2009 Residential Water Use

SURVEY RESULTS AND ANALYSIS OF RESIDENTIAL WATER USE FOR SEVENTEEN COMMUNITIES IN UTAH

RESIDENTIAL WATER USE

Utah Department of Natural Resources
Division of Water Resources
1594 West North Temple, Suite 310
P.O. Box 146201
Salt Lake City, Utah 84118

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This report was prepared under the direction of Todd Adams, Assistant Director of the Utah Division of Water Resources, and by a project team consisting of the following staff members:

Eric Klotz	Chief, Water Conservation and Education
Candice Hasenyager	Water Resource Engineer (Primary Author)

Other staff members provided significant assistance with reviewing, editing and preparing the document for publication.

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Dennis J. Strong, Director

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EXECUTIVE SUMMARY

The Division of Water Resources (DWRe) is tasked with providing a comprehensive state water plan, protecting Utah's rights to interstate waters and managing water resource project construction loan programs. As part of the DWRe water planning efforts, a residential water use study was conducted in 2009. This report summarizes the study and estimates the average indoor and outdoor use of residents in Utah. The purpose of this study is to duplicate the previous 2001 DWRe study (*Identifying Residential Water Use*) and update its findings.

Randomly selected residents from seventeen communities across the state were mailed a survey. The goal of the survey was to determine characteristics in each home; namely persons per household (pph), livable floor space, lot size, residential irrigation method, knowledge of Utah's "Slow the Flow" media campaign, and various conservation practices used in the home.

Water use data was analyzed from the surveyed residents and it was found that the average surveyed residential indoor water use was 62 gallons per capita per day (gpcd). Since this study only surveyed a small fraction of the state; the statewide indoor use was estimated to be 60 gpcd using regression equations. Therefore, the statewide indoor water use is now 14 percent lower than the statewide estimate of 70 gpcd found in 2001.

The water use data and survey information analyzed by this study also supports the following estimates:

- Outdoor water use was approximately 134 gpcd
- Resident in homes built after 1992 use 5 gpcd less than pre 1992 homes
- Residents in homes that have greater than 3,000 square feet of floor space used 13.6 gpcd more than homes that had less than 1,000 square feet
- Indoor water use increases insignificantly with respect to income level
- Evaporative coolers use about 28 gpd during summer months (about 6 gpcd annually)
- Residents using automatic sprinklers over water by about 30 percent

- Residents using a hose and sprinklers attachment under water approximately 17 percent

An additional analysis was conducted on 110 randomly surveyed residents in Salt Lake City to determine the effectiveness of Utah's "Slow the Flow" media campaign. It was found that half of those surveyed had heard of "Slow the Flow" and this group used 30 percent less water indoors. They had implemented more conservation practices in their home such as water efficient washing machines, aerator facets, low-flow shower heads and toilets. In addition, the "Slow the Flow" group also watered outdoors an average of eight percent less than other survey recipients from 2001-2007.

INTRODUCTION

Utah is facing an increase in population, which will place increased demands on water systems. Utah has experienced a 25 percent growth in population from 2000 to 2009. Alone this growth has a significant effect on residential water demands, as residential water use makes up 70 percent of the total use of public water suppliers deliveries, as seen in Figure 1.

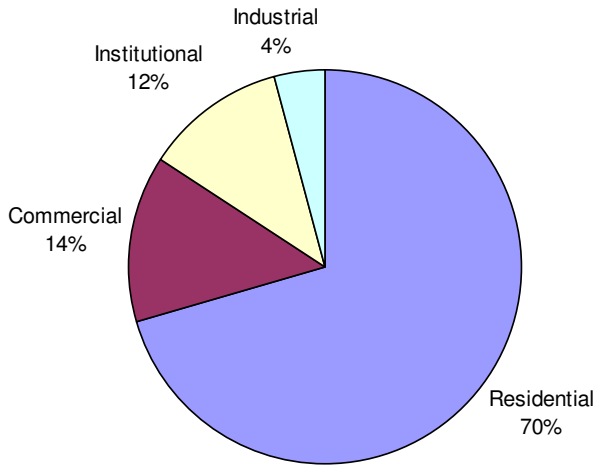

Figure 1. Utah public community water use, potable and secondary water (Source DWRe 2005)

Nationally, there have been several studies done over the last twenty years that have helped to better define residential water use. The U.S. Geological Survey (USGS) and the Denver Water Department released a residential water use study that analyzed sixteen sites located in the city and county of Denver, Colorado from 1980 to 1987 (Litke and Kauffman 1993). Several independent variables were selected, including persons per household (pph), property value, and lot size. The data used for analysis were collected in a variety of ways including information from water companies billing records, readings from inline flow meters on the main water line (recorded total flow), U.S. census blocks (used to obtain average person per household and age factor), and county assessor files (lot size and property value). The USGS study determined that the average

base indoor water use was 81 gallons per capita per day (gpcd). One of the observations made by the study was that more direct measurement of the number of people at home during the day would have resulted in a better estimate of the average indoor water use. The seasonal outdoor water use was established as 25 gallons per housing unit per day (gud) and varied significantly - up to 575 gud.

Six years later, the American Water Works Association (AWWA) Research Foundation, along with municipalities and water providers, produced an extensive report called *Residential End Uses of Water*, (Mayer and DeOreo, 1999). There were twelve areas included in the study throughout the U.S. and Canada. At each site, a thousand households were surveyed. The independent variables in this report included pph, income, property value and lot size, education, type of sprinkling system, swimming pools and appliances found in the house.

In this study, water use was divided into seasonal water use and indoor water use. The seasonal water use was found by taking the lowest billed month for water as only indoor use and then the remainder was considered seasonal water use. Seasonal water use was found to vary significantly with the location of the study area because of differing climates.

The average daily indoor water use had much less variability and was calculated to be 173 gallons per day (gpd). It was found that an increase in the pph was directly proportional to indoor water use, i.e. the higher the pph the less water used per person. This study indicated that the average indoor gallons per capita per day water use was found to be 69 gpcd.

After the release of the AWWA report, other states, counties and cities followed suit with their own initial residential water use studies. In 2001, the Utah Division of Water Resources (DWRe) released the *Identifying Residential Water Use* study that determined the average per capita water use both indoors and outdoors within the state of Utah. Thirteen communities were chosen throughout the state to be included in the study. Surveys were sent to randomly selected households within the thirteen communities. After the surveys were completed, the respective surveyed home billing records were acquired from the water suppliers. The summer months were considered to cover indoor and outdoor water use, whereas winter months were assumed to be indoor water use only.

The results were then compiled into communities of specific pph that would represent the state of Utah. It was found that the average indoor water use for surveyed residents was 68 gpcd and the average outdoor water use was 115 gpcd. A relationship was then created between pph and indoor water use, through multiple regression analysis. This relationship was used to determine a statewide indoor water use of 70 gpcd. It was also used to estimate the volume of gallons used and then compared to the surveyed gallons used within the community.

Table 1 summarizes the results found in the previously mentioned three major residential water use studies.

Table 1. Summary of previous residential water use studies

Residential Water Use Studies	Average Total use, GPCD	Average Indoor Use, GPCD	Average Outdoor Use, GPCD
USGS 1993 (National)	-	81	-
AWWA 1999 (National)	172	69	101
DWRe 2001 (Utah)	183	68	115

The main objective of this current DWRe residential water use study is to duplicate the approach used in the 2001 DWRe study to determine residential indoor use versus pph and residential outdoor use. In addition, this study also compared water usage with respect to the age of the homes; related outdoor water use to irrigation practices; compared outdoor water use to lot size; analyzed outdoor water use to household income; estimated the amount of water an evaporative cooler uses; looked into water use habits of residents who have knowledge of Utah's "Slow the Flow" media campaign; and introduced a remote-sensing-based approach to estimate watering of residential landscaped areas for a sample of Salt Lake City residents.

PROCESS AND PROCEDURE

Overview

A survey was developed and mailed to random residential water users in seventeen communities in Utah. The survey was used to determine characteristics about the house (livable floor space, lot size, irrigation method) and its occupants (pph, income, knowledge of "Slow the Flow" media campaign) related to water use. The water use billing records of survey respondents were also obtained and used to determine the average per capita water use (indoor and outdoor).

Selection of Study Areas

All water suppliers in Utah with over 500 residential connections were contacted by phone to verify that they retained residential water use records for at least three years. Three years of water use data were set as the necessary threshold for this study (to match what was done in the 2001 DWRe study). All water suppliers meeting the three-year data threshold were invited to participate in the study. Final selection of water suppliers to be included in the study was based not only on their willingness to participate and to provide data, but also based on them representing different geographic regions of the state. Figure 2 shows the locations of the seventeen communities included in the study.

Formulation of Survey

A survey instrument was created to determine selected household characteristics related to water use. In developing the survey used for this study, previous residential water use studies (discussed in the Introduction) were reviewed to determine which household characteristics most affected water use. These characteristics included pph, lot size, livable floor space inside the home, evaporative cooler use, year home was built, income level, outdoor irrigation application method, water using amenities and secondary water availability. All of the above characteristics were included in the survey that was

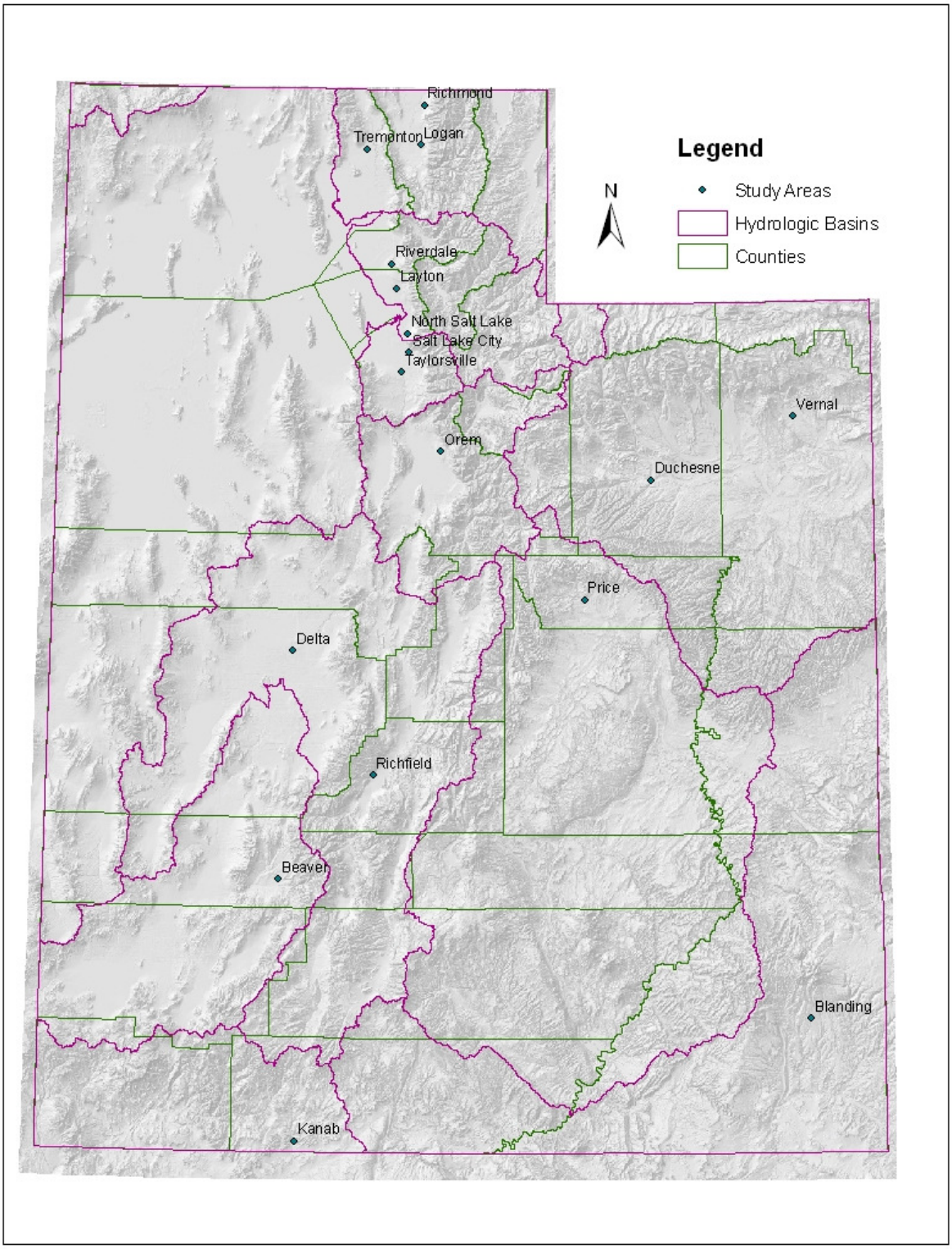

Figure 2. Study areas and location

created for this study. In addition, to these questions, several new ones were added to further understand water usage at the resident's home. Residents were asked if they: (1) had a moisture sensor or evapotranspiration (ET) controller to aid in their outdoor irrigation and (2) were aware of the state's "Slow the Flow" water conservation media campaign and other conservation practices being implemented in the home. See Appendix A for a copy of the survey form.

Sample Size and Response Rate

To ensure reliability of survey results, Equation 1 was used to determine a sample size that would result in a 95 percent confidence and a margin of error less than or equal to 3 percent.

$$n = \left(\frac{z^*}{2m}\right)^2 \qquad \text{Equation (1)}$$

where n = sample size

m = margin of error

z*=1.96 for 95 % confidence interval

The number of surveys that needed to be returned was found to be 1,067. An expected response rate of 25 percent was assumed based on the 36.7 percent response rate to the survey included in the previous 2001 DWRe study. To reach the threshold of 1,067 responses, 4,500 surveys were mailed to randomly selected residents within the seventeen communities included in the study. The number of surveys mailed to each service area was determined by a weighted fraction based on the number of connections. A minimum of 50 surveys were mailed to each service area. After the surveys were mailed, a four-week response time was allowed for the surveys to be returned. When received, responses were entered into a database for further analysis. The water suppliers within the communities that provided data for this analysis and the characteristics of the survey response can be found in Appendix A (Table 5). Overall, the response rate to the survey was 38 percent. After the four-week survey response period ended, the participating water suppliers were contacted to request the individual water use records for the survey respondents.

Pre-Processing and Quality Assurance of Water Use Records

Due to the differing times of meter reading for each water supplier, the data needed processing before they could be used in the study. Two suppliers read meters bi-monthly, seven read meters from March/April to October/November, and nine read the meters monthly throughout the year. To account for the suppliers that only read the meters from March/April to October/November; the first meter reading of the year and the last meter reading of the previous year were subtracted from each other to get the total use over the non-metered months. This total use was then distributed over the non-metered months to get a winter monthly average use. This is reasonable because the winter monthly use is fairly constant. Lastly, all of the water use records were converted to a unit of 1,000 gallons (since the water use data from the various water suppliers were measured in differing units), put into a database, and general outliers were removed from the dataset (outliers included negative and zero water use values).

Indoor Water Use Analysis

To determine residential indoor water usage, it was assumed water used during December through February was indoor use only. This is a reasonable assumption based on Utah's seasonal climate and preliminary review of water use records. The indoor water use was calculated for each resident by taking the winter use from December to February and dividing by the number of days to find the average gallons per day (gpd) in each household. The gpcd was found by dividing the gpd by the pph. The average gpd, gpcd and pph were then found for each water supplier.

Outliers were removed from the dataset to ensure that only indoor water use was included. The outliers were removed by following the procedure performed in the 2001 DWRe study. First, communities were analyzed on an individual basis; the data were separated into pph and ranked by calculated gpcd. In the 2001 DWRe study, below 20 gpcd was assumed to be a faulty meter or incorrect entry so those data points were eliminated. The data were then separated into quartiles. The high quartile range was determined by Equation 2. Data points that fell outside the high quartile range were removed from the dataset.

$$1.5 \times IQR \qquad \text{Equation (2)}$$

where IQR – Interquartile range

The relationship between indoor water usage to pph, age of the home, and floor space were determined by using a linear regression analysis. In addition, the amount of water used by an evaporative cooler in a respondent's homes was calculated. This amount was found by analyzing the water use from the respondents that indicated they had a separate irrigation system (secondary water). It was assumed that the difference in winter and summer water use was the evaporative cooler use since the resident was irrigating with secondary water.

Outdoor Water Use Analysis

Residential outdoor water use was assumed to be a portion of the water used from April to October. During these warm season months, water suppliers read the meters consistently on a monthly basis. The outdoor water use was calculated by subtracting the indoor (winter) use from the total use. Due to the high variability in outdoor water use, no outliers were removed. All water users included in the study were analyzed individually and all seventeen communities were analyzed as a group. The average monthly and summer water use in gallons per day and gallons per capita per day were computed. In addition, the average pph were also determined for all seventeen communities. A linear regression analysis was used to determine the relationships between outdoor water use and irrigation practices and lot size.

Salt Lake City Conservation Analysis

An additional aspect of this study was to determine if recent water conservation measures have affected residential water use. Salt Lake City (SLC) was selected for an additional study because it is the largest metropolitan area in Utah and an area critical for water conservation efforts to succeed. The state of Utah has a goal to reduce per capita water use within public community systems by at least 25 percent by 2050. To facilitate that goal, the Governor's Water Conservation Team (GWCT) was formed in 2001. This team includes the DWRe and the five largest water wholesalers (Jordan Valley Water

Conservancy District, Central Utah Water Conservancy District, Metropolitan Water District of Salt Lake and Sandy, Washington County Water Conservancy District, and Weber Basin Water Conservancy District). The GWCT has utilized the "Slow the Flow" media campaign for about ten years as a way to increase public awareness and send a consistent message about water conservation throughout the entire state.

From the survey respondents in SLC that had heard of the "Slow the Flow" media campaign, 55 residents were randomly selected to be included in the study. Another 55 residents were randomly selected from the group of SLC residents that had indicated in their survey that they had not heard of the "Slow the Flow" media campaign. The randomly selected 110 households and 55 in each group were analyzed to verify they were not clustered in specific locations of the city. In addition, the two groups were compared to ensure they had fairly similar characteristics. The returned surveys of both groups indicated similar irrigation methods, approximately 75 percent of each group used automated sprinklers, twelve percent used manually operated sprinkler systems and thirteen percent used a hose with sprinkler attachment. There was no secondary irrigation water available or used by either group.

A long-term water use record (2001 to 2007) was retrieved from Salt Lake City Department of Public Utilities. The water use record was analyzed to determine indoor and outdoor water use amounts on a monthly, seasonally, and annual basis. To compare and contrast the outdoor water use, the amounts were normalized by irrigated area of each house determined from remote sensing data analysis.

It was necessary to normalize the outdoor water use by dividing irrigated area in the same way the indoor water use is somewhat normalized using population and finding the gpcd water use. Image processing of satellite data was chosen as the method to quantify the irrigated area for each of the 110 households included in the "Slow the Flow" part of the study. The use of satellite data to quantify irrigated areas in urban environments is well established. For example, a 2002 Utah State University study by Kjelgren et al. analyzed residential and commercial water use in Layton, Utah using remote sensing data analysis. In their study, aerial images were overlaid with a parcel layer in geographical information system (GIS) software to determine the amount of grass, trees and shrubs, roofs with different covers, concrete, asphalt, bare soil, shadow,

water and meadows were contained in each parcel. The areas classified as grass and trees and shrubs were assumed to be irrigated. The irrigated area was multiplied by the theoretical depth of water required to meet consumptive demands determined by the reference ET calculations.

In this study, the individuals from the two groups included in the "Slow the Flow" analysis were located in a geospatial parcel database and a corresponding aerial image obtained from the Utah Automated Geographic Reference Center (AGRC). The image retrieved from the AGRC was a National Agricultural Imagery Program 2006 one-meter resolution color-infrared image. In the infrared image, the vegetated areas display red in color because of the reflection of the infrared radiation in the mesophyll cells and air spaces of the homeowner's landscape. The advantage of using an infrared image is the clear delineation of the vegetated areas when analyzing the dataset using image processing software. Figure 3 displays the parcel data overlaid onto the image.

Figure 3. NAIP 2006 one-meter resolution color-infrared imagery from AGRC, shown with one parcel boundary overlaid

ERDAS IMAGINE® was used to complete the image processing (Leica 2003). The image was imported into IMAGINE® and a signature file created by manually

sampling 30 points in the image representing two land covers, irrigated vegetation and hardscape. A supervised classification was then performed to classify the entire image.

The classified image was imported into Environmental Systems Research Institute (ESRI) ArcGIS as a GRID file and intersected with the parcel shapefile to quantify the amount of irrigated area in each parcel. Figure 4 shows the same parcel as Figure 3, but after classification. The green areas are irrigated while the tan/brown areas are hardscape. An error check was performed on the image by randomly inspecting 50 points. Ninety-three percent of the points were classified correctly. The incorrect classifications were found to be caused by shadows and tree canopies. The average irrigated area of the group of 55 residents that had heard of the "Slow the Flow" media campaign (the "yes group") was 7,070 square feet, while the average irrigated area for the group that had not heard of the "Slow the Flow" media campaign (the "no group") was 6,100 square feet.

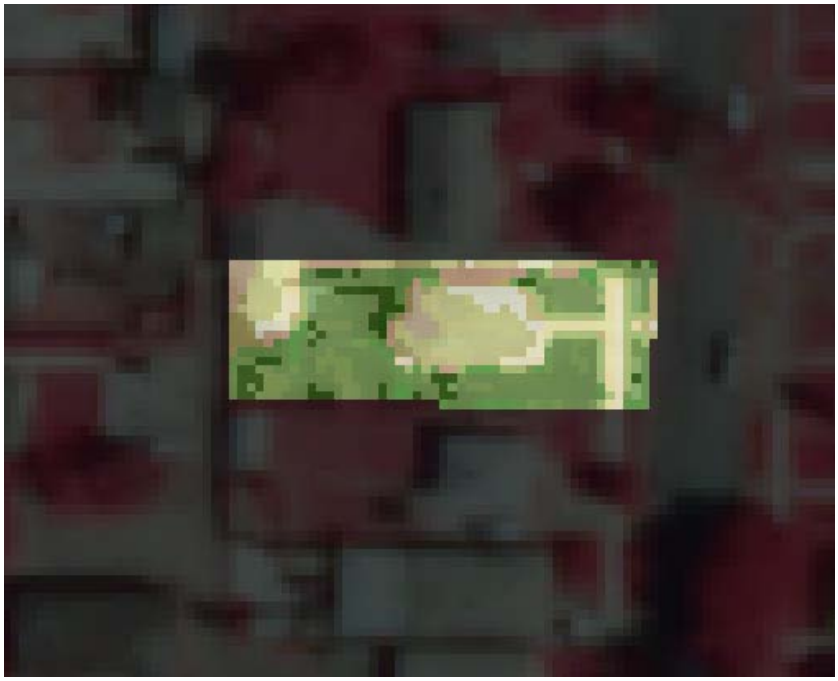

Figure 4. Classified image showing irrigated areas (greens) and hardscapes (browns) for a single parcel

The outdoor water use for each parcel was determined from the water use records (2001 to 2007) obtained from Salt Lake City. The average outdoor use for each month was determined by subtracting the average monthly use from December to February. To

normalize the outdoor irrigation amount, the outdoor use was divided by the estimated irrigated area from the image analysis.

The normalized outdoor irrigation amounts were then compared to the net reference ET values. The reference evapotranspiration (ET_o) represents the amount of water lost to evaporation and transpiration for a hypothetical reference crop, in this case turf grass. The four climatic factors that affect ET_o are solar radiation, air temperature, humidity and wind speed. The American Society of Civil Engineers (ASCE) standardized reference ET equation (3) was used to calculate ET_{sz} (ASCE 2005).

$$ET_{sz} = \frac{0.408\Delta(R_n - G) + \gamma \frac{C_n}{T + 273} u_2 (e_s - e_a)}{\Delta + \gamma(1 + C_d u_2)} \qquad \text{Equation (3)}$$

where ET_{sz} = standardized reference crop evapotranspiration
R_n = calculated net radiation at crop surfaces
G = soil heat flux density at the soil surface
T = mean daily temperature
u_2 = mean daily wind speed
e_s = saturation vapor pressure
e_a = mean actual vapor pressure
Δ = slope of the saturation vapor pressure-temperature curve
γ = psychrometric constant
C_n = numerator constant that changes with reference type
C_d = denominator constant that changes with reference type

The climatic factors were retrieved from the Murray, Utah weather station and the precipitation data were acquired from the Salt Lake City airport gage. The effective precipitation (80 percent of total precipitation) data was then subtracted from the ET_{sz} to determine the net evapotranspiration (ET_{net}).

RESULTS AND DISCUSSION

Indoor Water Use

The gallons per day used by residents indoors ranged from a low of 142 gpd in Blanding to a high of 227 gpd in Taylorsville, with a weighted average based on number of households responding to survey of 182 gpd. The gpcd were found by taking the gpd for each household divided by the number of pph. The average gpcd ranged from a low of 51 in Blanding, with a 2.8 average pph, to a high of 74 in Taylorsville, with a 3.1 average pph. The weighted average for all cities was 62 gpcd with a 2.93 average pph. There was no significant difference in gpcd found between rural and urban cities. The summary results for all water supplier service areas are found in Appendix B (Table 6).

In the 2001 DWRe study, the indoor water use was found to be 68 gpcd with an average pph of 3.51. Comparing the two study results, residential indoor water use has decreased by 6 gpcd (about 9 percent). This decline in water use is attributed to the 1992 changes to the plumbing code (which converts high water using devices to newer low-flow devices), newer Energy Star washing machines/dishwashers (which use less water) and an overall acceptance by the public on the state's water conservation message. The pph also decreased from 3.51 in 2001 to 2.93 in 2009. A decrease in the pph over the next 50 years has been projected by the Utah Governor's Office of Planning and Budget (GOPB).

The previous 2001 DWRe study also showed that as pph increased, the indoor water use per capita decreased. A community scale was used to estimate the relationship of yearly indoor water use per connection to the pph. Each of the 17 communities were grouped by the pph and an average water use was found for each pph. Figures 5 and 6 represent the same data going from yearly use to gpcd, respectively. Equations 4 and 5 define the curves in Figure 5 and Figure 6:

$$GPD_{Indoor} = 32.1 * PPH + 88.4$$ Correlation Coefficient R^2=0.67 Equation (4)

$$GPCD_{Indoor} = \frac{88.4}{PPH} + 32.1$$ (Derived from equation 4) Equation (5)

where:

gpd_{Indoor}	= Gallons per Household per Day
pph	= Persons per Household
$gpcd_{Indoor}$	= Gallons per Capita per Day Water Use

From Figure 6, it can be seen that as pph increases gpcd decreases. As mentioned earlier, this relationship was also found in the 2001 DWRe study. This can be attributed to the phenomenon of a household with more people becoming more efficient by doing full loads of dishes in their dishwashers and full loads of clothing in their washing machines.

Since this study only surveyed a small fraction of the state; Equation 5 was used to estimate the statewide indoor water use rate with the 2009 American Community Survey, which is used by the GOPB, found a (1-yr estimate) pph of 3.17. Using the equation, the statewide indoor use is reduced to 60 gpcd, about 14 percent lower than the 70 gpcd (statewide indoor) rate found in the 2001 DWRe study.

Another aspect of this study dealt with the question of whether the home was built before or after 1992 and if there had been any renovations/replacements of plumbing fixtures. The year 1992 was selected because the U.S. Energy Policy Act of 1992 required all plumbing fixtures sold to be low flow devices. It was found that there was a slight difference in indoor water use between those homes that were built before 1992 with and without renovations. There was a 15 gpd difference in the amount of indoor water used in homes built after 1992. This is approximately 5 gpcd (~9 percent decrease from estimate found in 2001 DWRe study) based on the average 2.93 pph found in this study.

Linear regression was used to determine if the amount of floor space in the home had any relationship to indoor water use. It was found that there was a difference of 13.6 gpcd (~19 percent decrease from estimate found in 2001 DWRe study), based on 2.93 pph, between the respondents who indicated that they had less than 1,000 square feet of

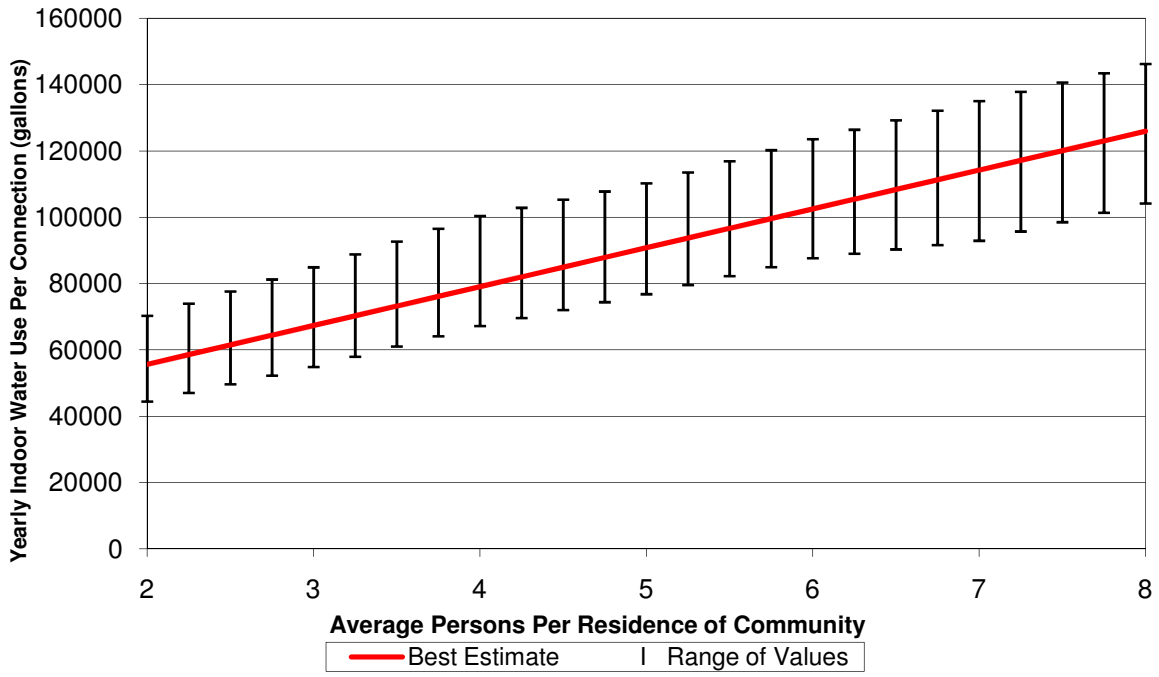

Figure 5. Yearly indoor water use for survey respondents

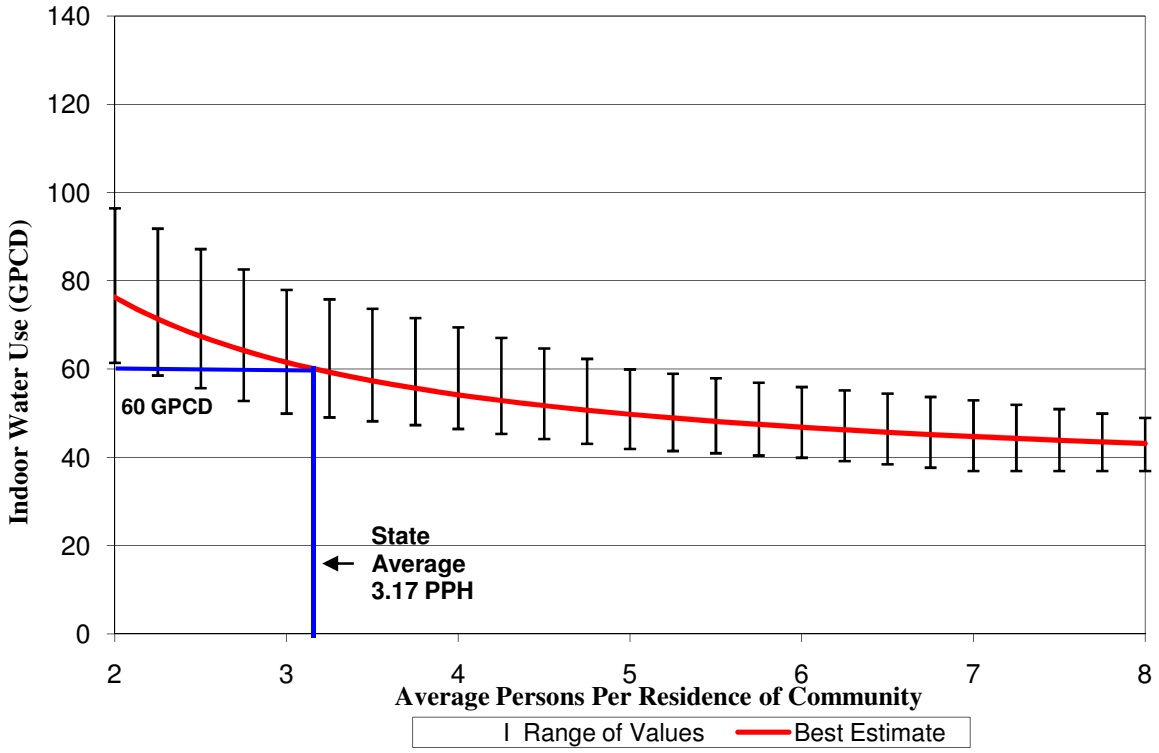

Figure 6. Average persons per residence of community

floor space and those that had more than 3,000 square feet. This difference is attributed to larger houses likely have more water using devices.

A comparison was also done comparing income to indoor water use using a linear regression analysis. The incomes levels were $0-$25,000, $25,000 -$50,000, $50,000 -$100,000, $100,000 -$150,000 and incomes greater than $150,000. The rate that water use increased by income was found by taking the indoor use of the $0-$25,000 and the $100,000 -$150,000 and dividing by 75. It was found that indoor water use increases insignificantly with respect to income level. This is similar to what was found in the 2001 DWRe study.

Lastly, the study looked at evaporative cooler use. The average summer water use per household that had an evaporative cooler was 293 gpd and without 265 gpd. Evaporative coolers were found to use 28 gpd during the summer months. Averaging this amount over the year with a 2.93 pph; evaporative coolers use about 5 gpcd. The 2001 DWRe study found that evaporative coolers use 6 gpcd based on yearly use requirements.

Outdoor Water Use

This study found that outdoor water use had a greater amount of variability compared to indoor use. The gpd ranged from a low of 228 in Beaver to a high of 1,169 in Delta, and the gpcd ranged from 68 in Beaver to 414 in Richfield. The average summer water use, for all the cities, was 729 gpd and 249 gpcd. The average outdoor water use distributed over a year was 134 gpcd.

This variability in summer water use is attributed to the availability of secondary irrigation water, various sizes of the lawns that are irrigated, leaks in sprinkling system and overwatering. In the 2001 DWRe study, the outdoor water use was found to be 115 gpcd. The outdoor water use found for the present study was 19 gpcd (14%) higher than the previous study. One attribute that likely increased outdoor water use is the average ET for this study (2004 to 2007) was 24.5 inches this was about 8 percent higher than in the 2001 DWRe study. ET is a major factor in outdoor water use throughout the western US.

The irrigation practices compared were automatic sprinkler systems (that turn on automatically with a timer), manual sprinkler systems (that are turned on by an irrigator), and hose with sprinkler attachment. The average indoor water use was determined (based on a 2.93 pph) for each of the irrigation practices and there was no significant difference found. The indoor water use was subtracted from summer use to determine outdoor water use. The automatic sprinkler systems used the most water at 660 gpd. The manual sprinkler systems used 410 gpd, while the hose with sprinkler attachments used 299 gpd. The 2001 DWRe study indicated that residents using manual sprinkler systems water approximately to the ET requirements. Assuming the same is true now, this study found that those with automatic sprinklers overwater by about 30 percent while residents using a hose with sprinkler attachment underwater by about 17 percent. This comparison in watering techniques can be seen in Figure 7.

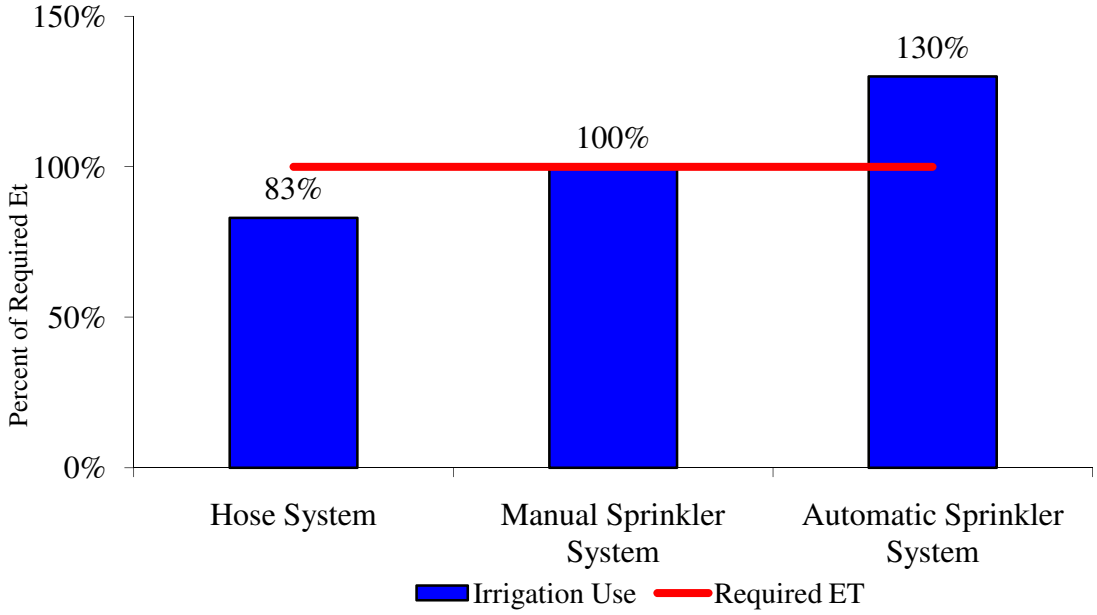

Figure 7. Three water techniques showing percent difference from Required ET

To determine the relationship of outdoor water use to lot size the water use data were sorted into residents with lot sizes less than ¼ acre, ¼ to ½ acre, ½ to ¾ acre and greater than ¾ acre. The calculated indoor water use for each category was subtracted from the summer use. Table 2 shows the resultant residential outdoor water use for each group. The percent difference between ¼ to ½ and ½ to ¾ was found to be small

compared to the other difference. This is attributed to the significant difference in the number of data points between the 2 groups.

Table 2. Summary of lot size and water use

Lot Size Group	Outdoor Water Use (gpd)	Percent Difference
Less than ¼ acre	449	
¼ to ½ acre	648	30%
½ to ¾ acre	682	5%
Greater than ¾ acre	896	24%

Salt Lake City Conservation Analysis

Overview

In this aspect of the study, indoor water use and implemented conservation practices were compared between two groups of residents (those that have heard of Utah's "Slow the Flow" media campaign and those who had not). A small sampling of residents were identified for this portion of the study. There were 55 households chosen within Salt Lake City for each group. In addition, outdoor water use was normalized by the irrigated area which allowed for a comparison between the irrigation (inch/growing period) and the ET_{net}.

Indoor Water Use

The SLC residents that had heard of the "Slow the Flow" media campaign (the "yes group") had an indoor use, averaged over a four-year period (2004 to 2007), of 63 gpcd with an average 3.3 pph. The "no group" had an indoor water use of 86 gpcd with an average 2.7 pph. Figure 8 shows the indoor water use for the two groups for each year and the four-year average. The percent difference between the four year averages of each group showed that the "yes group" used 30 percent less water indoors than the "no group", a statistically significant difference based on a T-test at a 95 percent confidence level. As mentioned earlier in this report, it was found that as pph increases the indoor water use per capita decreases. It would be expected that the indoor water use of the "no

group" would be greater than the "yes group" based solely on the difference in pph. After comparing the differing pph to Figure 6, it was found that there was only a 5 gpcd difference between the 3.3 and 2.7 pph. Taking this into account the "yes group" still used 23 percent less water indoors than the "no group."

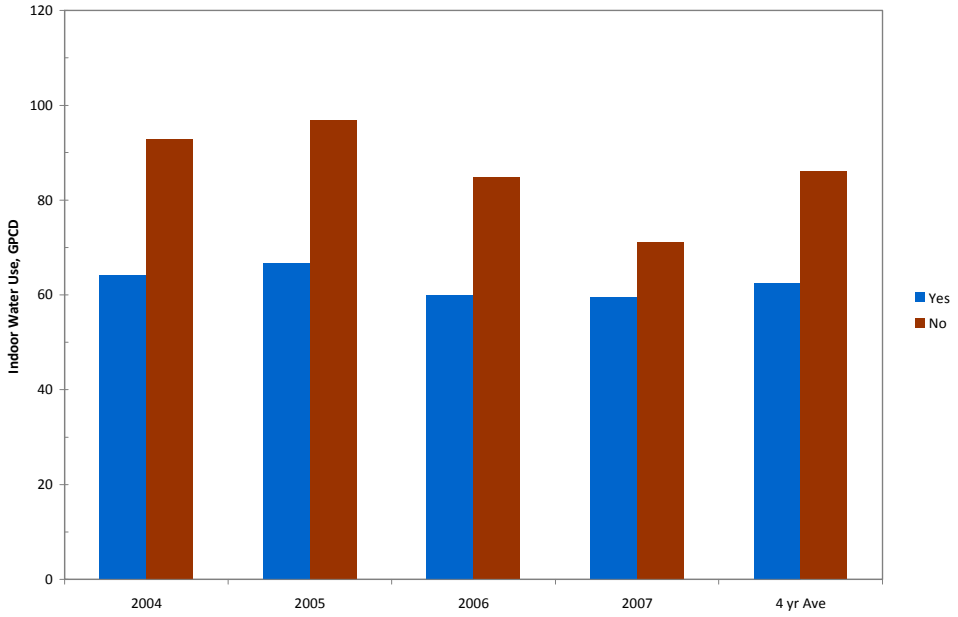

Figure 8. Indoor gpcd ("yes group" had heard of "Slow the Flow" and "no group" had not)

While survey respondents were only asked if they had heard of "Slow the Flow," there are other conservation programs in the area that may be influencing the results. Salt Lake City Department of Public Utilities has an aggressive conservation program that utilizes education, pricing, and policy programs. The Utah Rivers Council had been promoting a "Rip Your Strip" program during the study time period, and Jordan Valley Water Conservancy District, serving seventeen member agencies throughout the Salt Lake Valley, has many water conservation programs, including their Conservation Garden Park which is a demonstration garden displaying alternative water wise landscapes. In addition, since the early 1990s, the DWRe has been promoting many other water conservation programs besides the "Slow the Flow" media campaign. All of these efforts are likely responsible for decreased water use in both groups.

Conservation Practices Implemented

In 1992, maximum allowable water use rates were set for plumbing fixtures by the U.S. Energy Policy Act. This act required all new home construction to have low-flow plumbing fixtures installed. High water-using devices can still be found within homes constructed before 1992. It was found that 80 percent of the surveyed homes were built prior to 1992. Of that group, 60 percent of residents indicated they had replaced some plumbing fixtures. The "yes group" and the "no group" indicated that 88 percent of the homes were built prior to 1992, with 64 percent of those homes having some retrofit done to the plumbing fixtures.

Survey respondents were also questioned to determine their actions towards water conservation by replacing plumbing fixtures with more efficient ones. Figure 9 compares the percentage of practices implemented in each group. As shown in the figure, the "yes group" was much more likely to apply conservation practices.

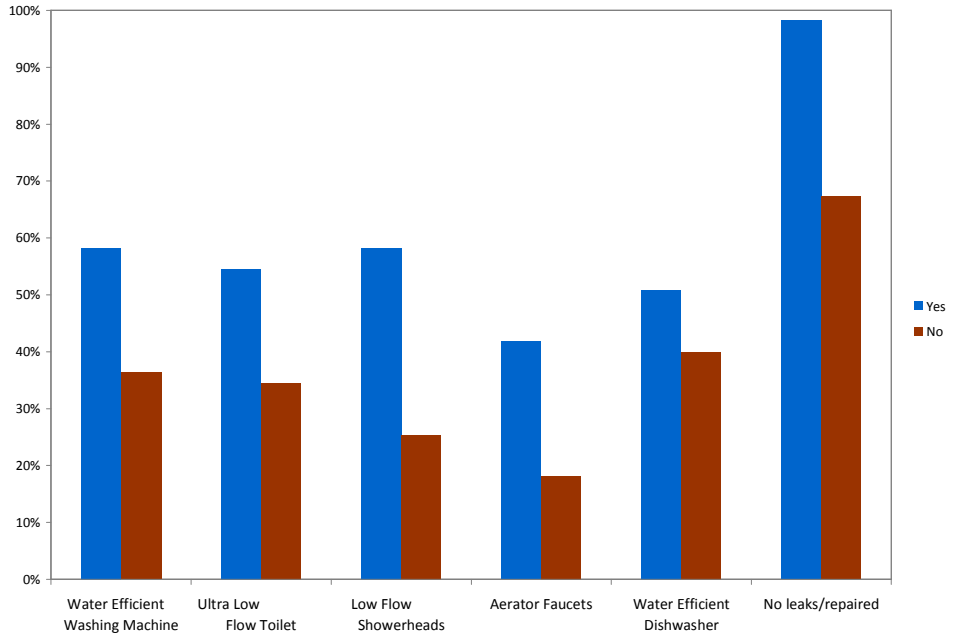

Figure 9. Percentage of conservation practices implemented in each group

Outdoor Water Use

The outdoor water use for both groups was analyzed on an annual basis from 2001 to 2007 and on a monthly basis for 2001, 2004, and 2007. Table 3 shows the mean and standard deviation (STDV) for each of the two groups.

Table 3. Mean outdoor use, gpd

Year	Yes Mean	STD	No Mean	STD
2001	821	580	778	417
2002	615	446	601	390
2003	589	400	557	435
2004	577	390	549	476
2005	562	373	512	406
2006	625	420	584	460
2007	811	483	816	551
Average	657	442	628	448

Figure 10 shows irrigation versus the ET requirements for turf grass for both the "yes" and the "no group." This figure also shows that the "yes group" consistently watered less during the analyzed period, which indicates that they are making an effort to reduce outdoor water use. On average the "yes group" used 8 percent less than the "no group." However when a statistical T-test was performed there was no statistically significant difference between the means.

As seen in Figure 10, both groups overwater their lawns compared to the standardized reference ET_{net}. An irrigation efficiency (ET_{net}/irrigated amount) was found for both groups to quantify the amount of overwatering occurring, shown in Table 4.

Table 4. Irrigation efficiency for both groups

Year	Yes Group	No Group
2001	65%	59%
2002	84%	78%
2003	85%	74%
2004	87%	83%
2005	80%	82%
2006	74%	70%
2007	80%	69%
Average	79%	72%

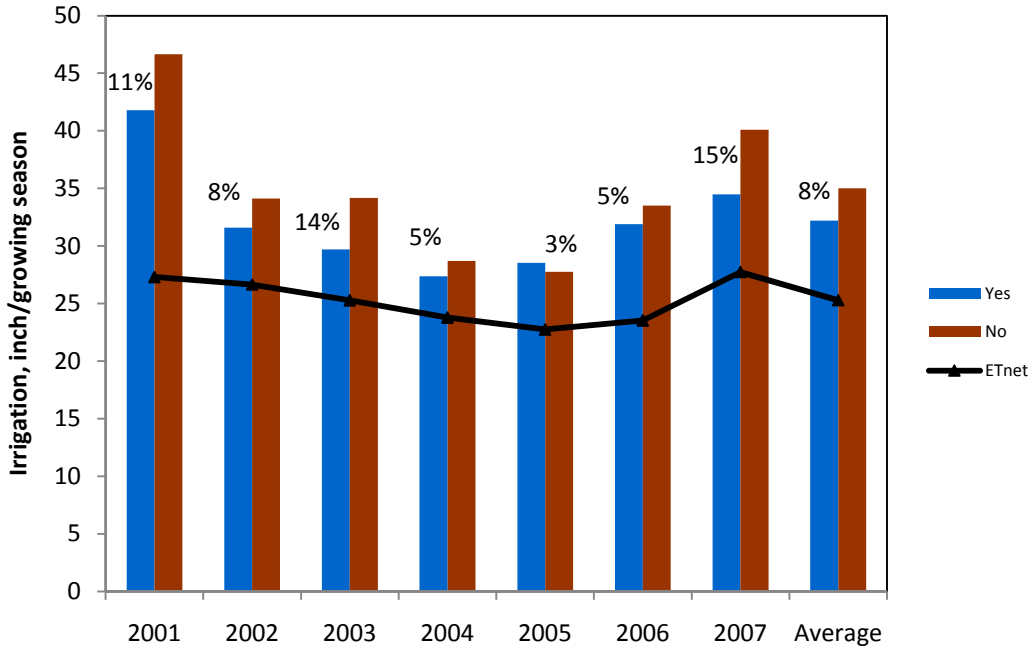

Figure 10. Normalized irrigation of inch/growing season compared to ET_{net}

As seen in Table 4, the irrigation efficiency increased from 2001 to 2004. This increase is attributed to the drought from 1999 to 2004. Drought conditions were heavily advertised during this time, which may have influenced the residents more than on going conservation education programs. This indicates that regardless of whether people had heard of "Slow the Flow," the drought message reached both groups and they responded by decreasing outdoor water use. Once the drought moved out of media headlines, a decrease in the irrigation efficiency is observed in both groups from 2006 to 2007.

The overall efficiency was higher for the "yes group" than the "no group." It is also interesting to note that in 2007 the "yes group" irrigation efficiency increased back to the 2005 level, another indicator that conservation-minded households are achieving greater outdoor water use efficiency overtime.

Three years (2001, 2004, and 2007) were analyzed to determine how each group irrigated monthly throughout the growing season. Figure 11 shows that during the 2001 growing season, the overall trend that is the "yes group" irrigated less than the "no group." September showed the most significant reduction between the groups by two inches. Comparing the water practices of both groups to ET_{net}, it is seen that overwatering occurred across the board. However, the majority of the overwatering

occurred at the end of the growing season from August to October. This was likely due to automatic timers set to water for midsummer weather that had not been adjusted with the declining ET requirement during the fall months.

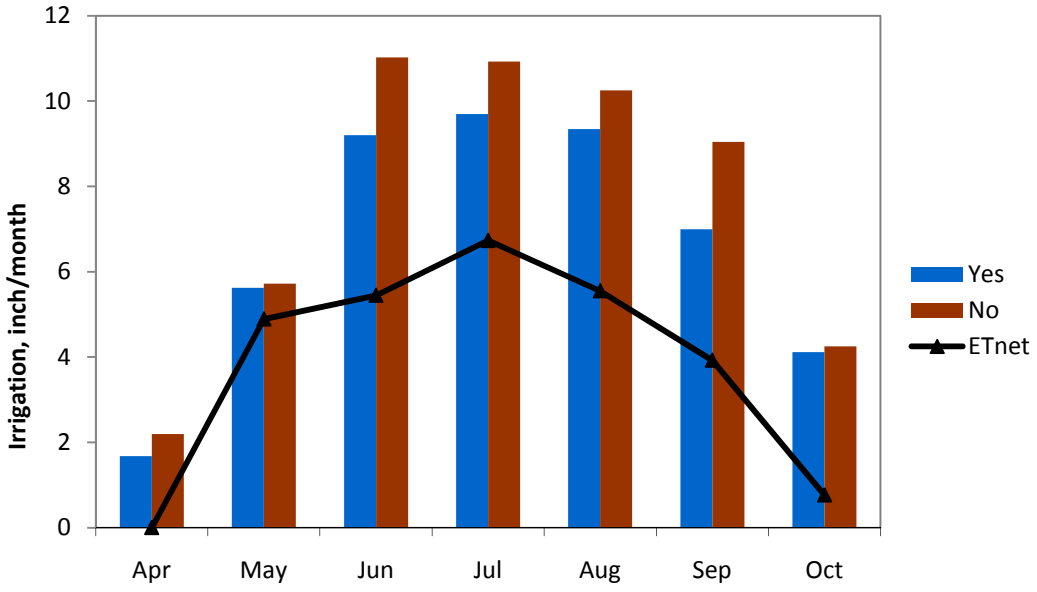

Figure 11. Monthly irrigation in 2001 compared to ET_{net}

The 2004 growing season can be seen in Figure 12. There is a minimal amount of difference between the two groups. Both groups irrigated to ET_{net} in the month of July. This figure indicates that people responded to the drought message in their irrigation practices regardless of whether they heard of "Slow the Flow."

Figure 13 represents the 2007 growing season. In June and July the "yes group" watered less than "no group" by 1 and 1.2 inches, respectively. This figure indicates that, although the groups were irrigating to ET_{net} in 2004, once the drought had passed, homeowners increased irrigation application. The increase was not as significant as the decrease seen in 2004. In July 2001, the "yes group" irrigated 36 percent over ET_{net} while the "no group" over irrigated by 48 percent. Comparing July 2001 to July 2007, the "yes group" irrigated 10 percent over ET_{net} and the "no group" over-irrigated by 25 percent. It can be seen that both groups are watering closer to ET_{net} after the drought.

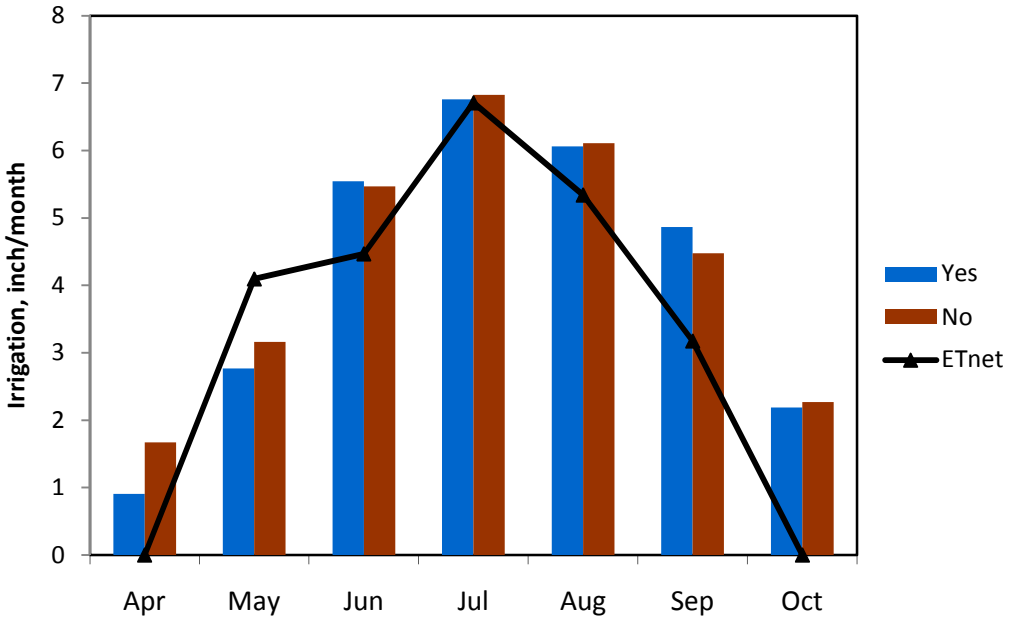

Figure 12. Monthly irrigation in 2004 compared to ET_{net}

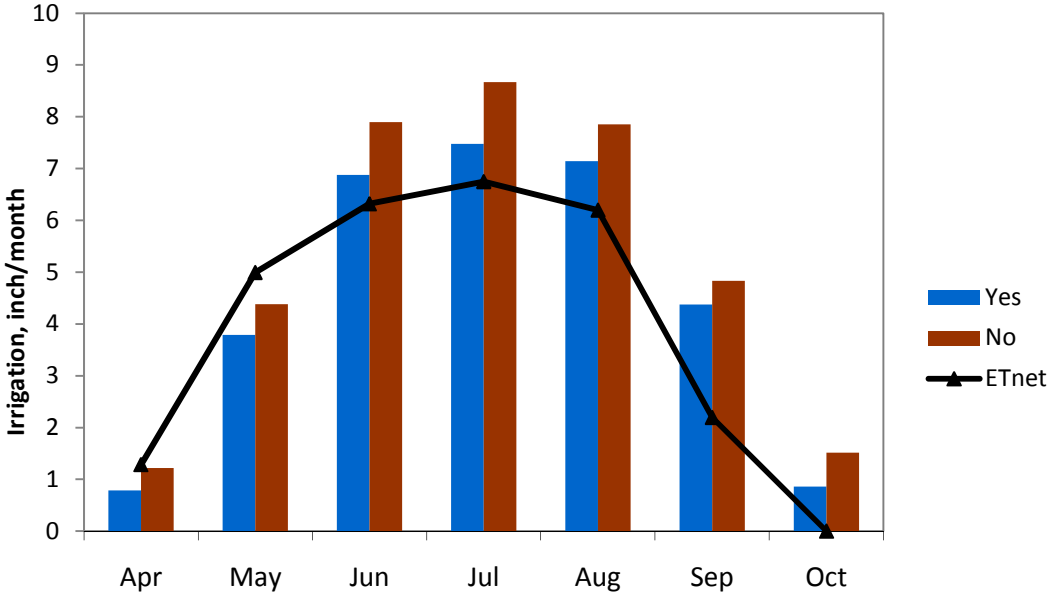

Figure 13. Monthly irrigation in 2007 compared to ET_{net}

The "yes group" did consistently water less than the "no group." This was seen in both the yearly and the monthly analysis. Collectively this indicates that the "yes group"

is irrigating more efficiently than the “no group.” However, both groups were still found to over irrigate compared to turf requirements (ET_{net}).

CONCLUSIONS

The results from the seventeen communities analyzed in this study indicate that overall residential water use in Utah has changed compared to the findings of the 2001 DWRe study. Using the results from this study, statewide residential indoor water use is now 61 gpcd, a 13 percent reduction from 70 gpcd found in the 2001 DWRe study. Outdoor use could not be modeled on a statewide basis but for the surveyed residents the outdoor use was found to be 134 gpcd.

The water use data and survey information supported that homes built after 1992 use approximately 5 gpcd (9 percent) less than pre 1992 homes. It was also found that homes with greater than 3,000 square feet of floor space used 13 gpcd (19 percent) more water indoors than homes with less than 1,000 square feet. Evaporative coolers were found to use about 28 gpd during the summer months (about 6 gpcd on a yearly basis). Lastly, it was found that residents irrigating with automatic sprinklers over water by about 30 percent while residents using a hose with sprinkler attachment underwater approximately 17 percent.

The results from the Salt Lake City analysis indicated that the "Slow the Flow" media campaign, and water conservation education in general, has been effective at reducing indoor residential water use. The analysis found that the group that had heard of the campaign ("yes group") used 30 percent less water indoors compared to the "no group." In the outdoor analysis, it was found that the "yes group" irrigated more efficiently than the "no group." However, both groups were found to over irrigate compared to ET_{net}; with the majority of the overwatering occurring during the last three months of the growing season.

Based on the results of this study, education-based conservation programs appear to be effective and are having a lasting effect. This study showed that during the drought from 2001 to 2004, residents responded to the media's message about the water shortage but once drought conditions eased, the "no group" rebounded quickly to its overwatering habits. However, this study also indicated that both groups still over irrigate when

compared to turf grass requirements (ET_{net}), such that additional and more precise water conservation education on outdoor watering practices may be necessary in the future.

APPENDIX A

Appendix A contains a sample of the letter and survey that were sent to random residents, and Table 5, which indicates corresponding response rates within each community in this study.

State of Utah
DEPARTMENT OF NATURAL RESOURCES

JON M. HUNTSMAN, JR.
Governor

GARY R. HERBERT
Lieutenant Governor

MICHAEL R. STYLER
Executive Director

Division of Water Resources

DENNIS J. STRONG
Division Director

08/12/2008

SAMPLE
ADDRESS
CITY UT ZIP

SAMPLE:

The Utah Division of Water Resources is responsible for helping communities meet their future water supply needs. Planning for sufficient drinking water requires that current in-home and outdoor water use patterns be identified. We are working with your water supplier to identify these important residential patterns.

Your home has been randomly selected, along with several others in your community, to participate in a survey designed to aid us in determining residential water use. Several factors (such as number of persons per household, type of irrigation system and income) that may affect water use will also be related to the water used in residential homes. This will aid us in determining which factors are the most influential. Attached is a survey and a self addressed, stamped envelope. Please take time to complete the questionnaire and return it in the envelope provided. Upon receiving your return survey we will contact your water supplier to obtain your water use records. Please be aware that the information provided will be kept confidential.

We are grateful for your cooperation.

Thank you,

Dennis J. Strong, P.E.
Director

1594 West North Temple, Suite 310, PO Box 146201, Salt Lake City, UT 84114-6201
telephone (801) 538-7230 • facsimile (801) 538-7279 • TTY (801) 538-7458 • www.water.utah.gov

«SupplierID»-«ContactID»

Figure 14. Sample letter sent with survey

Instructions:
The Division of Water Resources is grateful for your help. Please check the appropriate answer to the questions below.

1. What type of residence do you live in?
   - ❑ Single-family house
   - ❑ Multi-family house
   - ❑ Condo
   - ❑ Townhouse
   - ❑ Other, please specify _____

2. What is the closest approximation to your livable floor space including your basement?
   - ❑ Less than 1000 square feet ❑ 1000-2000 square feet
   - ❑ 2000-3000 square feet ❑ Larger than 3000 square feet

3. Do you have an evaporative (swamp) cooler? ❑ Yes ❑ No

4. Was your residence built before or after 1992? ❑ Before ❑ After

   If your house was built before 1992, have you done any renovations to your plumbing fixtures (i.e. toilet, shower, or faucets) after 1992?
   ❑ Yes ❑ No

5. For each of the following four years, please indicate the number of people that lived in this home and their corresponding age group. This section can have fraction amounts if someone was only living with you part of the year. Example: Mom, Dad, & an 18 year that went away to college in fall.

	Number of Persons per Age Group			
Year	19 yrs & older	18-13 yrs old	12 - 6 yrs old	5- 0 yrs old
EXAMPLE	2	2/3		
2007				
2006				
2005				
2004				

6. How large is your lot (you do not need to answer if you live in condo)?
   - ❑ Less than ¼ acre ❑ ¼ to ½ acre
   - ❑ ½ to ¾ acre ❑ ¾ to 1 acre or larger

7. How do you irrigate your yard?
   - ❑ Flood
   - ❑ Automatic sprinkler system
   - ❑ Manual operated sprinkler system
   - ❑ Hose with sprinkler attachment
   - ❑ Other, please specify_____

«SupplierID»-«ContactID»

Figure 15. Survey sent to random residents (Page 1)

Instructions:
The Division of Water Resources is grateful for your help. Please check the appropriate answer to the questions below.

8. Do you have a moisture sensor or ET controller in your yard to aid you in irrigation?
❑ Yes ❑ No

If yes, when did you install it?_____

9. Do you have a separate water source for irrigating your yard? Example: Secondary system, private well, agricultural source.
❑ Yes ❑ No

If yes, what percentage of you landscape is irrigated with this separate system?_____

10. Please indicate if there is either or both amenities are at this residence?
❑ Hot tub ❑ Swimming pool

11. What is your family's yearly income?
❑ Less than $25000 ❑ $25000 to $50000 ❑$50000 to $100000
❑ $100000 to 150000 ❑ Greater than $150000

12. Have you heard of the water conservation media campaign "Slow the Flow, Save H2O"? ❑ Yes ❑ No

13. The following is a list of conservation practices that are being implemented in single-family homes throughout Utah. Please check the boxes that apply to your household.
❑ Water efficient washing machines
❑ Installed ultra low flow toilet (1.6 gallon flush)
❑ Installed low flow showerheads
❑ Installed aerator faucets
❑ Water efficient dishwasher
❑ No leaks in toilet / faucet or they have been repaired

«SupplierID»-«ContactID»

Figure 16. Survey sent to random residents (Page 2)

Table 5. Summary of survey respondents return rate

Supplier Name	Number of Connections	Weighted Fraction	Weighted Number of Surveys	Number of Surveys Mailed	Number of Survey Returned	Return Rate
Beaver City Corporation	1210	0.01	32	50	13	26%
Logan Municipal Water System	14345	0.08	382	400	126	32%
Price Municipal Water System	2851	0.02	76	80	30	38%
Price River Water Improvement District	2051	0.01	55	60	13	22%
North SLC	3137	0.02	84	90	33	37%
SLC Corporation Culinary Water	80333	0.48	2139	2300	980	43%
Taylorsville-Bennion Improvement District	15202	0.09	405	425	125	29%
Blanding City Municipal Water System	1450	0.01	39	50	20	40%
Richfield Culinary Water System	2375	0.01	63	70	28	40%
Vernal Municipal Water System	2346	0.01	62	70	24	34%
Orem Municipal Water System	19265	0.11	513	550	173	31%
Layton City Water	16338	0.10	435	450	175	39%
Tremonton City Corporation	1942	0.01	52	50	27	54%
Richmond City Culinary Water System	717	0.00	19	50	21	42%
Duchesne Water System	801	0.00	21	50	20	40%
Kanab Municipal Water System	1697	0.01	45	50	22	44%
Delta City	920	0.01	24	50	18	36%
Riverdale City	2048	0.01	55	60	24	40%
Total	169028	1	4500	4905	1872	38%

APPENDIX B

Appendix B includes Tables 6 and 7, which contain winter and summer water use data for each community in this study.

Table 6. Winter water use results (December to February)

Cities	Households	Data Points	GPCD		GPD		PPH	
			Mean	STD	Mean	STD	Mean	STD
Beaver	13	108	53.6	22.5	182.1	77.7	3.40	1.86
Blanding	20	137	51.1	21.3	142.8	86.1	2.80	1.67
Delta	18	114	66.1	36.2	209.3	118.2	3.17	1.56
Dushesne	20	98	56.7	27.5	200.7	103.5	3.54	1.59
Kanab	22	154	72.0	42.9	166.5	109.0	2.31	1.48
Layton	175	1260	56.9	26.0	194.7	93.6	3.42	1.68
Logan	126	988	65.9	35.7	207.2	104.0	3.14	1.61
North Salt Lake	33	168	63.8	27.9	194.1	91.1	3.04	1.51
Orem	173	2238	62.4	28.0	224.9	100.4	3.60	2.00
Price	43	303	70.3	27.3	169.0	83.3	2.40	1.12
Richfield	28	227	64.2	30.6	174.4	78.9	2.72	1.38
Richmond	21	192	60.7	22.4	205.7	74.9	3.39	1.43
Riverdale	24	177	62.8	25.3	182.4	65.9	2.90	1.27
Salt Lake	980	7732	60.7	28.9	163.7	87.9	2.70	1.47
Taylorsville	125	1696	73.6	40.0	227.4	119.3	3.09	1.49
Tremonton	27	190	60.2	25.0	168.0	75.7	2.79	1.63
Vernal	24	166	67.7	29.2	183.4	81.7	2.71	1.32
Total**	1872	15948	62.2	29.7	182.1	92.5	2.93	1.54

**Weighted averages on totals row and GPCD column

Table 7. Summer water use results (April to October)

Cities	Secondary Use	Number Households	Data Points	GPCD		GPD		PPH	
				Mean	STD	Mean	STD	Mean	STD
Beaver	Yes	13	339	68	72	228	176	3.37	1.88
Blanding	No	20	508	331	388	912	697	2.76	1.63
Delta	No	18	356	366	446	1169	1024	3.19	1.60
Dushesne	Yes	20	380	85	137	291	272	3.41	1.64
Kanab	No	22	533	311	342	719	610	2.31	1.49
Layton	No	175	4232	184	251	627	604	3.40	1.66
Logan	No	126	3499	246	214	768	594	3.12	1.62
North Salt Lake	No	33	644	330	230	1002	516	3.03	1.57
Orem	No	173	6245	271	249	980	491	3.61	2.06
Price	No	43	1027	85	137	291	272	3.41	1.64
Richfield	No	28	726	414	452	1118	610	2.70	1.38
Richmond	Yes	21	676	151	93	511	443	3.38	1.45
Riverdale	No	24	629	269	244	756	430	2.81	1.26
Salt Lake	No	980	26110	264	251	722	460	2.73	1.54
Taylorsville	No	125	4981	192	128	592	246	3.07	1.49
Tremonton	No	27	625	315	244	870	485	2.76	1.62
Vernal	No	24	558	236	244	619	374	2.62	1.31
Total**	No	1872	52068	249	240	729	474	2.97	1.60

** Weighted average on totals row

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