SURVEY OF MUNICIPAL WATER LOSS PRACTICES IN TEXAS

Prepared for the

TEXAS WATER DEVELOPMENT BOARD

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Executive Summary

There are finite volumes of water supplies for public use in Texas. The careful accounting for the use of those supplies by public water supply systems is becoming increasingly more important as it is becoming more important to conserve these supplies to meet the needs of the growing population of the state. "Unaccounted for water" or "water loss" is an important benchmark of public water system operations. The efforts water utilities take for good system maintenance in controlling the loss of water are also extremely important functions. This report summarizes the results of an informational survey of a cross sectional sample of public water systems in Texas to determine the degree of efforts in water use auditing practices and water loss control measures.

In the spring and summer of 2004 a written survey was submitted to a sample of 960 public water systems out of the almost 2,400 systems in the state that serve at least 500 or more people. The sample was selected to cover a cross section of sizes (by population served) and a cross section of ownership types. 300 responses to the survey were returned.

The survey consisted of five sections and asked information about the service characteristics and a variety of questions based on typical water use accounting and water loss control practices in the water utility industry. Respondents were also asked to submit any water audit or water use worksheets or documents they use.

This report presents and discusses the survey responses in table format within the text and in Appendix 1. Also included is a tabulation of the written "fill in the blank" responses to certain questions in Appendix 2. Appendix 3 contains selection from the variety of actual water loss forms that were submitted. The report also touches on the basics of the International Water Association's recommended audit methodologies which gear around comprehensive water use measurement and performance indicators. There is a recap of the status of the efforts in this area by the American Water Works Association's Water Loss Committee.

The general findings of the survey reinforced the findings of other surveys and investigations that within the industry consistency in the terminology and techniques for water audit methodologies is needed. Also needed is more focus on water loss control measures such as leak detection, leak response, and meter management. It was also seen that utilities, especially the smaller and more rural, do not have consistent practices or procedures in water accounting.

One recommendation is that there be training offered to Texas utility operators and managers specifically oriented to present the basics as well as the most up to date recommended water audit methodologies and water loss techniques. Recognizing that there are many sizes of systems in Texas, recommendations are that various degrees of water auditing detail and frequency should be required.

Introduction

The State of Texas through its ongoing water planning processes has been developing water management strategies which center on both wise development of new sources of water and efficient management of existing supplies. It has long been recognized that fresh water supplies are a finite resource that require careful and sound management to ensure that adequate supplies are available to meet the needs of the population of the State. This report addresses the way water use is accounted for by municipal water systems in Texas.

Municipal water use makes up the second largest category of water use in the state, behind only agricultural water use. Water for municipal use is primarily provided to the ultimate users by public water systems. The difference in the amounts of water originally diverted or withdrawn by systems, but not ultimately delivered for beneficial use is figuratively known as “lost water” or “unaccounted for water.”

Reducing the amount of lost and unaccounted for water in municipal water use has been identified as an opportunity for significant conservation of water. Major strategies in achieving this are through improvements in the methods by which the managers and operators of the systems account for water use as well as improved infrastructure management practices to reduce water losses. Additionally, the 2004 Water Conservation Implementation Task Force has recommended water conservation goals that specifically set parameters for reporting and benchmarking water use in municipal water systems through use of a standard methodology for calculating total usage and residential usage in gallons per capita per day. Improving utility water loss accounting and practices will assist utilities in trying to achieve these goals.

This objectives and goals of this project were to survey a cross section of the municipal water systems in Texas to first determine current water loss accounting practices and resulting loss estimates, gain more information on current water loss prevention and management practices, and then make recommendations for more consistent water use accounting and water loss management.

Background

Traditionally it was understood that water systems could take the amount of water produced and put into the water system and subtract from it the amount of water sold to customers over the same period of time and call the difference "water loss" or "unaccounted for water." This is still a commonly used method throughout the water industry.

The water utility industry has long recognized that there is more to water loss calculations and that it is important to properly account for all uses of water in municipal utility operations. For many years, the American Water Works Association's (AWWA) Manual 36 titled *Water Audits and Leak Detection* has been considered an excellent reference for water accounting guidelines in the United States. This manual emphasizes water use calculations that include not only all metered uses within a system but also measured unmetered uses such as flushing, fire use and measured or estimated sources of unauthorized losses such as leaks or theft.

A 2002 survey of the State Regulatory Agencies on their Water Loss Reporting Practices (Beecher) done for the AWWA determined that nationally there really is no standard methodology for water accountability. The survey also found that the states' interpretations of and use of the results from water use analyses were not uniform.

Even in Texas there is not consistency within the regulatory agencies. The Water Development Board's (TWDB) old Water Use Survey forms require water loss calculations that specify water uses should include other "known water consumption" other than sales, but do not specifically address what is to be included or the methodology. The Texas Commission on Environmental Quality (TCEQ) has conservation planning requirements that certain municipal users have a program of leak detection, repair and water loss accounting to control unaccounted for uses of water. And, the Water Utility Division of TCEQ uses the percentage of water lost between sales and production as a benchmark when evaluating water system management efficiency.

The second part of this survey of municipal water accounting practices related to the measures utilities take to reduce or eliminate lost water. Historically, especially where water supplies have been relatively abundant, low priorities have been placed on making significant capital expenditures to quantify and control the use of water within the systems. Other than repairing major leaks it was not uncommon to accept significant percentages of "unaccounted for water." Now with the growing population creating a demand for the development for more water supplies, more stringent regulatory requirements for improved treatment of public drinking water supplies, and drought conditions periodically experienced in many parts of the state, it is economically beneficial to implement programs to reduce the amounts lost or wasted.

In recent years it has become very apparent to the water utility industry in North America and in Texas that much more attention should be paid to not only the accounting for and auditing of water supplies, but also that more emphasis be given to the control of water losses in public water system operations. The AWWA Leak Detection and Water Accountability Committee even renamed itself the "AWWA Water Loss Control Committee to add emphasis to the management of water loss part of its responsibility.

Extensive research and development of operating practices have been done with regard to water loss control in European countries through the International Water Association (IWA). The resulting well-defined water audit methodologies and water loss performance indicators have become known as the "IWA audit methodology." The IWA audit methodology is a more structured approach to reducing water losses as defined in terms of real losses (physical losses) and apparent losses (paper losses).

Real losses are those losses of water where the cost to the utility is the cost of purchasing and producing the water. Real losses include water lost from transmission lines and the distribution system from leaks, unnecessary line flushing and tank overflows. Apparent losses are those losses of water that if measured would be billed at the retail water rate.

The IWA audit methods utilize a two-step approach, a top-down audit followed by a bottom-up audit. The first step, the top-down audit, is a desktop audit using existing records and some estimation to provide an overall picture of water losses. Records and information needed for a top-down audit include quantity of water entering the system, customer billing summaries, leak repair summaries, average pressures, meter accuracy test, meter change-out summary, permitted fire hydrant use, and other water use data that may be kept on water theft and unmetered uses such as street cleaning.

The second step of the audit, the bottom-up approach, involves a detailed investigation into actual policies and practices of the utility. This step addresses development of better estimates of water use by the fire department, water used in line flushing and street cleaning, and metering of all authorized uses. The procedures of the detailed water audit also include using night flow and zonal analysis to better estimate leakage; analysis of leakage repair records for length of time from reporting to repair of the leak; and analyzing pressure throughout the system.

The IWA audit method recommends using indicators from the analyses in a water audit to improve water loss control procedures, including:

1) Real losses:
   Losses due to leakage and excess system pressure. Real losses can be reduced by more efficient leakage management, improved response time to repair leaks, improved pressure management and level control, and improved system maintenance, replacement, and rehabilitation. The cost of real losses is

estimated using the marginal production costs, such as energy and chemicals needed to treat and deliver the water.

2) Apparent losses:
Losses due to meter accuracy error, data transfer errors between meter and archives, data analysis errors between archived data and data used for billing/water balance, and unauthorized consumption including theft. The cost of apparent losses is estimated using the retail commodity rates.

3) Unavoidable Annual Real Losses ("UARL"):
This represents the theoretically low level of annual real losses in millions of gallons daily ("MGD") that could exist in a system if the current best management practices for leak management are successfully implemented. It is based on data obtained from systems where effective leakage management was implemented. The calculation of the UARL is based on number of miles of water mains, number of service connections, average water pressure, and length of service connections. The UARL is allocated to service lines and water mains. The revised AWWA M36 Manual will provide details on how to calculate unavoidable annual real losses.

4) Infrastructure Leakage Index ("ILI"):
Ratio of annual real losses divided by UARL. The ILI provides a ratio of current leakage relative to the best level obtainable with current best management practices for leakage. A ratio of 1.0 would indicate that the utility has reduced losses to the theoretically lowest level possible.

5) Economic Level of Leakage ("ELL"):
This is a calculation based on the cost of reducing leakage. It is the theoretical level at which the cost of leakage reduction meets the cost of the water saved through leakage reduction. These costs include not only the cost of producing water but also the avoided cost of replacing the water.

More guidelines and details for municipal utilities to use in implementing and improving their water loss accounting and management procedures are included in the chapter from the Texas Water Conservation Task Force's Best Management Practice Guide on *System Water Audit and Water Loss* found in Appendix 7. Additional information on the IWA methods and concepts can also be found in the resources bibliography in the Appendix.

The AWWA is revising the M36 Manual to include many of the IWA practices and much of its methodology. Due to the many ways utilities currently calculate unaccounted for water, common definitions, terminology, and accounting procedures are needed. One significant recommendation is that the term "unaccounted-for water" no longer be used in any manner in the water supply industry. A short discussion of the current status of the AWWA M36 manual revision is in the Appendix.

Survey Approach and Methodology

To get a good summary of the current status of municipal water accounting and water loss management practices of utilities around the state, TWDB determined that an informational survey was needed. A written survey was sent by mail in the spring of 2004 to a sample from the group of public water systems in Texas which provide water service to populations over 500.

The project team initially drew up the survey, called the *2004 Municipal Water Loss Survey*, to include many possible questions regarding water loss and water accounting that might be considered. The questions were then organized by general subtopic and distilled down to a number and mix that would not place an undue time requirement upon the respondent, but still allow meaningful information in a variety of subtopics to be obtained. The draft survey was submitted to the TWDB water conservation staff to ensure specific information of interest to them would be asked. The final survey as it was sent out is attached in the Appendix, and further discussion of the question series is in the next section.

The survey was designed to be completed by a person within the utility management that would have good knowledge of the water loss accounting as well as the water loss control measures that the utility currently practiced. This preference was reinforced within the cover letter accompanying the survey. The nature of the survey and the wording of the questions did assume that the person responding had specific experience and knowledge in the water utility management field, but care was taken to prepare the questions with a minimum of jargon or acronyms. The questions were also written to be as neutral as possible to minimize bias and not lead the respondent toward any specific answer.

The sampling methodology can best be described as “stratified sampling.” The survey was sent to a sample of the stated target population of all retail public water systems in Texas serving a population of 500 or more. An additional parameter to the sample selection from this group was that all of the top 100 water systems in the state by size would be included. The top 100 systems represent approximately 67 percent of municipal water use in Texas. From the 2003 Legislative session, HB 3338 required utilities to submit water audit data to the TWDB and it was important that the sample adequately represented utilities from various specified size groups:

- Those serving populations of 100,000 or more
- Serving 50,000 to less than 100,000
- Serving 3,300 to less than 50,000
- And serving less than 3,300 population

A very significant requirement was that the survey take into account other differences in service area characteristics, so the target group was segmented to ensure that specific ownership type categories would be sampled. There are several

different types of management structures for utilities in Texas. Each of the various categories has distinctive management characteristics that can affect budgets and operating philosophies. The state regulatory agencies, especially the TCEQ, have different regulations and degree of authority over the different ownership types and the different management structures in this project generally followed the different classification lines that the TCEQ uses.

Municipal systems. The majority of water systems in Texas are owned and operated by the city or town they serve. In most cases the water utility operations are run by a unit or division of the municipal government, usually the public works department or utility department. In many cases the municipal water system is operated along with other services such as the wastewater system and other services such as solid waste and roads and streets. Elected officials are ultimately responsible for funding and financing decisions in municipal systems.

Some larger municipal systems may be managed and operated by distinct, separate utility entities. In the 2003 database, there were 825 municipal systems in Texas serving at least 500 or more people.

Districts. There are also significant numbers of water districts of various types which can have some of the same characteristics as municipalities. Water districts are political subdivisions of the state and are formed primarily as a vehicle for infrastructure funding. Many water districts in Texas serve populations on the urban fringes of municipalities, and this group has a larger percentage of systems that are primarily distribution systems with water being purchased from wholesale suppliers. Water districts are often run by management companies that usually prepare accounting for all water uses.

Water Supply Corporations (WSCs). Generally defined as non-profit, member owned corporations, WSCs are also utilities formed with a primary mission to provide water to customers. They are located in mostly rural, unincorporated areas, and in many cases there is a more spread out nature to the service area with more distribution lines between connections than found in urban water systems. The survey also had a separate response category for Homeowner Associations, which in reality have many of the same characteristics of smaller rural water supply corporations.

Investor Owned Utilities. Another distinct utility type is the group known as IOUs which are systems operated under private ownership, generally with the intention of making a profit for the owners. Many of these are actually several small individual systems operated by a central management office. The survey was only sent for information on those individual systems serving a population of 500 or more.

Also included in this category of investor owned utilities are water systems serving residential customers that are privately owned as part of another business making venture such as a mobile home park. Privately owned water systems that do not serve community populations or residential customers were not included.

Other ownership classifications include governmental agency systems such as those owned by counties, the state, and federal government systems. These systems, military installations for example, do provide service to residential customers, but the service may not be metered or billed to the customer, thus affecting the importance and reliability of the water use accounting.

A small ownership classification, but very important are the regional authorities which produce and sell water to both retail customers directly as well as wholesale to other systems.

The sampling frame, or database from which the sample was selected was the 2003 TCEQ's Public Water Systems database. The TCEQ is the primary regulatory agency over the public water systems and this database is regularly updated with current information including population served. Out of the over 6,000 active public water systems in Texas, this database listed 2,395 with population served over 500. The water systems were sorted by order of population within the ownership subgroups and every fifth name was selected to receive a survey by mail. Additionally, whether included in the random selection or not, all of the top 100 largest systems in the state by size also received a survey.

One drawback to the TCEQ's database was that the listed contact official was usually the person designated for official contact and not always the most appropriate person to provide information about water management practices. The list was cross referenced against the TWDB's Water Use database which generally had a public works or utility operations official listed.

The project team recognized that the water utility industry in Texas is regularly requested to respond to surveys, questionnaires, and data requests from regulatory agencies, private research firms, and organizations such as AWWA. In order to encourage a response, the mailed survey included a cover letter on TWDB letterhead and was pre-stamped for return to a designated post office box listed under the name of TWDB Water Use Survey. And, instead of mailing, the option to respond to the survey by filing it out on-line by going to a web address was offered. The project team also made follow-up calls to the non-responders out of the top 100 by size group.

Project staff entered the data from the received surveys into a Microsoft ® Access database file. Data from the surveys completed on-line were merged into the database. After the initial completion of all data entry, information specific to each utility from Section I, was scanned to fill in missing information such as principal county or TCEQ Public Water System ID numbers.

Then, each of the categorical responses to the survey questions was analyzed by determining the proportion of positive, negative and non-responses. The proportional data is reported in series of two-way tables showing the percentage by category of response and type or population served by the utility. Each table has in addition to the

proportion of respondents to a particular question, the marginal distribution of total respondents and the response rate of the total sample. Data is also reported in bar charts in a number of cases for easier visual comparison. The significance of apparent differences in proportions was tested by computing the Z-statistic using SigmaStat 3.1®, and where significant, the results are acknowledged in the text.[1]

[1] SigmaStat for Windows Ver 3.10, Systat Software, Inc., 2004.

Survey Response

960 surveys were mailed and 300 responses were ultimately received. Recap totals of the target group, sample group, and surveys mailed and received are shown below.

BY TYPE OF UTILITY	TOTAL (pop=>500)	SURVEY SAMPLE	RESPONSES	% of Total
County Owned	7	7		
State	31	31	8	14%
Federal	21	21		
WSC	605	200	80	13%
District	590	200	42	7%
Municipal	825	400	157	19%
Investor	315	100	13	4%
Indian Reservation	1	1	0	
Others: HOA, non-comm, Authority	Incl. in above		0	
2003 TCEQ Water Utilities Database	**2395**	**960**	**300**	**13%**

The response distribution by size of population served is shown in the table below.

BY POPULATION GROUPS	All Utilities	Responses	% of All
pop 100,000 and over	26	14	53.8%
between 50,001 and 100,000	28	14	50.0%
between 10,001 and 50,000	201	41	20.4%
between 3,301 and 10,000	530	78	14.7%
500 to 3,300	1610	153	9.5%
	2395	**300**	

Table 1 shows the total number of respondents by population served and ownership type in a matrix. The matrix illustrates that more than half of all respondents were municipalities, and more than half of all respondents were small utilities (population served 500-3,000), but only 21% were both a municipality and a small utility. The next largest group of respondents was small Water Supply Corporations. Water Districts were the next most numerous respondents, and all of them served populations of 50,000 or less. Investor-Owned Utilities and Federal-, State-, County-run utilities were the smallest portion of respondents and all served populations of 10,000 or less. The largest populations served (50,001 or greater) were all municipally run utilities, and more than 80% of the utilities serving population between 10,001 and 50,000 were municipally owned. However, together these mid- to large-size municipal utilities made up 61 of the respondents, or just more than 20% of all respondents.

Table 1

Matrix of Respondents						
Type/Population:	500-3,300	3,301-10,000	10,001-50,000	50,001-100,000	100,000+	TOTAL
Municipality	63	33	33	14	14	157
Water District	19	16	7	0	0	42
Water Supply Corporation	55	24	1	0	0	80
Investor-Owned Utility	12	1	0	0	0	13
Federal, State, or County	4	4	0	0	0	8
TOTAL	153	78	41	14	14	300

Regional differences play a very important part in water use patterns as well. The statewide water planning process has 16 regional water planning areas which were developed taking into consideration population concentrations, climatic differences, and natural features such as river basins and aquifers. The distribution of the survey response by planning regions is shown in the next table.

BY REGION	Responses	Tot > 500 pop	Response %
Planning Group A	7	36	19.4%
B	6	32	18.8%
C	45	334	13.5%
D	26	170	15.3%
E	11	27	40.7%
F	13	67	19.4%
G	41	313	13.1%
H	45	717	6.3%
I	35	234	15.0%
J	0	24	0.0%
K	14	101	13.9%
L	29	169	17.2%
M	8	60	13.3%
N	8	50	16.0%
O	11	54	20.4%
Planning Group P	1	7	14.3%
	300	**2395**	

Survey Questions

Section I Utility Profile

The first section of the survey, the Utility Profile, asked for specific information about the utility and the person completing the survey – the demographic information. A major objective of the survey was to get a good cross sampling of utility systems of differing sizes, with the many different ownership and management structures, from both urban and rural areas, and from all geographic regions.

Questions 1 and 2 asked for the names of the utility and its principal TCEQ public water system identification number. This information was used to look up and cross check the master utility databases to determine and verify that the correct name information provided in the responses was accurate and also used to compare the supplied information from the respondents to that used in other statewide analyses.

The next four questions, 3 to 6, asked for the name, title, telephone number, and principal county where the utility does business. The survey was directed to the utility or public works official deemed most knowledgeable about the utility's water system accounting. However, in many cases another person actually submitted the response. Several utilities provide serve service in more than one county, and the principal county reported was used to determine the planning region.

Question 7 requested the current estimated population of the utility service area. As previously discussed, the TWDB in developing its new reporting requirements, has utilized population sizes as a break in requiring different levels of information in the new water use reporting forms. Most utilities know the number of meters or connections they serve, but many, primarily the smaller ones or those that do not serve municipalities may not accurately know the population served as this information is not routinely collected. However, as noted earlier, most of the planning methods for analyzing and determining water use for comparative purposes are based on gallons per capita.

The population requested from the respondents was compared to the figures used in TWDB planning reports and also to that recorded by TCEQ in its public water system database which it uses to evaluate system capacities. It was expected that in many cases the figure supplied is most likely a rounded estimate, but it was also expected that the utilities should have a fairly good idea of the number of people served. In a few cases, after a review of the information, a figure that was considered more reflective of the actual service population was substituted. In many cases the population served by a municipality may not correspond to the census or other generally distributed population figures because the utility may serve an area different from the

corporate limits, or may have other systems supplying water within its limits, or may sell water wholesale to other systems.

Question 8 requested utility service area coverage by square mile. Water loss as measured per unit of service area is one of many potential performance benchmarks in analyzing water use. It is noted that after reviewing the variability and quality of the response data to this question, further analysis in this area was not made.

Question 9 asked for the utility classification by management or ownership type. An extremely important part of this project is evaluation of water loss practices by different ownership or types of utilities. For analytical purposes, some utility classifications were combined based on similar characteristics.

Questions 10 and 11 were intended to get more information to classify the exact type of service the respondent supplies. Question 10 was asked to determine if the service was retail, wholesale, or a combination of the two. This is important, because if the service was wholesale, then there would be another service provider with the corresponding retail use. Also, consideration for wholesale service provision should be made in analyses utilizing population or distribution system sizes. Question 11 asked for the number of separate systems served.

Question 12 asked for the type of supply source, surface water or groundwater, and/or if the respondent purchased water from others.

The final questions (13 and 14) concerned the use of emergency suppliers. This information is related to water use accounting to determine if adjustments would be made if the emergency supply is used.

Section II Water Loss Accounting

This section of the survey was designed to gather information from the utility managers on their practices for water loss accounting and how the information is then used. Both the cover letter and the questionnaire specifically indicated that the responses were to be based on the utilities' current water loss accounting procedures. In general, the purpose of this section of the survey was to get a broader look at what are some of the common practices for systems of all sizes and types.

The first 11 questions were to be answered by checking specific answer categories that centered on what the respondents included in their water accounting procedures. The next to last question of this section asked for a short narrative description of the procedures used to calculate water loss and the final question in this section asked for the water loss accounting worksheet to be attached or submitted.

Question 1 was specifically placed at the start of the section. This question was designed to just get the respondent to indicate what the respondent recognized as the

system's "water loss as a percentage of total water entering the system" on an annual basis.

It was expected that this survey would show that there are significant differences in what different utilities include in their individual water use/water loss calculations. The response to this initial question would help determine if any differences occurred across different categories.

Question 2 asked if the respondents performed a Water Audit or other water accountability analyses for their system. Questions 3 and 4 followed by asking if there was a specific format or worksheet and whether a standardized audit form would be used if provided. Again, this information is important to determine if differences occur across different categories.

Questions 5, 6 and 7 were very important in determining what specific information was included in the water loss calculations. Question 5 asked "What best describes the typical water audit?" There was no open ended answer to be marked and only one answer was expected. The menu of choices given ranged from (1) used a simple percentage of water sold to water produced, (2) included some water uses other than sales, to (3) used a detailed water audit. The respondent could also indicate if he or she did not know what was in the water loss calculation.

Question 6 asked that the respondents mark all of the water uses other than customer sales that are included in their analyses. Multiple answers from six commonly used categories of water use could be marked for this question. An additional "Other" category could be filled in. All of the given water use categories are generally considered important for inclusion and the responses to this question would show the emphasis placed on them by the utilities.

Those that indicated that they did not include any other water uses other than metered sales were directed to Question 7 which asked for the reasons for not including additional water uses in the analysis. Multiple answers could be checked. The information from this question is intended to assist in understanding why more utilities do not do detailed analyses.

Questions 8, 9 and 10 were designed to find out how the water audit information after calculation is used by the utility. The objective of Question 8 was to determine if the respondents utilized their water audit or analysis procedures for detailed or specific review to determine trends or spot operational problems. Some of the choices offered (such as water loss by pressure zones) were included to see if this method was used by large utilities. More than one response could be marked.

Question 9 of this Section asked in more general terms how the results were reviewed, either compared to past results or general benchmarks, or not reviewed at all.

Question 10 was included to determine to what degree, under his or her own circumstances, the degree of confidence the respondent felt in their current method of calculating water loss by asking if it "fairly and accurately" reflected the amount of water loss. This was a subjective question, but in comparison with other findings could indicate the additional need for information and education in the procedures.

Question 11 asked for the background and training which the respondents have relied on for developing their water loss and water use information. More than one selection could be made from a list of generally known organizations that offer training and publications to the water utility industry in Texas. Those that selected "Other" were given a blank space to supply a response. These responses will help in targeting and disseminating additional training resources and information in the future.

With no detailed preliminary explanation or parameters purposely supplied, Question 12 asked each person responding to describe in their own words the procedures they used to calculate or determine water loss and water use. The written responses will provide good insight and background.

Question 13 concluded this Section on the Water Loss Accounting by requesting a copy of the actual water loss worksheets or documents used for calculation of water use. The option was also given for submittal of electronic versions. The individual worksheets were reviewed and good examples selected for additional review. This question somewhat redundant to a question in Section III that also asked for specific water use data to be submitted, and in most cases the worksheet report included was the same.

Section III Water Loss Minimization Efforts

While the previous sections of the survey looked at the various degrees of accounting practices for water use within the systems, Section III focused on the current practices for controlling and addressing water loss both from leaks and under registering customer meters.

Leak control is considered a significant method to reduce unaccounted for water within a water distribution system. The first six questions of this section were written to determine the degree of importance and emphasis given to leak detection as well as leak management practices.

The first question requested information on the use of Leak Detection and Repair Program. Three options were offered, (1) checking for visible leaks, (2) simply fixing leaks when reported, or (3) a proactive program of looking for leaks. An additional "Other" option was offered and several respondents filled in the blank.

The second question concerned the use of Leak Detection equipment. It is important to know to what degree utilities use leak detection equipment or services and

what types are most preferred. More than one use could be marked from the list of choices which included most common types and sources of leak detection equipment and services. There was a choice for "Other" and several for respondents to expanded on their leak detection techniques.

Question 3 continued with leak detection equipment use by asking more specifically how the equipment is used. The answers for this question included choices to determine whether the equipment was used more for proactive leak detection (surveys) or reactive leak detection (pinpointing known leaks).

Leaks on customer service lines and at connections to the distribution mains are known to be areas where significant volumes of water can be lost due to leaks. For most utilities in Texas, when the meter is set in the street right of way, the meter delineates the point at which utility repair responsibilities end. However in some other countries, utilities offer repairs on the customer's service line. So Question 4 asked if the utility had any specific programs or procedures for fixing leaks on the customer's service line. The follow up, Question 5, asked those that did to fill in the blank with specific procedures that were in place.

Question 6 specifically asked the respondents to check other water loss control measures that may be currently implemented in their ongoing operations. The first four items on the list are known good management practices, and an "Other not listed" option with a fill in the blank was offered.

Question 7 asked whether periodic meter calibrations and testing at the water production facilities are done, and whether the utilities have in place periodic customer meter replacements. Additional metering questions were included in Section IV, on historical water management practices.

Whether an organized leak repair log is kept is the focus of Question 8 which asked the respondent to select those items that were included in the log. .

The age and materials of water distribution systems can affect the number and frequency of water leaks. The next three questions addressed the physical make-up of the distribution systems. Respondents were first asked to give the total lengths of pipe by typical different sizes in Question 9. Then in Question 10, the approximate percentage of the system composed of different pipe material was requested. And, in Question 11, the approximate age distribution by 10 year increments was asked for. This information is useful to determine if leakage and water loss can be correlated based on pipe type and age.

An area where significant water savings can be realized is in reducing or minimizing the time it takes to respond to and repair leaks. The next two questions, 12 and 13, asked for the average time to fix large leaks and small leaks. A related Question 14 and the final one of this section asked how many full time leak crews were dedicated to locating and repairing leaks.

Section IV Historical Water Management

This section of the survey was developed to gather more information about the individual utilities' historical water use and the service profile of the system. The primary intent of this was to compare and determine the degree to which factors such as meter replacement and pressure zone management are addressed by the.utilities.

Questions 1 through 5 asked for information related to the customer meters. The total current number of active meters by meter size was asked for in Question 1. Beyond just the normal number of metered connections, this question offered a selection for utilities to indicate if the number of separate irrigation meters, and later, a separate Question 5 asked if the utility metered private fire lines.

Question 2 asked if within those totals for No. 1, were there master metered submetered accounts, wholesale accounts, or very large accounts such as institutional or industrial service. In evaluating usage per capita or usage per connection, it is important to know if some meters are actually serving significant large volume users or large population segments.

More accurate measurement of water can be obtained through regular meter replacement programs. Question 3 asked for the meter replacement policy criteria such as age of meters or volume of water passed. And Question 4 asked for the average age of meters within a range of years.

Question 6 asked for the number of distinct pressure zones and Question 7 followed up by asking if the separate pressure zones were separately metered. Questions 8 asked specifically for the pressure ranges in the zones.

Fill in the blanks were given in Question 9, which asked the utilities to provide basic water production and usage information for calendar year 2003 or a more recent twelve month period. At the end of this question the instructions offered the option to provide the information requested in an already compiled worksheet or report. It should be noted that Question 13 of Section II asked for a typical worksheet to be attached as well, and although not stated, submittal of actual in use documents was preferred. As mentioned earlier, this was a redundant question from Section 2.

Section V Additional Information

The formal survey concluded with Section IV, but Section V gave the opportunity for respondents to submit and additional comments or questions related to any part of the survey or in general about the water loss accounting and related programs.

Analysis of Data

Results and Data Review

The results and analyses of the survey response data are summarized in this section. In addition to the charts and tables below, additional tables summarizing the results of the survey data are included in Appendix 1.

Each of the tables shows the overall results distribution of responses expressed as a percentage to particular survey questions including the proportion of respondents who responded positively to a particular question. The tables are based upon either the population served or the type of utility. There are corresponding tables showing the same results separated by the other parameter (population served or type) located in the Appendix. A number of questions are discussed below and both tables are included in the Appendix.

1. Reported Water Loss

In response to the very first question of Section II, "What is your system's water loss?", almost 90% of all respondents reported their water losses (Table 2), with 9.3% responding that they did not calculate water losses. The bulk of those respondents were from federal-, state-, or county-owned water systems, which do not meter end users. The largest group of respondents at 46.4% fell in the two ranges of 5% to 15% water loss inclusive. The overall distribution was slightly skewed with 8% reporting more than 25% water loss, and 24.3% reporting water loss between 15% and 25%. Only 10.3% of respondents reported that they had water loss below 5%. When compared by size, significant differences were found between the smallest utilities reporting (population 500-3,300) and the mid-range utilities (population 10,001-50,000), with 17.6% of the smallest utilities reporting between 10% and 15% versus 39% of the mid-range utilities reporting that water loss (Table A-1).

One-half of respondents with a population of 50,001 or greater reported water loss in the 5% to 10% range. This differed significantly from those with a population of 50,000 or below, which ranged from 19.5% to 21.8% reporting loss in the 5% to 10% range. The only population group with a significantly higher response rate in the 10% to 15% loss range was that with a population of 10,001 to 50,000, which reported 39%, as compared to the overall reporting of 22.7% in the range.

When examined by type, one of eight of the federal-, state-, and county-owned systems reported water loss between 10% and 15%. The remaining seven responded that they do not calculate water loss. This is unsurprising since these systems typically do not meter end users. Nine of 13 investor-owned utilities reported water loss rates below 15%. Water districts had the largest proportion of responses, with water losses

below 15%. More than 83% of the water districts reported less than 15% water loss. Of all types, in only water districts and investor-owned utilities all respondents reported that they did calculate water loss rates as a part of doing business.

Table 2

What is the system's water loss as a percentage of total water entering the system?						
Type:	Municipality	Water District	Water Supply Corporation	Investor Owned Utility	Federal, State, or County	**TOTAL**
x > 25%	7.6%	2.4%	12.5%	7.7%	0.0%	8.0%
25% > x > 20%	8.9%	4.8%	12.5%	7.7%	0.0%	9.0%
20% > x > 15%	15.9%	9.5%	20.0%	7.7%	0.0%	15.3%
15% > x > 10%	23.6%	19.0%	23.8%	23.1%	12.5%	22.7%
10% > x > 5%	21.7%	47.6%	17.5%	23.1%	0.0%	23.7%
x < 5%	8.3%	16.7%	8.8%	30.8%	0.0%	10.3%
Don't calculate	11.5%	0.0%	3.8%	0.0%	87.5%	9.3%
Non-respondents	2.5%	0.0%	1.3%	0.0%	0.0%	1.7%
N	157	42	80	13	8	300

2. Questions Relating to Performing Water Audits

Almost three of four respondents (74.7%) perform a water audit or otherwise calculate water loss or perform a water use accountability analysis. Just less than 10% (8.7%) responded that the analysis was performed less often than annually. The remainder responded that they do not perform such processes, or did not reply. There were no significant differences in response rates based upon size of utility.

The only type of utility that responded negatively (seven of eight) to the question of performing a water loss audit or accountability analysis was the federal, state, and county group (Table A-3). This is probably only indicative of the lack of meters on end users for these systems. The remaining types of utilities responded from a low of 68.2% for municipalities to a high of 92.9% for water districts that perform audits or otherwise calculate water loss on an annual basis.

Table 3 shows the responses by utility size to the method for calculating water loss amounts. The most prevalent (37.7%) method of calculating water loss percentages is based upon “the difference between the total amount of water supplied to the system and the total water sold”. Approximately the same amount number of respondents (37.0%) included some other method of adjusting for unmetered water

uses in the water loss calculation. Only 15% of all respondents indicated that they identify all other uses in addition to all metered water in a detailed water audit procedure. The remaining respondents indicated they were not sure, or did not reply to this question.

Table 3

Which best describes the typical water audit or water loss calculation or analysis procedure?						
Population:	500-3,300	3,301-10,000	10,001-50,000	50,001-100,000	100,000+	TOTAL
The difference between total water sales at the customer meters and the total water supplied to the system	45.1%	35.9%	24.4%	14.3%	28.6%	37.7%
The difference between total water sales plus some other metered or unmetered water uses and the total water supplied to the system	32.7%	33.3%	43.9%	64.3%	57.1%	37.0%
A detailed water use audit that includes all metered water uses and all other identified water uses	9.2%	17.9%	29.3%	21.4%	14.3%	15.0%
Do not know exactly what is in the water loss calculation	7.8%	7.7%	0.0%	0.0%	0.0%	6.0%
Non-respondents	5.2%	5.1%	2.4%	0.0%	0.0%	4.3%
N	153	78	41	14	14	300

When examined by type, 84.6% of investor-owned utilities reported that they calculated water loss using the simple difference between sales and total water supply (Table A-8). This compares to municipalities, water districts and water supply corporations reporting between 35.7% and 38.8% using this simple method. All of the federal-, state-, and county-owned utilities reported either not knowing (75%) or not responding (25%) to this question.

The sample respondents split almost evenly between those who use special forms or worksheets (34.8% overall) and those who report water losses as part of their annual report (37.7%). The remaining respondents (23%) indicated they did not use a specific method for reporting water losses. The largest utilities (population greater than 100,000) indicated a significantly higher portion of utilities (64.3%), which use a special form or worksheet to calculate water losses (Table A-4). Only the federal-, state-, and

county-owned utilities diverged from the overall pattern of responses with 62.5% indicating they used no form versus 25% indicating the use of a form or including it in an annual report (Table A-5).

The vast majority of respondents of all sizes and types indicated they would use a standardized water audit worksheet if provided. The total positive response was 73.3%, with 78.3% of municipalities (Tables A-6 and A-7) as the highest response rate, and 50% of federal-, state-, and county-owned systems indicating they would use such a worksheet.

3. Details of Current Water Audits and Water Loss Calculations

Table 4 shows the responses to the question that asked what identified water uses other than metered sales were included in the existing audit. The most likely type of water use to be included was routine line flushing, which was included by 77.7% of the respondents. The next most likely type of unmetered water to be considered was estimated water lost to leaks (64.0%), and a similar number of respondents (61.7%) also account for water used by the fire department in either fire fighting or fire hydrant testing. Three alternatives received a similar proportion of positive response. Just more than a third of overall respondents indicated that they include either bulk sales, including construction; municipal uses, such as parks, median watering, street cleaning or sewer; and/or in plant uses, storage tank overflows, or plant backwash in their calculations. However, there was a significant difference by size in the response to two of these three options. More than half of mid- to larger-sized utilities responded positively to including bulk sales and municipal uses in their water loss calculations. The difference in response to the inclusion of bulk sales between the utilities with populations between 500 and 3,300 at 23.5% and the utilities with populations from 3,301 to 10,000, at 37.2% was also statistically significant. This may be due to the relative infrequency of bulk sales in the smallest utilities. Utilities serving population in the range of 10,001 to 100,000 populations also showed a significantly higher accounting for in plant uses that the smallest utilities (53.7% and 57.1% versus 30.0%). But the utilities with populations in the range of 3,301 to 10,000 and those with greater than 100,000 were not significantly different.

The apparent difference between the responses to the question of the best description of a typical water audit or water loss calculation, and the responses summarized in Table 4 to specific water uses or losses accounted for by respondents, may be that current methodology in presenting “Water Loss” includes some unmetered water that can be accounted for, but no standard method for accounting for such uses.

Table 4

Identified water use other than metered sales to customers included in current water use analysis						
Population:	500-3,300	3,301-10,000	10,001-50,000	50,001-100,000	100,000+	TOTAL
Fire department, including either fire fighting or hydrant testing	59.5%	65.4%	63.4%	57.1%	64.3%	61.7%
Leaks, estimate of water lost during the leak	64.7%	65.4%	68.3%	42.9%	57.1%	64.0%
Routine line flushing	77.8%	79.5%	78.0%	71.4%	71.4%	77.7%
Bulk water sales, including construction	23.5%	37.2%	56.1%	64.3%	57.1%	35.0%
Municipal uses, such as parks, street medians, sewer or street cleaning	20.3%	32.1%	56.1%	85.7%	71.4%	33.7%
In plant uses, storage tank overflows or filter backwash	30.0%	38.5%	53.7%	57.1%	42.9%	37.3%
Other water uses	6.5%	10.3%	7.3%	14.3%	7.1%	8.0%
None of the above	13.7%	11.5%	12.2%	0.0%	21.4%	12.7%
Non-respondents	3.3%	1.3%	0.0%	0.0%	7.1%	1.0%
N	153	78	41	14	14	300

When examined by type (Table A-9), investor-owned (23.1%) and Federal-, state- or county-owned utilities (25%) were significantly lower in including fire-fighting water use than the overall sample (61.7%). They also were significantly lower in including bulk water sales (0% each versus 35.0% overall). Water districts, water supply corporations and investor owned utilities reported significantly lower levels of accounting (0% to 9.5%) for municipal uses including street medians, parks and/or street cleaning than municipalities (58%). Investor-owned utilities reported the lowest accounting for in-plant uses (7.7%) while all other types reported between 37.5% and 39.5% that they identified in-plant uses, including storage tank overflows or filter backwash in water loss accounting.

Most of the respondents who answered none-of-the-above to the previous question were small (21 of 37) or municipal utilities (22 of 37). Similar numbers

reported they do not have any significant water uses other than metered sales or are only able to calculate billed water sales (16 of 37). The next highest portion (10 of 37) reported that they did not have time to calculate water losses (3.3% of the total sample). Only seven (2.3% of the total sample) reported that they did not know how to calculate water losses (Tables A-10 and A-11).

Almost 70% of respondents indicate that they only audit the system as a whole (Table A-12). Water use or loss by class of customer is considered by 10.7% of respondents; individual pressure zones are evaluated by 9%; and 6.7% look at seasonal water loss patterns. The remaining categories were less than 5% of respondents and are summarized in Table A-12. Two thirds of respondents (67.4%) compare their audit results to past results to determine if they are better or worse; while 38.3% also compare them to benchmarks (Table A-13).

In response to the last question of the section on water loss accounting, approximately 69.3% of all respondents felt that their current method of calculating water loss fairly and accurately represents the amount of "water loss" in their system (Tables A-14 and A-15). Those who responded otherwise split about evenly between those who indicated that their current method does not accurately reflect "water loss" (12.7%) and those who did not know (14%). Again, by type, the federal-, state-, and county-owned systems responded with a majority of "don't know."

4. Leak Detection and Response

Table 5 includes responses to questions regarding the type and availability of leak detection equipment, training and general familiarity with leak detection methods. Overall, more than half of the respondents indicated that they have not performed leak detection with specialized equipment. The response data appears to separate by size of population served, with six of 10 utilities serving populations of 10,000 or less indicating that they have not used leak detection equipment. Utilities with populations of 10,001 or higher were significantly more likely to have performed leak detection activities with less than 30% responding that they had not performed leak detection. Less than 15% of large utilities (population greater than 100,000) indicated that they had not done leak detection. A little more than one of five respondents owns leak detection equipment and uses it as needed. Again, population served is significant here with an increasing rate of utilities that own their leak detection equipment as size of population served increases. This peaks with the 64.3% of the largest utilities owning their equipment. Of those utilities that contract with professional leak detection firms to do their leak detection, those serving populations in the range of 10,001 to 100,000 are significantly higher than the smallest utilities (17.1% and 35.7% versus 5.9%). Overall, 10.0% of the respondents contract with professional firms to do their leak detection.

Table 5

Please check all that apply to your use of leak detection equipment:						
Population:	500-3,300	3,301-10,000	10,001-50,000	50,001-100,000	100,000+	TOTAL
We own our own leak detection equipment and use it as needed.	10.5%	19.2%	41.5%	35.7%	64.3%	20.7%
We rent or borrow leak detection equipment from TWDB or other sources and use it ourselves.	9.2%	3.8%	9.8%	0.0%	7.1%	7.3%
We contract with a professional leak detection firm to do leak detection on our system using specialized equipment.	5.9%	9.0%	17.1%	35.7%	14.3%	10.0%
The TWDB (or other agency) came out and trained us to use leak detection equipment to survey our system.	3.3%	3.8%	2.4%	7.1%	7.1%	3.7%
We use the free leak detection available from the TWDB.	5.9%	6.4%	4.9%	0.0%	0.0%	5.3%
We do some flow tests, but no mechanical or electronic equipment is used.	8.5%	6.4%	12.2%	7.1%	14.3%	8.7%
We have not performed any specialized leak detection with equipment or flow testing to identify leaks.	62.7%	57.7%	29.3%	28.6%	14.3%	53.0%
Other	6.5%	1.3%	4.9%	0.0%	7.1%	4.7%
Non-respondents	7.2%	9.0%	12.2%	0.0%	0.0%	8.0%
N	153	78	41	14	14	300

When looked at by type of utility (Table A-16) investor-owned utilities varied significantly from other types when it comes to ownership of leak detection equipment (0% versus 20.7% of total sample). The majority (62.5%) of federal-, state- or county-owned utilities have not performed any specialized leak detection with equipment or flow testing to determine leaks. The remaining utility types did not vary significantly for any of the leak detection options reported above and in Table A-16.

Nine percent of respondents indicated that they fix leaks on the customer side of the meter, while ninety percent indicated the do not (Table A-17). Tables A-19 and A-20 show the level of detail in which utilities organize their leak detection results. Only the largest utilities significantly and consistently exceed the overall average response in the following categories: pin or mark areas to visually indicate problems (64.3% vs. 14.7%); classify leaks based upon size and location (64.3% vs. 22.0%); cataloging the nature and cause of leak (64.3% vs. 27.0%); recording pipe material and replacement parts (78.6% vs. 34.7%) as compared to those which don't have a leak log or keep specific repair records (14.3% vs. 37.7%). When examined by type, only the federal-, state- or county-owned utilities varied significantly in their record keeping with none keeping visual records or estimates of water loss during repairs compared with 14.7% and 32.7% of overall respondents respectively.

5. Metering

Table 6 shows the proportion of respondents that perform regular meter calibration and testing, and periodic customer meter replacement separated by size of utility. Just more than half of all utilities perform regular meter calibration and testing at treatment facilities. The larger utilities were more likely to have a regular meter calibration program. Utilities serving populations of 10,001 or more were much more likely to have a meter calibration program with more than 75% of all such utilities reporting a program. Periodic customer meter replacement program had a higher percentage of response, with 75% of all utilities replacing meters. Only the very largest utilities (population greater than 100,000) had a significantly higher rate of meter replacement, with 100% indicating they performed regular customer meter replacement.

Table A-18 shows the same data separated by type of utility. Federal-, state- or county- utilities were the only category of utility that had a significantly different response based upon type. Most of them (62%) did not respond to this question, and only one indicated they do regular meter calibration, while two indicated they periodically replace meters.

Table 6

With regard to meters at the plants and within the system, do you currently have:						
Population:	500-3,300	3,301-10,000	10,001-50,000	50,001-100,000	100,000+	TOTAL
Regular meter calibration and testing at the treatment facilities (including well meters if a groundwater user)	46.4%	55.1%	75.6%	85.7%	85.7%	56.3%
Periodic customer meter replacement programs	68.0%	78.2%	80.5%	71.4%	100.0%	74.3%
Non-respondents	11.8%	7.7%	4.9%	0.0%	0.0%	10.7%
N	153	78	41	14	14	300

Review of Specific Utility Worksheets

Prior to implementation of the new reporting requirements in 2005, there have been no required water use forms for Texas utilities that focus specifically on water use accounting other than the annual Water Use Surveys of the TWDB. And, there are no generally circulated standardized forms other than perhaps those found in training literature or the AWWA Manuals. Two separate questions in the 2004 Municipal Water Loss Survey asked respondents to submit documents or worksheets specific to their own operations. One question asked for a copy of the typical water use calculation worksheets, and the other question offered the respondents the option of including their typical spreadsheet that contained the water use information for the calendar year of 2003 or a recent twelve month period.

A total of 131 different utilities sent in items as an attachment to their returned survey. Sixteen of those sent spreadsheets electronically when responding to the survey on-line. It also should be noted that several of the very large municipal systems in Texas noted that they did perform water audits, but did not submit complete audit documents. These forms and documents provided an informal insight to the practices utilities utilize, different from that possible through the structured questions of the survey. The actual, in-use forms and worksheets and work papers included a variety of water use accounting styles, assumptions, and showed that different degrees of importance are placed on certain aspects of water accounting.

Even though several utilities answered the question that they performed a water audit, most submitted annual summary worksheets or monthly water use reports. The different water use worksheets could be separated into general categories:

- Summary documents that showed water pumped and water sales and the subsequent computation of water loss percentage. Several systems just submitted a copy of their completed TWDB Water Use Survey form or TCEQ Monthly Operating Report form.
- Summary document with water pumped and sold and with some additional adjustments for unmetered water. The majority of the worksheets sent in were in this category.
- Detailed or specialized worksheets. Several good worksheets that could be classified as water audits were sent in, and many came with secondary worksheets that showed backup calculations for the leak, flushing, or other unmetered use volumes recorded.

Overall, the review of these 136 hard copy worksheets reinforced the need for standardized definitions and methodology for computing water loss. Across the board, for both the larger utilities and smaller ones, there was a lack of consistency in the adjustments made in the water use computations. Selected examples of good practices and procedures are attached in the Appendix.

One important finding is that a significant number of the smaller systems, including almost all of the water supply corporations and many smaller municipalities utilize the standard report form or summary from billing software programs which automatically computes the water loss percentage from billing data. While most of these standard report forms had a computation based on monthly water sales and water amounts pumped, only some had a line for input of fire and flushing adjustments.

Another observation from this review of the actual water accounting documents is that there is a wide variety of methods used to report and quantify the various adjustments to account for non-customer usage. The most common are line flushing, fire department use, water lost during leaks, and other uses. Most utilities did recognize the need to make adjustments and some were quite careful or resourceful in accurate figures while others used very basic estimates.

1. Line flushing: This category of other water use was included more than any other. Many worksheets called this "hydrant flushing" or combined it with "fire flushing." Many worksheets had a line for "estimated" flushing uses and appeared to put in the same amount each month, or use a percentage of total production. Several respondents attached the calculation page where they actually tabulated flushing uses on an individual basis using a volume per minute or similar method.

2. Fire department use: Another known significant use of non-metered water comes from either hydrant exercising and training by the fire department or from actual use in fighting fires. Many utilities had a separate sheet for the fire department to report water use each month, while others estimated the fire department's use.

3. Water lost due to leaks: As discussed earlier, water lost through leaks represents the largest volume of unaccounted for water. Increasing emphasis will be put in quantifying the amount of leakage and improving leak detection and leak repair procedures. Very few worksheets had any kind of line adjustment or accounting for water lost due to leaks. Those few that did made estimates based on standard charts of water flow for certain size leak holes, or used a standard estimate of water lost per mile of distribution line. One medium sized city simply estimated "water lost due to leaks" each month as a percentage of the total amount pumped.

4. Other common non-customer, authorized water uses: In addition to the above, many utility accounting worksheets had additional itemized water uses that were considered important and specifically included in their worksheets. The AWWA M36 Manual also recommends that these be included:

- Process water or other water used internally at the water treatment plants and wastewater treatment plants
- Water used at city buildings, parks, road medians, etc. Some used metered amounts and others used estimates.
- New construction within the system
- Sewer cleaning

- Street cleaning
- Wash trucks
- Construction meters
- Theft

5. Adjustments to water production amounts: There are also recommended adjustments to the reported amounts of water supplied to the system that can make a big difference in accuracy of the calculations. Very few of the worksheets submitted had adjustments to the water production amounts supplied to the system, but those that did included:

- Storage tank drainage or overflows
- Changes in tank or reservoir levels
- Corrections for meter reading lag time
- Adjustment for meter accuracy.

There were other accounting or water use adjustment practices within the sample of worksheets that deserve mention. Only one utility actually computed the cost per 1000 gallons of water to produce and then computed the value of lost water as part of its regular analysis. One or two utilities had places on their worksheets for adjustments to the meter reading for meter error. One utility had a correction factor for under reading customer meters, but did not appear to be applying it.

Appendix 3 contains samples from the various worksheets and data summaries submitted in response to the survey.

Although not included in the examples Appendix, there are also some fairly detailed and extensive water accounting procedures being implemented by some of the very largest municipal utilities in the State. Fort Worth first performed a full water use accountability audit that embraces the measures of the IWA method for 2001 data. San Antonio Water System has had very good accounting practices in place, and recently has begun to move toward use of IWA concepts. The City of Austin does have an extensive water accounting electronic spreadsheet which among other things, balances the system supply reservoirs and meter reading cycles for more accurate analysis of water loss figures..

Conclusions and Recommendations

It became a challenge to come up with conclusions from a survey such as this one which covered several different areas of both water use accounting and practices for water loss management. The survey covered a large target sample that ranged from small utilities to the largest in the state. However, if there can be one general conclusion, it is that the Texas municipal utility industry has not placed the significance or importance on water use accounting that will be expected from it in the future.

Overall, the survey supported the same findings as the recent national Survey of State Agency Water Loss Reporting Practices that there are no consistent standards for defining, computing or reporting water use and water loss. Additionally, the survey verified that there should be more emphasis and awareness on the water loss control measures such as leak detection and response, meter testing and replacement, and asset management.

One purpose of the survey was to determine if there were significant differences between sizes of utilities in their water loss calculation practices. Utilities of all sizes will soon be required by law to file a water audit. In setting the guidelines there is flexibility for different requirements for water audits for different sizes of utilities.

Generally, as expected, the larger utilities (50,000 or greater) did show more detail and sophistication in what they included as part of their water accounting (see Tables 3 and 4). However, there is still a fairly large portion of that group that indicated they used the simple water sales to water produced ratio as the basis of determining water loss. Analysis of the response data, the responses to the open ended question of "how do you compute water loss?" (see Appendix 4), and the hard copy worksheets, showed that many large utilities will need to make a significant changes and upgrades in their procedures to shift toward a more structured approach to water loss accounting. In reality, most utilities of all sizes will have to refocus their priorities to this area.

Recommendation: There must be uniform standards of terminology, computing, interpreting, reporting, and analyzing any data done through a water audit.

A primary method to disseminate and ensure that there is widespread acceptance of the standardized procedures should be through education and training that targets water loss accounting and improved loss control. When audit requirements are set, the TWDB should work with the water industry including the Texas Section AWWA, Texas Engineering Extension Service (TEEX), and the Texas Rural Water Association (TRWA) to develop training classes specifically related to this area. This training should include development of consistent approaches and education centered around performing water audits and interpreting the results to improve the water accountability of the utility. It should begin with the basics and include such topics as:

- How to measure water lost through leaks

- Estimating water use in system flushing
- Determining water use in fire flow activities
- Determining other non-metered water uses
- Recognizing and making adjustments to water supply amounts

Education in the practices of water loss control should also be a focus of training. There should be increased emphasis on and training for water utility managers and operators in:

- Regular, on-going leak detection.
- Improved response time for leak repair,
- Cost effective programs for meter testing and replacement.
- Regular and on-going system maintenance and rehabilitation.
- The techniques of pressure management to reduce losses and leaks.
- The techniques of flow analysis to determine problem areas within the system.

Indications are that the AWWA committee in revising the Water Audit Manual M36 will recommend using the IWA or closely related audit methodologies. This method, outlined in more detail earlier in the Background Section, starts with a top down analysis and then is followed by a bottom up approach to address both real and apparent losses discovered in the top down analysis.

INTERNATIONAL STANDARDS FOR WATER AUDIT FORMAT

<table>
<tr><td rowspan="2">Own Sources</td><td rowspan="4">System Input (allow for Known Errors)</td><td>Water Exported</td><td rowspan="2">Authorized Consumption</td><td>Billed Authorized Consumption</td><td rowspan="2">Revenue Water</td><td>Billed Water Exported
Billed Metered Consumption
Billed Unmetered Consumption</td></tr>
<tr><td rowspan="3">Water Supplied</td><td>Unbilled Authorized Consumption</td><td rowspan="3">Non-Revenue Water</td><td>Unbilled Metered Consumption
Unbilled Unmetered Consumption</td></tr>
<tr><td rowspan="2">Water Imported</td><td rowspan="2">Water Losses</td><td>Apparent Losses</td><td>Unauthorized Consumption
Customer Metering Inaccuracies and Data Handlin Error</td></tr>
<tr><td>Real Losses</td><td>Leakage on Mains
Leakage and Overflows at Storage
Leakage on Service Connections up to Point of Customer Metering</td></tr>
</table>

Source: *Performance Indicators for Water Supply Systems, 2000,* IWA Publishing

The procedures for performing a water audit and the various indicator calculations may seem to be complicated and time consuming. And, compared to the current degree of analysis many utilities are doing today they are. It is probably not realistic to expect the smaller sized systems to perform the sophisticated audit

methodologies completely. However, the principles and concepts are good for systems of all sizes and all will improve their water audit methodologies and subsequent water savings by implementing them all or parts of the fundamental procedures.

- Large systems (greater than 100,000) should be encouraged to begin implementation of all IWA/AWWA audit methodologies within one year after the AWWA Water Loss Committee issues the revised M36 Manual. Annual audits. .
- Systems with service populations of 50,000 to 100,000 should adopt a modified approach and at least do top down water audit that addresses both real and apparent losses each year. The every fifth year audit should include a discussion of measures taken to address problems.
- Systems from 10,000 to 50,000 should be required to do a top-down audit each year. The every fifth year audit should include a discussion of measures taken to address problems.
- All smaller systems should be required to keep water use records consistent with a top down format. The every fifth year audit should include a discussion of measures taken to address problems.

APPENDICES

APPENDIX 1: Data Tables

Table A-1

What is the system's water loss as a percentage of total water entering the system?						
Population:	500-3,300	3,301-10,000	10,001-50,000	50,001-100,000	100,000+	TOTAL
x > 25%	8.5%	7.7%	7.3%	7.1%	7.1%	8.0%
25% > x > 20%	11.1%	9.0%	4.9%	7.1%	0.0%	9.0%
20% > x > 15%	15.7%	15.4%	22.0%	7.1%	0.0%	15.3%
15% > x > 10%	17.6%	24.4%	39.0%	7.1%	35.7%	22.7%
10% > x > 5%	20.9%	21.8%	19.5%	50.0%	50.0%	23.7%
x < 5%	11.8%	10.3%	2.4%	21.4%	7.1%	10.3%
Don't calculate	12.4%	10.3%	2.4%	0.0%	0.0%	9.3%
Non-respondents	2.0%	1.3%	2.4%	0.0%	0.0%	1.7%
N	153	78	41	14	14	300

Table A-2

Do you perform a water audit or otherwise calculate or perform water loss or water accountability analyses for your water utility system?						
Population:	500-3,300	3,301-10,000	10,001-50,000	50,001-100,000	100,000+	TOTAL
Yes	69.9%	78.2%	75.6%	92.9%	85.7%	74.7%
No	19.0%	16.7%	7.3%	0.0%	14.3%	15.7%
Sometimes, but not on an annual basis	9.8%	3.8%	17.1%	7.1%	0.0%	8.7%
Non-respondents	1.3%	1.3%	0.0%	0.0%	0.0%	1.0%
N	153	78	41	14	14	300

Table A-3

Do you perform a water audit or otherwise calculate or perform water loss or water accountability analyses for your water utility system?						
Type:	Municipality	Water District	Water Supply Corporation	Investor Owned Utility	Federal, State, or County	TOTAL
Yes	68.2%	92.9%	83.8%	76.9%	12.5%	74.7%
No	15.9%	7.1%	11.3%	23.1%	87.5%	15.7%
Sometimes, but not on an annual basis	14.6%	0.0%	3.8%	0.0%	0.0%	8.7%
Non-respondents	1.3%	0.0%	1.3%	0.0%	0.0%	1.0%
N	157	42	80	13	8	300

Table A-4

Is there a special format or worksheet used to do this?						
Population:	500-3,300	3,301-10,000	10,001-50,000	50,001-100,000	100,000+	TOTAL
Yes	30.0%	35.9%	36.6%	28.6%	64.3%	34.0%
No, but we do it as part of our operating reports	40.5%	38.5%	31.7%	42.9%	14.3%	37.7%
No specific format or worksheet	23.5%	24.4%	22.0%	28.6%	7.1%	23.0%
Non-respondents	5.9%	1.3%	9.8%	0.0%	14.3%	5.3%
N	153	78	41	14	14	300

Table A-5

Is there a special format or worksheet used to do this?						
Type:	Municipality	Water District	Water Supply Corporation	Investor Owned Utility	Federal, State, or County	TOTAL
Yes	31.8%	40.5%	38.8%	23.1%	12.5%	34.0%
No, but we do it as part of our operating reports	31.2%	47.6%	45.0%	53.8%	12.5%	37.7%
No specific format or worksheet	29.3%	9.5%	13.8%	23.1%	62.5%	23.0%
Non-respondents	7.6%	2.4%	2.5%	0.0%	12.5%	5.3%
N	157	42	80	13	8	300

Table A-6

Would you use a standardized water audit worksheet if provided one?						
Type:	Municipality	Water District	Water Supply Corporation	Investor Owned Utility	Federal, State, or County	TOTAL
Yes	78.3%	66.7%	72.5%	53.8%	50.0%	73.3%
No	17.8%	23.8%	18.8%	46.2%	50.0%	21.0%
Non-respondents	3.8%	9.5%	6.3%	0.0%	0.0%	5.0%
N	157	42	80	13	8	300

Table A-7

Would you use a standardized water audit worksheet if provided one?						
Population:	500-3,300	3,301-10,000	10,001-50,000	50,001-100,000	100,000+	TOTAL
Yes	68.6%	74.4%	85.4%	92.9%	64.3%	73.3%
No	24.2%	20.5%	9.8%	7.1%	35.7%	21.0%
Non-respondents	5.9%	5.1%	4.9%	0.0%	0.0%	5.0%
N	153	78	41	14	14	300

Table A-8

Which best describes the typical water audit or water loss calculation or analysis procedure?						
Type:	Municipality	Water District	Water Supply Corporation	Investor Owned Utility	Federal, State, or County	TOTAL
The difference between total water sales at the customer meters and the total water supplied to the system is the water loss.	35.7%	35.7%	38.8%	84.6%	0.0%	37.7%
The water loss is the difference between total water sales plus some other metered or unmetered water uses and the total water supplied to the system.	39.5%	42.9%	37.5%	7.7%	0.0%	37.0%
Water loss is based on a detailed water use audit that includes all metered water uses and all other identified water uses.	14.0%	21.4%	17.5%	0.0%	0.0%	15.0%
Do not know exactly what is in the water loss calculation.	5.7%	0.0%	2.5%	7.7%	75.0%	6.0%
Non-respondents	5.1%	0.0%	3.8%	0.0%	25.0%	
N	157	42	80	13	8	300

Table A-9

Identified water use other than metered sales to customers included in current water use analysis						
Type:	Municipality	Water District	Water Supply Corporation	Investor Owned Utility	Federal, State, or County	TOTAL
Fire department, including either fire fighting or hydrant testing	66.9%	57.1%	63.8%	23.1%	25.0%	61.7%
Leaks, estimate of water lost during the leak	60.5%	57.1%	75.0%	53.8%	62.5%	64.0%
Routine line flushing	72.0%	83.3%	90.0%	61.5%	62.5%	77.7%
Bulk water sales, including construction	45.9%	23.8%	27.5%	0.0%	0.0%	35.0%
Municipal uses, such as parks, street medians, sewer or street cleaning	58.6%	9.5%	3.8%	0.0%	25.0%	33.7%
In plant uses, storage tank overflows or filter backwash	39.5%	38.1%	37.5%	7.7%	37.5%	37.3%
Other water uses (fill in the blank)	7.0%	14.3%	6.3%	7.7%	12.5%	8.0%
None of the above	14.0%	9.5%	7.5%	30.8%	25.0%	12.7%
Non-respondents	3.2%	0.0%	0.0%	0.0%	12.5%	1.0%
N	157	42	80	13	8	300

Table A-10

If answered "none of the above" for the last question, what are the reasons for not including additional water uses in the analysis?						
Population:	500-3,300	3,301-10,000	10,001-50,000	50,001-100,000	100,000+	TOTAL
Do not have the time or resources available to collect additional uses	6	0	3	0	1	10
Do not have any significant water uses other than metered sales	7	5	2	0	2	16
Billing program only accounts for all metered water uses	7	5	2	0	2	16
Do not know how to accurately estimate other water uses	5	1	0	0	1	7
Non-respondents	1	1	0	0	0	2
TOTAL	21	8	5	0	3	37

Table A-11

If answered "none of the above" for s2q6, what are the reasons for not including additional water uses in the analysis?						
Type:	Municipality	Water District	Water Supply Corporation	Investor Owned Utility	Federal, State, or County	TOTAL
Do not have the time or resources available to collect additional uses	7	1	0	2	0	10
Do not have any significant water uses other than metered sales	8	3	4	1	0	16
Billing program only accounts for all metered water uses	12	2	2	0	0	16
Do not know how to accurately estimate other water uses	5	0	0	1	1	7
Non-respondents	1	0	0	0	1	2
TOTAL	22	4	5	4	2	37

Table A-12

Please check any of the following that you calculate in your current water audit or water use analysis procedures:		
	Percent	Number
Water use and water loss broken out by individual pressure zones	9.0%	27
Water use and water loss by different classes of customers (i.e. residential, commercial, industrial, or other)	10.7%	32
Water use or water loss by different geographical zones or areas	5.0%	15
Water use or water loss by night flows	0.03%	1
Water use or water loss by seasonal periods	6.7%	20
Water loss on a per unit (per foot, mile, etc.) of distribution system	1.7%	5
Only the system as a whole	69.3%	208
None of the above	8.3%	25
Non-respondents	3.3%	10

Table A-13

How do you use the results of the system water use calculations or analysis?		
	Percent	Number
Compare to past results to see if they are better or worse than in past periods	67.4%	202
Compare the results to general benchmarks for % water loss	38.3%	115
Just enter them into the records	11.0%	33
None of the above	6.6%	20
Non-respondents	4.0%	12

Table A-14

Do you think your current method of calculating water loss fairly and accurately reflects the amount of "water loss" in the system?						
Population:	500-3,300	3,301-10,000	10,001-50,000	50,001-100,000	100,000+	TOTAL
Yes	63.4%	74.4%	80.5%	57.1%	85.7%	69.3%
No	11.8%	11.5%	12.2%	35.7%	7.1%	12.7%
Do not know	19.0%	10.3%	7.3%	7.1%	7.1%	14.0%
Non-respondents	5.9%	3.8%	0.0%	0.0%	0.0%	4.0%
N	153	78	41	14	14	300

Table A-15

Do you think your current method of calculating water loss fairly and accurately reflects the amount of "water loss" in the system?						
Type:	Municipality	Water District	Water Supply Corporation	Investor Owned Utility	Federal, State, or County	TOTAL
Yes	66.9%	83.3%	73.8%	69.2%	0.0%	69.3%
No	14.6%	11.9%	11.3%	0.0%	12.5%	12.7%
Do not know	14.0%	4.8%	10.0%	30.8%	75.0%	14.0%
Non-respondents	4.5%	0.0%	5.0%	0.0%	12.5%	4.0%
N	157	42	80	13	8	300

Table A-16

Please check all that apply to your use of leak detection equipment:						
Type:	Municipality	Water District	Water Supply Corporation	Investor Owned Utility	Federal, State, or County	TOTAL
We own our own leak detection equipment and use it as needed.	27.4%	21.4%	11.3%	0.0%	12.5%	20.7%
We rent or borrow leak detection equipment from TWDB or other sources and use it ourselves.	7.6%	7.1%	6.3%	15.4%	0.0%	7.3%
We contract with a professional leak detection firm to do leak detection on our system using specialized equipment.	14.0%	9.5%	5.0%	0.0%	0.0%	10.0%
The TWDB (or other agency) came out and trained us to use leak detection equipment to survey our system.	3.2%	4.8%	3.8%	7.7%	0.0%	3.7%
We use the free leak detection available from the TWDB.	1.9%	7.1%	11.3%	7.7%	0.0%	5.3%
We do some flow tests, but no mechanical or electronic equipment is used.	7.6%	9.5%	10.0%	15.4%	0.0%	8.7%
We have not performed any specialized leak detection with equipment or flow testing to identify leaks.	50.3%	47.6%	58.8%	61.5%	62.5%	53.0%
Other (fill in the blank)	3.2%	0.0%	7.5%	7.7%	25.0%	4.7%
Non-respondents	7.0%	11.9%	8.8%	0.0%	12.5%	8.0%
N	157	42	80	13	8	300

Table A-17

Does the utility have any specific programs or procedures to fix leaks on the customer service lines?		
	Percent	Number
Yes	9.0%	27
No	90.0%	270
Non-respondents	1.0%	3
N	100.0%	300

Table A-18

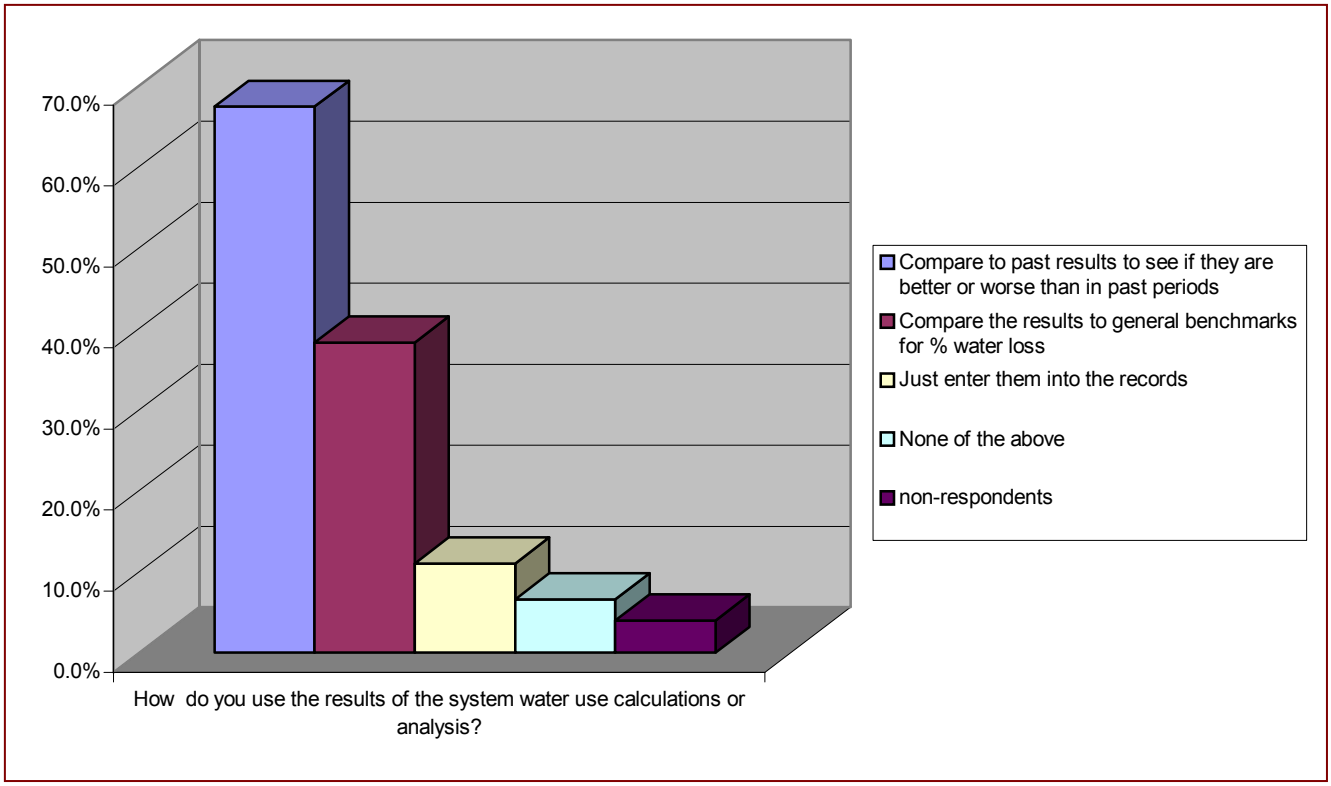
With regard to meters at the plants and within the system, do you currently have:						
Type:	Municipality	Water District	Water Supply Corporation	Investor Owned Utility	Federal, State, or County	TOTAL
Regular meter calibration and testing at the treatment facilities (including well meters if a groundwater user)	62.4%	69.0%	46.3%	30.8%	12.5%	56.3%
Periodic customer meter replacement programs	75.2%	78.6%	73.8%	76.9%	25.0%	74.3%
Non-respondents	7.0%	4.8%	15.0%	15.4%	62.5%	10.7%
N	157	42	80	13	8	300

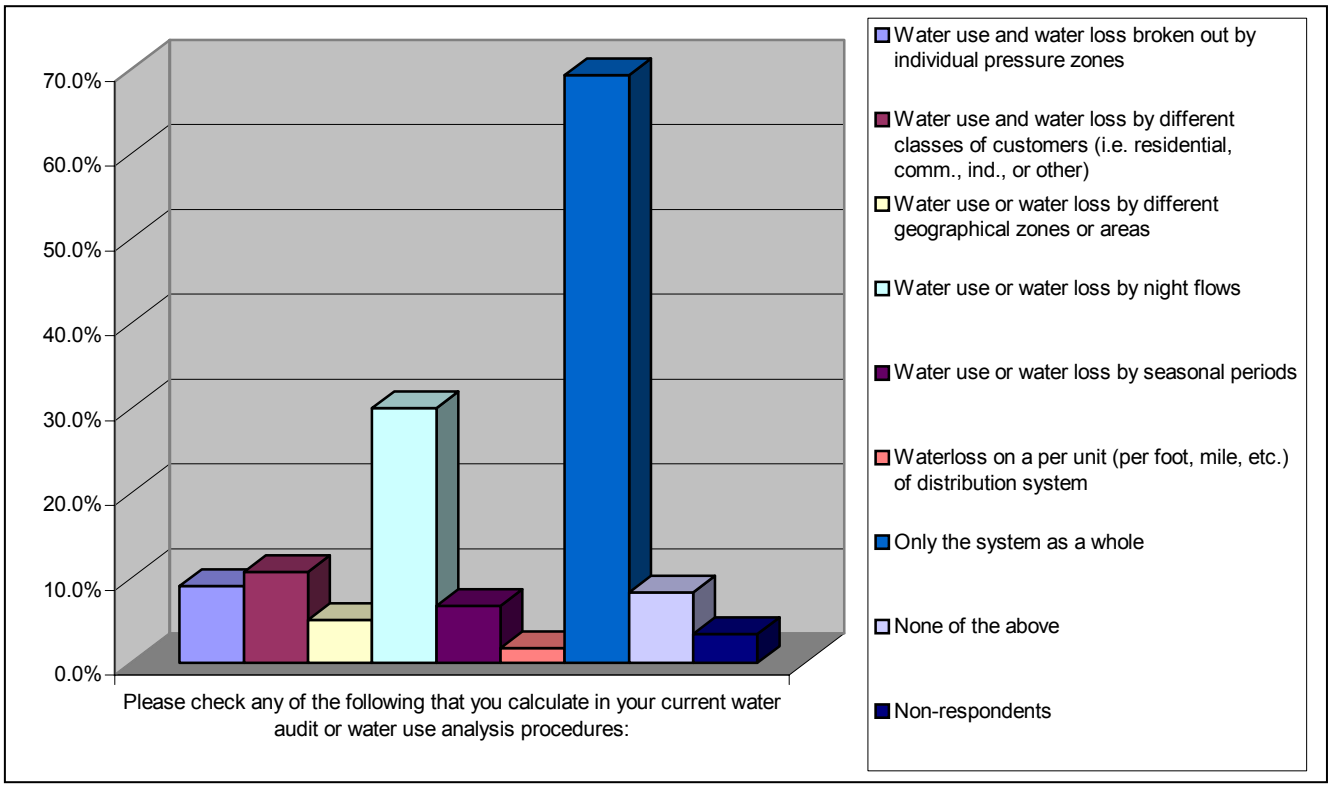
Table A-19

Do you keep an organized repair log? / Mark all that is included in the repair log.						
Population:	500-3,300	3,301-10,000	10,001-50,000	50,001-100,000	100,000+	TOTAL
Pin or marked maps that visually show problem areas	6.5%	10.3%	31.7%	28.6%	64.3%	14.7%
Classify leaks based on size and location	12.4%	19.2%	43.9%	35.7%	64.3%	22.0%
Nature and cause of the leak	19.0%	28.2%	34.1%	50.0%	64.3%	27.0%
Pipe material and replacement parts	22.2%	32.1%	56.1%	78.6%	78.6%	34.7%
Estimate of water lost during repair	26.8%	32.9%	51.2%	28.6%	42.9%	32.7%
Do not have a leak log or keep specific repair records	46.4%	41.0%	14.6%	14.3%	14.3%	37.7%
Other (fill in the blank)	13.7%	10.3%	7.3%	0.0%	21.4%	11.7%
Non-respondents	15.7%	1.3%	2.4%	0.0%	0.0%	8.0%
N	153	78	41	14	14	300

Table A-20

Do you keep an organized repair log? / Mark all that is included in the repair log:						
Type:	Municipality	Water District	Water Supply Corporation	Investor Owned Utility	Federal, State, or County	TOTAL
pin or marked maps that visually show problem areas	22.3%	7.1%	5.0%	15.4%	0.0%	14.7%
classify leaks based on size and location	30.6%	16.7%	11.3%	7.7%	12.5%	22.0%
nature and cause of the leak	30.6%	23.8%	20.0%	30.8%	37.5%	27.0%
pipe material and replacement parts	39.5%	35.7%	26.3%	30.8%	25.0%	34.7%
estimate of water lost during repair	26.8%	47.6%	41.3%	23.1%	0.0%	32.7%
do not have a leak log or keep specific repair records	34.4%	42.9%	37.5%	53.8%	50.0%	37.7%
other (fill in the blank)	10.8%	16.7%	11.3%	15.4%	0.0%	11.7%
Non-respondents	8.9%	2.4%	8.8%	0.0%	12.5%	8.0%
N	157	42	80	13	8	300


70.0%
60.0%
50.0%
40.0%
30.0%
20.0%
10.0%
0.0%
How do you use the results of the system water use calculations or analysis?
Compare to past results to see if they are better or worse than in past periods
Compare the results to general benchmarks for % water loss
Just enter them into the records
None of the above
non-respondents


70.0%
60.0%
50.0%
40.0%
30.0%
20.0%
10.0%
0.0%
Please check any of the following that you calculate in your current water audit or water use analysis procedures:
Water use and water loss broken out by individual pressure zones
Water use and water loss by different classes of customers (i.e. residential, comm., ind., or other)
Water use or water loss by different geographical zones or areas
Water use or water loss by night flows
Water use or water loss by seasonal periods
Waterloss on a per unit (per foot, mile, etc.) of distribution system
Only the system as a whole
None of the above
Non-respondents

APPENDIX 2: Written Responses to Questions

Appendix 2

The following are the written responses to Open ended or Fill-in-the-blank survey questions.

Section II, Question 6: Mark all identified water uses, other than metered sales to customers, included in your water use analysis. Category "Other":

Pop:	1,934	District	Adjustment of master meters.
Pop:	2,896	Municipal	City Pool
Pop:	65,000	Municipal	Flushing of line extensions.
Pop:	8,000	WSC	Hays & County Water Trucks
Pop:	2,889	WSC	Instrumentation
Pop:	3,293	Other	Landscaping, agricultural, sanitation
Pop:	31,880	Municipal	Line installed / repaired
Pop:	62,350	Municipal	Due to non-payment by customers
Pop:	5,196	Government	Main Breaks
Pop:	87,227	Municipal	Meter Inaccuracy
Pop:	1,188,580	Municipal	Meter testing unbilled municipal use
Pop:	6,450	Municipal	Periodic tank overflows
Pop:	4,935	WSC	Sale to another provider
Pop:	1,446	Municipal	Sewer plant in use
Pop:	3,192	District	Swimming pool
Pop:	7,215	Municipal	Unaccounted for
Pop:	5,500	District	Wash Down
Pop:	7,200	WSC	We just try to make a note.
Pop:	5,475	District	Well Flushing
Pop:	22,830	District	Well Flushing
Pop:	840	District	Well flushing

Section II, Question 11: Check all Training Resources or other resources that you have relied upon for information and procedures for determining and evaluating water loss and water use information: Category "Other".

Customized computer program
Finance Director
Flush meter back wash
Information entered on Texas Water Development Board Annual Survey
Past manager's procedures
Resources on the internet
Small system
Water Conservation Annual Report
Wholesale Water Works Supply Co

Section II, Question 12: Briefly describe the procedures you use to calculate of determine water loss and water use:

Pop: 6,447	District	(total water billed to customers)+ (identified losses)/water pumped from wells
Pop: 1,506	District	(Total water metered)+ (identified losses)/total water pumped from wells
Pop: 3,045	WSC	(Water sold plus estimated loss due to leaks & flushing) divided by (water pumped plus water purchased)
Pop: 7,140	District	1. Add last yr total pumpage. 2. Add last yr total water sales. 3. Add last yrs. Total non-sale water usage. 4. Subtract 2 & 3 from 1. 5. Total loss
Pop: 5,196	Government	1. Compare water production to metered sales. 2. Account for water used for routine flushing. 3. Account for water used to flush water repairs. 4. Account for water used to hydrant flushing. 5. Estimate for water lost in leaks.

Pop: 2,325	Municipal	1. Leak Audit 2. Leak repair summaries 3. Leak detection Survey Daily log 4. New meter installation(due to dead meters 5. Line flushing water use (not metered) 6. Water for Fire fighting & training (not metered) 7. Charts of determine water loss (flow)
Pop: 650		"1. Total Monthly Production & Sales from master meters and customer meters. 2. Calculate Gross Loss. 3. Calculate other known user, ie: plant use, line flushing, fire department use, etc...4. Calculate adjustment for meter accuracy based on age of meters
Pop: 1,308	District	1.Collect information on leaks and repairs during reporting period, 2.Collect Information on line flushing and tank overflowing. 3.Subtract water sold from water produced. 4.Subtract estimated gallonage from leaks, main breaks, flushing, and tank overflow
Pop: 2,896	Municipal	A. Total gallons pumped for months 15th to the 15th B. Total gallons billed to customers for the month Subtract B from A A-B=C (your systems total loss in gallons) (C/A) * 100 = 5 water loss
Pop: 1,377 ,		Above average use of metered water from wells during leak
Pop: 25,515	Municipal	Acquire water produced form monthly reports
Pop: 7,271	Municipal	Add gallons billed with hydrants flushed and direct water sales then subtract from total gallons pumped
Pop: 8,000	WSC	Add total pump usage & purchase of water, less water sales, less all know unbilled water, what is left is unknown loss

Pop: 936	Municipal	Added all water pumped in 1,000 gallon measurements (owned & bought) less billed pumpage, less water vendor pumpage, less misc. metered sold, less est. loss through hydrant flushing and water ground storage draining for cleaning
Pop: 1,320	Municipal	All information is entered into a computer program that calculates the loss as part of a director's report
Pop: 22,860	Municipal	All known usage i.e. purchase or facilities fire usage and flushing are subtracted from the yearly pumpage which comes from a flow meter totalizer. The difference is considered water loss.
Pop: 2,337	WSC	All water is metered. Water sold is subtracted from water pumped total minus flushing & fire loss.
Pop: 1,188,580	Municipal	All water operations divisions' purification, pumping, distribution, as well as waste water collection and fire department provide monthly work sheets with unmetered losses. Billing records provide billed information and metered but unbilled.
Pop: 1,116	Municipal	Amt of water sold is divided by the amt of water pumped for a 30 day period coinciding with billing cycle. A % is derived in gallons of water loss.
Pop: 3,192 .	District	Any water not billed for that was produced is calculated as water loss. All metered sales are considered water use
Pop: 1,500	WSC	As a part of monthly director's report, water sold through meters, est. water loss from leaks, water flushed for air & dead ends.
Pop: 1,059	WSC	At end of Billing cycle rpt is created for total water billed, all meters read even turned off meters, all flush valves have a test meter use to calculate flow. Leaks are est. by size, time of leak, subtract water used from water produced check daily prod
Pop: 735	Municipal	Billing program calculates water loss

Pop: 1,446.	Municipal	Calculate water prod -total from daily log & subtract metered water & other known amts
Pop: 9,987	Municipal	Calculate water pumped and subtract water sold = water lost
Pop: 14,862	Municipal	Calculated GPM/size of break
Pop: 10,193	Municipal	Compare annual amount pumped less amount billed from billing program for annual person
Pop: 3,349	Municipal	Compare diff between water purchased & water sales metered.
Pop: 4,260	District	Compare gallons billed to purchase w/ consideration for unbilled meters.
Pop: 70,850	Municipal	Compare monthly water purchase to water metered. Difference is water loss.
Pop: 780	WSC	Compare total water sales to total metered water for that month.. Take into acct for old meters not registering correctly. Volunteer fire dept. is allotted 20,000-30,000 gal. per month.
Pop: 127,427	Municipal	"Compute total production (water purchases plus metered groundwater production), Compute accounted for water (all metered water sales plus uses documented by water maintenance division - leak estimates, W/W flushing, dead-end flushing, etc), Review unaccounted for water (total gallons, percentages of the system, review trends, etc)
Pop: 3,393	District	Computer Billing Program
Pop: 3,176	District	Computer meter reading entries note increases/decreases per account. Computer end of the month report leak detection
Pop: 816	WSC	Computer print out of Director's report
Pop: 516.	Government	Computer program compares total water produced with total water sold

Pop: 34,575.	Municipal	Customer meter are read monthly and production meter are daily. All metered consumption and other known loses are subtracted from total pumpage
Pop: 3,800	Municipal	Daily loss and monthly reports
Pop: 2,475	District	Daily master meter reading less filter backwash use, less est. known leaks, less est. use flushing lines, less water sold.
Pop: 664	Municipal	Daily worksheets write down meter readings at all three wells and calculate water usage
Pop: 3,429	WSC	Determine water purpose by wells from daily well reports
Pop: 28,520	Municipal	Difference in production and metered sales taking into account water used in surface water production. Line flushing, well testing.
Pop: 20,000	Municipal	Divide gallons billed through billing system by gallons produces for the approximate billing cycle
Pop: 3,003	District	Divide total purchased and pumped water into difference between that and billed water total.
Pop: 4,816	Other	Don't do water loss
Pop: 2,889	WSC	Each month after meters are read, the amount of water sold, plus known leaks, overflows, backwash water, and water sent through on line analyzers is compared to raw water and distribution water metered for roughly the same period. The difference is unaccounted for water.
Pop: 2,478	Municipal	Enter water produced subtract line flushing, fire dept use then divide that figure into amt of water sold to get % loss

Pop: 8,886	Municipal	Estimate water lost through meter leaks, service leaks, main breaks, flushing fire hydrants, street sweeping, sewer cleanings, watering trees @ park
Pop: 2,745	District	Figure difference in master metered pumpage and gallons registered on customer meters and estimated amount for flushing and fire protection. Fire department sometimes gives monthly totals based on how many times they fill their pumpers and tankers.
Pop: 4,737.	WSC	From master meter to # of service connections getting total also if there are any water also if break in the pressure zone what size line and pressure and how long leak was running.
Pop: 1,269	WSC	Gross water purchased by meter loss gross water sold for same date meter readings. Loss allowances for flushing, leaks, fire usage etc. equals net loss.
Pop: 867	Government	Have one employee who reads the meters daily and sample the water. Our DOS billing program shows water billed, monthly. Difference between the two is our water loss.
Pop: 7,200	Municipal	I get data on total gallons pumped into distribution from SCADA report on a single distribution meter. Sales come from residential and business meter reading billing reports plus I add bulk water sales (metered).
Pop: 4,377.	District	I receive a statement from billing on customer usage, corrections in billing, over-read, under read meters. I then use my daily pumpage reports to add up the water pump daily. Then calculate the % of accountability
Pop: 540.	Municipal	I take the total number of gallons pumped at the wells and subtract the estimated totals of water loss from leaks and water used at wastewater treatment plant.

Pop: 3,618	WSC	I take the water pumped & water sold subtract get the water lost then subtract the water.
Pop: 2,732 .	Municipal	I take the water sold to all our customers and the total water we pump and purchase and divide the water pumped and purchased into the water not accounted for to get the percentage
Pop: 3,584	Municipal	I total up the total surface water produced less the total volume sold.
Pop: 1,100	Municipal	I use master meter reading at our station for total water pumped. Then we read every meter in town for water sales. I then compare meters pumped to water sold.
Pop: 4,203	Other	Keep track of the use by master meters that are part of the SCADA system. Figure out the difference between what was billed and what was pumped. Master meters are tested annually by a professional technician. Water loss report. Please see attachment.
Pop: 209,030	Municipal	Known flow rates times amountt of time water is known to have run= lost gallons.
Pop: 3,462	WSC	Length of time (hours) pumped by 60 minutes by 60 seconds divided by seconds it takes to pump 1 gallon
Pop: 1,188	District	Loss=water pumped from wells-water metered-water flushed
Pop: 894		Master meters @ 2 points
Pop: 1,935	WSC	Master meters are read at the same time the customers meter are read. These figures are entered into the system totals in our billing programs. Each master meter loss if figured then re-entered into the computer for the director's report which shows overall usage

Pop: 5,064	Municipal	Monthly pumpage compared to gallons through all commercial, residential and city owned meters
Pop: 726	WSC	Monthly readings of customer meter reading and well pump meter readings are entered into a computer using RVS utility billing system software.
Pop: 2,667	Government	Monthly: Reading from well meters are compared with customer meters. Computer does math and determines % water loss.
Pop: 9,924	WSC	Our engineers gave us a computer program. We enter the usage and sold and the computer calculates the water loss
Pop: 13,575	Municipal	Plant Prod minus retail , wholesale, bulk= loss
Pop: 14,170	District	Production less metered, flushing, leaks, backwash
Pop: 1,710	Municipal	Pumpage, sales, city use, leaks/flushed divide pumpage =unaccounted
Pop: 3,162	District	Pumped versus billed, estimate water loss on leaks, backwash water on filter, monthly flushing
Pop: 8,132	Municipal	Purchased water + pumped water - metered water = water loss
Pop: 800	Municipal	Purchases - sales divided purchase x 100 = % loss and unaccounted for
Pop: 610	Municipal	Read all meters and use total sales of vending machine, calculate leaks and compare to total pumpage
Pop: 1,599	Municipal	Record water sale, record daily master meter reads

Pop: 750	WSC	Records of gallons sold. Records of gallons pumped. Keep a log of leaks and flushing
Pop: 550	WSC	RVS Program

Pop: 2,700,000	Municipal	See page 5 of 15 #5 The water loss is the difference between total water sales plus some other metered or unmetered water uses and total water supplied to the system
Pop: 3,000	WSC	Software program calculated water loss
Pop: 750		South Texas Water Authority's Regional System is basically a "closed" system that has transmission lines to 9 customers. Water metered going "in" to the system at the meter located at the O.N. Stevens Plant (City of Corpus Christi) is compared on a daily
Pop: 718,612	Municipal	Spreadsheet emailed directly to George Freitag 4/1/2004, "TWDB Loss 032004.xls"
Pop: 65,000 (BTU) and	Municipal	Start with our High-Service production (Water Pumped) and subtract the accounted for water loss from it. This gives us a water available for sale figure. We then get the water sold from our billing department subtract it from our water availability
Pop: 3,678	WSC	Subtract gallons sold & get est. leak loss gallons pumped & flushing
Pop: 1,914	Municipal	Subtract metered & unmetered water from total water pumped
Pop: 8,211	Municipal	Subtract metered water sales from annual production
Pop: 23,718 .	District	Subtract metered water use, hydrant flushing and estimated leaks from Monthly Water Pumpage
Pop: 1,410	Municipal	Subtract the total consumption that was billed subtract the city use from the production of the wells.
Pop: 4,350	District	Subtract water sold from water pumped then we divide water loss by water pumped times 100

Pop: 618	Municipal	Take meter reading @ master meter daily go from consumer read date to consumer read date for amt sold on master meter & deduct amt billed to consumer then calculate approximate loss.
Pop: 1,905	WSC	Take meter reading at plant monthly and add estimates of flushing, leaks and compare to water sales
Pop: 6,978	Municipal	Take monthly pump records on water bought. Obtain report from finance office. Total all sales to retail, wholesale, comm. Add metered water that goes to city functions. Subtract the total form water purchased for water loss amt.
Pop: 2,403 .	Municipal	Take monthly treated water from plant minus water billed total's, est. leak loss, flushing total, bulk water add, fire hydrant used by Fire Dept the diff would be water loss
Pop: 615	Government	Take the total of water produced by the well as measured by the utility's meter. Subtract the total water sold/billed as measured by customers' meters. This difference gives you the amount of gallons lost. To find % we divide the water loss by water production
Pop: 5,868	Municipal	Take total water billed (metered & unmetered) + estimated consumption, then divide by total water supplied.
Pop: 8,499	Municipal	The city goes by what meter [????]
Pop: 1,461	Municipal	The city secretary uses a computer program to calculate water loss
Pop: 9,000	Municipal	The difference between total purchased and total water sales is the water loss. As of Oct. 1, 2003 we are keeping records of estimates of water used flushing mains and lost as result of water leaks.
Pop: 3,117	District	The difference between total sales supplied at the meter and the total gallons pumped. Also taken into account is water used flushing and leaks.

Pop: 500	Municipal	The difference between water sales and water supplied, taking into consideration the amount used for flushing lines
Pop: 4,893	District	The district meters water production, sales and filter backwash. Water sales and backwash usage are subtracted from production to determine loss.
Pop: 513	WSC	The only water loss we have is when I flush lines or we have a leak. Our lines or from 1" to 4". The meter we use is determine by our master meters.
Pop: 2,061	WSC	The procedure is generated by a computer.
Pop: 12,798	Municipal	The water loss is the difference between total water sales plus some other metered or unmetered water uses and the total water supplied to the system.
Pop: 950	District	There is a meter at every well and a master meter at every pump station. Master meter is read every day and recorded. At the end of each month the master reading is compared to gallons billed.
Pop: 1,018	Municipal	These figures are included in the City's annual audit performed by a consultant in Frisco, TX.
Pop: 615	Government	To determine water use, we calculate the total water bills 2. To determine water loss, we subtract water billed from water supplied.
Pop: 2,000	Municipal	To take water sales from purpose from wells and purchase of treated lake water.
Pop: 42,298	Municipal	Total amount of water billed + hydrant flushing + main flushing + backwashing + chemical plant water + distribution leaks + lab. Water divided by water pumped.
Pop: 3,760	Municipal	Total amt of metered water sold is added w/ known unmetered uses & is subtracted from the total amt of water pumped into the system.
Pop: 56,250	Municipal	Total billed water sales + metered un billed usage + water usage less water purchases from TRA & Fort Worth
Pop: 1,569	Municipal	Total ground water intake, total water sold

Pop: 25,482	Municipal	Total of all metered sales plus quantifiable but unmetered uses divided by total water produced.
Pop: 5,500	District	Total production surface less sold & other known consumption
Pop: 2,286	WSC	Total pumpage minus meter use sales minus metered flushing, minus volunteer fire dept. usage equals loss.
Pop: 4,400	Municipal	Total pumped wells minus.actual billed gallons minus 10% for inaccurate meters minus gallons for flushing and leaks = total unaccountable water
Pop: 4,215	WSC	Total pumped, total sold, accountable loss, unaccountable loss, water loss %.
Pop: 3,200	Municipal	Total raw water-water pumped to distribution=plant loss water pumped to distribution- total water sales= dist. Loss
Pop: 2,937	Municipal	Total water bought, total water sold, Est. none meter and municipal usage
Pop: 270,000	Municipal	Total water entering water treatment facility less total metered water sales.
Pop: 10,701	District	Total water produced (metered), Total water sold (metered), Total identified and estimated losses, Total amount of lost water, loss %, number of leaks repaired on system and service connections.
Pop: 3,095	District	Total water produced minus estimated water used for flushing and fire department use divided into water sold. Our billing programs figures the loss and provides a comparison.
Pop: 201,855	Municipal	Total water production - total water sales = water loss
Pop: 759	WSC	Total water production metered at both well # 1 and well #2 minus total water sold to customers unaccounted for water is then divided by water production times 100 equals percent of water loss.

Pop: 1,446	WSC	Total water pumped minus total water sold -fire & line flushing= total water loss divide total water loss into total water pumped= water less %.
Pop: 4,725 .	WSC	Total water pumped minus water sold add in water use at sewer plant, report from fire dept. estimates of leaks(written) flushing etc
Pop: 2,200	WSC	Total water purchased is reduced by metered usage, flushing, and overflows. The remaining gallons constitute water loss.
Pop: 10,758	District	Total water sold-metered total water pumped into system water used for flushing lines total water leaks and amount of time line was leaking (estimated) water used to refill storage tanks.
Pop: 5,905	Other	Total water supplied to the system minus total water sales we include unmetered water uses: Ex: Fire Department use, sewer line cleaning, etc.
Pop: 3,000	Other	Total water use in CCF x 748.1
Pop: 1,095	WSC	Total well prod is compared to total metered sales. Other usage is from line breaks, leakage, maintenance.
Pop: 14,579	Municipal	Total well pumpage minus the total metered water sales equals the total water loss. This is done on a monthly basis.
Pop: 4,149	Municipal	Use 12 month moving average with purchase water vs. meter sales all taps are metered.
Pop: 4,236	WSC	Use leak report
Pop: 2,946	Municipal	Use the consumption number off the monthly billing service recap. & divide that by the monthly total pumpage amount off the monthly report.
Pop: 32,000	Municipal	Utility billing provides water sold. System flushing is estimated. Water pumpage is calculated. The % loss is determined.
Pop: 693	District	Water billed is compared to water pumped into the system on a monthly

		basis and compared to prior periods
Pop: 4,639		Water is calculated by meters and logged on a daily basis.
Pop: 21,033	Municipal	"Water is purchased through a single meter, read daily.
Pop: 24,033	Municipal	Water is purchased through a single meter, read daily. Purchased water - (customer meter readings & known loss / Purchased Water
Pop: 825	WSC	Water loss is determined by the diff between the master meter on the well & water is metered when sold to customer. Water loss is due to leaks.
Pop: 111,800	Municipal	Water loss is the difference of water purchased and water billed including internal uses. All metered and unmetered water usage is used for this calculation.
Pop: 1,860 .	Municipal	Water metered vs. water pumped
Pop: 642	WSC	Water operator needs master meter daily and keep records at end of month.
Pop: 2,860	District	Water operators log non metered usage including flushing, leaks, or any other non metered usage on flushing report. I key this data into an RVS computer program as part of end of month procedures each month.
Pop: 29,914	Municipal	Water produced - unmetered water sales.
Pop: 1,320	WSC	Water produced less water sold less flushing and leaks
Pop: 35,082	Municipal	Water pump monthly reports, water sold/billed report, obtain info on large dept use, obtain inform on large main breaks, obtain nor on large flushing lines, have all water accts/usage with meters, on slow/stopped meters -we audit ea billing, average, & re
Pop: 1,500	WSC	water pump, water sold, water loss accounted for, water loss unaccounted for.
Pop: 13,747	Municipal	Water pumped - water sales & estimated use from city.
Pop: 2,400	WSC	Water pumped and bought to water sold
Pop: 3,195	WSC	Water pumped from wells minus water

		sold to customers. That # is then divided by water pumped from wells.
Pop: 1,527	WSC	Water pumped less metered water sales
Pop: 2,808	Municipal	Water pumped minus water sold = water loss
Pop: 1,455	WSC	Water pumped this month, water sold this month, water used for flushing.
Pop: 1,161	WSC	Water pumped, less water sold, less water flushed, less bulk sales = water loss
Pop: 5,193	Municipal	Water pumped-water solid = water loss. All wells have meters, all well meters are read each day.
Pop: 27,908	Municipal	Water purchased from Dallas Water Utilities. Water metered by City, all customers & city use. Water used during unidirectional flushing program activities. Water flushed during dead end main flushing activities, storage tank draining/overflows. Street dept. use for street sweeping activities. Water breaks and known smaller leaks.
Pop: 2,700	WSC	Water purchased, less metered customers, less fire dept. use, and less bulk sales if any
Pop: 28,103	Municipal	Water sales by user category plus treatment plant usage compared to treated and raw water pumped.
Pop: 8,695	Municipal	Water Sales minus (Self-Supplied + Purchased)
Pop: 1,100	Municipal	Water software calculates loss
Pop: 46,660	Municipal	Water sold - water treated
Pop: 1,934	District	Water sold (water pumped - water for flushing and master meter adjustment)
Pop: 1,977	WSC	Water sold plus fire, flushing & leak est. minus that total from water pumped then divide that total by water pumped
Pop: 8,000	Municipal	Water treated- water sold minus contact distr. Flushing. Fire dept for total usage daily inspections sewer runs = total loss
Pop: 3,293	Other	Water use - all water is purchased from city of Gatesville and is metered incoming the unit. Water purchased from others is

		reported to TCEQ monthly. Any water loss including landscaping washing of walk ways leaks reported for repairs and sanitation purposes
Pop: 1,900	WSC	Water use and loss are figured in our billing software. Meter readings are entered monthly for each customer and this gives our monthly usage. I enter the total gallons we received from our water supplier. The billing software system then figures our water loss.
Pop: 24,975.	District	Water use is calculated by meters from suppliers, and loss is calculated from customer meter and subtracted from master meters. In addition routine flushing and most major main break leaks are totaled and used in this equation
Pop: 24,485	Municipal	Water use is calculated by totaling all water meters, fire use estimated of leaks. Unmetered water estimates. Water loss is determined by the difference between total water pumped by the treatment plants with the water use subtracted from the total.
Pop: 2,271	District	Water use is determined by metered usage by customers. The water produced is obtained from water well meter readings
Pop: 1,950	WSC	Water use is determined by reading meters each month for each customer. Master meters are read, showing water pumped. We take the total water pumped less water sold and divide total by water pumped to arrive at water loss.
Pop: 534	WSC	Water use is metered at each connection, water loss is such a small % we have not calculated it.
Pop: 636	Government	Water use is metered. Water loss is calculated by flushing lines, old meter loss, and subtracting water loss thru leaks.
Pop: 62,350	Municipal	Water use is the amount of purchased water versus metered water and the difference between those is the Water Loss.
Pop: 33,302	Municipal	Water used is calculated by metering

		residential commercial, bulk use, municipal use, and wholesale use. Unmetered usage such as dead end and routine flushing and water breaks are
Pop: 26,531	Municipal	We take all the water production readings for the whole year and divide the metered into the reading total.
Pop: 3,890	Municipal	We add our total pumped from ground storage and purchased and subtract what will be billed out.
Pop: 2,455	Municipal	We are using a touch read meter system which city staff uses monthly to collect water usage at all metered accounts. The readings are the turned in to city hall and are billed accordingly
Pop: 1,200	WSC	We buy our water from city of Ennis. We take reading from city of Ennis master meters 2 deduct water we billed our customers, this is about a 20% loss
Pop: 1,219,113	Municipal	We calculate water loss by the difference between the total amount of water pumped within a calendar year and the total billed amount within that year. Billed accounts include residential, commercial, apartment, industrial, wholesale, municipal, and irrigation
Pop: 77,271	Municipal	We collect raw and treated water meter readings at all three of our water treatment plants daily. We read customer meters daily and compile total sales monthly. We ask fire dept of estimate for fire fighting monthly. Also, the street dept, parks and water distr. Div. are asked to submit estimates for usage.
Pop: 2,600	WSC	We compare sales total to water purchases each month and consider flushing, lead during the month and fire fighting during the month.
Pop: 2,420	WSC	We have 7 wells & pump stations all connected together. Each month we have a total water pumped figure from the wells. We have a total metered water sold figure, calculated from all the meters added together. We subtract metered sold from total pumped from well meters all added together-this gives us gross

		water loss. I estimate deductions for leaks & flushing.
Pop: 2,022	WSC	We have a Scada system that tracks our water pumping
Pop: 2,964	Municipal	We looked @ sales to our customers vs. our production.
Pop: 5,195	Other	We read the master meter coming in at our point of entry from the city of Waco on a daily basis. We notice if we have a spike in usage we have 750 hours that are not metered. Also, most irrigation systems on campus are not metered. Therefore we can not determine an accurate water loss.
Pop: 2,900	Municipal	We read the master meter, where we take water, from San Patricio Municipal Water District twice daily. Written reports on all leaks. Bulk sales and etc
Pop: 2,394	Municipal	We subtract amt of water billed from amt of water purchased less amt of water flushed divided by amount of water purchased
Pop: 1,500	WSC	We subtract the amt sold from the amt pumped. Whatever that difference is we divide by the amt pumps to get our % of unaccounted for water.
Pop: 38,121	Municipal	We take the total water pump & purchase - water sold, leaks flushed and municipal used for grand total
Pop: 1,489	WSC	We take water purchased & subtract our meter reading, leaks & flushing from this figure. This gives us our water loss & we figure our %.
Pop: 3,453	WSC	We use our monthly report after meter reading & deduct flushing totals & deduct estimated leak loss.
Pop: 2,594	WSC	We use the increase in well pumpage and add 10%. Most leaks has leaked a little before showing up. Water used for flushing filter systems is metered. For end flushing we use a 5 gal. bucket to time and set flow at 6 gals. per minute.
Pop: 3,759	District	We utilize customer meter readings to compare to well pumpage for the corresponding dates.
Pop: 1,799	Municipal	Well head meter totals, less metered

		sales, minus estimated loss to leaks. Fire, flushing etc. = non sales on loss.
Pop: 576	WSC	Well pumpage minus meter reading calculation and known usage equal difference or loss! Less divided by pumpage equal % of loss.
Pop: 606	Municipal	Well water metered- water sold
Pop: 8,781	WSC	When flushing lines we use a flow meter or 5 gal container and multiply as needed. When repairing leaks we use the 5 gal container method when possible, with smaller leaks we try to visualize if the water on the ground could fill a 5 gal container. When repairing leaks we use the 5 gal container method when possible, with smaller leaks we try to visualize if the water on the ground could fill a 5 gal container. We also consider weather conditions and approximately how much could have been saturated into the ground or ran off to a culvert or back to the lake. On major leaks we determine the GPM from the line size and multiply as needed. The wasted water chart is also used.
Pop: 1,650	WSC	When we check meters @ wells each day if there is an excessive difference, then we look for leaks or breaks on water lines.

Section III, Question 1: Which of the following best describes your Utility's Leak Detection and Repair Program? Category "Other".

Pop: 2200000	Municipal	Above program just started April 04
Pop: 42000	Municipal	Annual leak detection survey conducted by 2 contracted services. 1/4 of the city each year.
Pop: 836	Governm ent	Check distribution site and customers locations for leaks one time a month during meter reading
Pop: 1242	WSC	Check pressure gauges for loss of pressure monitor these areas or reduce pressure.
Pop: 774969	Municipal	Combination of All above
Pop: 3000	WSC	Current monitoring of pumpage @ each pump station
Pop: 23,713	District	Daily visual by Operators throughout the District.
Pop: 1699	Municipal	Hard search conducted if loss evident
Pop: 550	WSC	I can also tell when we have a leak by the amount of water that we use at our master meters.
Pop: 8328	WSC	Low level monitoring system
Pop: 3300	WSC	Meter change out
Pop: 2500	WSC	Meter supply tanks for various pressure systems and compare to water sold in this pressure system. Any large discrepancy indicates a leak.
Pop: 4350	WSC	Monitor daily usage compared to last month & same month a year ago to determine if we have a problem
Pop: 36,811	Municipal	Monitor wells 24/7
Pop: 2000	WSC	Pump station usage
Pop: 35000	Municipal	SCADA system at water production
Pop:	WSC	Spike in daily well production
Pop: 8000	District	Walk water lines periodically
Pop: 3450	WSC	We are constantly squeezing valves looking for leaks

Section III, Question 2: Please mark all that apply to your use of leak detection equipment. Category "Other"

Pop: 2100	WSC	A close watch for leaks by operator and customers, determines the leaks.
Pop: 600	WSC	Borrow from Texas rural water
Pop: 1200	WSC	Check for leaks visible
Pop: 1242	WSC	Check line sectional with pressure equip. And cut off sections to see of pressure rises then hunting that area that shows loss of pressure.
Pop: 5000	Other	City of Waco leak detection crew
Pop: 31880	Municipal	Demo of various electronic equipment
Pop: 430	Municipal	If loss reaches over 20% we walk the water lines until we find the problem.
Pop:	Municipal	in process, not started
Pop:	Municipal	meter chief
Pop: 591	WSC	One listening microphones
Pop: 3600	WSC	Our losses are usually 5% less, if more we conduct system wide visible leak survey.
Pop: 1056	WSC	Our system is small & leaks are easily found.
Pop: 774969	Municipal	Perform flow tests with AFD
Pop: 2000	Other	Pressure Gauge
Pop: 26255	Municipal	Remote distribution system pressure telemetry
Pop: 4000	WSC	System checks
Pop:	WSC	Walk the lines isolation valves w/ microprocessor
Pop: 836	Government	We are currently using MGMC construction company to check for leaks in our system as needed.
Pop: 2000	WSC	We have an extensive SCADA alarm system with connections to each of our zones so that we can see any problems at a glance to our computer.

Section III, Questions 4 and 5, If you marked yes that you have specific programs to fix leaks on the customer service lines. Please indicate what specific programs or procedures where you fix leaks on the customer service lines?

Pop: 2,200,000	Municipal	Customer service lines are fixed from main to meter only.
Pop:	Municipal	Free customer audits
Pop: 3726	District	If a leak is located, it is required.
Pop: 836	Government	If leak found on customers lines we notify customers and often they reimburse us to fix their leaks.
Pop: 2500	WSC	If leak is notice by a meter reader it is fixed as soon as possible.
Pop: 30500	Municipal	If not meter we estimate the amount of water loss and record it on our leak report form.
Pop: 5064	Municipal	If owner has a leak he is told about it and given 5-10 day to repair and city inspects or meter is locked until problem area is repaired.
Pop: 4500	WSC	If the leak is in downstream but close to meter we repair.
Pop: 1300	WSC	If we break it we fix it.
Pop: 610	Municipal	If we know it has a leak we shut water off at the meter until they fix it.
Pop: 702	District	If we notice a leak the customer is told to fix it.
Pop: 1000000	Municipal	Low income customers can qualify for the free leak repair through the "Plumbers to People" program
Pop:	Municipal	Meter reader reports
Pop: 2000000	Municipal	N/A
Pop: 3000	Other- Military Base	Scheduled preventive maintenance is performed. If a leak occurs the Public Works trouble desk is called and the leak is reported. The Public Works personnel are notified of the leak and will go to the location to repair.
Pop: 3274	Other	Security or maintenance personnel reports & work request is submitted with set or adjusted priority attached and is reviewed by maintenance staff ASAP.
Pop: 2100	Municipal	Turn off until repaired.

Pop: 1242	WSC	Visual
Pop: 4700	Other	We do not repair anything after the meter. The value before meter needs to be turned off by an operator and also when back on.
Pop: 600	WSC	We fix leaks on our side of meter when called or found when reading meter.
Pop: 1461	Municipal	We have a hand held meter reading unit that indicates high water usage from the last reading.
Pop: 410	WSC	We hire licensed contractors.
Pop: 4400	Government	We log and repair all leaks as soon as possible
Pop: 138000	Municipal	We offer "Leak Adjustments" for documented repair of hidden water leaks on the customer's system. We estimate the leak volume (by looking at usage trends) and write off half of that volume from the bill. City personnel do not perform these repairs, but
Pop: 2000	District	We repair all leaks brought to our attention within 24" of the District's meter box. The resident is notified that they are responsible to repair any leaks farther that 24" from the meter box.
Pop: 2786	District	We repair from water main tap service line to meter.
Pop: 9944	District	We replace all polybutylene service lines and check customer low-pressure reports.
Pop: 1451	Municipal	When leaks are found they are fixed in a timely manner.
Pop: 6447	District	When leaks are identified they are repaired
Pop: 1500	District	When service line leaks are identified, they are repaired
Pop: 5500	District	Work order / priority repairs - worse leaks repaired first

Section III, Question 6: Please list all other water loss control measures that you currently implement in your ongoing operations: Category "Other not listed"

Pop: 1300	WSC	Change out stuck meters that are not registering a usage.
Pop: 600	WSC	Check amount of water flowed in 2 places each day
Pop: 1056	WSC	Customers help us
Pop: 2500	District	Daily analysis of production to detect new and unfound leaks.
Pop: 2100	Municipal	In the process of locating all read mater meters with GPS & compare to high resolution recent aerial photograph.
Pop: 24000	Municipal	Meter Replacement Program
Pop: 27508	Municipal	Meter replacement program and testing program
Pop: 1200	WSC	Mostly flushing lines and slow meter
Pop: 3400	District	Observed leak detections
Pop: 4200	District	Ongoing meter replacement program
Pop: 7400	Municipal	Visual Inspection & work orders through meter readers
Pop: 21	WSC	Walk & drive the lines

Section IV, Question 3: How often do you replace residential meters? Category "Other, please describe"

Pop: 3,000	WSC	1.5-2 million gallons
Pop: 2,100	Municipal	10% or more per year
Pop: 327	WSC	10% per year
Pop: 4,200	District	100 meters per year
Pop: 22,336	Municipal	15 yrs
Pop: 4,500	WSC	20% every meter replaced 5 yr basis
Pop: 30,000	District	5 to 6 years
Pop: 15,651	WSC	5 yrs
Pop: 21	WSC	5-10 yrs
Pop: 5,500	District	8 yrs old
Pop: 138,000	Municipal	Combo: when problems are indicated and set schedule
Pop: 1,809	Government	Customer question accuracy
Pop: 1,150	Government	Customer wants the meter removed

Pop: 5,000	Other	Don't have any
Pop: 5,200	Other	Don't have residential meters
Pop: 1,242	WSC	If meter 3 tops works in a
Pop: 27,508	Municipal	If they stop working
Pop: 702	District	In the process now some meters are 30 years old
Pop: 2,400	Municipal	Meter stops / or can't read
Pop: 2,000	Other	Once a year. No individual meters used (master)
Pop: 4,450	District	Random survey of meters are pulled & sent in for testing of accuracy. If below 95% they are replaced.
Pop: 400	WSC	Random testing on required by administration.
Pop: 44,122	Municipal	Replace for non-pay, return checks, transfer
Pop: 7,000	Municipal	Started a meter change out & ran out of money to purchase new meters.
Pop: 26,255	Municipal	Use a set schedule and when a problem is reported
Pop: 460	Municipal	We are looking into the possibility of starting a set schedule
Pop: 3,274	Other	We do not own usage or capacity flow meters
Pop: 4,295	Municipal	We replaced all water meters.
Pop: 64,663	Municipal	We use both years and volume in some cases
Pop: 550	WSC	When I can't read the numbers on the meter
Pop: 430	Municipal	When meters go out replaced immediately
Pop: 1,056	WSC	When register goes over 1,000,000

APPENDIX 3: Examples of Water Audit Worksheets

Water Usage and Loss Report

th	Water ped	Water Sold	Loss Percent	Average Use	Active Meters	Zero Use Meters	Over 50000	40001 50000	30001 40000	20001 30000	10001 20000	8001 10000	6001 8001	4001 6000	2001 4000	1 2000
10/02	6,619,600	6,005,330	9.28	7,300	822	70	6	3	7	21	126	84	129	160	123	93
02	5,788,800	4,635,950	19.92	5,630	822	65	5	1	1	15	62	53	131	187	185	117
03	5,804,700	4,540,890	21.77	5,520	822	66	5	0	4	7	64	52	118	198	181	127
03	5,797,400	5,224,760	9.88	6,350	822	73	6	1	4	8	84	77	138	181	153	97
03	5,055,400	4,431,090	12.18	5,390	822	82	4	0	2	4	63	57	150	189	170	101
03	5,984,300	4,532,970	24.03	5,510	822	70	4	3	2	12	46	57	100	203	196	129
03	7,479,500	5,973,660	20.13	7,260	822	66	5	3	10	18	112	80	142	148	144	94
03	9,665,500	7,914,040	18.12	9,590	825	71	13	9	14	47	185	66	122	117	103	78
03	7,537,600	7,431,620	1.41	8,970	828	70	5	5	12	43	193	93	99	122	107	79
03	11,322,100	8,041,650	28.97	9,710	828	70	9	6	23	41	178	84	112	116	110	79
03	10,002,000	9,947,790	0.54	11,990	829	74	16	10	29	74	217	85	86	99	77	62
9/03	6,027,600	4,962,340	17.67	5,980	829	67	6	2	0	11	74	63	141	192	165	108

12 Month Totals

otal Water Pumped	87,084,500	Average Water Pumped	7,257,042
otal Water Sold	73,642,090	Average Water Sold	6,136,841
ire and Line Flushing	22,090	Average Fire & Flushing	1,841
otal Water Loss	13,420,320	Average Loss	1,118,360
ater Loss Percentage	15.41%	Average Loss Percentage	15.41%
		Average Customer Use	7,433

[redacted] Water Supply Corp.

[redacted]WSC

Water Audit Worksheet

Audit Period: ***December 2003***

		Water Volume in Gallons
1. Gross Total Water Supply to Distribution System		17,585,000
2. Adjustments to Water Supplied During Audit Period		
2.1 Storage Volume Removed from System	(+)	
2.2 Storage Volume Added to System	(-)	(39,130)
3. Net Water Produced		17,545,870
4. Gallons of Metered Water Sold	(-)	(10,941,000)
5. Gross Unaccounted - For Water		6,604,870
6. Identified/Estimated Water Loss		
6.1 Fire Fighting		45,000
6.2 Unbilled Accounts (CCWSC, R. Byrd, Waco Bay Fire Dept)		428,600
6.3 Leaks/Water Main Flushing		550,900
6.4 Construction		
6.5 Storage Tank Drainage		
6.6 Storage Overflows		
6.7 Theft		
6.8 Other		
6.9 Total Identified/Estimated Loss		1,024,500
7. Net Unaccounted For Water Loss (Line 5 less line 6.9)		5,580,370
8. Percentage of Unaccounted For Water Loss (Line 7 x 100 divided by line 3)		32%

Cost of Unaccounted For Water

9. Cost of Water, If Purchased (Unaccounted For Volume x Unit Price of Water)	$	1,540.18
9.1 Variable Production Cost (Cost of Power for pumping plus cost of chemicals, plus average cost of pump repairs, times the % on Line 8.) (Util. - $3,204.53, Chemicals - $4,442.30, Repairs - $1,451.09 $9,097.92 x 32%	$	2,911.33
9.2 Total Production cost of Unaccounted for Water Loss (add lines 9 & 9.1)	$	4,451.51

Water loss Accounting Document

[redacted] WSC

Wasted Water Chart

Size of Leak	GPM	Gallons in 24 Hrs.
1/32"	.12	180
1/16 "	.47	690
1/8"	1.92	2,760
1/4"	7.66	11,030
1/2"	30.67	44,160
3/4"	38.19	55,000
1"	122.66	176,640
2"	490.67	706,560
4"	1962.67	2,826,240
6"	6085.46	8,763,060
8"	7850.67	11,304,960
10"	16904.05	24,341,840
12"	31402.67	45,219,840

Water Usage and Loss Report

Month	Water Pumped	Water Sold	Loss Percent	Average Use	Active Meters	Zero Use Meters	Over 50000	40001 50000	30001 40000	20001 30000	10001 20000	8001 10000	6001 8001	4001 6000	2001 4000	1 2000
07-01	7,700	3,344,200	%-43331.17													
				6,680	500	41	2	1	5	15	63	41	55	95	109	73
08-01	1,987,780	5,662,640	%-185.53	11,320	500	36	7	7	15	36	111	41	59	69	61	58
09-01	4,259,100	3,220,410	24.15	6,400	503	42	3	0	6	7	46	40	73	111	104	71
10-01	2,925,110	2,192,670	24.75	4,350	503	45	1	1	1	1	17	24	55	114	151	93
11-01	3,086,220	2,661,250	13.41	5,260	505	39	2	1	2	1	30	38	69	115	128	80
12-01	3,239,790	2,696,250	16.58	5,320	506	43	1	0	2	4	29	30	83	121	122	71
01-02	2,785,470	2,401,390	13.15	4,760	504	41	3	0	1	1	23	18	57	134	147	79
02-02	2,603,220	2,266,210	12.95	4,490	504	39	1	0	3	0	21	23	59	126	144	88
03-02	2,426,120	2,193,750	9.20	4,330	506	37	2	0	1	2	15	20	55	129	150	95
04-02	2,827,670	2,560,790	9.17	5,050	507	40	1	1	1	3	28	30	77	135	111	80
05-02	2,724,530	2,325,360	14.45	4,510	515	43	2	0	1	3	16	31	62	135	129	93
06-02	2,803,960	3,165,670	%-13.32	6,130	516	46	2	1	1	3	64	48	90	95	89	77
07-02	2,994,660	2,873,140	3.84	5,560	516	48	2	1	3	4	37	46	74	107	106	88
08-02	4,147,820	4,038,240	2.39	7,820	516	53	4	3	5	16	85	53	61	94	75	67
09-02	3,571,360	3,674,220	-3.55	7,090	518	53	2	1	5	9	74	51	76	100	75	72
10-02	18,262,390	2,433,930	86.64	4,710	516	53	1	0	2	3	24	31	65	124	125	88
11-02	6,293,460	11,438,190	%-81.99	22,080	518	50	2	0	0	2	35	27	70	131	121	80
12-02	5,114,610	2,149,180	57.90	4,140	518	54	1	0	0	0	16	28	54	126	137	102
01-03	2,644,330	2,215,550	15.72	4,260	519	59	1	0	0	0	17	29	63	139	127	84
02-03	3,009,730	2,688,230	9.67	5,190	517	50	1	0	2	2	31	43	71	130	105	82
03-03	3,405,490	2,119,870	36.96	4,080	519	54	1	1	0	2	13	21	44	115	171	97
04-03	3,984,280	2,512,760	24.76	4,820	521	44	1	0	0	2	34	31	70	127	113	99
05-03	3,779,510	3,133,090	11.79	5,990	523	48	1	0	3	9	57	46	75	106	90	88
06-03	3,423,100	3,035,870	9.95	5,790	524	42	2	1	0	8	58	47	65	122	90	89
07-03	4,393,000	4,327,000	1.16	8,240	525	46	3	1	10	31	87	45	70	84	82	66
08-03	5,324,100	5,990,240	%-12.89	11,400	525	44	8	7	15	33	115	47	51	76	71	58
09-03	4,089,300	3,116,360	22.98	5,910	527	46	2	1	0	9	57	43	72	105	108	84
10-03	3,164,120	2,826,330	10.14	5,350	528	42	1	1	0	6	46	39	72	117	106	98
11-03	3,477,270	2,660,280	23.11	5,030	528	39	1	0	2	4	35	28	69	112	136	102
12-03	2,763,170	2,416,450	12.23	4,560	529	44	2	2	0	2	18	25	57	120	156	103
01-04	3,181,700	3,219,350	-4.30	6,060	531	47	3	1	1	6	68	43	88	117	76	81
02-04	2,892,280	1,786,580	36.54	3,350	532	53	1	0	0	0	16	11	38	94	175	144
03-04	2,526,530	2,075,000	14.79	3,880	534	58	2	0	0	1	13	19	43	120	165	113

85 Month Totals

Total Water Pumped	322,222,740
Total Water Sold	256,285,500
Fire and Line Flushing	2,384,150
Total Water Loss	63,553,090
Water Loss Percentage	19.72%

Monthly Averages

Average Water Pumped	3,790,856
Average Water Sold	3,015,124
Average Fire & Flushing	28,049
Average Loss	747,683
Average Loss Percentage	19.72%
Average Customer Use	6,359

[redacted] Unaccounted for
Water and Meter Count

Month of November

	Days	MG	Notes
Raw Water Metered	30	8.03	
Treated Water Metered	30	7.86	
Filter Backwash Usage		0.17	
Treated Water Sold	29.5	5.96	
Adjusted Water Sold * ** takes into account the time from last meter reading*		6.06	
Total Estimated Water Losses		0.36	
a) Fire Dep't. uses		0.01	
b) flushing		0.08	
c) tank overflows		0	
d) leaks and refilling		0.2	White Rim
e) instrumentation		0.07	
Total Accounted Water ** *** Adjusted water sold + est. water lost*		6.42	
% Unacc. Water	18.31		

Meters billed 1016

City of [redacted] # 1010294

UFW CALCULATIONS

Analysis Period: January 2003 to December 2003

Line	ITEM	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER	MONTHLY AVERAGE (MG)
1.0	Task 1 - Supply													
1.1	610 Avenue A - Surface Water	13,409,400	12,252,100	13,000,000	15,746,000	20,624,500	19,053,800	20,849,200	20,879,200	20,130,700	20,409,400	19,814,100	20,989,800	18,096,517
1.2	Virginia St. Well	0	18,000	0	0	185,000	0	0	0	22,000	0	75,000	0	25,000
1.3	702 Avenue D - Surface Water	0	0	662,100	12,151,300	9,272,500	7,421,900	11,155,700	9,200,100	4,423,500	7,061,500	2,471,800	2,538,000	5,529,867
1.4	9th Street Well	0	0	567,000	0	0	0	102,000	0	0	0	4,000	0	56,083
1.5	7th St./Avenue G - Allen-Genoa Surface Water	16,607,100	15,291,200	16,060,100	6,678,000	1,110,300	60,000	0	1,400	3,343,300	11,141,500	15,368,400	11,552,500	8,101,150
1.6	Allen-Genoa Well	0	17,000	0	0	12,046,000	12,195,000	6,865,000	12,417,000	10,107,000	0	0	3,170,000	4,734,750
1.7	7th St./Avenue G - Texas Surface Water	12,762,300	12,337,100	16,496,600	11,984,300	7,685,900	7,749,200	1,460,100	5,953,500	6,455,500	6,827,100	10,056,700	7,235,700	8,917,000
1.8	Texas Street Well	0	23,000	0	0	0	0	4,386,000	0	0	0	0	0	367,417
1.9	7th St./Avenue J - Nevada Surface Water	9,761,800	5,700	0	0	7,432,100	7,839,800	1,180,800	100	0	100	0	0	2,185,033
1.10	Nevada St. Well	3,911,000	12,781,000	12,372,000	10,186,000	999,000	0	5,713,000	6,977,000	6,157,000	7,480,000	3,125,000	6,094,000	6,316,250
1.11	Total Water Production (sum 1.1 thru 1.10)	56,451,600	52,725,100	59,157,800	56,745,600	59,355,300	54,319,700	51,711,800	55,428,300	50,639,000	52,919,600	50,915,000	51,580,000	54,329,067
1.12	Production Meter Overreads/Reading Errors													(435,300)
1.13	Estimated Surface Water Meter Error (+ or -)													0
1.14	Estimated Well Meter Error (+ or -)													0
1.15	Other Gains or Losses (+ or -)													0
1.16	Total Adjustments to WaterProduction (+ or -)													(435,300)
1.17	Total Adjusted Water Production	56,451,600	52,725,100	59,157,800	56,745,600	59,355,300	54,319,700	51,711,800	55,428,300	50,639,000	52,919,600	50,915,000	51,580,000	53,893,767
2.0	Task 2 - Consumption													
2.1	Total Consumption Billed (Books 1 to 30)	41,599,000	43,176,200	36,367,200	39,189,400	45,595,000	53,192,200	44,813,400	46,777,100	45,809,200	39,306,200	49,297,300	36,142,100	43,438,692
2.2	Total Consumption Billed thru City Accts (Bk 31)	189,600	256,300	197,500	339,600	275,000	270,100	204,300	235,500	225,300	164,900	419,500	302,300	256,658
2.3	Total Un-corrected Consumption Billed (all	41,788,600	43,432,500	36,564,700	39,529,000	45,870,000	53,462,300	45,017,700	47,012,600	46,034,500	39,471,100	49,716,800	36,444,400	43,695,350
2.4	Adjustments for Estimated Consumption & Re-reads. (+ or -)													#DIV/0!
2.5	Total Adjusted Consumption Billed (line 2.3+	41,788,600	43,432,500	36,564,700	39,529,000	45,870,000	53,462,300	45,017,700	47,012,600	46,034,500	39,471,100	49,716,800	36,444,400	#DIV/0!
2.6	*Estimated Meter Error (+ o r-)*													
2.7	Estimated Meter Under-registration - Small Meters													
2.8	Estimated Meter Under-registration - Large Meters (>1")													
2.9	Estimated Meter Under-registration - City Meters (Book 31)													
2.10	Total Estimated Meter Under-registration													
2.11	Total Consumption Allowed (line 2.6 + 2.11)	41,788,600	43,432,500	36,564,700	39,529,000	45,870,000	53,462,300	45,017,700	47,012,600	46,034,500	39,471,100	49,716,800	36,444,400	#DIV/0!

City of [redacted]

JBS Associates, Inc.

UFW CALCULATIONS

alysis Period: January 2003 to December 2003

Lin...	ITEM	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER	MONTHLY AVERAGE (MG)
2.12	**Total Unaccounted for Water (line 1.17 less**	14,663,000	9,292,600	22,593,100	17,216,600	13,485,300	857,400	6,694,100	8,415,700	4,604,500	13,448,500	1,198,200	15,135,600	#DIV/0!
		26.0%	17.6%	38.2%	30.3%	22.7%	1.6%	12.9%	15.2%	9.1%	25.4%	2.4%	29.3%	#DIV/0!
3.0	***Task 3 - Authorized Un-metered Consumption***													
3.1	Fire Hydrant Use (Fire Dept.)													#DIV/0!
3.2	Line Flushing (Leak Repairs) {Water-loss from c	0	255,420	340,560	85,140	170,280	212,850	0	170,280	1,106,820	0	0	85,140	202,208
3.3	Sewer Jetting (1,600 gallons/problem or metered)													#DIV/0!
3.4	Parks & Gardens (Not metered)													0
3.5	Other Unmetered Uses													#DIV/0!
3.6	Construction								6,900					0
3.7	Pressure Tests or Water Quality Problems	60,400	14,800	85,645	33,000	111,570	161,575	119,110	152,110	98,800	182,490	183,040	209,000	117,628
3.8	Total Estimate of Authorized Un-metered							119,110	329,290	1,205,620	182,490	183,040	294,140	385,615
3.9	**Total Adjusted Unaccounted for Water (line 2.12 less 3.8)**	14,663,000	9,292,600	22,593,100	17,216,600	13,485,300	857,400	6,574,990	8,086,410	3,398,880	13,266,010	1,015,160	14,841,460	#DIV/0!
4.0	**Task 4 Identification of Losses by Type**													
4.1	Accounting Errors													0
4.2	Unauthorized Connections (includes "lost" meters)													0
4.3	System Controls Malfunction													0
4.4	Leakage in Elevated Storage Reservoirs													0
4.5	Leakage in Ground Storage Reservoirs													0
4.6	Storage Reservoir Overflow													#DIV/0!
4.7	Evaporation from Storage Reservoirs (no cover at Allen Genoa Tank)													0
4.8	Visible Leaks (Loss rate estimates from repair cr	38,502	485,470	2,298,684	3,053,748	4,300,735	4,092,378	3,869,654	4,035,833	5,624,806	1,165,939	3,251,856	3,508,810	2,977,201
4.9	Water Theft (Contractors, etc.)													0
4.10	**Total of Identified Leakage (sum lines 4.1 a 4.9)**	**38,502**	**485,470**	**2,298,684**	**3,053,748**	**4,300,735**	**4,092,378**	**3,869,654**	**4,035,833**	**5,624,806**	**1,165,939**	**3,251,856**	**3,508,810**	**#DIV/0!**
5.0	**Potential Distribution System Leakage**	**14,624,498**	**8,807,130**	**20,294,416**	**14,162,852**	**9,184,565**	**-3,234,978**	**2,705,336**	**4,050,577**	**-2,225,926**	**12,100,071**	**-2,236,696**	**11,332,650**	7,463,708
5.1	**Total Recoverable Leakage (75%)**	10,968,374	6,605,348	15,220,812	10,622,139	6,888,424	-2,426,234	2,029,002	3,037,933	-1,669,445	9,075,053	-1,677,522	8,499,488	5,597,781
5.2	**% Production due to Recoverable Leakage**	19.4%	12.5%	25.7%	18.7%	11.6%	-4.5%	3.9%	5.5%	-3.3%	17.1%	-3.3%	16.5%	10.4%

City of [redacted]

MONTH YEAR	MINIMUM TAKE OR PAY	MINIMUM MONTHLY TAKE	ACTUAL WATER PURCHASED	ACCOUNT WATER	DIFFERENCE PURCHASED/ACCOUNT	DIFFERENCE TAKE/PURCHASED	NON-ACCOUNT WATER
Oct-02	13,660,013,000	1,138,334,000	1,029,052,000	1,042,735,000	13,683,000	(109,282,000)	12,333,802
Nov-02	12,521,679,000	1,138,334,000	890,830,000	775,530,000	(115,300,000)	(247,504,000)	17,710,736
Dec-02	11,383,345,000	1,138,334,000	752,891,000	670,016,000	(82,875,000)	(385,443,000)	19,140,636
Jan-03	10,245,011,000	1,138,334,000	807,834,000	737,821,000	(70,013,000)	(330,500,000)	1,445,038
Feb-03	9,106,677,000	1,138,334,000	706,268,000	632,526,000	(73,742,000)	(432,066,000)	13,905,277
Mar-03	7,968,343,000	1,138,334,000	824,606,000	698,942,000	(125,664,000)	(313,728,000)	7,114,371
Apr-03	6,830,009,000	1,138,334,000	1,029,033,000	730,717,000	(298,316,000)	(109,301,000)	5,446,581
May-03	5,691,675,000	1,138,334,000	1,210,988,000	931,677,000	(279,311,000)	72,654,000	8,575,551
Jun-03	4,553,341,000	1,138,334,000	1,105,101,000	1,047,774,000	(57,327,000)	(33,233,000)	4,567,580
Jul-03	3,415,007,000	1,138,334,000	1,538,900,000	1,114,577,000	(424,323,000)	400,566,000	10,678,682
Aug-03	2,276,673,000	1,138,334,000	1,893,799,000	1,502,846,000	(390,953,000)	755,465,000	18,958,952
Sep-03	1,138,339,000	1,138,334,000	1,099,529,000	1,438,814,000	339,285,000	(38,805,000)	10,112,092
TOTAL	13,660,013,000	13,660,013,000	12,888,831,000	11,323,975,000	(1,564,856,000)	(771,177,000)	129,989,298
	100%	100%					

* ALL READINGS ARE IN GALLONS

METERED USAGE (NTMWD)	12,888,831,000		
ACCOUNT WATER (SOLD)	11,323,975,000	87.86%	
DIFFERENCE	1,564,856,000	12.14%	
NON-ACCOUNT WATER	129,989,298	1.01%	
* TOTAL NON-ACCOUNT	1,434,866,702	11.13%	TOTAL NON-ACCOUNT %

* SYSTEM LEAKAGE

(1) Damaged Meters
(2) Water Main Breaks
(3) 1,000 to 3,000 Gals Per Mile = 2,000,000 Gals

* AUTHORIZED USES

(1) Fire Protection
(2) New Construction
(3) Line Flushing
(4) Maintenance Flushing
(5) Street Dept Storm Sewer Flushing
(6) Filling Jet Trucks
(7) Semi Annual Fire Hydrant Flushing
(8) T.D.H. Flushing

* SYSTEM WATER LOSES

(1) Vandalism
(2) Jumpers
(3) Unauthorized Fire Hydrant Flushing

[redacted] Water System

Water Consumption Analysis

MONTH: JAN 2003

PUMPED WATER	Well #1	Well #2			
Initial Meter Reading	56992100	63059400	Gallons	(1)	Date: 12-17-02
Final Meter Reading	57125700	64000700	Gallons	(2)	Date: 1-17-02
Pumpage	133,600	911,300	Gallons	(3)	Line 2 - Line 1
Total Pumpage	1,044,900			(3A)	Well #1 + #2
Initial Tank Level	29.0		Ft.	(4)	
Final Tank Level	27.0		Ft.	(5)	
Water Level Change	2.0		Ft.	(6)	Line 4 - Line 5
Vol/Ft.	5,250		Gallons	(7)	
Change in Volume	10,500		Gallons	(8)	Line 7 x Line 6
Net Water Usage	1,055,400		Gallons	(9)	Line 3A+/-Line 8

ANALYSIS:

Total Vol. Water Sold 996,930 (10)

Gallons Lost 58,470 (11) (Line 9 - Line 10)/Line 9)

=(1,055,400 - 996,930)/(1,055,400)

= 5.5 %

[redacted]

City of [redacted]

OPERATIONS & MAINTENANCE REPORT

ESTIMATED WATER LOST THROUGH LEAKS

0 - Meter Leaks at 5 GPM Average 2 HRS
5 GPM X = GPM
GPM X = GPM

0 - ¾" Service Line Leak at 35 GPM
35 GPM X 2 HRS (Estimate)
35 GPM X 120 = 4,200 GPM
4,200 GPM X = GALLONS LOST

0 - 1" Service Line Leak at 45 GPM
45 GPM X 2 HRS (Estimate)
45 GPM X 120 = 5,400 GPM
5,400 GPM X = GALLONS LOST

0- 6" Main Break Leaking an Average of
2 Hrs at 265 GPM
265 GPM X 120 = 31,800 GPM
31,800 GPM X 1 = GALLONS LOST

0 - 8" Main Break Leaking an Average of
55380 GPH X 2 HRS =110,760 GALLONS
110,760 GAL X = GALLONS LOST

0 -12" Main Break Leaking an Average of
2 HRS at 508920 GPH = 1,017,840 GALLONS
1,017,840 GAL X = GALLONS LOST

TOTAL GALLONS LOST THIS PERIOD – GALLONS

TOTAL GALLONS USED BY FIRE DEPARTMENT FOR THIS PERIOD – GAL
TOTAL GALLONS USED BY UTILITY DEPT. FOR SEWER CLEANING – GAL
TOTAL GALLONS USED BY PUBLIC WORKS FOR STREET – GAL

TOTAL GALLONS LOST THIS PERIOD – GALLONS

City of [redacted]

PUBLIC WORKS MONTHLY REPORT

MONTH OF FEBRUARY 2004

TOTAL NUMBER OF CUSTOMERS----------	1538
NEW CONNECTS----------	19
DISCONNECTS----------	27
WATER TAPS----------	
SEWER TAPS----------	
RE-READS OF HIGH & LOW READINGS----------	
DISCONNECTS FOR NON-PAYMENT----------	20
WATER LEAKS----------	5
STOPPED METERS----------	
METER CHANGES----------	
UNSTOPPED SEWER LINES----------	20
NAME OF METER READERS----------	Pete,Bobby,Troy
% OF ERRORS IN READING METERS----------	LESS THAN 1%
MONTHLY RAINFALL----------	
GALLONS TREATED AT WASTEWATER PLANT----------	
TOTAL GALLONS PUMPED FROM WATER WELLS----------	12,425,000
TOTAL GALLONS ACTUALLY BILLED----------	11,419,700
TOTAL GALLONS FOR CITY BUILDINGS, PARKS, ETC.-----	
TOTAL UNACCOUNTABLE WATER----------	1,005,300
(FIRES, FLUSHING, WATER LEAKS, ETC.) 10%for inaccurate meters	100,530
	904,770
WATER MAIN AND DEAD END FLUSHING	26,735
LEAKS	69,360

TOTAL UNACCOUNTABLE WATER(about 7%)	808,675	**(Goal is 15%)**
20% of total gallons pumped from wells is:	2,485,000	

STREETS & DRAINAGE:
Daily Routine (See attached)
BUILDING PERMITS :

WATER AUDIT WORKSHEET

FOR: City of [redacted] AUDIT STUDY PERIOD: Jan - Dec 1999

Line	Item	Subtotal	Water Volume Total Cumulative	Units (Gallons)
Task 1 _ Measure Supply				
1	Uncorrected total water supply to the distribution system (total of master meters)	1,515,014,000		
2 A-C	Adjustments to total water supply			
2A	Source meter error (+ or _)	(5,041,000)		
2B	Change in reservoir and tank storage (+ or -)	0		
2C	Other contributions or losses (+ or -)	0		
3	Total adjustments to total water supply (add lines 2A, 2B, and 2C)		(5,041,000)	
4	Adjusted total water supply to the distribution system (add line 1 and line 3)		1,509,973,000	
Task 2 Measure Metered Use				
5A-C	Uncorrected total metered water use			
5A	Permanent Meters	1,163,643,100		
5B	Contract Meters	15,544,200		
5C	Public Works IWAP	704,480		
6	Total Uncorrected metered water use		1,179,891,780	
6A	Adjustments due to meter reading lag time (+ or -)	2,941,829		
7	Metered deliveries (add lines 5A-C, and 6A)		1,182,833,609	
8A-C	Total sales meter error and sytem service meter errors (+ or -)			
8A	Residential meter error	35,912,506		
8B	Large meter error	9,479,210		
8C	Total (add lines 8A and 8B)		45,391,716	
9	Corrected total metered water deliveries (add lines 7 and 8C)		1,228,225,325	
10	Corrected total unmetered water (subtract line 9 from line 4)		281,747,675	

Water Volume

	Item	Subtotal	Total Cumulative	Units (Gallons)
	Authorized unmetered water uses			
	Firefighting and firefighting training	12,000,000		
11B	Main flushing	1,764,140		
11A-M	Authorized unmetered uses (continued)			
11C	Fire Hydrant Flow Tests	50,000		
11D	Sewer Cleaning			
11E	Street Cleaning			
11F	Schools			
11G	Landscaping in public areas:			
	Parks			
	Golf Courses			
	Cemeteries			
	Playgrounds			
	Highway median strips			
	Other landscaping			
11H	Pump Lubrication	346,896		
11I	Tank Overflows	84,000		
11J	Construction sites	86,239		
11K	Water quality and other testing (pressure testing pipe, water quality, etc.)	3,000		
11L	Process water at treatment plants	20,000		
11M	Other unmetered uses			
12	Total authorized unmetered water (add lines 11A through 11M)		14,354,275	
13	Total water losses (subtract line12 from line 10)		267,393,400	
14A-H	Identified water losses			
14A	Accounting procedure errors			
14B	Illegal connections			
			Water Volume Total	Units

Line	Item	Subtotal	Cumulative	(Gallons)
14C	Malfunctioning distribution system controls			
	Dead meters	3,772,966		
14E	Evaporation			
14A-H	Identified water losses (continued)			
14F	Reservoir overflow	60,000		
14G	Discovered leaks	65,206,080		
14H	Theft	500,000		
15	Total identified water losses (add lines 14A through 14H)		69,539,046	
16	Total Unaccounted For Water (subtract line 15 from line 13)		197,854,354	
17	Recoverable leakage (multiply line 16 by 0.75)		148,390,766	
18	Percent of Water Loss (divide line 16 by line 4)	13.1%		

Line	Item	Dollars per Unit of Volume
19A-B	Cost savings	
	Cost of water supply	
19B	Variable operation and maintenance costs	
20	Total costs per unit of recoverable leakage (add lines 18A and line 18B)	

Line	Item	Dollars per Year
21	One-year benefit from recoverable leakage (multiply line 17 by line 19)	
22	Total benefits from recovered leakage (multiply line 20 by 2)	
23	Total costs of leak detection project	
24	Benefit to cost ratio (divide line 21 by line 22)	

Prepared by:

Name [redacted]

Title Water Production Supervisor Date 03/15/2000

[redacted] WATER SUPPLY CORPORATION
WATER LOSS COMPUTATION

February 20, 2004 through March 19, 2004

	11	22	33		Unit		
	Pump #1	Pump #2	Pump #3	Well#2	Pump#2+Wel	Totals	
+ [redacted] Mtr. Rdg. Tot	**4,573,000**	**642,000**	**463,000**	**297,400**	**939,400**	**5,975,400**	+
[redacted] Billing Register	3,623,630	616,540	393,200	285,500	902,040	4,918,870	
+/- any adjustments					-	2,300	leaks/flushing
- = **Accounted water**	**3,623,630**	**616,540**	**393,200**	**285,500**	**902,040**	**4,921,170**	-
= = **Water loss**	**949,370**	**25,460**	**69,800**	**11,900**	**37,360**	**1,054,230**	=
% Water loss/gain	20.76%	3.97%	15.08%	4.00%	3.98%	17.64%	

Register Routes:
11 - Pump #1
22 - Pump #2
33 - Pump #3

*The following leaks were repaired during this period:

3/9/04 - leak at meter - small loss - PS #2

[redacted] WATER SUPPLY CORPORATION
MONTHLY WATER LOSS SUMMARY
February 20, 2004 through March 19, 2004

Day Read	PUMP 1 (1000)	PUMP 2 (1000)	PUMP 3 (1000)	WELL #2 (100)	HAULERS (100)	Usage Pump #1	Usage Pump #2	Usage Pump #3	Usage Well No.2	GROSS Usage	Adjust./ Gallons Flushed	Net Usage	FYI ADJ. HAULERS	Day Used
20	47305	10361	64762	549583	784									19
21	47482	10380	64780	549675	784	177,000	19,000	18,000	9,200	223,200	-	223,200	-	20
22	47659	10399	64798	549767	784	177,000	19,000	18,000	9,200	223,200	-	223,200	-	21
23	47835	10419	64816	549858	784	176,000	20,000	18,000	9,100	223,100	-	223,100	-	22
24	47991	10438	64826	549957	837	156,000	19,000	10,000	9,900	194,900	-	194,900	5,300	23
25	48121	10464	64844	550078	872	130,000	26,000	18,000	12,100	186,100	-	186,100	3,500	24
26	48251	10478	64862	550146	887	130,000	14,000	18,000	6,800	168,800	-	168,800	1,500	25
27	48390	10492	64862	550203	887	139,000	14,000	-	5,700	158,700	-	158,700	-	26
28	48564	10515	64880	550308	888	174,000	23,000	18,000	10,500	225,500	-	225,500	100	27
29	48738	10538	64898	550413	888	174,000	23,000	18,000	10,500	225,500	-	225,500	-	28
1	48911	10560	64915	550517	888	173,000	22,000	17,000	10,400	222,400	-	222,400	-	29
2	49027	10578	64934	550600	88	116,000	18,000	19,000	8,300	161,300	2,090	159,210	(80,000)	1
3	49194	10603	64952	550708	909	167,000	25,000	18,000	10,800	220,800	-	220,800	82,100	2
4	49382	10634	64974	550845	972	188,000	31,000	22,000	13,700	254,700	-	254,700	6,300	3
5	49544	10665	64992	550987	972	162,000	31,000	18,000	14,200	225,200	-	225,200	-	4
6	49715	10689	65005	551104	972	171,000	24,000	13,000	11,700	219,700	-	219,700	-	5
7	49886	10713	65018	551221	972	171,000	24,000	13,000	11,700	219,700	-	219,700	-	6
8	50057	10738	65030	551339	972	171,000	25,000	12,000	11,800	219,800	-	219,800	-	7
9	50296	10767	65048	551477	973	239,000	29,000	18,000	13,800	299,800	-	299,800	100	8
10	50450	10789	65068	551583	1001	154,000	22,000	20,000	10,600	206,600	-	206,600	2,800	9
11	50605	10812	65088	551690	1029	155,000	23,000	20,000	10,700	208,700	-	208,700	2,800	10
12	50877	10844	65107	551833	1181	272,000	32,000	19,000	14,300	337,300	-	337,300	15,200	11
13	51026	10870	65126	551950	1181	149,000	26,000	19,000	11,700	205,700	-	205,700	-	12
14	51175	10896	65145	552067	1181	149,000	26,000	19,000	11,700	205,700	-	205,700	-	13
15	51323	10923	65163	552183	1181	148,000	27,000	18,000	11,600	204,600	-	204,600	-	14
16	51453	10938	65181	552258	1181	130,000	15,000	18,000	7,500	170,500	-	170,500	-	15
17	51594	10954	65200	552326	1181	141,000	16,000	19,000	6,800	182,800	210	182,590	-	16
18	51713	10980	65201	552445	1181	119,000	26,000	1,000	11,900	157,900	-	157,900	-	17
19	51878	11003	65225	552557	1181	165,000	23,000	24,000	11,200	223,200	-	223,200	-	18
						4,573,000	642,000	463,000	297,400	5,975,400	2,300	5,973,100	39,700	

Note:
Adjustments:

Gross Total 5,975,400
Daily Ave. 213,407

5,975,400 Total
(2,300) Line flush/adjustments*
(4,918,870) Register
1,054,230
17.64

APPENDIX 4: 2004 Municipal Water Loss Survey

TEXAS WATER DEVELOPMENT BOARD

March 1, 2004

Re: Water Loss Survey

Dear Utility Manager:

The Texas Water Development Board (TWDB) has contracted with GDS Associates, Inc. to conduct a water loss survey of public water suppliers in Texas. The survey will gather information and analyze water loss practices from professionals who operate water systems. Your participation is welcome because it will help us to better understand the methodologies and procedures practiced in accounting for water and water loss across the state. We have selected cities of all sizes, water supply corporations, municipal utility districts as well as investor-owned utilities to participate in this important survey.

As you may know, the 78th Texas Legislature passed House Bill 3338 (HB3338) which requires water utilities that provide potable water to file a water audit every five years with the TWDB. Your input would be valuable to the TWDB staff in preparing the water auditing methodologies and guidelines that will eventually be used by water system managers like yourself.

Water system staff who are knowledgeable about accounting for water and water loss activities should complete the survey. GDS Associates, Inc. should be contacted at the numbers provided in the survey form. I would like to thank you for your input and participation in the survey.

Sincerely,

J. Kevin Ward
Executive Administrator

2004 MUNICIPAL WATER LOSS SURVEY

Your utility has been selected among a cross-sectional sample of community water systems within the state of Texas to participate in a water loss survey. This Water Loss Survey is conducted for the Texas Water Development Board by GDS Associates, Inc. to gather specific utility operational and personal perspectives data about water loss within your system. This information and data will assist us in making recommendations to the Texas Water Development Board and will ultimately assist with the development of guidelines and programs pertaining to water loss analysis and water audit reporting.

By completing this survey as accurately as possible we will gain technical data that can be analyzed and specific water use practice information that can be comparatively evaluated. The information you provide in this survey will be used only for the purposes of this data analysis and development of policy recommendations. Your input is key to the future of water availability and conservation in the State of Texas.

This survey is divided into four (4) sections.

Section I: Utility Profile
Information about the utility and the person completing the survey.

Section II: Water Loss Accounting
Information on the utility's current water audit and water loss accounting practices.

Section III: Water Loss Minimization Efforts
Information about the efforts and procedures that are currently practiced to identify and control water loss.

Section IV: Historical Water Management
Specific data about the utility's historical water production and water use.

Section V: Additional Information
Additional information, data, or thoughts you may have on water use planning, losses or conservation.

Please complete and return this survey by 3/31/04. Upon completion please close, fold and staple or tape survey with the return address and postage stamp on the outside. For your convenience this survey can be completed on-line at http://www.gdsassociates.com/twdbwaterlosssurvey. Thank you for your participation and we look forward to receiving your response.

SECTION I
UTILITY PROFILE

Please provide preliminary information about your water utility and the personnel providing survey feedback:

1. **Name of Utility:** _____

2. **Texas Commission on Environmental Quality (TCEQ) Public Water System Identification Number: #** _____

3. **Name of person responding:** _____

4. **Title of person responding:** _____

5. **Phone number where you can be contacted:** _____

6. **Principal county of utility service area:** _____

7. **Current estimated population of utility service area:** _____

8. **Utility service area coverage (sq. mi.):** _____

9. **Utility classification (please check the one structure that best describes your system):**
   - ❑ Municipality
   - ❑ Non-municipal regional system (Authority, River Authority)
   - ❑ Water District (MUD, SUD, FWSD, UD, etc.)
   - ❑ Water Supply Corporation
   - ❑ Investor Owned Utility
   - ❑ Federal, State, or County
   - ❑ Homeowners group
   - ❑ Not a public utility (do not charge rates) serves residential
   - ❑ Non-community

❑ Other _____

10. Please check all that apply:

❑ Retail customers only

❑ Wholesale service only

❑ Retail customers and wholesale service to others that serve retail customers.

11. How many separate water systems do you own or operate? (i.e. distinct PWS Numbers)

❑ Only this one (1)

❑ More than ten (11+)

❑ Two to ten (2 - 10)

12. Supply source, check all that apply:

❑ Surface water

❑ Groundwater

❑ Both surface and groundwater sources

❑ Purchased water from others

13. If you purchase treated water from others, or are part of a regional supply source, please indicate the supplier or suppliers: _____

14. Do you have additional suppliers during emergency demand periods?

- ❑ Yes
- ❑ No

15. If yes, please indicate the supplier or suppliers: _____

SECTION II

WATER LOSS ACCOUNTING

This section focuses on how you currently account for or compare the relative amounts of water "consumed" to that "produced" and calculate what is commonly known as "water loss" or "unaccounted for water."

1. Taking into account your water utility system operations as a whole for the past year, and based on the analysis techniques you currently use to calculate or evaluate "water loss or water use" in your system operating reports, what is your system's "water loss" as a percentage of total water entering the system?

- ❑ Greater than 25%
- ❑ Less than 25% but greater than 20%
- ❑ Less than 20% but greater than 15%
- ❑ Less than 15% but greater than 10%
- ❑ Less than 10% but greater than 5%
- ❑ Less than 5%
- ❑ Do not calculate water loss

2. Do you currently perform a Water Audit or otherwise calculate or perform water loss or water accountability analyses for your water utility system?

- ❑ Yes
- ❑ No
- ❑ Sometimes, but not on an annual basis

3. Is there a special format or worksheet that you use to do this?

- ❑ Yes
- ❑ No, but we do it as part of our operating reports
- ❑ No specific format or worksheet

4. Would you use a standardized water audit worksheet if provided one?

- ❑ Yes
- ❑ No

5. Which of the following best describes the typical water audit or water loss calculation or analysis procedure that you perform to get the figure reported in Question 1 of this section?

- ❑ The difference between total water sales at the customer meters and the total water supplied to the system is the water loss.
- ❑ The water loss is the difference between total water sales plus some other metered or unmetered water uses and the total water supplied to the system.
- ❑ Water loss is based on a detailed water use audit that includes all metered water uses and all other identified water uses.
- ❑ Do not know exactly what is in the water loss calculation

6. Mark all identified water uses other than metered sales to customers, included in your current water use analysis:

- ❑ Fire Department, including either fire fighting or hydrant testing
- ❑ Leaks, estimates of water lost during the leak
- ❑ Routine line flushing
- ❑ Bulk water sales, including construction
- ❑ Municipal uses, such as parks, street medians, sewer or street cleaning
- ❑ In plant uses, storage tank overflows or filter backwash
- ❑ Other water uses: _____
- ❑ None of the above (go to Question 7)

7. For Question 6, if you answered "None of the above," what are the reasons for not including additional water uses in your analysis? If you checked any boxes in Question 6, skip this question.

- ❑ Do not have the time or resources available to collect additional uses
- ❑ Do not have any significant water uses other than metered sales

- ❑ Our billing program only accounts for all metered water uses
- ❑ Do not know how to accurately estimate other water uses

8. In your current water audit or water use analysis procedures, please check all of the following that you calculate or otherwise review:

- ❑ Water use and water loss broken out by individual pressure zones
- ❑ Water use and water loss by different classes of customers (i.e. residential, commercial, industrial, or other)
- ❑ Water use or water loss by different geographical zones or areas
- ❑ Water use or water loss by night flows (by districts or zones)
- ❑ Water use or water loss by seasonal periods
- ❑ Water loss on a per unit (per foot, mile, etc.) of distribution system
- ❑ Only the system as a whole
- ❑ None of the above

9. After you have done the system water use calculations or analysis, how do you use the results?

- ❑ Compare to past results to see if they are better or worse than in past periods
- ❑ Compare the results to general benchmarks for % water loss
- ❑ Just enter them into the records
- ❑ None of the above

10. Do you think that your current method of calculating water loss fairly and accurately reflects the amount of "water loss" in the system?

- ❑ Yes
- ❑ No
- ❑ Do not know

11. Check all of the training or other resources that you use or have relied on for information and procedures for determining and evaluating water loss and water use information:

- ❑ American Water Works Association (AWWA) manuals (M36 or others) and publications
- ❑ Texas Water Development Board (TWDB) manuals and publications
- ❑ Workshops and training sessions from Texas Engineering Extension Service (TEEX), Texas Rural Water Association (TRWA), or Texas Water Development Board (TWDB)
- ❑ AWWA Water Loss Committee Report 2003
- ❑ Basic knowledge gained over the years
- ❑ Other _____

12. Please briefly describe the procedures that you use to calculate or determine water loss and water use (If you need additional space, please attach):

13. Please attach a copy of the typical water loss accounting documents or worksheets that are used for calculation of water use.

SECTION III

WATER LOSS MINIMIZATION EFFORTS

This section focuses on gathering information about your water loss maintenance efforts. It takes into account your efforts to reduce water loss through such practices as leak detection, system repairs and water accounting procedures.

1. Which of the following best describes your utility's Leak Detection and Repair Program?

- ❑ Periodic system surveys where we check for visible leaks
- ❑ Leaks are fixed when discovered by us or reported by customers.
- ❑ A Leak Detection Program that includes use of detection equipment, flow measurement, or other means of proactively looking for non-visible leaks
- ❑ Other not listed: _____

2. Please mark all that apply to your use of leak detection equipment; for example, listening microphones, sonic devices, correlators, or other equipment incorporated into your system to detect leaks.

- ❑ We own our own leak detection equipment and use it as needed.
- ❑ We rent or borrow leak detection equipment from TWDB or other sources and use it ourselves.
- ❑ We contract with a professional leak detection firm to do leak detection on our system using specialized equipment.
- ❑ The TWDB (or other agency) came out and trained us to use leak detection equipment to survey our system.
- ❑ We used the free leak detection equipment available from the TWDB.
- ❑ We do some flow tests, but no mechanical or electronic equipment is used.
- ❑ We have not performed any specialized leak detection with equipment or flow testing to identify leaks.
- ❑ Other _____

3. If you responded to the question above that you have used mechanical or electronic leak detection equipment at least once, what best describes the reason(s) for using the equipment:

- ❑ Each year, we survey a portion of the water distribution system to locate leaks

- ❑ Leak detection equipment is only used when there is a known leak that couldn't be found otherwise.
- ❑ We use leak detection equipment to pinpoint leak locations before digging.
- ❑ We have had a formal leak detection survey done at least once.

4. Does your utility have any specific programs or procedures where you fix leaks on the customer service lines?

- ❑ Yes
- ❑ No

5. If you marked yes to Question 4, please indicate what specific procedures you have in place to monitor and manage leaks on the customer service laterals**.**

_____

6. Please check all other water loss control measures that you currently implement in your ongoing operations:

- ❑ Systematic distribution line replacements or rehabilitation (before major problems occur)
- ❑ Pressure management to reduce volumes of loss
- ❑ Search for and enforce against illegal and unmetered connections
- ❑ Leak or pressure analysis through hydraulic modeling
- ❑ Other not listed _____

7. With regard to meters at the plants and within the system, do you currently have:

- ❑ Regular meter calibration and testing at the treatment facilities (including well meters if a groundwater user)
- ❑ Periodic customer meter replacement programs

8. Do you keep an organized leak repair log, and if so, mark all that is included?

- ❑ Pin or marked maps that visually show problem areas
- ❑ Classify leaks based on size and location
- ❑ Nature and cause of leak

- ❑ Pipe material and replacement parts
- ❑ Estimate of water lost during repair
- ❑ Do not have a leak log or keep specific repair records
- ❑ Other information _____

9. Total length of distribution lines (in feet or miles, indicate which), not counting service laterals:

- ❑ Lines less than 6 inch diameter _____
- ❑ 6 inch and 8 inch diameter _____
- ❑ 10 inch and 12 inch diameter _____
- ❑ 14 inch through 24 inch diameter _____
- ❑ greater than 24 inch up through 36 inch diameter _____
- ❑ greater than 36 inch diameter _____

10. Please indicate the major types of pipe material in distribution system and indicate if possible the approximate percentage of each:

- ❑ Cast or ductile iron, approximately _____ % of system
- ❑ PVC, approximately _____ % of system
- ❑ Galvanized steel, approximately _____ % of system
- ❑ Concrete (including lined), approximately _____ % of system
- ❑ Other, please describe _____, approximately _____ % of system

11. Typical age of materials

- ❑ 10 years or less, approximately _____ % of system (0-10)
- ❑ 11 to 20 years, approximately _____ % of system (11-20)
- ❑ 21 to 30 years, approximately _____ % of system (21-30)
- ❑ 31 to 40 years, approximately _____ % of system (31-40)
- ❑ Older than 40 years, approximately _____% of system (41+)

12. What is the average time it takes to fix a large leak on a main line after it is reported or found?

- ❑ Less than one day (1)
- ❑ Two to Seven days (2-7)
- ❑ More than one week (8 or more)

13. What is the average time it takes to fix a small leak at a valve or service line after it is reported or found?

- ❑ Less than one day (1)
- ❑ Two to seven days (2-7)
- ❑ One week to one month (8-30)
- ❑ More than one month but less than three months (31-90)
- ❑ Three months or more (91+)

14. Do you have one or more full time crews dedicated to locating and repairing leaks?

- ❑ Yes If yes, how many?_____
- ❑ No

SECTION IV
HISTORICAL WATER USE MANAGEMENT

This section is to collect more specific information about your utility characteristics.

1. Please indicate the size category based on the number of active retail meter accounts:

- ❑ Residential and small commercial, 5/8 or ¾ inch, _____
- ❑ 1 inch _____
- ❑ 1 ½ inch _____
- ❑ 2 inch _____
- ❑ 4 inch _____
- ❑ 6 inch or greater _____
- ❑ Separate Irrigation Meters _____

2. Are any of the following included in the connections listed in Question 1? Check all that apply:

- ❑ Master meter for submetered residential facilities
- ❑ Wholesale service
- ❑ Major institutional or industrial service

3. How often do you replace residential meters?

- ❑ Only when the meters stop working or the billing system identifies a significant meter malfunction.
- ❑ On a set schedule such as every ten years
- ❑ When a set water volume has gone through the meter
- ❑ Other, please describe _____

4. What is the average age of residential meters?

- ❑ Less than five years (<5)
- ❑ Five to nine years (5–9)

- ❑ Ten to twenty years (10-20)
- ❑ More than twenty years (>20)
- ❑ Do not know the average age

5. Do you meter private fire lines in your system?

- ❑ We meter all fire lines
- ❑ We meter only new fire lines
- ❑ No, we don't meter fire lines
- ❑ We don't have private fire lines

6. Number of distinct Pressure Zones within the distribution system:

- ❑ Just One (1)
- ❑ Two (2)
- ❑ Three or more (3+)

7. If more than one, is each Pressure Zone separately metered:

- ❑ Yes
- ❑ No

8. What are the average System Pressures or Pressure Ranges (in psi) in each pressure zone that the system is operated under: _____

9. For the calendar year of 2003 or a typical recent 12 month period, please provide the following information, as it is compiled and available, that gives a good representation of the water use and water loss within your system.

Time period from _____ to _____.

Total water supplied (include all sources):_____

Total water billed through metered consumption: _____

Unmetered billed consumption: _____

Other known and authorized estimated or metered consumption (Fire Dept., flushing, etc.) _____:

Note: If you already have this information in another format such as worksheets, spreadsheets, or water audit reports, you may attach that information instead of filling in the blanks above. Please staple additional information inside the survey when closing.

This concludes the formal survey on water loss and water accountability. If you have additional comments or information that you believe are pertinent to the evaluation of your system or water loss in general, please use the following section for such comments or data. Once again, thank you for your participation.

Note: Randomly selected systems will be contacted prior to 03/26/2004 by project staff to provide assistance, however if you require assistance and you have not been contacted by that date please contact GDS Associates at (512) 494-0369 for questions or clarification.

SECTION V - ADDITIONAL COMMENTS OR INFORMATION

Please feel free to provide any comments or additional information on specific topics asked about this survey, or in general about your water loss accounting and related programs.

APPENDIX 5: List of Respondents

LIST OF RESPONDING UTILITIES

Managers or staff from the following Texas public water systems completed and submitted surveys in response to the survey that was mailed in the Spring of 2004. 960 surveys were mailed and --- were returned due to deficient address or other similar problems. Of the total of 300 responses 272 returned the survey by mail and 28 used the online option. Some utilities submitted a survey by mail and a water audit worksheet by e-mail.

PUBLIC WATER UTILITY	COUNTY	RWPG	2003 POP
Addicks Utility District	Harris	H	2,271
Alto Rural WSC	Cherokee	I	3,678
Angelina WSC	Angelina	I	3,000
Armstrong WSC	Bell	G	1,935
Austin Water Utility	Travis	K	718,612
Bacliff Mud	Galveston	H	7,140
BBS WSC	Anderson	I	1,059
Bethany WSC	Johnson	G	3,588
Bethel Ash WSC	Henderson	C	4,236
Bistone Municipal Water Supply	Limestone	G	4,893
BMWD Bulverde Hills	Comal	L	840
BMWD Hill County	Bexar	L	22,830
BMWD Timberwood Park	Bexar	L	5,475
Bright Star Salem WSC	Wood	D	4,398
Buchanan Lake Village	Llano	K	636
Chalk Hill SUD	Rusk	I	3,393
City of Addison	Dallas	C	14,166
City of Alamo Heights	Bexar	L	10,193
City of Albany	Shackelford	F	2,010

PUBLIC WATER UTILITY	COUNTY	RWPG	2003 POP
City of Allen	Collin	C	62,350
City of Alto	Cherokee	I	1,710
City of Amarillo	Randall, Potter	A	129,600
City of Anthony	El Paso	E	3,800
City of Arlington	Tarrant	C	350,000
City of Arp	Smith	I	1,446
City of Barstow	Ward	F	639
City of Baytown	Harris, Chambers	H	70,850
City of Beaumont	Jefferson	I	113,866
City of Beckville	Pinola	F	1,116
City of Bertram	Burnet	K	1,914
City of Brazoria	Brazoria	H	3,864
City of Breckenridge	Stephens	G	5,868
City of Brenham	Washington	G	1,200
City of Bruceville	McLennan	M	4,740
City of Bryan	Brazos	G	65,000
City of Bullard	Smith	I	1,860
City of Callisburg	Coke	F	1,461
City of Carrollton	Dallas, Denton	C	111,800
City of Centerville	Leon	H	992
City of Cleburne	Johnson	G	26,000
City of Cleveland	Liberty	H	7,271
City of Conroe	Montgomery	H	36,811
City of Copperas Cove	Coryell	G	33,302
City of Corpus Christi	Nueces	N	270,000
City of Corsicana	Navarro	I	24,485
City of Covington	Hill	G	500

PUBLIC WATER UTILITY	COUNTY	RWPG	2003 POP
City of Crandall	Kaufman	C	3,201
City of Deer Park	Harris	H	28,520
City of Delhart	Dallas	A	7,200
City of Denton	Denton	C	87,227
City of Devine	Medina	L	5,193
City of Dilley	Frio	L	5,633
City of Dorchester	Grayson	C	1,320
City of Dumas	Moore	A	13,747
City of East Tawakoni	Rains	D	775
City of Edna	Jackson	P	6,600
City of Farmers Branch	Dallas	C	27,908
City of Farwell	Parmer	O	1,395
City of Floydada	Floyd	O	3,890
City of Friendswood	Galveston	H	32,000
City of Galveston	Galveston	H	69,000
City of Garland	Dallas	C	209,030
City of Giddings	Lee	G	6,006
City of Goliad	Goliad	L	1,998
City of Gorman	Eastland	G	1,100
City of Grand Prairie	Dallas	C	127,427
City of Grapeland	Houston	I	2,778
City of Grapevine	Tarrant	C	42,298
City of Greenville	Hunt	D	24,336
City of Groveton	Trinity	H	2,394
City of Gunter	Grayson	C	1,018
City of Hamilton	Hamilton	G	2,937
City of Happy	Swisher	O	647

PUBLIC WATER UTILITY	COUNTY	RWPG	2003 POP
City of Haskell	Haskell	G	3,349
City of Heath	Rockwall	C	4,149
City of Henderson	Rusk	I	11,191
City of Honey Grove	Fannin	C	2,325
City of Hughes Springs	Cass	D	1,965
City of Humble	Harris	H	14,579
City of Huxley	Shelby	I	2,166
City of Italy	Ellis	E	1,799
City of Jacksonville	Cherokee	I	9,987
City of Kaufman	Kaufman	C	6,450
City of Kemp	Kaufman	C	2,403
City of Kendleton	Fort Bend	H	606
City of Kilgore	Gregg	D	11,555
City of Killeen	Bell	G	84,488
City of Kingsville	Kleberg	N	34,575
City of Knox City	Knox	G	1,440
City of La Porte	Harris	H	31,880
City of Lake Jackson	Brazoria	H	25,515
City of Lampasas	Lampasas	G	7,215
City of LaVernia	Wilson	L	1,599
City of Lednard	Fannin	C	2,478
City of Lewisville	Denton	C	83,198
City of Live Oak	Bexar	L	8,886
City of Lockney	Floyd	O	2,000
City of Longview	Gregg	D	77,271
City of Lorenzo	Crosby	O	1,400

PUBLIC WATER UTILITY	COUNTY	RWPG	2003 POP
City of Lubbock	Lubbock	O	201,855
City of Magnolia	Montgomery	H	2,964
City of Manor	Travis	K	1,410
City of Marshall	Harrison	D	22,860
City of Meadows Place	Fort Bend	H	5,064
City of Melissa	Collin	C	1,236
City of Mexia	Limestone	G	6,978
City of Miami	Roberts	A	600
City of Midland	Midland	F	98,045
City of Midlothian (Ellis Co.)	Ellis	E	8,000
City of Nacogdoches	Nacogdoches	I	29,914
City of New Waverly	Walker	H	1,569
City of Nocona	Montague	B	3,198
City of North Richland Hills	Tarrant	O	56,250
City of Odem	San Patricio	N	2,900
City of Panorama Village	Montgomery	H	2,946
City of Paris	Lamar	D	28,103
City of Pearland	Brazoria	H	38,121
City of Pearsall	Frio	L	8,732
City of Pharr	Hidalgo	M	46,660
City of Plainview	Hale	O	20,000
City of Plano	Couin	C	237,000
City of Post	Garza	O	3,708
City of Quitman	Wood	D	2,024
City of Ralls	Crosby	O	2,100
City of Rankin	Upton	F	800

PUBLIC WATER UTILITY	COUNTY	RWPG	2003 POP
City of Richardson	Dallas, Collin	C	92,300
City of Richland Hills	Tarrant	C	8,132
City of Richwood	Brazoria	H	2,732
City of Rockdale	Milam	G	5,425
City of Rockport	Aransas	N	21,033
City of Sadler	Grayson	C	500
City of San Angelo	Tom Green	F	79,980
City of San Marcos	Hays	L	41,700
City of Schulenburg	Fayette	K	2,455
City of Seymour	Baylor	B	2,896
City of Shavano Park	Bexar	L	2,040
City of Sherman	Grayson	C	35,082
City of Sonora	Sutton	G	2,808
City of South Houston	Harris	H	12,798
City of Sterling	Sterling	G	1,109
City of Sugarland	Ft. Bend	H	25,482
City of Sulphur Springs	Hopkins	D	8,211
City of Taylor	Williamson	G	13,575
City of the Colony	Denton	C	26,531
City of Thornton	Limestone	G	540
City of Trent	Taylor	G	618
City of Tye	Taylor	G	1,100
City of Uvalde	Uvalde	L	16,092
City of Van	Van Zandt	D	3,373
City of Vega	Oldham	A	936
City of Victoria	Victoria	L	63,435

PUBLIC WATER UTILITY	COUNTY	RWPG	2003 POP
City of Waskom	Harrison	D	1,450
City of West Columbia	Brazoria	H	4,400
City of White Settlement	Tarrant	C	14,862
City of Whitesboro	Grayson	C	3,760
City of Wichita Falls	Wichita	B	108,888
City of Winnsboro	Wood	D	3,584
City of Winters	Runnels	F	3,200
City of Woodway	McLennan	M	8,695
City of Yoakum	DeWitt, Lavaca	L	6,450
City or Ore City	Upshur	D	1,650
Coke County WSC	Coke	F	550
Combine WSC	Kaufman	C	2,600
Combined Consumers WSC	Hunt	D	8,781
Community WSC	Tarrant	C	3,510
Coolcrest Water System	Bexar	L	867
County Line WSC	Hays	L	2,337
Creedmoor Maha WSC	Travis, Caldwell, Hays, Bastrop	L	8,000
Crest Water Co	Johnson	G	2,667
Crosby MUD	Harris	H	3,162
Crowley Municipality	Tarrant	C	8,499
Crystal Systems Inc	Smith	I	5,196
CY Champ PUD	Harris	H	6,447
Cypress Springs SUD	Franklin	D	10,758
Dallas Water Utility	Dallas	C	1,188,580
Denton County FWSD 7	Denton	C	550
Desert WSC	Grayson, Collin, Fannin	C	1,446
Dialville Oakland WSC	Cherokee	I	825

PUBLIC WATER UTILITY	COUNTY	RWPG	2003 POP
Dog Ridge WSC	Bell	G	4,737
East Bell WSC	Bell	G	3,045
East Garrett WSC	Ellis	E	1,200
East Montana Water System	El Paso	E	4,203
Edom WSC	Van Zandt	D	1,359
El Paso County Tornillo Wa Imprv Dist	El Paso	E	3,176
Enloe Lake Creek WSC	Delta	D	510
Flo Community WSC	Leon	H	3,828
Fort Bend County WCID No. 2	Fort Bend	H	23,718
Frognot WSC	Collin, Hunt	C	1,500
G & W WSC	Grimes, Waller	G	2,022
Galveston County MUD 12	Galveston	H	3,900
Garfield WSC	Travis	K	1,527
Gaston WSC	Rusk	I	1,650
Glidden FWSD # 1	Colorado	K	636
G-M WSC	Sabine	I	9,924
Golden WSC	Wood	D	3,453
Gonzales County WSC	Gonzales	L	6,156
Goodfellow Air Force Base	Tom Green	F	4,816
Grey Forest Water System	Bexar	L	564
Groom Municipal Water System	Carson	A	610
Gum Creek WSC	Cherokee	I	1,269
Gum Springs WSC	Harrison	D	7,200
H & H WSC	McLennan	M	1,455
Haciendas Del Norte WID	El Paso	E	693
Hamby WSC	Taylor	G	1,500
Hardin WSC	Liberty	H	4,224

PUBLIC WATER UTILITY	COUNTY	RWPG	2003 POP
Harris County FWSD 47	Harris	H	4,377
Harris County MUD 53	Harris	H	12,183
Harris County MUD No. 264	Harris	H	3,759
Harris County WCID 50	Harris	H	3,003
Harris County WCID 99	Harris	H	1,506
Highland Utilities	Burnett	K	735
Houston Public Utilities	Harris	H	2,700,000
Jarrell Schwertner WSC	Williamson	G	3,429
Jefferson County WSCID 10	Jefferson	I	5,500
Jonestown WSC	Travis	K	2,889
La Joya WSC	Hidalgo	M	30,066
Lakeside WSC	Tyler	I	1,092
Lakeway MUD	Travis	K	8,002
Libby WSC	Nacogdoches	I	513
Liberty City WSC.	Gregg	D	4,725
Lilly Grove SUD	Nacogdoches	I	2,475
Lost Creek MUD	Travis	K	4,260
Luella WSC	Grayson	C	2,420
MacBee SUD	Van Zandt	D	6,045
Markham MUD	Matagorda	K	1,188
Meeker MWD	Jefferson	I	3,117
Mexia State School	Limestone	G	1,575
Montgomery County WC & ID #1	Montgomery	H	3,192
Mount Enterprise WSC	Rusk	I	1,905
Mount Houston Road MUD	Harris	H	1,308

PUBLIC WATER UTILITY	COUNTY	RWPG	2003 POP
Mount Zion WSC	Rockwall	C	2,061
MS WSC	McLennan	M	642
NAS JRB FORT WORTH	Tarrant	C	3,000
Neches WSC	Anderson	I	1,809
New Prospect WSC	Rusk	I	1,320
Nicona Hills WSC	Montague	B	700
North Hardin WSC	Hardin	I	6,700
North Runnels WSC	Runnels, Taylor	F	1,500
North Rural WSC	Palo Pinto, Parker	G	2,700
Oak Village North	Comal	L	1,806
Oenaville & Belfalls WSC	Bell	G	525
Old Highway 90 Water System	Medina	L	615
Orangefield Water Supply	Orangefield	I	3,618
Pecos County WCID 1	Pecos	F	2,860
Pendleton WSC	Bell	G	2,400
Pleasant Springs WSC	Anderson	I	780
Ponderosa Western Village WSC	El Paso	E	894
Recklaw WSC	Cherokee, Rusk	I	576
Red River Authority of Texas	Cottle	B	650
Ricardo WSC	Kleberg	N	2,200
Richland SUD	San Saba, McCulloch	K	1,934
Rio Brazos WSC	Parker	C	726
Robertson County WSC	Robertson	G	2,594
Rockett SUD	Ellis	E	24,975
Sacul WSC	Rusk, Nacogdoches	I	534

PUBLIC WATER UTILITY	COUNTY	RWPG	2003 POP
Salado WSC	Bell	G	4,215
San Antonio Water System	Bexar	L	1,219,113
Shackelford WSC	Shackelford	G	1,900
Shirley WSC	Hopkins	D	1,950
Skellytown Municipal Water System	Carson	A	664
South Ellis County WSC	Ellis	E	1,161
South Sabine WSC	Sabine	I	2,286
South Texas Water Authority	Kleberg, Nueces	N	750
Spring Creek Valley Estates	Harris, Montgomery	H	651
Staples Farmers Corp	Guadalupe	L	615
Tarkington SUD	Liberty	H	2,745
TDCJ Hughes Unit	Coryell	G	3,293
TDCJID Chase Alberti Unit	Bee	N	4,639
Terrell County WCID 1	Terrell	E	950
Texas AM University Kingsville	Kleberg	N	5,500
Texas State Technical College	Mc Lennan	M	5,195
The Oaks WSC	Bexar	L	1,095
Town of Highland Park	Dallas	C	9,000
Town of Ponder	Denton	C	1,485
Town of Ransom Canyon	Lubbock	O	1,100
Town of Woodlock	Montgomery	H	735
Travis County WCID 10	Travis	K	7,953
Tri County SUD	Falls	G	4,350
Trinity Bay Conservation District	Chambers	H	10,701
Trophy Club MUD	Denton	C	7,860

PUBLIC WATER UTILITY	COUNTY	RWPG	2003 POP
Twin Creek WSC	Robertson	L	1,977
Two Way WSC	Grayson	C	3,095
Virginia Hills WSC	Henderson	C	3,195
Waller Country Club Estates	Waller	H	507
Walnut Creek SUD	Parker, Wise	C	14,170
Washington County Railroad	Montgomery	H	516
Waskom Rural WSC	Harrison	D	750
Webb County Water Utilities	Webb	M	5,905
West Gregg SUD	Gregg	D	3,816
West Harrison WSC	Harrison	D	675
West Medina WSC	Medina	L	816
West TX State School TX Youth Comm	Ward	F	548
Westbound WSC	Eastland	G	1,489
Wildwood Resort City	Tyler, Hardin	I	1,377
Woodbine WSC	Cooke	C	4,935
Woodlake Josserand WSC	Trinity	H	759
Woodrow Osceola WSC	Hill	G	3,462
Wright City WSC 1	Smith	I	1,140
Yancey WSC	Medina	L	4,878

APPENDIX 6: Status of AWWA Water Loss Committee

Current Development in the Adoption of the International Water Association's Water Audit Methodology in North America.

1. The American Water Works Association (AWWA) Water Loss Control Committee issued its significant committee report "Applying World-wide Best Management Practices in Water Loss Control" in *Journal AWWA* in August 2003. The report is notable in that it advocates the use of the International Water Association (IWA)/AWWA water audit methodology and progressive loss control techniques implemented internationally in recent years.

2. The AWWA Water Loss Control Committee continues to conduct the rewrite of the M36 publication, *Water Audits and Leak Detection*. Rewriting and editing work are roughly 60% complete with the new manual in print likely in late 2005. Mary Ann Dickinson, Lisa Maddaus and Amy Vickers from the AWWA Water Conservation Division were added to the M36 sub-committee in June to build a wide consensus on the manual content. As of January 2005, the rewriting of the M36 continues but it will probably be June before the final draft is complete, publication hoped for by in mid-2006.

3. Various water utilities are adopting the new methods mentioned above. Notable in this regard, however, is that the American Water Works Service Company has embraced these methods as a corporate mandate.

4. The California Urban Water Conservation Council is actively reviewing the use of the above methods in revising one or more of it best management practices.

5. The project "Evaluating Water Loss and Planning Loss Reduction Strategies" (#2811), coordinated by the American Water Works Association Research Foundation (AWWARF), is in the final approval phase with the report likely out in early 2005. This research also finds that the IWA/AWWA water audit methodology offers the most rational approach to drinking water system auditing.

6. The AWWARF project (#2928) "Leakage Management Technologies" launched in midyear of 2004 and will pilot innovative leakage management techniques in the North American setting. This will include the establishment of permanent District Metered Areas with leakage measurement and pressure control capabilities. A number of large water utilities are involved, including: Philadelphia Water Department, Halifax Regional Water Commission, Seattle Public Utilities, Dallas Water Utilities, Birmingham Water Works Board, Arizona-American Water Company, El Dorado Irrigation District, Metropolitan Domestic Water Improvement

District and Community Water Company of Green Valley. It will be 2006-2007 before a final report is issued on this project.

7. Besides Texas, a growing number of state and regional agencies now have interest in improving accountability and managing losses in drinking water systems including the Washington State Dept. of Health, Maryland Dept of the Environment, as well as the Delaware River Basin Commission.

8. A number of utilities in North America have already conducted one or more IWA audits including Halifax, Nova Scotia; Kansas City, Missouri; Nashville; Orlando; Asheville, North Carolina; and Fort Worth. Many other utilities including Los Angeles and San Antonio are initiating studies using IWA water audit methodology. The Metropolitan North Georgia Water Planning District's Water Supply and Water Conservation Management Plan includes elements from the IWA/AWWA method and new loss control techniques.

9. Water Audit Software: The Water Loss Control Committee is in the process of developing a very basic, user-friendly water audit software package (IWA/AWWA method) that will be available and downloadable from the AWWA website for free. The committee hopes to have this tested and available by June 2005. The software will align with the proposed new M36 content, but will be a separate instrument.

APPENDIX 7: Best Management Practice: System Water Audit and Water Loss

From:

Texas Water Development Board
Report 362
Water Conservation Implementation Task Force
Best Management Practices Guide
November 2004

2.1 System Water Audit and Water Loss

A. Applicability

This BMP is intended for all Municipal Water User Groups ("utility"). This BMP should be considered by a utility that

1) would like to analyze the benefits of reducing its unaccounted for water,
2) has not conducted a periodic water audit,
3) wants to determine if under-registering meters is impacting its revenues, or
4) has not implemented a leak reduction program.

To maximize the benefits of this BMP, the utility uses the information from the water audit to revise meter testing and repair practices, reduce unauthorized water use, improve accounting for authorized but unbilled water and implement effective water loss management strategies. HB 3338 only requires a water utility to conduct a water audit every five years. By adopting this BMP, a utility will be implementing a more frequent implementation of water auditing and loss reduction techniques than required by HB 3338. Small utilities may want to use parts of this BMP, without following every step.

B. Description

System Water Audits and Water Loss Programs are effective methods of accounting for all water usage by a utility within its service area. Performing a reliable water audit is the foundation of proper water resource management and loss control in public drinking water systems. There has been much recent interest in revising and developing water audit procedures to move away from simply considering "unaccounted for water" to a systematic methodology of accounting for all water uses. The structured approach of a water audit allows a utility to reliably track water uses and provide the information to address unnecessary water and revenue losses. The resulting information from a water audit will be valuable in setting performance indicators and in setting goals and priorities for cost-effectively reducing water losses.

Compiling a water audit is a two-step approach, a top-down audit followed by a bottom-up audit. The first step, the top-down audit, is a desktop audit using existing records and some estimation to provide an overall picture of water losses. For those utilities that gather the information necessary to fill in the Texas Commission on Environmental Quality's Utility Profile, (http://www.tnrcc.state.tx.us/permitting/forms/10218.pdf) that information is the first step of a top-down audit. If a utility has been conducting a water audit using the American Water Works Association ("AWWA") M36 Manual, the utility will already have the data needed to complete the first step of this audit. The records that will be needed include quantity of water entering the system, customer billing summaries, leak repair summaries, average pressures, meter accuracy test, meter change-out summary, permitted fire hydrant use, and other records that may be kept on water theft and unmetered uses such as street cleaning. AWWA is currently revising the M36 Manual, which will provide additional guidance on implementing this BMP. TWDB will also be

publishing a report on HB 3338, which will have information that will assist in implementing this BMP.

The second step of the audit, the bottom-up approach, involves a detailed investigation into actual policies and practices of the utility. This part of the audit is phased in over several years. There are several areas to be addressed including development of better estimates of water use by the fire department, water used in line flushing and street cleaning, and metering of all authorized uses. The procedures of the detailed water audit also include using night flow and zonal analysis to better estimate leakage; analysis of leakage repair records for length of time from reporting to repair of the leak; and analyzing pressure throughout the system.

Several indicators from the analyses in a water audit should be considered by utilities in order to improve water loss control procedures. These include:

1) Real losses:
   Losses due to leakage and excess system pressure. Real losses can be reduced by more efficient leakage management, improved response time to repair leaks, improved pressure management and level control, and improved system maintenance, replacement, and rehabilitation. The cost of real losses is estimated using the marginal production costs, such as energy and chemicals needed to treat and deliver the water.
2) Apparent losses:
   Losses due to meter accuracy error, data transfer errors between meter and archives, data analysis errors between archived data and data used for billing/water balance, and unauthorized consumption including theft. The cost of apparent losses is estimated using the retail commodity rates.
3) Unavoidable Annual Real Losses ("UARL"):
   This represents the theoretically low level of annual real losses in millions of gallons daily ("MGD") that could exist in a system if the current best management practices for leak management are successfully implemented. It is based on data obtained from systems where effective leakage management was implemented. The calculation of the UARL is based on number of miles of water mains, number of service connections, average water pressure, and length of service connections. The UARL is allocated to service lines and water mains. The revised AWWA M36 Manual will provide details on how to calculate unavoidable annual real losses.
4) Infrastructure Leakage Index ("ILI"):
   Ratio of annual real losses divided by UARL. The ILI provides a ratio of current leakage relative to the best level obtainable with current best management practices for leakage. A ratio of 1.0 would indicate that the utility has reduced losses to the theoretically lowest level possible.
5) Economic Level of Leakage ("ELL"):
   This is a calculation based on the cost of reducing leakage. It is the theoretical level at which the cost of leakage reduction meets the cost of the water saved through leakage reduction. These costs include not only the cost of producing water but also the avoided cost of replacing the water.

In order to reduce water losses due to leakage, a utility should maintain a proactive Water Loss Program. A structured approach to leakage management has proven to be successful in limiting losses. Potential elements of an active Water Loss Program include:

1) Conducting regular inspections and soundings of all water main fittings and connections;
2) Using a water loss modeling program. A model can range from the AWWA M36 Manual Water Audit Spreadsheet to a commercially available statistical model;
3) Metering individual pressure zones;
4) Establishing district metering areas ("DMA") and measuring daily, weekly or monthly flows with portable or permanently installed metering equipment;
5) Continuous or intermittent night-flow measurement;
6) Installing temporary or permanent leak noise detectors and loggers;
7) Reducing repair time on leaks since long-running small to medium size leaks can be the greatest volume of annual leakage;
8) Controlling pressure just above the utility's standard-of-service level taking into account fire requirements outdoor seasonal demand and requisite tank filling;
9) Operating pressure zones based on topography;
10) Limiting surges in pressure; and
11) Reducing pressure seasonally and/or where feasible to reduce losses from background leaks.

If a utility has not had regular leak surveys performed it will probably need at least three leak surveys performed in consecutive years or every other year for these reasons:

1) The first survey will uncover leaks that have been running for a long time;
2) The second survey will uncover additional long-running leaks whose sounds were masked by larger nearby leaks; and
3) By the third survey, the level of new leaks should start to approximate the level of new reported leaks.

The utility should make every effort to inform customers when leaks exist on the customer side of the meter. If customer service line leaks are significant, a utility might consider the option of making the repairs itself.

The utility should reduce apparent losses since reducing these losses will increase utility revenue. Some of the areas that should be examined are:

1) Customer meter inaccuracy due to meter wear, malfunction or inappropriate size or type of meter;
2) Data transfer error when transferring customer metered consumption data into the billing system;
3) Data analysis errors including poor estimates of unmetered or unread accounts;
4) Inaccurate accounting resulting in some accounts not being billed for water use;

5) All forms of unauthorized consumption including meter or meter reading tampering, fire hydrant theft by contractors, unauthorized taps, and unauthorized restoration of water service cutoffs; and
6) Unmetered municipal connections (every effort should be made to meter municipal connections in order to better account for water use.)

C. Implementation

To successfully implement this BMP, the utility should start by forming a working group from the following work areas: management, distribution, operations, production, customer service, finance, and conservation. Each of these work areas has an essential role to play in implementing this BMP. Smaller utilities may have the same person doing several of these functions and therefore the working group may just be one or two individuals. The utility should also consider a public involvement process to solicit outside input as well as to enhance public relations.

Initially the working group should focus on gathering relevant data and identifying current practices listed above in Section B that form the basis for the top-down audit. Some of the questions that should be addressed during the top-down audit are:

1) How often do we test production meters? Commercial meters over 1 inch? Over 2 inches?
2) How often do we replace or repair ⅝ and ¾-inch meters?
3) How inaccurate are the ⅝ and ¾ inch meters on average when they are replaced?
4) Do we estimate total leakage from each leak based on the leakage flow rate and length of leakage from time reported when we fix leaks?
5) How long does it take to repair leaks, itemized by size of leak?
6) Are customers encouraged to report leaks?
7) Do we have a system for tracking location of leaks and a method to calculate when it is cost-effective to replace mains and service lines?
8) Are meter readers trained to look for and report leaks?
9) Do we adjust consumption records when billing records are adjusted?
10) Is backwash and other in-plant water use optimized?
11) How effective is our theft reduction program?

Based on the data collected and information from the questions above, the utility should have enough information to complete a top-down audit.

An ILI of 3 should be used as an example of an achievable target. If the ILI is 3 or below, then further implementation of the BMP is not required until the following year. This would indicate that the utility already has an effective water audit and water loss program. If the ILI is above 3, then the utility should implement a more effective water audit and water loss program. The utility then proceeds to conduct a bottom-up audit.

In conducting the bottom-up audit, the utility addresses the relevant issues identified during the top-down audit and further investigates those issues discussed in Section B. The utility uses the results of the audit to focus on the best approaches to reduce both real and apparent losses

Depending on whether the ILI is relatively high or low determines the number of years it may take to reduce the ILI to 3.

Each subsequent year, the utility completes another top-down audit. Over time the utility should be able to gradually reduce its ILI to 3. If the utility finds the ILI is increasing, then it should perform a bottom up audit.

D. Schedule

To accomplish this BMP, the utility should:

1) Gather the necessary information for conducting the top-down audit, develop the procedures and complete the audit within the first twelve (12) months of implementing this BMP.
2) The bottom-up refinements should start to be implemented in the twelve (12) months immediately following the completion of the top-down audit if the ILI exceeds 3.
3) Based on the goal of achieving an ILI target of 3, the utility continues to implement bottom-up refinements to reduce real and apparent losses each subsequent year until the utility achieves an ILI of 3.
4) The utility's ILI should be calculated each year.

E. Scope

To accomplish this BMP, the utility should do the following:

1) Conduct a periodic system audit following the methodology contained in the revised AWWA M36 Manual and the report that TWDB is preparing as part of implementing HB 3338.
2) Develop and perform a proactive distribution system water loss program and repair identified leaks.
3) If the utility's ILI is greater than 3:
    a. Implement a pressure reduction strategy if warranted;
    b. Implement a program to reduce real losses, including a leak detection and repair program;
    c. Implement a program to reduce apparent losses; and
    d. Advise customers when it appears that leaks exist on the customer's side of the meter and evaluate a program to repair leaks on the customer's service line.

F. Documentation

To track the progress of this BMP, the utility should gather and have available the following documentation:

1) A copy of each annual system audit, the ILI for each year, and a list of actions taken in response to audit recommendations.
2) Annual leak detection and repair survey, including number and sizes of leaks repaired.
3) Number of customer service line leaks identified and actions taken to repair these leaks.
4) Pressure reduction actions taken, if any; and
5) Annual revenue increased through reducing apparent losses.

G. Determination of Water Savings

Potential water savings are an integral part of the system water audit process and should be contained in the audit report. Based on the results of the audit, the utility should set goals for reducing its losses.

H. Cost-Effectiveness Considerations

Direct costs that should be considered in implementing this BMP include the initial and ongoing costs for performing and updating the water audits and capital costs for items such as leak detection equipment and billing software upgrades. Utilities may wish to do the work in house with technical staff or by using outside consultants and contractors.

A recommended method to make cost effectiveness decisions is based on the economic value of real losses and apparent losses. (*See,* Section I. References for Additional Information, 4.) Real losses are losses due to leaks and are valued at actual costs to produce and deliver the water. Apparent losses, sometimes called paper losses, are those attributable to meter and billing inaccuracies and are valued at the retail rates charged by the utility. The amount of lost revenue due to real losses, based on the utility's marginal production cost, and apparent losses, valued at the retail rate charged to customers, can be compared to the costs of reducing the sources of loss.

I. References

1) *Water Loss Control Manual,* Julian Thornton, McGraw-Hill 2002.
2) *M36 Manual,* AWWA, 1999.
3) *Applying Worldwide BMPs in Water Loss Control,* AWWA Water Loss Control Committee, Journal AWWA, August 2003.
4) *Survey of State Agency Water Loss Reporting Practices: Final Report to the AWWA Technical and Education Council,* Beecher Policy Research, 2002.

Benefit Cost Analyses of Leak Reduction Program: A Note for the Canadian Water and Wastewater Association, Alan Lambert, 2002.

APPENDIX 8: Resources and References

References

1) *Water Loss Control Manual,* Julian Thornton, McGraw-Hill, 2002.
2) *Water Audits and Leak Detection, M36 Manual,* AWWA, 1999.
3) *Applying Worldwide BMPs in Water Loss Control,* AWWA Water Loss Control Committee, Journal AWWA, August 2003.
4) Survey of State Agency Water Loss Reporting Practices: Final Report to the AWWA Technical and Education Council, Beecher Policy Research, 2002.
5) Benefit Cost Analyses of Leak Reduction Program: A Note for the Canadian Water and Wastewater Association, Alan Lambert, 2002.
6) Detailed Water Audit Spreadsheet for FY 2001 in IWA Format, City of Forth Worth Water Department.
7) *Leak Detection and Water Loss Control,* Tech Brief, A National Drinking Water Clearinghouse Fact Sheet, Zacharia M. Lahlou, , May 2001.
8) *Select Committee on Public Accounts Eight Report,* Office of Water Services (OFWAT), London, England.
9) *Leakage Reduction—has an economic frontier been reached?(draft),* David Howarth, Water and Waste Treatment, 2003.
10) *Water Conservation—the role of institutional mechanisms in England and Wales,* 2002 AWWA Water Sources Proceedings, David Howarth, Environment Agency, Las Vegas, 2002.
11) *Water Loss Management in England and Wales,* AWWA 2002 Water Sources Proceedings, David Howarth, Environment Agency, Las Vegas, 2002.
12) *Using Dataloggers to Find Leaks and other Water Waste,* 2002 AWWA Water Sources Proceedings, Dale Lessick, Irvine Ranch, Las Vegas, 2002.

13) *Water Loss Recovery—Our Greatest Untapped Water Resource?,* 2002 AWWA Water Sources Proceedings, George Kunkel, Philadelphia Water Department, Las Vegas, 2002.

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15) *A Review of Performance Indicators for Real Losses from Water Supply Systems,* A. O. Lambert, IWA/ AQUA, 2000.

16) *Tracking Down Those Water Losses! A Case Study for Asheville, North Carolina,* 2004 AWWA Water Sources Conference Proceedings, Lisa Maddaus, Austin, 2004.

17) *Use of Flow Modulated Pressure Management in York Region, Ontario to Reduce Distribution System Leakage,* 2004 AWWA Water Sources Conference Proceedings, Austin, 2004.

18) *What do We Know about Pressure: Leakage Relationships in Distribution Systems, ,* 2004 AWWA Water Sources Conference Proceedings, A. Bardsley, Austin, 2004.

19) *International Approach to Water Loss Reduction in Halifax,* 2003 AWWA DSS Conference, Kenneth Brothers, 2003.

20) *Practical Steps for Reducing Apparent Water Losses,* Presentation at 2004 AWWA DSS Conference, Rob Thiemann, City of Kansas City, 2004.

21) *Nashville's 1St Water Audit, the IWA/AWWA Methodology,* 2004 AWWA DSS Conference, Leanne Scott, Metro Water Services, 2004

APPENDIX 9: Texas Water Development Board EXECUTIVE ADMINISTRATOR's Comments

ATTACHMENT 1

RECVD 01/06/20

TEXAS WATER DEVELOPMENT BOARD
Contract No. 2003-483-511
Draft Final Report Review Comments
"Survey of Municipal Water Loss Practices in Texas"

Intro - 3rd paragraph. Might also discuss HB 2660 that states in part: "Targets must include goals for water programs....."

Executive Summary not included. Will there be one?

Page 4 -Appendices need identification such as a letter or number.
Last sentence the is misspelled.

Page 4 - Last paragraph. "he" should be "the".

Page 5 - Last paragraph. …requirement was that the survey take, not takes.

Page 5 - Last sentence, next to last paragraph should read. "that the TWDB will be compiling data on for the required water audit."

Page 6 - In the paragraph "Water Supply Corporations" Middle sentence needs clarification.

Page 12 - 1st paragraph delete the second from.

Page 12 - There are 2 commas in 3rd paragraph.
4th paragraph will may, please clarify.
4th paragraph has 3 periods.

Page 12 - 4th paragraph. Multiple periods.

Page 13 - 6th paragraph. Two (2) periods.

Page 14 - 2nd paragraph. Last sentence….occur not occurs.

Page 15 - 5th paragraph. Not clear and has a typo.

Page 15 - 5th paragraph. Extra words.

Page 17 - Delete utilityies in first paragraph.
4th paragraph seems to have the word "be" missing.
6th paragraph first sentence more should be used not most.
6th paragraph has 2 periods after a sentence.
6th paragraph review second sentence.

Page 17 – 1st
paragraph. Utilities twice.

Page 17 - 4th paragraph. Incomplete sentence.

Page 30 - last paragraph. Seems to have the word to missing.

Page 30 - 34th paragraph. All utilities will have to provide the audit, including those <500.

Page 31 - What are these recommendations based on?

Page 49 - Bottom of table is on page 50.

Tables - Good if tables with the same question could be on facing pages and follow the same layout IE population then type (or at least be consistent).

What will Appendix 3 consist of?

General comments: review for grammar, punctuation and verb tense (past tense is used where present should be).