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IRRIGATION SCHEDULING FOR LARGE WATER USERS

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ABSTRACT

Utah is in its sixth year of drought and water audits of large properties is an effective water conservation educational program. Over the past five years, 164 audits have been conducted (17 apartments, 23 businesses, 13 churches, 7 golf courses, 37 homeowner associations, 22 parks, 20 public facilities and 25 schools). Information from audits is used in developing a watering schedule for each property. By following the schedule over the growing season, the water used will be close to the turf water requirement (evapotranspiration). Water use records are evaluated over a five year period. The year of the audit, the average property saved 12.5% on their irrigation water. During the following year the average property was able to save another 13.8% on landscape water. The total savings over two years was 24.6%. The average water wasted before the water audit was 632,827 gallons per acre during the growing season.

INTRODUCTION

Utah is one of the fastest growing states and is also the second driest state in the nation. Enough people are added to the Utah population to make a new city the size of Salt Lake City (160,000) about every three years *(Utah Division of Water Resources, 2003*). It is also the third most urban state in the nation with about 80% of the population living along the Wasatch Mountain Front in six counties (Wahlquist, 1981). With wise planning by the pioneers and several reservoirs completed by the U.S. Bureau of Reclamation (usually with a two year irrigation supply), Utah has enjoyed inexpensive water for many years. Consequently, inefficient irrigation systems are tolerated and poor lawn watering schedules are promoted.

[1] Utah State is an affirmative action/equal opportunity institution

With six years of drought, water conservation issues became very important in Salt Lake County as well as in the entire state of Utah. Our future water supply will not be adequate for the growing population (Utah Division of Water Resources, 2001). Our first step is to stop water waste. Using water more efficiently will accomplish two important things 1) Utah's precious water supply is conserved, and 2) costly water development projects may be delayed. Over the past five years, Utah State University Extension in Salt Lake, Utah and other Counties have developed a partnership with many water districts; the lead agencies being Jordan Valley Water Conservancy District (JVWCD), the Central Utah Water Conservancy District (CUWCD) [administers the Central Utah Water Completion Act] and the Salt Lake City Public Utilities (SLCPU). USU Extension hires, trains, and oversees the college interns (mostly horticulture and plant science students) serving the requests of the water districts while JVWCD, CUWCD and SLCPU and their partner water districts fund the Slow the Flow Save H_2O program making water audits free to the public. Appointments are scheduled by calling to a toll free 'Slow the Flow Save H_2O' telephone line or directly to a USU County Extension office. Television and radio advertising is professionally created and changed each year. Advertisements have popularized the Slow the Flow slogan so that it is generally recognized by the public. The Water Check Educational Program is promoting a new ethic of efficient outdoor, culinary water use (*Jackson, 2002; Jackson and Hinton, 2002; Jackson and Mohadjer, 200*3).

WATER CONSERVATION EDUCATION

The Slow the Flow Save H_2O Water Conservation Program, including both the large property irrigation audits and the residential Water Check program, was designed to help Utah citizens use water more wisely in the landscape. Outdoor water use clearly represents the greatest opportunity for water savings. In 1998, the Utah State Legislature passed the "Water Conservation Plan Act" which required all water conservancy districts and water retailers with over 500 service connections to submit water conservation plans to the Utah Division of Water Resources. Most of the conservation plans focused on outdoor water use since most of the culinary water along the Wasatch Front is used in the landscape. In 1999, the Jordan Valley Water Conservancy District (JVWCD) initiated the Slow the Flow Save H_2O water conservation program in Salt Lake County. They were joined by the Central Utah Water Conservancy District (CUWCD), Salt Lake City Public Utilities (SLCPU) and Utah State University Extension (USU EXTENSION) in magnifying this program. As part of the overall conservation effort, the Water Check program is a personalized water conservation education program. We found that conservation efforts can be most effective when consumers are well informed from a one-on-one session at their own site evaluating their own system (Jackson, 2000).

FUNDING FOR WATER AUDITS

The Slow the Flow Save H_2O Water Check Program is provided free of charge as a public service in Salt Lake, Utah, Wasatch, Juab, Duchesne and Uintah counties by the CUWCD, JVWCD, SLCPU and their partner water districts. The water audit program is a personalized water conservation education program serviced by Utah State University Extension.

IRRIGATION WATER AUDITS OF LARGE PROPERTIES

Both the Jordan Valley Water Conservancy District and the Central Utah Water Conservancy District expanded the partnership with USU Extension to accomplish full water audits of large water users such as parks, schools, churches and public facilities. For 2003 they asked to make the priority with large water users over the residential program. A full water audit of all the zones of a large property is much more time consuming than a residential water check. It is still a series of tests which are conducted on the watering system to determine how much water the system puts out (precipitation rate), the soil type, infiltration rate, the evenness of the water application (distribution uniformity or efficiency) and includes the walk through of numerous zones on several time clocks. Water use records are requested, analyzed and used to recommend a watering schedule. A confidential report is issued to those requesting the water audit. All computerized reports are made available to the water districts.

WATER AUDIT METHODS

Water audit methods determining the distribution uniformity, precipitation rate, water pressure, etc. follow the guidelines established by the Irrigation Association (*IA Handbook, 1996*). The guidelines are summarized in the "Landscape Irrigation Auditor Training Manual" (1). The procedures were originally developed by the Irrigation Training and Research Center (ITRC) at California Polytechnic State University as part of their landscape water management program. About half of the 22 Utah State University Interns participating in the water check program are certified Landscape Irrigation Auditors. The term "Water Check" was developed for the public and is a shortened version of a full water audit.

Catch cups used during 1999 and 2000 were from ITRC supplied in the water audit kits. Catch cups supplied by the U.S. Bureau of Reclamation were used in the later water checks.

The Utah Division of Water Resources has calculated the Net ET for the past 50 years at a Salt Lake County weather station maintained by Utah State University Extension along with weather records from the Salt Lake City Airport. The average net ET for the area is 22.9 inches of water during the growing season. Our net ET value (averaging three weather stations along the Wasatch Front local term for Utah Mountainous Area with the urban population) is 24.7 inches. A typical Utah lawn has an irrigation water requirement beginning in mid-April, rises to a peak in July, and then falls rapidly until mid-October. The summer rainfall pattern for the past ten years averages 8.4 inches during the growing season. The rest of the lawn water requirement is through irrigation, usually using culinary water. The turf water requirement used to compare water use in the Water Check Program has been estimated using a 30 year average of three weather stations in Salt Lake County. Data is summarized by county in Research Report 145 by the Utah Agricultural Experiment Station. The average evapotranspiration for turf is calculated in the publication at 24.7 inches of water required for the growing season of April 1st through October 15th to maintain a green lawn (*Hill, 1998; Ervin, 1998; U.S. Geological Survey, 1995*).

BACKGROUND OF OUTDOOR WATER AUDITS

As the Irrigation Association started certifying outdoor irrigation audits, several Utah State University County Agents and Specialists became certified. We first initiated outdoor water audits in Salt Lake County during 1995. To establish the value of water audits as an educational water conservation program, a partnership was established between Salt Lake City Public Utilities, the Audubon Society and Utah State University Extension in Salt Lake County. The first outside

funding came by a grant from the Central Utah Water Conservancy District under the Water Conservation Credit Program. Additional funding came to USU Extension from the Utah Division of Water Resources, Salt Lake City Public Utilities and the U.S. Bureau of Reclamation.

The Water Check Program was built upon the early water audit education program established by Utah State University Extension in Salt Lake County. Funding for advertising by the water districts made a terrific difference in educating the public about water conservation and the availability of personalized site assessments. A demonstration water audit was performed at the State Capitol in 2000 and a residential water check at the Governor's home during 2001. The Governor and his wife made use of the water check information to improve their sprinkler system and conserve outdoor water. The Governor has now established a state-wide water conservation initiative and the slogan and principles established in the Slow the Flow Save H_2O program. Because of the generous funding and statewide advertising, the water audit program remains a personalized water conservation education program funded by the water districts and serviced by Utah State University Extension (Jackson, 2000).

INTERN TRAINING FOR WATER AUDITS

Interns are given five days of orientation, training and field experience with water auditing procedures and irrigation systems the first week of May. We move to a new site each day covering the various topics. Friday is a day for water checks where a new water checker accompanied an experienced person. At the end of the five days, even our least experienced intern in horticulture is ready to meet the public and accomplish water checks. Every intern has their own audit kit and tool box.

SCHEDULING IRRIGATION WATER AUDITS

The Slow the Flow Save H_2O telephone number was continued this year as 1- 877-728-3420. The telephone system was up-graded and interesting water conservation messages added for customers to listen to while waiting. The link to Utah County performed smoothly with their new telephone number. The toll free number serves all six counties involved in the Slow the Flow Water Conservation Program. Citizens leave their name and address if they live outside Salt Lake County. These messages are automatically transferred to the Utah County Extension Office.

TABLE 1

2003 FULL IRRIGATION AUDITS IN SALT LAKE COUNTY

CITY	# of AUDITS
Draper	2
Holladay	4
Midvale	2
Murray	5
Riverton	3
Salt Lake City	9
Sandy	4
South Jordan	3
Taylorsville	4
West Jordan	7
West Valley City	5
2003 TOTAL	48

TABLE 2

2003 FULL IRRIGATION AUDITS OUTSIDE SALT LAKE COUNTY

CITY	# of AUDITS
Bountiful	3
Eagle Mountain	1
Highland	1
Layton	3
Mona	1
Nephi	2
Ogden	3
Orem	12
Provo	9
Saratoga Springs	2
Springville	1
2003 TOTAL	38

WATER AUDIT DISTRIBUTION BY CITY

During the summer of 2003, a total of 86 irrigation water audits were accomplished on large properties. **Table 1** shows the distribution of

water audits between the eleven cities represented in Salt Lake County. Salt Lake City had the most audits (9) followed b y West Jordan City (7).

The Utah County team accomplished 38 audits of large properties during 2003. **Table 2** shows the distribution of audits by city. Orem had the most audits (12) followed by Provo (9). From 2001 through 2003, a total of 185 irrigation audits of large water users have been accomplished.

GROWTH IN THE NUMBER OF LARGE SYSTEM AUDITS

Irrigation audits of large properties were initiated under the Slow the Flow Save H_2O program during 2001. A total of 25 properties within Salt Lake County were accomplished this first year. The program has grown each year (**Table 3**) with a total of 186 full reports completed and organized in the computer. **Table 3** summarizes the number of audits by year both within Salt Lake County and in other counties (124 properties in Salt Lake County and 61 in other counties). Confidential summaries of these water audits are available from individual water districts.

TABLE 3

NUMBER OF LARGE PROPERTY AUDITS BY YEAR

YEAR	SALT LAKE COUNTY	OTHER COUNTIES	TOTAL
2001	25	0	25
2002	51	23	74
2003	48	38	86
TOTAL	**124**	**61**	**185**

TABLE 4

Water Audits of Large Properties

Reports	Type of Property
16	Apartments
44	Businesses
13	Churches
6	Golf Courses
37	Homeowner Associations
22	Parks
21	Public Facilities
25	Schools
2	Other
186	Total Audits Completed

LARGE SYSTEMS DIVIDED INTO CATEGORIES

There are eight categories for data summarization and report organization: 1) Apartments 2) Businesses 3) Churches 4) Golf Courses 5) Homeowner Associations 6) Parks 7) Public Facilities and 8) Schools. If an audit doesn't fall into one of these categories, it is reported under the "other" category. **Table 4** lists all of the audits completed in each category. Businesses (44) and Homeowner Associations (37) were the most popular categories requesting fact sheets and water conservation assistance. Additional information about each participant is listed in confidential reports on file with the water purveyor.

RECOMMENDED WATERING SCHEDULE

In order to simplify a watering schedule, a schedule was developed based on an interval between deep irrigations (with the accompanying recommendation that at least ½ inch of water be applied at each irrigation) and ET values over the past thirty years. This makes it so that ET calculations need not be made on a daily or weekly basis by property managers. Adjusting the timer

monthly to better follow this demand curve will save water and money. It took two years of discussions with various agencies and water districts before everyone could agree to the schedule based on intervals between irrigations. Now, during the fifth year of drought, all agencies recommend this schedule shown on **Table 5**. If followed, this schedule will bring the water use down near the turf water requirement (net ET of 22.9 inches of water per growing season). As with any irrigation schedule, there is a need to know the precipitation rate of a zone. This schedule is included in every audit report and has been well received by those having irrigation audits.

TABLE 5

Customized Water Schedule

- **Sprinkler run time is based on precipitation rate measurements, soil type, and slope**
- **Run time remains the same but watering intervals change monthly**

MONTH	INTERVAL
Startup until April 30	Once Every 6 Days
May	Once Every 4 Days
June	Once Every 3 Days
July	Once Every 3 Days
August	Once Every 3 Days
September	Once Every 6 Days
October 1 to Shutdown	Once Every 10 Days

IRRIGATION TIMING EXAMPLE FOR POP-UP HEADS

TABLE 6

Time Required to Apply 1/2 inch of Water to a Loam Soil

Precipitation Rate	Minutes
4 inch/hour	4 min in 2 cycles
3 inch/hour	5 min in 2 cycles
2 inch/hour	7 min in 2 cycles
1.4 inch/hour	21 minutes
1 inch/hour	30 minutes
0.7 inch/hour	43 minutes
0.3 inch/hour	100 minutes

Irrigation times for a Loam Soil
Average precipitation rates based on catch cup tests.

TABLE 7

Time Required to Apply 1/2 inch of Water to a Clay Soil

Precipitation Rate	Minutes
4 inch/hour	3 min in 3 cycles
3 inch/hour	3 min in 3 cycles
2 inch/hour	5 min in 3 cycles
1.4 inch/hour	7 min in 3 cycles
1 inch/hour	10 min in 3 cycles
0.7 inch/hour	15 min in 3 cycles
0.3 inch/hour	50 min in 2 cycles

Irrigation times for a Clay Soil
Average precipitation rates based on catch cup tests.

The water check program recommends application of at least ½ inch of water at each irrigation and to let the soil surface dry between waterings. Water should wet the soil at least eight inches deep. In order to use the schedule properly, one needs to determine how long it takes each zone of a sprinkler system to put out ½ inch of water. Since the average fixed pop-up head system output is 1.4 inches/hour, the sprinklers should run for 21 minutes on sandy or loam soils to put out ½ inch of water. If the property has a clay soil, split the 21 minutes into three cycles of 7 minutes applied about one hour apart. Remember that the larger rotor type heads on the average have a precipitation rate about half (0.7 inches per hour) the rate of fixed pop-up heads. Therefore, to apply ½ inch of irrigation water, run the system for 45 minutes on sandy and loam soils and three cycles of 15 minutes each (about one hour in between each cycle). The schedule recommends applying 0.5 inches of water at each irrigation (21 minutes), but if the soil and root depth allow, one should increase the application to 0.75 inches (32 minutes) or 1.0 inch of water (43 minutes) assuming an average precipitation rate of 1.4 inches per hour.

Although the average precipitation rate is about 1.4 inches per hour for pop-up heads and 0.7

TABLE 8

Time Required to Apply 1/2 inch of Water to a Sandy Soil	
Precipitation Rate	**Minutes**
4 inch/hour	8 minutes
3 inch/hour	10 minutes
2 inch/hour	15 minutes
1.4 inch/hour	21 minutes
1 inch/hour	30 minutes
0.7 inch/hour	43 minutes
0.3 inch/hour	100 minutes

Irrigation times for a Sandy Soil
Average precipitation rates based on catch cup tests.

inches per hour for rotor heads, the sprinkler head range varies from 0.3 to 4 inches per hour. A water check also supplies information on the required time to apply ½ inch of water to a loam (**Table 6**), clay (**Table 7**) or a sandy (**Table 8**) soil.

FOLLOWING THE RECOMMENDED SCHEDULE

A water audit was performed at a business facility in Salt Lake County (NPCEJ04). This organization came close to watering at the turf water requirement (ET) in spite of an average irrigation system. Their 'watering deep about twice a week' brought them close to ET with a very lush, green lawn. They used 9,918,411 gallons of culinary water during the season for 12.9 acres of irrigated landscape. This is only 123% of ET. Yet, for their fixed heads, they had a water pressure of 80 psi (way too high), a distribution uniformity of 34% (should be close to 70%), and a precipitation rate of 2.5 inches per hour (should be close to 1.4 inches). For their rotor heads (which was the majority of the heads on this large property) they had a pressure of 95 psi, a distribution uniformity of 62% and a precipitation rate of 0.9 inches per hour. Even with low uniformity in the fixed head areas, they timed their irrigations for deep water penetration into the soil and then waited several days for the next irrigation.

POOR WATERING HABITS

A shallow watering every day is about the worst thing you can do for a lawn because it keeps the roots short. Short roots make it necessary to water every day during the hot days of July and August to keep the lawn from going dormant. With a uniform soil and proper irrigation, a bluegrass lawn should have a root system up to 12 inches deep. The deeper the root system, the more days you can wait between irrigations. Unfortunately, many residents and managers of large properties along the Wasatch Front water every day. The average residential lawn has a root system only 5.7 inches deep. It was a surprise to find that the average grass roots on the large properties were only 4.3 inches deep as shown in **Table 9**. This illustrates the effect of overwatering. The average large property uses two or three times as much water as the turf water requirement.

TABLE 9

Large Water Users

185 Large Water Audits Done in 2001-2003

	Average	High	Low
Landscape Information			
Property Size	654,426 ft^2	7,492,320 ft^2	9,011 ft^2
Acreage	15 acres	172 acres	0.21 acres
Landscape Size	265,177 ft^2	5,488,866 ft^2	4,448 ft^2
Landscape Size in Acres	6 acres	126 acres	0.10 acres
% of Lot Landscaped	55%	100%	12%
Hardscape Size	363,508 ft^2	7,492,320 ft^2	0 ft^2
Root Depth	4.3 inches	16 inches	1 inches

INEFFICIENT SPRINKLER SYSTEMS

Efficient irrigation is an important water conservation goal. Overwatering not only wastes water, but it weakens and kills more plants than underwatering. Another wasteful practice seen all too often is misapplication of water, resulting in rotted fences and house siding, flooded sidewalks and rivers of water wastefully flowing down gutters. The average distribution uniformity (efficiency) of fixed pop-up heads is 55% (**Table 10**). The larger rotor heads operated by the large water use properties audited to date should be more efficient at a higher water pressure but also averaged out at 55% distribution uniformity (**Table 10**). A properly installed irrigation system should be a minimum of 70% efficient. An efficient irrigation system is also based on zoning plants with similar water needs together and using the irrigation method that waters each zone most efficiently. Turf and non-turf areas definitely need separate zones because of the differing water needs. As a rule of thumb, shrub areas require about one-half as much water as turf areas.

TABLE 10

Large Water Users

185 Large Water Audits Done in 2001-200

	Average	High	Low
Irrigation System			
Fixed Head Pressure	49 psi	112 psi	1 psi
Rotor Head Pressure	50 psi	104 psi	1 psi
Fixed Distribution Uniformity	55%	82%	7%
Rotor Distribution Uniformity	55%	84%	8%
Fixed Precipitation Rate	1.49	3.1	0.26
Rotor Precipitation Rate	0.74	2.46	0.13

PICTURE 1

With large water use sites, we found irrigation systems that were poorly designed, improperly installed, out of adjustment, and/or in need of repair. We found some new irrigation systems (3 schools and 1 church) installed during the year by contractors to be between 50% and 60% efficient. We found most controllers (timers) set to apply more water than needed by the landscape especially those with a high precipitation rate where water was applied faster than the soil infiltration rate. With regards to scheduling, most of the controllers were set to irrigate more frequently than required by the landscape.

Precipitation rate is a measure of how much water is emitted from a sprinkler head over time. It is measured either in inches of water per hour (like a rain storm) or in gallons per minute. **Picture 1** illustrates a typical

catch cup test performed at all sites. Initial catch cups (cone with metal stand) used in this program were from the Irrigation Association. During the last two years the cones with plastic legs (U.S. Bureau of Reclamation) were used. There was very little variation in water measurement when the two styles of cups were compared side by side.

The average fixed pop-up head puts out 1.5 inches of water per hour (**Table 10**). We found a range in precipitation rates from 3.7 inches per hour down to 0.3 inch per hour. Most soils can not absorb water at this fast of an application rate. Sprinklers generally apply water faster than a very heavy rainstorm which weathermen classify as rainfall greater than 0.4 inches/hour. The precipitation rate for the larger rotor heads was about half the rate of the fixed pop-up heads at 0.74 inches per hour (**Table 10**).

HIGH WATER PRESSURE

We found high water pressure to be a major problem in every city and county. Homes with in-ground sprinkler systems should have pressure regulators installed. The average water pressure measured during the day at a sprinkler head is about 50 pounds per square inch (psi) (**Table 10**). This is too high for the typical fixed pop-up sprinkler head and increases misting and evaporation. Nearly all fixed pop-up sprinkler heads are manufactured for use between 15 and 30 psi of water pressure. On the other hand, the large rotor sprinkler heads usually work best at pressures greater than 50 psi (**Picture 2**). Irrigation system pressure is a major problem along the Wasatch Front. It needs to be corrected by separating the water pressure to fixed pop-up heads and to rotor heads or to have the system designed with the correct head spacing for the pressure delivered.

PICTURE 2

SOIL TEXTURE DETERMINATION

Soil cores were taken with standard soil probes to determine grass root depth and soil type. For soil type determination, a portion of the soil is slowly moistened and kneaded in the hand to determine a sandy soil, a clay soil or a loam soil (outlined by Utah State University and the U.S. Bureau of Reclamation). A soil that is predominately sand can have water retention problems, while a clay-dominated soil will have problems with water infiltration. The infiltration rate of the soils evaluated in this study ranged from 0.1 to about 1.5 inches per hour (**Table 11**). As part of the watering schedule, water cycling is promoted for those sites with slopes and/or clay-type soils. The amount of water applied

TABLE 11

Soil Infiltration Rates

Sandy Soils	1.5 inch/hour
Sandy Loam Soils	0.7 inch/hour
Loam Soils	0.5 inch/hour
Clay Loam Soils	0.3 inch/hour
Clay Soils	0.1 inch/hour

during an irrigation event is dependent upon the application (precipitation) rate and the run time. Where infiltration rates are low, multiple run cycles may be required to avoid excessive runoff. Multiple run cycles should be separated by soak times lasting about an hour each. There appears to be no uniform soil texture for a residential yard in Salt Lake Valley. Homes are built on the benches and hills with sandy soils and in the valley where clay-type soils dominate. For soil textures, this study found that 53.2% of the residential sites had clay-type soils, with 34.3% sandy-type soils and only 12.5 % had silty-type soils. The variability of the soil type at parks, schools, churches and public facilities was not quite as variable as at residential sites, but a layer of sand or subsoil was a common occurrence. Compaction of the soil was a common situation at schools as one would suspect.

CULINARY WATER WASTE

The great majority of landscapes in the five counties covered by this study use culinary water outdoors as well as indoors. The average resident uses twice as much water as a healthy lawn requires. Parks, churches, apartments and schools studied were more wasteful than homeowners, using nearly three times as much water as required (**Table 12**). Irrigation water audits include a measurement of the landscape size (expressed in either acres or square feet) and evaluation of the total gallons of water used on the landscape during the growing season. The tables included in this report express the outdoor water used in gallons per acre of turf or in inches of water used over any given area. The initial group of properties studied during 1995 and 1996 used an average of 79.1 inches of water (345% of the turf standard water use of 22.9 inches). Adding all of the apartments, churches, parks, schools and public facilities now in the data base, the average water use is down to 226% (51.8 inches) of the standard for turf which is still a horrendous amount of water to waste. This is far greater than the 201% of standard used by the average homeowner with the turf water requirement being 100%. **Table 12** breaks out the water waste calculation compared to ET by category. In this study to date, apartment complexes, public facilities and churches appear to be the most wasteful.

TABLE 12

Water Waste by Large Properties

% of ET_{TURF}	Type of Property
307%	Apartments
304%	Public Facilities
300%	Churches
288%	Schools
262%	Homeowner Associations
218%	Small Businesses
200%	Home Owners
165%	Parks
120%	Water-wise Citizens
100%	Turf Water Requirement (ET)
88%	Golf Courses
70%	Xeriscape Landscapes

A water audit was completed on a public facility (6PFEJ08) in Salt Lake County. The report demonstrated an inefficient system (50% distribution uniformity averaged over all zones) with 13% of their 412 sprinkler heads needing adjustment or replacement. The six controllers varied in irrigation system run times by 35%. The average precipitation rate for fixed, pop-up heads was 1.8 inches per hour and for rotor heads, 0.6 inches per hour. Irrigation of many flower and shrub areas was included in lawn watering zones.

An examination of the water use records indicated that 13,421,527 gallons of culinary water was used during the growing season on the landscape. To maintain a healthy lawn, only 4,558,659 gallons of water would be required. With an irrigated landscape area of 7.33 acres, the water use during 1996 was 42 gallons of drinking water per square foot of landscape. The turf water

requirement [evapotranspiration (ET for turf)] is only 14.28 gallons per square foot per season. Therefore, irrigation water used on this facility was 294% of ET. A total of 8,498,001 gallons of water were wasted during the year on this property at a cost of $15,224 (in 2001 dollars calculated from the Salt Lake City Public Utilities summer water charge of $1.34 per 100 cubic feet of water outside of the Salt Lake City boundary).

At the request of a public official in June 2001, a second water audit was conducted on the same landscape. The precipitation rates, mixed head zones and mixed landscape zones were about the same. As was recommended in the first audit, the Imperial Controllers had been replaced and many of the misaligned heads had been repaired and replaced. The 2000 water year was significantly warmer than 1999, and 14% more outdoor water was used during the 2000 growing season over the 1999 year. For the calculation of landscape water used, we averaged 1998, 1999 and 2000 water use records. The current landscape area is 319,489 square feet and the average irrigation water used during the last three growing seasons was 9,911,499 gallons (31 gallons/square foot/season). Compared to the turf water demand (14.28 gallons/square foot/season) the average annual turf requirement for the landscape was 4,923,526 gallons/square foot/season. It is evident from these numbers that city park personnel had reduced their landscape water use at this facility by 35% from the 1996 values. Unfortunately, they were still wasting a great amount of culinary water (201% of ET). This example points to the fact that it sometimes takes years to budget for the installation of a new irrigation system; yet a tune up of an irrigation system pays for itself in water conservation.

Using this site to calculate water waste, a total of 4,987,973 gallons of culinary water are being wasted annually at this site. This amount of water is equal to 15.3 acre feet. The average residential lot size along the Wasatch Front is 13,589 square feet (0.31 acres). The average residential irrigated landscape is 7,894 square feet (0.19 acres). On the average, lots are 61% landscape and 39% hardscape. This means that the 4,987,973 gallons of water wasted at this site would irrigate the average size landscape along the Wasatch Front for 41 years. Another way of saying this is that the wasted water for one growing season at this public facility would be adequate for 41 homes. The cost of the wasted water in 2001 dollars was $8,935.67 a year at that site.

SECOND EXAMPLE OF A LARGE WATER WASTER

As bad as the public facility was in the previous example (6PFEJ08), there are several examples in the 186 audit reports that illustrate greater water waste. Public facility 8PFEJ05 used 14,369,241 gallons of culinary water during the growing season on 4.6 landscaped acres. This equates to 71.7 gallons/square foot/season. Compared to the turf water requirement of 14.28 gallons/square foot/season, these maintenance professionals were watering at 502% ET. Calculations indicate an annual waste of 28.8 acre feet (9,381,268) or enough water to irrigate the lawns of 77.1 average residential landscapes for a whole year! Unfortunately, our water audit database includes one property using 8.52 times the turf water requirement.

WATERING FAILURE AT A PUBLIC FACILITY

At the request of the director of a Salt Lake County Public Facility, we determined that trees in the newly planted landscape were dying from overwatering and worked out a watering schedule for them. They also determined to replace the lawn in the front landscape with native plants including a separate drip irrigation system. The building is located on a 2.61 acre site with 1.08 acres under irrigation. A full 25% of the landscape is classified as a xeriscape type landscape with 75% under turf. The water use records for the site were evaluated for 1999 and 2000. We expected the

outdoor water use to be very close or less than the turf water demand value because of the change in landscape. Of the 1,998428 gallons of water used annually, only 6% is used indoors while 94% was used outdoor during the landscape growing seasons. The year after reducing their lawn area, the landscape was still overwatered by 64%. A xeriscape landscape is not the answer to saving water unless people change their watering schedule to fit the landscape zones.

WATER SAVINGS AFTER WATER AUDITS

The question is always asked, "Do water audits save water and money?" The answer of course is "It depends...." There are many factors that influence large water use properties and their ability to immediately start saving water. Experience demonstrates that by shifting to the recommended irrigation schedule and adjusting head alignment can result in a 10 to 20% reduction in water use the month after a water audit. On the other hand, some facilities require a year or more to alter the budget for major adjustments or a totally new irrigation system.

Summarizing the large water audits conducted during 2001, we had 13 audits with outdoor water values for multiple years. With a turf water requirement (ET) value of 22.9, one property used only 26.7 inches of water (117.8% of ET). The range of values for the properties was 26.7 inches to a high of 95.8 (418% of ET) with a mean of 67.1 inches. The average water waste was 42.4 inches above ET which indicates an average value of 285%.

TABLE 13

2002 Water Audits
Water Conservation by Large Properties

AUDIT	TOTAL LANDSCAPE GALLONS USED PER YEAR 1999	2000	2001	2002	2003
02GC05	132,213,937	158,144,853	191,189,249	**148,166,533**	136,412,461
02GC01	102,124,739	105,591,719	113,893,771	**122,820,403**	102,426,183
02GC07	118,570,566	148,768,822	135,527,726	**118,790,478**	93,537,250
02PK17	103,849,446	123,108,950	104,037,942	**69,581,322**	65,536,886
02GC06	66,386,197	74,887,965	69,838,217	**73,953,713**	58,869,545
02GC04	16,925,594	37,951,126	97,009,466	**103,214,126**	56,372,122
02GC02	41,639,365	50,359,549	50,763,469	**33,456,245**	50,530,093
02PK15	42,305,982	44,410,106	46,095,350	**43,056,226**	41,420,350
02APT02	16,204,971	19,544,791	17,046,471	**17,714,435**	12,230,099
02APT11	11,150,436	7,922,816	7,033,444	**8,410,512**	9,737,464
02PK20	13,223,892	11,938,080	12,041,304	**11,533,412**	9,535,504
02HOA02	5,812,708	8,082,888	8,111,312	**5,665,352**	9,092,688
02PK14	7,274,450	8,819,818	9,853,554	**7,893,046**	8,759,230
02PF06	11,424,307	12,665,987	12,175,299	**10,730,911**	8,449,511
02PK09	9,688,844	9,560,188	6,578,660	**4,661,536**	5,808,220
02PK07	6,989,312	6,580,904	6,624,288	**4,279,308**	4,752,044
02PK11	8,217,977	10,247,301	7,226,129	**5,647,101**	4,673,205
02PK06	4,794,381	6,151,253	5,335,933	**3,614,785**	3,800,289
02HOA02	3,976,678	3,106,006	2,488,906	**1,801,494**	3,689,446
02PK10	5,628,700	10,601,404	8,685,028	**4,606,184**	3,587,408
02APT03	5,419,363	5,841,983	4,479,875	**4,613,767**	3,384,055
02APT08	1,659,722	2,060,650	2,386,030	**1,222,890**	2,644,090
02OT01	3,881,746	3,248,938	3,673,802	**2,834,546**	1,913,758
02APT01	1,529,959	1,495,850	957,290	**1,138,830**	1,040,094
02PF07	1,835,031	1,860,463	1,126,675	**540,991**	800,547
02APT06	3,826,618	3,154,914	1,629,742	**1,397,114**	520,458
02CH01	892,813	841,949	838,957	**753,685**	507,593
02HOA04			1,921,612	**1,092,080**	445,808
02CH07			1,507,500	**690,500**	1,266,500
02SCH05			3,735,000	**3,496,000**	2,905,000
02HOA01			1,707,684	**1,084,600**	982,872
Average	27,683,249	32,479,603	30,178,054	26,402,004	22,762,283
	Average % water use from previous year			87.5%	86.2%
	% Water Reduction (24.6%) over two years by 2002 Audits				75.4%

LWA db Outdoor Savings 0204

Table 13 summarizes the total gallons of water used in the landscape by 28 large water use properties audited by our interns during 2002. (Unfortunately, we are still struggling to obtain the water use records on the other half of the properties as well as those audited during 2003). Data in the table 13 shows that even in the third year of drought (2001) properties used about the same level of water as the prior two years. The year of the audit (2002) the average property saved 12.5% (listed as 87.5%) on their irrigation water. During the following year the average property was able to save another 13.8% on landscape water. The total savings over two years was 24.6%. The State Division of Water Resources announced recently that the

Governor's Slow the Flow Save H_2O media campaign at a cost of over $400,000 saved an average of nearly 9% over the same period of time. Most of these water savings were accomplished by a sprinkler system tune-up, purchasing more modern controllers, and paying attention to irrigation scheduling.

REDUCED WATER USE AT A SCHOOL IN WEST JORDAN CITY

A new RainBird Maxicom central control irrigation system was installed at a school in West Jordan City. The system had its own weather station with sensors for air temperature, solar radiation, relative humidity, wind speed, wind direction and rainfall. The information is calculated for Evapotranspiration for turf on a daily basis and supplied to the computer running the irrigation system. Each irrigation zone is then programmed for the correct minutes to water each week. A total of 54% of the 10.8 acre site is irrigated landscape. During 1998, 1999 and 2000, the school used an average of 3,314,112 gallons of irrigation water during the growing season. This equated to a value of 28.8 gallons of culinary water per square foot per season. Before automation they were watering at 189% of the actual turf water requirement. After the Maxicom automated system was installed, the water use records indicated that this facility irrigated at 98% of the current years water requirement. When an entire sprinkler system is replaced with an automated system based on a weather station, the total water used can be brought down to the same level as the standard (ETturf).

TABLE 14

2002 Water Audits of Large Properties
Water Conservation Compaired to ET Values

		TOTAL LANDSCAPE GALLONS USED per YEAR per ACRE				
AUDIT	Acres	1999	2000	2001	2002	2003
02GC05	387.9	340,845	407,695	492,883	381,971	351,669
02GC01	170.5	598,972	619,306	667,999	720,354	600,740
02GC07	161.1	736,006	923,456	841,265	737,371	580,616
02GC06	144.8	458,468	517,182	482,308	510,730	406,558
02GC04	172.0	98,405	220,646	564,009	600,082	327,745
02GC02	58.1	716,684	866,774	873,726	575,839	869,709
02APT02	6.7	2,418,652	2,917,133	2,544,249	2,643,946	1,825,388
02APT11	2.5	4,460,174	3,169,126	2,813,378	3,364,205	3,894,986
02PK20	15.6	847,685	765,262	771,878	739,321	611,250
02PK14	8.9	817,354	990,991	1,107,141	886,859	984,183
02PF06	4.0	2,856,077	3,166,497	3,043,825	2,682,728	2,112,378
02PK09	17.5	553,648	546,296	375,923	266,373	331,898
02PK07	8.7	803,369	756,426	761,412	491,874	546,212
02PK11	5.6	1,467,496	1,829,875	1,290,380	1,008,411	834,501
02PK06	5.3	904,600	1,160,614	1,006,780	682,035	717,036
02HOA02	3.2	1,242,712	970,627	777,783	562,967	1,152,952
02PK10	4.5	1,250,822	2,355,868	1,930,006	1,023,596	797,202
02APT03	3.3	1,642,231	1,770,298	1,357,538	1,398,111	1,025,471
02APT08	3.7	448,574	556,932	644,873	330,511	714,619
02OT01	3.1	1,252,176	1,048,045	1,185,097	914,370	617,341
02APT01	0.7	2,185,656	2,136,929	1,367,558	1,626,900	1,485,849
02PF07	0.9	2,038,923	2,067,181	1,251,861	601,101	889,497
02APT06	0.8	4,783,273	3,943,643	2,037,178	1,746,393	650,573
02CH01	1.4	637,723	601,392	599,255	538,346	362,566
02HOA04	1.3			1,478,163	840,062	342,929
02CH07	1.1			1,370,455	627,727	1,151,364
02SCH05	5.8			643,966	602,759	500,862
02HOA01	1.0			1,707,684	1,084,600	982,872
02PF05	3.7				1,213,892	1,226,054
02APT04	0.6				4,096,774	3,601,613
02SCH02	0.3				4,729,273	2,954,515
02PF03	9.1				581,758	406,484
32	37.9	Number of Audits and Average Landscape Size				
AVG Gallons per Acre		1,407,639	1,438,333	1,219,925	1,218,423	1,062,422
Turf Water Requirement		632,781	681,666	687,097	678,950	678,950
Gallons Wasted per Acre		774,857	756,667	532,827	539,474	383,472
Turf ET in Inches		23	25	25	25	25
Times 27,158 gal/ac in.		632,781	681,666	687,097	678,950	678,950
% OVER ET		222%	211%	178%	179%	156%

WATER SAVINGS COMPARED TO TURF WATER REQUIREMENT

The water savings information presented in **Table 13** was recalculated to compare with the turf water requirement (ETturf). **Table 14** presents the data in total landscape gallons used per year on a per acre basis. With ET at a value of 100% on the bottom line, the properties were using about twice as much water as the turf required during 1999 and 2000. After working with the properties and recommending a watering schedule based on an irrigation system audit, the average property was only 36% over evapotranspiration.

SATISFACTION SURVEY OF CONTACT PEOPLE FOR LARGE PROPERTIES

A Utah State University Extension telephone survey was

conduced in November of 2003 to determine the impacts of the Large Water Audit Program. The survey was summarized as follows: “The participants surveyed were very positive about the Water Check Program and felt that it was a useful tool in helping them to save water. Several participants even wanted to thank us again for our efforts. Several other positive comments included: "The water auditors did a great job, were knowledgeable and well prepared"; "The report was extremely helpful. I was able to take it to my boss and the property owners to show what could be done to lower costs, great information"; "Water information in reports had great impacts on money handlers"; "Nice to have an objective opinion from the Extension Service because they were not selling anything"; "Great analysis, schedule seems to work well"; "The report was very well done, the water auditors were very knowledgeable".

“This phone survey was conducted for the participants who received a Large Water Audit either in 2002 or 2003. Contacts for 61 properties were surveyed representing 38% of the 2002-2003 Water Audit participants. A few of the survey participants were responsible for more than one property. Survey participants were asked five standard questions and also given a chance to elaborate on their answers. The standard questions were: 1.Was the Water Check Helpful? 2. Was the irrigation system improved as a result of the Water Check? 3. Was the landscape altered or lawn size reduced as a result of the Water Check? 4. Was the report helpful? 5. Was there anything that could have been done better? / Suggestions for improvements?”

Results by Question Number:

1. Was the Water Check Helpful?

59	yes	1	no	1	don't know		

2. Was the irrigation system improved as a result of the Water Check?

53	yes	2	no	4	plan to	2	no need

3. Was the landscape altered or lawn size reduced as a result of the Water Check?

3	yes	55	no	2	plan to
1	stated that perennials will be used next year instead of annuals				

4. Was the report helpful?

60	yes	1	mentioned that the report was sent to the wrong person

5. Was there anything that could have been done better? / Suggestions for improvements?

This was an open-ended question in which many people responded no, and then expressed positive feelings about things that went well. A few suggestions for improvements were: Cover information about fertilization, shrubs, trees, low water use plants, and water conservation tips for outdoor water features. It was also mentioned that getting the report sooner would have been helpful. This may be resolved by sending a preliminary report without water information and then following up after water records have been received.

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