4321.8	5080.4	6012.4	6737.8	7551.5	8240.3

Water Requirements for the Southeast Area

<i>River Basin</i>	<i>Total Water Demand (thousands of acre-feet per year)</i>						
	<i>1990</i>	<i>2000</i>	<i>2010</i>	<i>2020</i>	<i>2030</i>	<i>2040</i>	<i>2050</i>
Sabine River Basin	79.5	86.0	93.9	102.4	111.0	123.1	135.8
Neches River Basin	245.7	261.4	275.4	287.3	299.4	321.7	345.2
Neches-Trinity Coastal Bas	397.2	329.9	316.6	304.3	303.1	306.7	310.6
Trinity River Basin	141.3	138.5	141.0	144.0	148.1	159.3	174.5
Trinity-San Jacinto Coastal	128.5	143.2	147.9	152.6	156.9	167.0	179.9
San Jacinto River Basin	786.4	949.7	1030.9	1128.7	1201.4	1298.3	1386.4
San Jacinto-Brazos Coastal	405.1	464.2	497.8	529.7	567.3	617.9	668.4
Brazos River Basin	371.6	427.3	463.4	492.7	529.1	583.2	639.2
Total, Southeast Area	2555.3	2800.0	2967.0	3141.8	3316.4	3577.0	3840.0

State of Texas Total Water Demand by Water Use Type

<i>Use Types</i>	<i>Water Demand (Millions of Acre-Feet/Year)</i>					
	<i>1990</i>			<i>2050</i>		
	<i>Texas</i>	<i>SE Area</i>	<i>%</i>	<i>Texas</i>	<i>SE Area</i>	<i>%</i>
Municipal	3,178,398	777,542	24.5%	3,601,657	1,536,382	42.7%
Manufacturing	1,560,047	900,037	57.7%	2,564,547	1,435,446	56.0%
Irrigation	10,123,335	721,092	7.1%	8,177,217	469,917	5.7%
Livestock	274,069	27,780	10.1%	330,305	28,962	8.8%
Mining	148,839	18,263	12.3%	291,397	115,371	39.6%
Power	434,116	110,477	25.4%	937,900	253,500	27.0%
Total	15,718,804	2,555,191	16.3%	15,903,023	3,839,578	24.1%

Water Requirements for the Houston Metro Area

<i>River Basin</i>	<i>Water Demand (Thousands of Acre-Feet/Year)</i>						
	<i>1990</i>	<i>2000</i>	<i>2010</i>	<i>2020</i>	<i>2030</i>	<i>2040</i>	<i>2050</i>
Neches	9	7	6	6	6	5	5
Neches-Trinity	106	87	79	72	70	68	66
Trinity	116	109	101	97	97	96	96
Trinity-San Jacinto	128	143	148	153	157	167	180
San Jacinto	782	943	1,024	1,122	1,194	1,291	1,379
San Jacinto-Brazos	405	464	498	530	567	618	668
Brazos	262	302	326	342	358	387	416
Total, Houston Metro	1,808	2,056	2,183	2,321	2,449	2,632	2,810

APPENDIX B: Houston Metro Conservation Data

HoustonMetro - Advanced Conservation

BASIN/COUNTY		WATER SAVINGS (Acre-Feet/Year)						
		1990	2000	2010	2020	2030	2040	2050
BRAZOS	BRAZORIA	n/a	672	1,379	2,148	2,303	2,480	2,964
	FORT BEND	n/a	81	149	198	179	151	175
	WALLER	n/a	470	932	1,523	1,680	1,868	2,253
		n/a	121	298	427	444	461	536
NECHES	LIBERTY	n/a	10	24	27	25	20	23
NECHES- TRINITY	CHAMBERS	n/a	58	124	149	163	148	146
	GALVESTON	n/a	45	96	131	133	127	129
	LIBERTY	n/a	12	27	17	29	20	16
		n/a	1	1	1	1	1	1
SAN JACINTO		n/a	17,621	35,469	46,759	45,798	40,110	43,152
	FORT BEND	n/a	426	959	1,476	1,706	1,754	2,201
	HARRIS	n/a	15,770	31,571	40,871	39,276	33,346	35,035
	LIBERTY	n/a	75	175	211	215	183	195
	MONTGOMERY	n/a	1,309	2,664	4,054	4,454	4,677	5,539
	WALLER	n/a	41	100	147	147	150	182
		n/a	4,657	9,820	13,461	13,747	13,404	15,201
SAN JACINTO- BRAZOS	BRAZORIA	n/a	891	1,796	2,353	2,236	1,988	2,441
	FORT BEND	n/a	945	1,910	3,182	3,672	4,095	4,927
	GALVESTON	n/a	1,300	2,710	3,430	3,377	3,113	3,337
	HARRIS	n/a	1,521	3,404	4,496	4,462	4,208	4,496
TRINITY		n/a	209	451	555	532	454	503
	CHAMBERS	n/a	24	53	66	69	65	66
	LIBERTY	n/a	185	398	489	463	389	437
TRINITY- SAN JACINTO	CHAMBERS	n/a	653	1,292	1,674	1,614	1,372	1,637
	HARRIS	n/a	54	110	142	135	115	130
	LIBERTY	n/a	596	1,175	1,524	1,471	1,251	1,500
		n/a	3	7	8	8	6	7
TOTAL		n/a	23,880	48,559	64,773	64,182	57,988	63,626

* Water Saving quantities represent the differential required to meet the goals of the "Advanced" Water Conservation Scenario in Phase II (given the current "Expected" Water Conservation Scenario). 1990 values are historical data (same in both scenarios).

Houston Metro Area: Advanced Water Conservation Analysis

BASIN / COUNTY	WATER SAVINGS (acre-foot / year)						
	1990	2000	2010	2020	2030	2040	2050
BRAZOS / BRAZORIA							
Expected Conservation Measures	1,678	2,241	2,291	2,403	2,640	2,808	3,187
Advanced Conservation Measures	1,678	2,160	2,142	2,205	2,461	2,657	3,012
Water Saving (acre-foot)	0	81	149	198	179	151	175
BRAZOS / FORT BEND							
Expected Conservation Measures	9,937	13,423	16,490	20,383	25,591	31,465	37,720
Advanced Conservation Measures	9,937	12,953	15,558	18,860	23,911	29,597	35,467
Water Savings	0	470	932	1,523	1,680	1,868	2,253
BRAZOS / WALLER							
Expected Conservation Measures	3,975	4,603	5,326	6,092	6,930	7,889	9,124
Advanced Conservation Measures	3,975	4,482	5,028	5,665	6,486	7,428	8,588
Water Savings	0	121	298	427	444	461	536
NECHES / LIBERTY							
Expected Conservation Measures	287	290	304	313	333	356	378
Advanced Conservation Measures	287	280	280	286	308	336	355
Water Savings	0	10	24	27	25	20	23
NECHES-TRINITY / CHAMBERS							
Expected Conservation Measures	925	1,225	1,498	1,811	2,008	2,142	2,260
Advanced Conservation Measures	925	1,180	1,402	1,680	1,875	2,015	2,131
Water Savings	0	45	96	131	133	127	129
NECHES-TRINITY / GALVESTON							
Expected Conservation Measures	935	608	615	659	713	693	573
Advanced Conservation Measures	935	596	588	642	684	673	557
Water Savings	0	12	27	17	29	20	16
NECHES-TRINITY / LIBERTY							
Expected Conservation Measures	23	12	12	13	14	15	16
Advanced Conservation Measures	23	11	11	12	13	14	15
Water Savings	0	1	1	1	1	1	1
SAN JACINTO / FORT BEND							
Expected Conservation Measures	12,117	13,281	17,056	21,635	27,523	34,003	42,528
Advanced Conservation Measures	12,117	12,855	16,097	20,159	25,817	32,249	40,327
Water Savings	0	426	959	1,476	1,706	1,754	2,201

Houston Metro Area: Advanced Water Conservation Analysis

BASIN / COUNTY	WATER SAVINGS (acre-foot / year)						
	1990	2000	2010	2020	2030	2040	2050
SAN JACINTO / HARRIS							
Expected Conservation Measures	441,790	568,329	621,429	689,123	729,624	780,370	818,404
Advanced Conservation Measures	441,790	552,559	589,858	648,252	690,348	747,024	783,369
Water Savings	0	15,770	31,571	40,871	39,276	33,346	35,035
SAN JACINTO / LIBERTY							
Expected Conservation Measures	2,133	2,359	2,578	2,761	3,088	3,211	3,390
Advanced Conservation Measures	2,133	2,284	2,403	2,550	2,873	3,028	3,195
Water Savings	0	75	175	211	215	183	195
SAN JACINTO / MONTGOMERY							
Expected Conservation Measures	26,851	38,395	46,121	55,474	67,096	79,508	93,703
Advanced Conservation Measures	26,851	37,086	43,457	51,420	62,642	74,831	88,164
Water Savings	0	1,309	2,664	4,054	4,454	4,677	5,539
SAN JACINTO / WALLER							
Expected Conservation Measures	912	1,289	1,585	1,828	2,126	2,451	2,892
Advanced Conservation Measures	912	1,248	1,485	1,681	1,979	2,301	2,710
Water Savings	0	41	100	147	147	150	182
SAN JACINTO - BRAZOS / BRAZORIA							
Expected Conservation Measures	22,046	26,022	28,519	31,375	35,835	39,420	45,190
Advanced Conservation Measures	22,046	25,131	26,723	29,022	33,599	37,432	42,749
Water Savings	0	891	1,796	2,353	2,236	1,988	2,441
SAN JACINTO - BRAZOS / FORT BEND							
Expected Conservation Measures	14,987	27,491	34,875	44,055	56,003	69,424	84,009
Advanced Conservation Measures	14,987	26,546	32,965	40,873	52,331	65,329	79,082
Water Savings	0	945	1,910	3,182	3,672	4,095	4,927
SAN JACINTO - BRAZOS / GALVESTON							
Expected Conservation Measures	32,752	40,016	43,282	47,509	52,813	56,577	59,988
Advanced Conservation Measures	32,752	38,716	40,572	44,079	49,436	53,464	56,651
Water Savings	0	1,300	2,710	3,430	3,377	3,113	3,337
SAN JACINTO - BRAZOS / HARRIS							
Expected Conservation Measures	37,111	52,064	58,653	66,396	71,550	78,726	82,576
Advanced Conservation Measures	37,111	50,543	55,249	61,900	67,088	74,518	78,080
Water Savings	0	1,521	3,404	4,496	4,462	4,208	4,496
TRINITY / CHAMBERS							
Expected Conservation Measures	656	668	781	943	1,060	1,139	1,198
Advanced Conservation Measures	656	644	728	877	991	1,074	1,132
Water Savings	0	24	53	66	69	65	66

Houston Metro Area: Advanced Water Conservation Analysis

BASIN / COUNTY	WATER SAVINGS (acre-foot / year)						
	1990	2000	2010	2020	2030	2040	2050
TRINITY / LIBERTY							
Expected Conservation Measures	5,015	5,470	5,710	6,088	6,684	7,106	7,708
Advanced Conservation Measures	5,015	5,285	5,312	5,599	6,221	6,717	7,271
Water Savings	0	185	398	489	463	389	437
TRINITY - SAN JACINTO / CHAMBERS							
Expected Conservation Measures	1,264	1,674	1,809	2,013	2,145	2,257	2,362
Advanced Conservation Measures	1,264	1,620	1,699	1,871	2,010	2,142	2,232
Water Savings	0	54	110	142	135	115	130
TRINITY - SAN JACINTO / HARRIS							
Expected Conservation Measures	12,951	18,402	20,137	22,263	23,538	25,520	27,349
Advanced Conservation Measures	12,951	17,806	18,962	20,739	22,067	24,269	25,849
Water Savings	0	596	1,175	1,524	1,471	1,251	1,500
TRINITY - SAN JACINTO / LIBERTY							
Expected Conservation Measures	77	87	90	95	104	111	121
Advanced Conservation Measures	77	84	83	87	96	105	114
Water Savings	0	3	7	8	8	6	7

APPENDIX C: Expected Conservation Alternatives

Expected Conservation Alternatives¹

Residential	
• Water Audits	Local officials would offer indoor/outdoor water audits to existing single-family & multi-family residential customers w/ high water use.
• Appliance Labeling	Local officials would promote a program at the State level to provide point-of-sale information about water-efficient washing machines & dishwashers.
Commercial	
• Indoor Audits	Local officials would offer on-site interior inspection & produce a customized report describing fixture inspections, leak tests, retrofit possibilities, cooling tower operation & improvements, etc.
• Cooling Tower Audits	Local officials would offer audits to measure the number of cycles of concentration and to suggest improvements in operations, such as addition of a chemical feed system to increase the cycles of concentration.
Public	
• Indoor/Exterior Audits	Local officials would perform water audits at all public buildings focusing on indoor plumbing fixtures & irrigation water uses.
• Pool/Fountain Audits (for government & public facilities)	Local officials would provide audits on-site & produce a customized report that describes fixture & valve inspections, leak tests, retrofit possibilities, pool/fountain cleaning & backwashing operation & improvements, & recycling opportunities for each site. A leak detection by a private contractor would be provided if warranted.
• Pool/Fountain Standards	All new publicly owned pools and fountains would be required to meet water efficiency minimum standards as established.
• In-House Programs	Targets all local government departments not currently charged for water. Directors/managers of these would receive an "in-house" bill, detailing their water usage. A goal of 20% water usage (by a specific time period) would be established.
Other Programs	
• Unaccounted-for-Water	Local officials would increase its leak protection & repair program w/ goal of reducing "lost-and-unaccounted-for" water to 10% (from current average of 17%).
• Public Education	Local officials would offer water conservation education to all schools, civic associations, Girl Scout & Boy Scout troops, etc.
• <i>Waterwise & Energy Efficient Program</i>	Local officials would maintain a partner w/ the Harris-Galveston Coastal Subsidence District to provide 5 th grade students in the area w/ a 2-week conservation education program that provides retrofit devices (low-flow shower head, kitchen aerator, bathroom aerator, etc.).

¹ Meeting Notes, City of Houston Water Conservation Program, April 3, 1997. Presentation of *City of Houston Final Draft Water Conservation Plan*, March 1997.

APPENDIX D: Water Supply Availability

Table 12: Southeast Area Water Supply Availability: 2000—2050

Category	Amount (Thousands of Acre/Feet-Year)								Total Southeast
	Sabine	Neches	Trinity	Trinity	Trinity- San Jacinto	San Jacinto	San Jacinto- Brazos	Brazos	
2000									
In-Basin Demands	86.0	261.4	329.9	138.5	143.2	949.7	464.2	427.3	2800.2
In-Basin Supplies									
Groundwater	23.3	110.5	7.5	34.3	26.6	451.7	74.9	130.5	859.3
Surface Water	1190.4	846.9	0.0	1356.4	0.0	257.7	57.8	488.2	4197.4
TOTAL	1213.7	957.4	7.5	1390.7	26.6	709.4	132.7	618.7	5056.7
Transfers									0.0
Imported Supplies	0.9	1.4	322.4	0.0	116.6	300.3	331.5	0.0	1073.1
Export Demands	1.4	280.5	0.0	582.5	0.0	60.0	0.0	148.7	1073.1
In-Basin Reserves	282.9	209.1	0.0	0.0	0.0	0.0	0.0	0.0	492.0
Net Surface Water Availability	844.3	207.8	0.0	669.7	0.0	0.0	0.0	42.7	1764.5
2010									
In-Basin Demands	93.9	275.4	316.6	141.0	147.9	1030.9	497.8	463.4	2966.9
In-Basin Supplies									
Supplied by Groundwater	23.3	111.6	7.9	36.6	25.7	292.3	80.9	141.9	720.2
Supplied by Surface Water	1190.4	846.9	0.0	1356.4	0.0	257.7	57.8	487.6	4196.8
TOTAL	1213.7	958.5	7.9	1393.0	25.7	550.0	138.7	629.5	4917.0
Transfers									
Imported Supplies	1.0	2.0	308.7	0.0	122.2	540.9	359.1	0.0	1333.9
Export Demands	2.0	279.5	0.0	839.2	0.0	60.0	0.0	153.2	1333.9
In-Basin Reserves	282.9	209.1	0.0	0.0	0.0	0.0	0.0	0.0	492.0
Net Surface Water Availability	835.9	196.5	0.0	412.8	0.0	0.0	0.0	12.9	1458.1
2020									
In-Basin Demands	102.4	287.3	304.4	144.0	152.6	1128.7	529.7	492.7	3141.8
In-Basin Supplies									
Groundwater	23.3	112.8	8.3	38.7	31.1	251.1	87.1	156.1	708.5
Surface Water	1190.4	846.9	0.0	1356.4	0.0	257.7	57.8	487.1	4196.3
TOTAL	1213.7	959.7	8.3	1395.1	31.1	508.8	144.9	643.2	4904.8
Surface Water Transfers									
Imported Supplies	1.0	2.6	296.1	0.0	121.5	679.9	384.8	0.0	1485.9
Export Demands	2.6	266.9	0.0	993.4	0.0	60.0	0.0	163.0	1485.9
In-Basin Reserves	282.9	209.1	0.0	0.0	0.0	0.0	0.0	0.0	492.0
Net Surface Water Availability	826.8	199.0	0.0	257.7	0.0	0.0	0.0	-12.5	1271.0

Table 12: Southeast Area Water Supply Availability: 2000—2050, Continued

Category	Amount (Thousands of Acre/Feet-Year)								
	Sabine	Neches	Trinity	Trinity	Trinity-San Jacinto	San Jacinto	San Jacinto-Brazos	Brazos	Total Southeast
2030									
In-Basin Demands	111.0	299.4	303.1	148.1	156.9	1201.4	567.7	529.1	3316.7
In-Basin Supplies									
Groundwater	23.4	114.6	8.7	41.2	27.9	266.3	87.8	169.4	739.3
Surface Water	1190.4	846.9	0.0	1356.4	0.0	257.7	57.8	486.6	4195.8
TOTAL	1213.8	961.5	8.7	1397.6	27.9	524.0	145.6	656.0	4935.1
Surface Water Transfers									
Imported Supplies	1.0	4.1	294.4	0.0	129.0	726.2	422.1	0.0	1576.8
Export Demands	4.1	265.3	0.0	1072.6	0.0	60.0	0.0	174.7	1576.7
In-Basin Reserves	282.9	209.1	0.0	0.0	0.0	0.0	0.0	0.0	492.0
Net Surface Water Availability	816.8	191.8	0.0	176.9	0.0	-11.2	0.0	-47.8	1126.5
2040									
In-Basin Demands	123.1	321.7	306.7	159.3	167.0	1298.3	617.9	583.2	3577.2
In-Basin Supplies									
Groundwater	23.5	116.3	8.8	43.8	29.6	280.5	88.8	181.1	772.4
Surface Water	1190.4	846.9	0.0	1356.4	0.0	257.7	57.8	486.0	4195.2
TOTAL	1213.9	963.2	8.8	1400.2	29.6	538.2	146.6	667.1	4967.6
Surface Water Transfers									
Imported Supplies	1.0	4.6	297.9	0.0	123.5	710.9	460.8	0.0	1598.7
Export Demands	4.6	268.7	0.0	1075.3	0.0	60.0	0.0	190.1	1598.7
In-Basin Reserves	282.9	209.1	0.0	0.0	0.0	0.0	0.0	0.0	492.0
Net Surface Water Availability	804.3	168.3	0.0	165.6	-13.9	-109.2	-10.5	-106.2	898.4
2050									
In-Basin Demands	135.8	344.8	310.6	174.5	179.9	1386.4	668.4	639.2	3839.6
In-Basin Supplies									
Groundwater	23.6	118.3	9.0	46.7	31.0	291.8	89.7	197.3	807.4
Surface Water	1190.4	846.9	0.0	1356.4	0.0	257.7	57.8	485.4	4194.6
TOTAL	1214.0	965.2	9.0	1403.1	31.0	549.5	147.5	682.7	5002.0
Transfers									
Imported Supplies	1.1	5.1	301.6	0.0	123.5	710.9	476.3	0.0	1618.5
Export Demands	5.3	272.2	0.0	1075.4	0.0	60.0	0.0	205.6	1618.5
In-Basin Reserves	282.9	209.1	0.0	0.0	0.0	0.0	0.0	0.0	492.0
Net Surface Water Availability	791.1	144.2	0.0	153.2	-25.4	-186.0	-44.6	-162.1	670.4

Table 13: Trans-Texas Water Program Supply Availability: 20000 - 2050

<i>Amount (Thousands of Acre-Feet/Year)</i>						
Category	2000	2010	2020	2030	2040	2050
Scenario 1						
Available Southeast Supply	1764.5	1458.1	1271	1126.4	898.4	670.4
West-Central Demand			150	300	450	600
Net Surface Water Availability	1764.5	1458.1	1121	826.4	448.4	70.4
Scenario 2						
Available Southeast Supply	1764.5	1458.1	1271	1126.4	898.4	670.4
West-Central Demand				100	200	300
Net Surface Water Availability	1764.5	1458.1	1271	1026.4	698.4	370.4
Scenario 3						
Available Southeast Supply	1764.5	1458.1	1271	1126.4	898.4	670.4
West-Central Demand	0	0	0	0	0	0
Net Surface Water Availability	1764.5	1458.1	1271	1126.4	898.4	670.4

APPENDIX E: Recommended Conservation Plan

Excerpted from the City of Houston *Final Draft Water Plan*, Section 7. March 1997.

Table 7-7
Recommended Conservation Plan

Sector	Program	Element	50 Year Avg Water Savings mgd	Water Savings in 2001 mgd	Total Costs Through 2001 \$1,000	Benefit- Cost Ratio (50 years)
Residential						
	Res Water Audits		0.42	0.18	\$429	1.00
	Appliance Labeling		0.71	0.06	\$75	21.71
Subtotal			1.13	0.24	\$504	
Commercial						
	Indoor Audits		1.17	0.49	\$528	2.23
	Cooling Tower Audits		0.48	0.30	\$210	18.67
Subtotal			1.65	0.79	\$738	
Public						
	Indoor Audits		0.36	0.30	\$313	3.03
	Exterior Audits		0.86	0.72	\$258	10.84
	Pool/Fountain Audits	City	0.28	0.17	\$354	6.26
	Pool/Fountain Standards		0.25	0.04	\$155	4.32
	City In-House Program		0.20	0.20	\$50	54.83
Subtotal			1.95	1.43	\$1,130	
Other						
	Unaccounted For Water		11.65	6.4	\$4,400	6.28
	Public Education		4.51	3.62	\$3,925	1.78
	Water Wise & Energy Efficient		0.42	0.41	\$500	3.68
Subtotal			16.58	10.43	\$8,825	
Total			21.31	12.89	\$11,197	3.69

levels during the drought period from 1988 to 1993. In order to achieve reductions ranging from 25 percent for single-family residential customers to 50 percent for irrigation customers, EBMUD employed a four-tier increasing block rate structure. At the end of the program in 1993, rates ranged from \$1.10 per 100 cubic feet (Ccf) to \$4.14 per Ccf. At \$1.37 per Ccf, the second tier of the rate structure was considered to be the break-even rate, the amount needed to be collected from each Ccf in order for the District to be in a revenue neutral position. For water sold in the upper two tiers, revenues were divided into normal charges (based on \$1.37) and excess use charges (the amount in excess of \$1.37). For example, for each unit sold in the highest tier, revenue was recognized as \$1.37 of normal revenue and \$2.77 (\$4.14 minus \$1.37) of excess use revenue. Excess use revenues, which totaled nearly \$9 million for 1993, were designated to be used to fund the extra expenses associated with both drought-specific costs and conservation program costs.

WATER CONSERVATION GOALS

Table 7-10 shows overall water saving goals broken down by type of customer. Table 7-11 shows periodic goals on a per capita basis. In the year 2006, the plan establishes a goal of reducing total per capita demand by 11 gallons per capita per day (7 percent). The goals will decline slightly thereafter unless new programs are started. These goals will enable demand tracking to be done periodically to compare achievements with the plan.

Table 7-10
Recommended Plan Water Saving Goals, mgd

Sector	Program	Element	50 Year Avg	Year			
				2005	2015	2025	2050
Residential							
	Res Water Audits		0.42	0.42	0.42	0.42	0.42
	Appliance Labeling		0.71	0.22	0.80	0.93	0.93
Subtotal			1.13	0.64	1.22	1.35	1.35
Commercial							
	Indoor Audits		1.17	1.22	1.22	1.22	1.22
	Cooling Tower Audits		0.48	0.50	0.50	0.50	0.50
Subtotal			1.65	1.72	1.72	1.72	1.72

Table 7-10 (continued)
Recommended Plan Water Saving Goals, mgd

Sector	Program	Element	50 Year Avg	Year			
				2005	2015	2025	2050
Public							
	Indoor Audits		0.36	0.37	0.37	0.37	0.37
	Exterior Audits		0.86	0.90	0.90	0.90	0.90
	Pool/Fountain Audits	City	0.28	0.28	0.28	0.28	0.28
	Pool/Fountain Standards		0.25	0.08	0.18	0.28	0.50
	City In-House Program		0.20	0.20	0.20	0.20	0.20
Subtotal			1.95	1.83	1.93	2.03	2.25
Other							
	Unaccounted For Water		11.65	11.52	12.80	12.80	12.80
	Public Education		4.51	3.81	4.35	4.88	5.82
	Water Wise & Energy Efficient		0.42	0.74	0.08	0.00	0.00
Subtotal			16.58	16.07	17.23	17.68	18.62
Total			21.31	20.26	22.10	22.78	23.94

Differences due to rounding

Table 7-11
Recommended Plan Water Savings Goals

Year	Water Savings mgd	Water Use w/o Conservation mgd	Projected Population	Per Capita Use w/o Conservation gpcd	Per Capita Use with Conservation gpcd	Percent Reduction
1996	0	269	1,719,576	156.43	156.43	0.00%
2001	10.04	285	1,820,331	156.56	151.05	3.52%
2006	21.76	304	1,937,726	156.88	145.66	7.16%
2016	22.18	348	2,218,072	156.89	146.89	6.37%
2050	24.26	473	3,016,887	156.78	148.74	5.13%

Note: Water Use w/o Conservation includes Retail Water Sales and Unaccounted-for Water

Section 3

POPULATION AND WATER DEMAND PROJECTIONS

Table 3-2
Water Demand Projections
Using City of Houston Population Projections

	Base use gpd/acct 1994	Current no. of accounts 1994	1990	1994	2000	2010	2020	2030	2040	2050	Units
City of Houston Population Projection			1,603,524	1,680,892	1,796,943	2,030,820	2,342,906	2,528,380	2,761,854	3,016,887	Population
Retail Accounts:											
Single family residential	210.50	323,193		323,193	345,507	390,475	450,482	486,144	531,035	580,071	Accounts
indoor	173.56			55.90	59.97	67.77	78.18	84.37	92.16	100.68	mgd
outdoor	36.95			11.90	12.77	14.43	16.64	17.96	19.62	21.43	mgd
Multi-family residential	191.70	383,515		383,515	409,993	463,355	534,561	576,879	630,149	688,338	Residences
indoor	169.36			65.20	69.44	78.47	90.53	97.70	106.72	116.58	mgd
outdoor	22.31			8.60	9.15	10.34	11.93	12.87	14.08	15.36	mgd
Commercial accounts	1,657.90	34,524		34,524	36,908	41,711	48,121	51,931	56,726	61,964	Accounts
indoor	1,396.20			47.80	51.49	58.20	67.14	72.45	79.14	86.45	mgd
outdoor	262.70			9.00	9.70	10.96	12.64	13.64	14.90	16.28	mgd
Lawn meter accounts	924.90	3,485		3,485	3,726	4,211	4,858	5,242	5,726	6,255	Accounts
indoor	289.03			1.00	1.08	1.22	1.40	1.52	1.66	1.81	mgd
outdoor	635.87			2.20	2.37	2.68	3.09	3.33	3.84	3.96	mgd
Municipal & Institutional	4,374.60	4,501		4,501	4,812	5,438	6,274	6,770	7,396	8,078	Accounts
indoor	3,736.64			16.40	17.98	20.32	23.44	25.30	27.63	30.19	mgd
outdoor	637.96			2.80	3.07	3.47	4.00	4.32	4.72	5.15	mgd
Industrial accounts	14,315.70	293		293	313	354	408	441	481	526	Accounts
indoor	11,871.56			3.40	3.72	4.20	4.85	5.23	5.72	6.24	mgd
outdoor	2,444.14			0.70	0.77	0.87	1.00	1.08	1.18	1.29	mgd
Total no. of accounts		749,511		749,511	801,258	905,544	1,044,704	1,127,407	1,231,513	1,345,232	Accounts
Total Indoor (mgd)				190	204	230	266	287	313	342	mgd
Total Outdoor (mgd)				35	38	43	49	53	58	63	mgd
TOTAL RETAIL (mgd)				225	241	273	315	340	371	405	mgd
Unaccounted-for Water				38	40	46	53	57	62	68	mgd
Wholesale				296	296	296	296	296	296	296	mgd
TOTAL (mgd)				558	576	614	663	692	728	768	mgd

City of Houston Recommended Conservation Plan
 DETAIL FOR PROGRAM: Appliance Labeling
 PERSPECTIVE: UTILITY

Year	Water Savings (gal/day)	Total Costs (000 \$)	Total Benefits (000 \$)	Net Benefits (000 \$)	Package Deliver (number)
1997	0	0	0	0	0
1998	6198	26	3	-22	420
1999	18593	21	10	-11	840
2000	37185	14	20	6	1260
2001	61975	14	33	19	1680
2002	92963	14	49	36	2100
2003	130148	14	69	55	2520
2004	173531	14	92	78	2940
2005	223111	14	118	105	3360
2006	278888	14	148	134	3780
2007	340864	14	181	167	4200
2008	402839	14	214	200	4200
2009	464814	14	247	233	4200
2010	526789	14	279	266	4200
2011	588764	14	312	299	4200
2012	650740	14	345	331	4200
2013	706517	14	375	361	4200
2014	756097	14	401	387	4200
2015	799480	14	424	410	4200
2016	836665	14	444	430	4200
2017	867653	14	460	446	4200
2018	892443	14	473	460	4200
2019	911036	14	483	469	4200
2020	923431	14	490	476	4200
2021	929628	14	493	479	4200
2022	929628	14	493	479	4200
2023	929628	14	493	479	4200
2024	929628	14	493	479	4200
2025	929628	14	493	479	4200
2026	929628	14	493	479	4200
2027	929628	14	493	479	4200
2028	929628	14	493	479	4200
2029	929628	14	493	479	4200
2030	929628	14	493	479	4200
2031	929628	14	493	479	4200
2032	929628	14	493	479	4200
2033	929628	14	493	479	4200
2034	929628	14	493	479	4200
2035	929628	14	493	479	4200
2036	929628	14	493	479	4200
2037	929628	14	493	479	4200
2038	929628	14	493	479	4200
2039	929628	14	493	479	4200
2040	929628	14	493	479	4200
2041	929628	14	493	479	4200
2042	929628	14	493	479	4200
2043	929628	14	493	479	4200
2044	929628	14	493	479	4200
2045	929628	14	493	479	4200
2046	929628	14	493	479	4200

City of Houston Recommended Conservation Plan
 DETAIL FOR PROGRAM: C/I Indoor Audits
 PERSPECTIVE: UTILITY

Year	Water Savings (gal/day)	Total Costs (000 \$)	Total Benefits (000 \$)	Net Benefits (000 \$)	Packages Delivered (number)
1997	0	0	0	0	0
1998	0	0	0	0	0
1999	0	0	0	0	0
2000	243525	264	127	-137	250
2001	487050	264	254	-10	250
2002	730575	264	381	117	250
2003	974100	264	508	244	250
2004	1217625	264	635	371	250
2005	1217625	264	635	371	250
2006	1217625	264	635	371	250
2007	1217625	264	635	371	250
2008	1217625	264	635	371	250
2009	1217625	264	635	371	250
2010	1217625	264	635	371	250
2011	1217625	264	635	371	250
2012	1217625	264	635	371	250
2013	1217625	264	635	371	250
2014	1217625	264	635	371	250
2015	1217625	264	635	371	250
2016	1217625	264	635	371	250
2017	1217625	264	635	371	250
2018	1217625	264	635	371	250
2019	1217625	264	635	371	250
2020	1217625	264	635	371	250
2021	1217625	264	635	371	250
2022	1217625	264	635	371	250
2023	1217625	264	635	371	250
2024	1217625	264	635	371	250
2025	1217625	264	635	371	250
2026	1217625	264	635	371	250
2027	1217625	264	635	371	250
2028	1217625	264	635	371	250
2029	1217625	264	635	371	250
2030	1217625	264	635	371	250
2031	1217625	264	635	371	250
2032	1217625	264	635	371	250
2033	1217625	264	635	371	250
2034	1217625	264	635	371	250
2035	1217625	264	635	371	250
2036	1217625	264	635	371	250
2037	1217625	264	635	371	250
2038	1217625	264	635	371	250
2039	1217625	264	635	371	250
2040	1217625	264	635	371	250
2041	1217625	264	635	371	250
2042	1217625	264	635	371	250
2043	1217625	264	635	371	250
2044	1217625	264	635	371	250
2045	1217625	264	635	371	250
2046	1217625	264	635	371	250

City of Houston Recommended Conservation Plan
 DETAIL FOR PROGRAM: COH In-House Program
 PERSPECTIVE: UTILITY

Year	Water Savings (gal/day)	Total Costs (000 \$)	Total Benefits (000 \$)	Net Benefits (000 \$)	Packages Delivered (number)
1997	202000	50	103	53	1
1998	202000	0	103	103	1
1999	202000	0	103	103	1
2000	202000	0	103	103	1
2001	202000	0	103	103	1
2002	202000	0	103	103	1
2003	202000	0	103	103	1
2004	202000	0	103	103	1
2005	202000	0	103	103	1
2006	202000	0	103	103	1
2007	202000	0	103	103	1
2008	202000	0	103	103	1
2009	202000	0	103	103	1
2010	202000	0	103	103	1
2011	202000	0	103	103	1
2012	202000	0	103	103	1
2013	202000	0	103	103	1
2014	202000	0	103	103	1
2015	202000	0	103	103	1
2016	202000	0	103	103	1
2017	202000	0	103	103	1
2018	202000	0	103	103	1
2019	202000	0	103	103	1
2020	202000	0	103	103	1
2021	202000	0	103	103	1
2022	202000	0	103	103	1
2023	202000	0	103	103	1
2024	202000	0	103	103	1
2025	202000	0	103	103	1
2026	202000	0	103	103	1
2027	202000	0	103	103	1
2028	202000	0	103	103	1
2029	202000	0	103	103	1
2030	202000	0	103	103	1
2031	202000	0	103	103	1
2032	202000	0	103	103	1
2033	202000	0	103	103	1
2034	202000	0	103	103	1
2035	202000	0	103	103	1
2036	202000	0	103	103	1
2037	202000	0	103	103	1
2038	202000	0	103	103	1
2039	202000	0	103	103	1
2040	202000	0	103	103	1
2041	202000	0	103	103	1
2042	202000	0	103	103	1
2043	202000	0	103	103	1
2044	202000	0	103	103	1
2045	202000	0	103	103	1
2046	202000	0	103	103	1

City of Houston Recommended Conservation Plan
 DETAIL FOR PROGRAM: PF Pool/Fountain Audits-COH
 PERSPECTIVE: UTILITY

Year	Water Savings (gal/day)	Total Costs (000 \$)	Total Benefits (000 \$)	Net Benefits (000 \$)	Packages Delivered (number)
1997	0	0	0	0	0
1998	0	0	0	0	0
1999	56521	118	29	-89	1
2000	113041	118	58	-60	1
2001	169562	118	87	-31	1
2002	226082	118	116	-2	1
2003	282603	118	145	27	1
2004	282603	0	145	145	0
2005	282603	0	145	145	0
2006	282603	0	145	145	0
2007	282603	0	145	145	0
2008	282603	0	145	145	0
2009	282603	0	145	145	0
2010	282603	0	145	145	0
2011	282603	0	145	145	0
2012	282603	0	145	145	0
2013	282603	0	145	145	0
2014	282603	0	145	145	0
2015	282603	0	145	145	0
2016	282603	0	145	145	0
2017	282603	0	145	145	0
2018	282603	0	145	145	0
2019	282603	0	145	145	0
2020	282603	0	145	145	0
2021	282603	0	145	145	0
2022	282603	0	145	145	0
2023	282603	0	145	145	0
2024	282603	0	145	145	0
2025	282603	0	145	145	0
2026	282603	0	145	145	0
2027	282603	0	145	145	0
2028	282603	0	145	145	0
2029	282603	0	145	145	0
2030	282603	0	145	145	0
2031	282603	0	145	145	0
2032	282603	0	145	145	0
2033	282603	0	145	145	0
2034	282603	0	145	145	0
2035	282603	0	145	145	0
2036	282603	0	145	145	0
2037	282603	0	145	145	0
2038	282603	0	145	145	0
2039	282603	0	145	145	0
2040	282603	0	145	145	0
2041	282603	0	145	145	0
2042	282603	0	145	145	0
2043	282603	0	145	145	0
2044	282603	0	145	145	0
2045	282603	0	145	145	0
2046	282603	0	145	145	0

CITY OF HOUSTON Recommended Conservation Plan
 DETAIL FOR PROGRAM: Unaccounted for Water Improvements
 PERSPECTIVE: UTILITY

Year	Water Savings (gal/day)	Total Costs (000 \$)	Total Benefits (000 \$)	Net Benefits (000 \$)	Packages Delivered (number)
1997	1280000	880	655	-225	1
1998	2560000	880	1311	431	1
1999	3840000	880	1966	1086	1
2000	5120000	880	2622	1742	1
2001	6400000	880	3277	2397	1
2002	7680000	880	3933	3053	1
2003	8960000	880	4588	3708	1
2004	10240000	880	5244	4364	1
2005	11520000	880	5899	5019	1
2006	12800000	880	6555	5675	1
2007	12800000	880	6555	5675	1
2008	12800000	880	6555	5675	1
2009	12800000	880	6555	5675	1
2010	12800000	880	6555	5675	1
2011	12800000	880	6555	5675	1
2012	12800000	880	6555	5675	1
2013	12800000	880	6555	5675	1
2014	12800000	880	6555	5675	1
2015	12800000	880	6555	5675	1
2016	12800000	880	6555	5675	1
2017	12800000	880	6555	5675	1
2018	12800000	880	6555	5675	1
2019	12800000	880	6555	5675	1
2020	12800000	880	6555	5675	1
2021	12800000	880	6555	5675	1
2022	12800000	880	6555	5675	1
2023	12800000	880	6555	5675	1
2024	12800000	880	6555	5675	1
2025	12800000	880	6555	5675	1
2026	12800000	880	6555	5675	1
2027	12800000	880	6555	5675	1
2028	12800000	880	6555	5675	1
2029	12800000	880	6555	5675	1
2030	12800000	880	6555	5675	1
2031	12800000	880	6555	5675	1
2032	12800000	880	6555	5675	1
2033	12800000	880	6555	5675	1
2034	12800000	880	6555	5675	1
2035	12800000	880	6555	5675	1
2036	12800000	880	6555	5675	1
2037	12800000	880	6555	5675	1
2038	12800000	880	6555	5675	1
2039	12800000	880	6555	5675	1
2040	12800000	880	6555	5675	1
2041	12800000	880	6555	5675	1
2042	12800000	880	6555	5675	1
2043	12800000	880	6555	5675	1
2044	12800000	880	6555	5675	1
2045	12800000	880	6555	5675	1
2046	12800000	880	6555	5675	1

City of Houston Recommended Conservation Plan
 DETAIL FOR PROGRAM: Public Education Program
 PERSPECTIVE: UTILITY

Year	Water Savings (gal/day)	Total Costs (000 \$)	Total Benefits (000 \$)	Net Benefits (000 \$)	Packages Delivered (number)
1997	690000	705	353	-352	1
1998	1398000	765	716	-49	2
1999	2124000	825	1088	263	3
2000	2856000	885	1463	578	4
2001	3615000	945	1851	906	5
2002	3660000	1005	1874	869	5
2003	3705000	1018	1897	879	5
2004	3765000	1031	1928	897	5
2005	3810000	1045	1951	906	5
2006	3855000	1058	1974	916	5
2007	3900000	1072	1997	925	5
2008	3945000	1086	2020	934	5
2009	4005000	1100	2051	951	5
2010	4050000	1114	2074	960	5
2011	4095000	1131	2097	966	5
2012	4155000	1148	2128	980	5
2013	4215000	1165	2158	993	5
2014	4290000	1183	2197	1014	5
2015	4350000	1201	2228	1027	5
2016	4410000	1219	2258	1040	5
2017	4470000	1237	2289	1052	5
2018	4530000	1255	2320	1064	5
2019	4605000	1274	2358	1084	5
2020	4665000	1293	2389	1096	5
2021	4725000	1304	2420	1116	5
2022	4770000	1314	2443	1129	5
2023	4800000	1325	2458	1133	5
2024	4845000	1335	2481	1146	5
2025	4875000	1346	2496	1151	5
2026	4920000	1357	2520	1163	5
2027	4950000	1367	2535	1167	5
2028	4995000	1378	2558	1179	5
2029	5025000	1389	2573	1184	5
2030	5070000	1401	2596	1196	5
2031	5100000	1413	2612	1199	5
2032	5145000	1426	2635	1209	5
2033	5190000	1439	2658	1219	5
2034	5235000	1452	2681	1229	5
2035	5280000	1465	2704	1239	5
2036	5340000	1478	2735	1257	5
2037	5385000	1491	2758	1266	5
2038	5430000	1505	2781	1276	5
2039	5475000	1518	2804	1286	5
2040	5520000	1532	2827	1295	5
2041	5565000	1561	2850	1289	5
2042	5610000	1591	2873	1282	5
2043	5670000	1621	2904	1283	5
2044	5715000	1652	2927	1275	5
2045	5775000	1683	2957	1274	5
2046	5820000	1715	2980	1265	5

City of Houston Recommended Conservation Plan
 DETAIL FOR PROGRAM: Waterwise & Energy Efficient
 PERSPECTIVE: UTILITY

Year	Water Savings (gal/day)	Total Costs (000 \$)	Total Benefits (000 \$)	Net Benefits (000 \$)	Packages Delivered (number)
1997	81776	100	42	-58	3571
1998	163575	100	84	-16	3572
1999	245374	100	126	26	3572
2000	327172	100	168	68	3572
2001	408971	100	209	109	3572
2002	490770	100	251	151	3572
2003	572569	100	293	193	3572
2004	654367	100	335	235	3572
2005	736166	100	377	277	3572
2006	817965	100	419	319	3572
2007	736189	0	377	377	0
2008	654390	0	335	335	0
2009	572592	0	293	293	0
2010	490793	0	251	251	0
2011	408994	0	209	209	0
2012	327195	0	168	168	0
2013	245396	0	126	126	0
2014	163598	0	84	84	0
2015	81799	0	42	42	0
2016	0	0	0	0	0
2017	0	0	0	0	0
2018	0	0	0	0	0
2019	0	0	0	0	0
2020	0	0	0	0	0
2021	0	0	0	0	0
2022	0	0	0	0	0
2023	0	0	0	0	0
2024	0	0	0	0	0
2025	0	0	0	0	0
2026	0	0	0	0	0
2027	0	0	0	0	0
2028	0	0	0	0	0
2029	0	0	0	0	0
2030	0	0	0	0	0
2031	0	0	0	0	0
2032	0	0	0	0	0
2033	0	0	0	0	0
2034	0	0	0	0	0
2035	0	0	0	0	0
2036	0	0	0	0	0
2037	0	0	0	0	0
2038	0	0	0	0	0
2039	0	0	0	0	0
2040	0	0	0	0	0
2041	0	0	0	0	0
2042	0	0	0	0	0
2043	0	0	0	0	0
2044	0	0	0	0	0
2045	0	0	0	0	0
2046	0	0	0	0	0