Water Wise Irrigation Practices and Perceptions WWIPP Phase II

Task 5: Final Report

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DELIVERABLES

A comprehensive report written to discuss the quantification of residential outdoor water use water conservation and behavior change. The effect of the model planning will be seen through the campaign treatments. To measure irrigation savings, billing data was compared to estimated evapotranspiration and precipitation for the time period. This data was obtained from existing weather stations in the campaign areas. The fact sheet will serve as an executive summary outlining the key findings of the research.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

GIS	Graphic Information System
IUM	Indoor Use Metric
PCU	Pinellas County Utilities
SWB	Soil Water Balance
SWFWMD	Southwest Florida Water Management District
TBW	Tampa Bay Water
UF-IFAS	University of Florida Institute of Food and Agricultural Sciences
UF-IRB	University of Florida Institutional Review Board
WWIPP	Water-wise Irrigation Practices and Perceptions

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Water-Wise Irrigation Perceptions and Practices Phase II

Fact Sheet

The WWIPP Phase II program aimed to capture outdoor water use savings by educating homeowners on irrigation principles through monthly/seasonal newsletters that focused on principles of irrigation scheduling.

The research area was within the Pinellas-Anclote River Basin under the jurisdiction of the Southwest Florida Water Management District (SWFWMD). The questionnaires and newsletters were developed by the University of Florida and reviewed by the SWFWMD.

Program Participation

Potable Users	Reclaimed Users	Nonparticipant Potable Users **(n=100)**
21 participants	**28 participants**	

To determine any effect on outdoor water use by the participant homes during the study period, the estimated outdoor use was compared to a nonparticipant group during the same period, a theoretical irrigation need, and the estimation of outdoor water use for the participant group prior to the study. Potable water savings were significant when compared to the estimated irrigation application of the participant group to the nonparticipant group (p=0.028) and the theoretical need (p=0.025) during the study period. Additionally, a correlation existed between the increase in knowledge and decrease in water use over time. Evident by the low water use ratio, 0.6, the sample population of both participants and nonparticipants are water conservative.

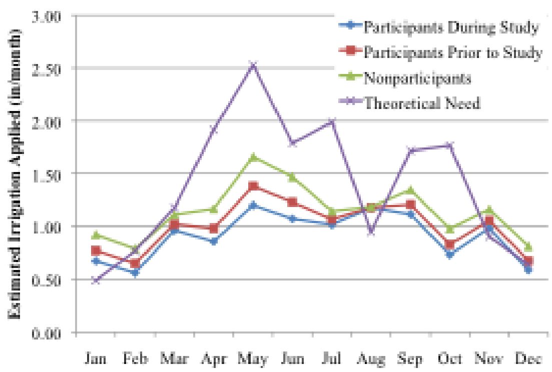
Program Steps

- Solicitation of participants with sign-up web link.
- Irrigation system evaluation interview. This interview established current irrigation habits and baseline information regarding irrigation system and lawn/landscape.
- Homes were contacted at monthly or seasonal intervals, encouraging the reprogramming of irrigation time clocks.
- Utility data obtained from Tampa Bay Water GovNet online database.
- This data was used to monitor the proposed outcome and reduction of water use as a feedback loop.

Irrigation Schedule Matrix

- Each newsletter contained a new unique seasonal or monthly run time schedule.
- Aside from the run time matrix, the seasonal newsletter is the same as the monthly newsletter for the first month of each season.
- Reclaimed water participants received run times only listed by equipment type (spray head versus rotor head).

Program Evaluation



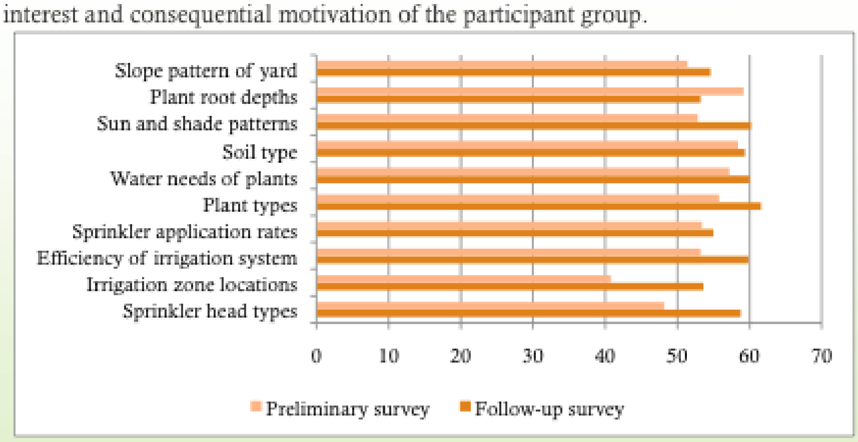
The primary objective of the program was to promote the use of irrigation scheduling. From the self-reported expected behavior change, 93% of participants plan continued fulfillment of this objective aim. In WWIPP Phase I, only 69% of the participants actually fulfilled this aim, based on self-reported data.

Knowledge score was calculated from the response to questions on preliminary and follow-up surveys regarding a broad spectrum of the landscape and irrigation system characteristics discussed in the subject matter of the program newsletter.

Based on the follow-up survey responses, there was a gain in knowledge by the program participants for all characteristics aside from plant root depths (where the follow-up survey yielded less understanding) and soil type (where the responses remained approximately equivalent). Greatest increases in knowledge score were reported for the irrigation system characteristics regarding zone locations and sprinkler head types.

Both irrigation zone locations and sprinkler head types were an integral part of the irrigation evaluation interview. Participants were asked to record this information in an effort to obtain the proper run time recommendations for their "unique" systems. The exercise yielded a positive principle in increased learning and retention. Therefore, the program promoted active learning with interactive information provided regarding water conservation research results. Furthermore, by incorporating hands-on interaction with the irrigation system, cognitive learning was enhanced.

The newsletter click count averaged 91% per newsletter issue. This high level of response concurs with the expressed interest and consequential motivation of the participant group.



Knowledge scores from preliminary (reclaimed water group only, n=28) and follow-up (all participants, n=45) surveys for landscape and irrigation system characteristics

2

Introduction

This project was developed as a Phase II of the Water-wise Irrigation Practices and Perceptions (WWIPP) survey. Phase I investigated outdoor water-use practices and perceptions of single-family homes, through a mail-out questionnaire booklet. The Phase I survey targeted lawn and garden practices, environmental skill, knowledge of ordinances, motives for conservation/use, and perception of community conservation/use of the typical household. The goal of Phase I was to investigate and document user knowledge of residential outdoor water used for irrigation compared to actual use data. The quantification of this information will help to identify areas in need of increased public awareness. Areas of concern include misunderstandings of outdoor water use principles, irrigation scheduling, and the integration of technological devices such as rain sensors, soil moisture sensors, and weather-based controllers.

Phase II included an examination and review of various models based on social-psychological theories of behavior and change, the study of how social conditions affect human actions. The ideal model selection for consumer behavior attempts to capture both internal and external dimensions of pro-environmental behavior. An example of an internal influence can be irrigation scheduling knowledge, while and external factor can be homeowner association deeds. The motivation for conservation and drivers of behavioral change can be more easily understood using conceptual models. More specifically, models can demonstrate social and psychological influences of the typical homeowner as well as pro-environmental consumer behavior. A model used with the collected data in Phase I can help to develop suggestions that can be incorporated to implement change in outdoor water use behavior for irrigation conservation.

According to the conclusions drawn from the household survey, the following significant barriers and benefits were identified (Haley and Dukes 2009). There was an overall misunderstanding of plant water needs and seasonal scheduling of irrigation systems. Further, there was confusion as to the terminology in reference to rain shut-off devices versus rain sensors. Respondents expressed room for improvement and interest in learning, suggested a sense of reliability of rain shut-off device functionality, and conservation behavior relating to water source. Finally, there was influence of property value or property size on irrigation water use.

Scenario Planning

The development of a scenario plan can be used to weigh the options between impact and feasibility of an irrigation conservation campaign. The purpose of scenario planning is to develop a set of unpredictable interventions with plausible alternative social, technical, economic, environmental, educational, political or aesthetic trends as key driving forces. From the Phase I survey conclusions, the ideal scenarios determine the most successful targeted water-wise irrigation education approach in Phase II with application in the development and implementation of a campaign to stress irrigation conservation practices, as determined to be under-employed from Phase I. The identification of key drivers, and using storylines to "wind tunnel" strategic options will help to identify effective components of the campaign models.

Figure 1 presents the influences of community, technological, political, and water purveyors on irrigation water use. There are some common and divergent views within the clusters illustrated. The overall theme encourages irrigation water use conservation. However, for many of the new technological devices to function most effectively the system should be set to run outside the irrigation day regulations. "Smart" controllers (such as soil moisture sensor systems or weather-based controllers) monitor and use information about site conditions. They are able to reduce outdoor water use by applying the right amount of water based on those factors when installed and scheduled correctly. Essentially, these irrigation controllers receive feedback from the irrigated system and schedule or adjust irrigation duration and/or frequency accordingly. Policy states that all systems must have some type of rain shut-off device (Florida Statutes 2010), but there is little enforcement of this ordinance by local entities. The local utilities have steadily increased water costs over the last five years; they have also encouraged the use of alternative sources (PCU 2010a). Different irrigation water sources (e.g. reclaimed) are given different watering restrictions, which can be confusing within the community (PCU 2010b). Further, alternative sources are given cost incentives that may encourage overuse, such as non-metered flat rates.

From the internal influences that stem from the community/policy/technology/utility cluster diagram in Figure1, Figure 2 presents possible water conservation activities within quadrants suggesting high or low impact and the predictability of outcome.

Scenario plan story lines

As part of creating the Scenario Plan, story line possibilities are developed. Based on potential for irrigation effectiveness presented above, the four story lines explored are:

Scenario 1 – Rain sensor incentive/citation
Scenario 2 – Irrigation scheduling incentive/citation
Scenario 3 – Smart choices
Scenario 4 – Alternative action

The rain sensor incentive/citation scenario would aim to increase community awareness of the rain sensor ordinance. In this scenario the participant would be given information regarding rain shut-off device functionality and requirement in the form of a fact sheet. The participant will also be informed of the possibility of a fine; if the rain sensor ordinance is not complied with, a citation could be issued by local utilities. As a positive offering on the part of the program, a free rain sensor along with installation instructions and window decal will be offered as an incentive for program participation. In this scenario other more technologically advanced devices (e.g. “smart” controllers) would also satisfy the aim. The key drivers in this scenario include: technology innovation, growing environmental awareness, policy intervention.

The irrigation scheduling incentive/citation scenario would aim to increase community awareness of watering day restrictions and seasonal irrigation scheduling. In this scenario the participant would be given information regarding (1) day of week restriction based on house number and water source and (2) seasonal irrigation scheduling guidelines in the form of a fact sheets and/or website link. The participant would also be informed of the possibility of a fine; if the day of week restriction is not complied with, a citation could be issued by local utilities. As a positive offering on the part of the program, a personalized laminated irrigation system run time card will be created as incentive for program participation. In this scenario other more technologically advanced devices (e.g.

“smart” controllers) if set properly would also satisfy the aim. Here, the key drivers include: technology innovation, growing environmental awareness, policy intervention.

The third scenario story line, smart choices, offers variance to watering restriction based on the use of “smart” irrigation technology. If a “smart” controller is installed and certified as set properly, the home may be exempt from irrigation day regulations, based on increased technology. In this scenario the participant would be given information regarding “smart” controller functionality in the form of a fact sheet. These homes have the possibility of using less water because of the increased technology during wet years. However, during dry years, it is possible, that the controller could allow for additional irrigation events. Furthermore, previous irrigation habits must be considered. This scenario story line would be considered beyond WWIPP scope as it is a policy suggestion that outside of the currently ordinance. However, research has shown water savings with the use of “smart” irrigation technology coupled with such a variance (Davis et al. 2009). A consequence of this scenario is that a neighbor might notice the off day irrigation events without the knowledge that the house is utilizing a “smart” controller. This neighbor may then possibly irrigate on off days as well. The key drivers: of this scenario are: technology innovation, growing environmental awareness, decreased policy intervention.

The final scenario story line, alternative action, would require homes within an alternative water source availability area to be required to use that alternative water sources (e.g. reclaimed, shallow well, or surface water) for irrigation. This scenario would require less enforcement and policy intervention, since all homes in a neighborhood would have similar watering days and times of day based on source type. However, this scenario is also beyond the WWIPP scope as it would mandate infrastructure on the part of the homeowner. This scenario would also prevent neighbors from being influenced to irrigate on off days or hours based on source allowances. A consequence would be that a homeowner may irrigate more than previously with alternative water source because environmental awareness may become skewed by lower water costs. There could be a change in the aquifer recharge cycle or a drain on the reclaimed storage, which would lead to new problems with water demand for the public supply. Key Drivers: Decreased environmental awareness, decreased policy intervention.

Some wildcards that must be taken into consideration for these scenarios could be (1) irrigation days could be severely restricted, making the technology less effective, (2) all homes could be plumbed for reclaimed water, (3) extreme drought, or (4) excessively wet years.

Wind tunnel strategic options

A wind tunnel matrix for the four trial scenarios is illustrated in Table 1. From this matrix, it can be observed which scenarios might be most feasible for implementation. The rain sensor and irrigation scheduling scenarios would be the most conducive to the scope of the WWIPP participant Phase, based on the number of cells with (+) symbols in Table 1. Previous research has indicated that the inexpensive technology and seasonal irrigation scheduling both promote irrigation water conservation. These scenarios are in compliance with the current jurisdiction and both can be implemented using the principals of Community Based Social Marketing. The Alternative Action and "Smart" Choices scenarios both have impractical aspects of implementation, note cells with (-) symbols in Table 1.

Community Based Social Marketing

Community-based social marketing goes beyond the scope of public awareness to identify and overcome barriers in efforts to create long lasting changes in behavior, increasing impact and predicting outcome. This technique has been effective in promoting sustainable behavior (McKenzie-Mohr and Smith 1999). When trying to create a more sustainable practice of residential automatic irrigation behavior, two feasible options, with favorable impact, are to encourage the installation of rain sensor and/or practice irrigation scheduling.

Irrigation scheduling refers to setting the runtimes of the irrigation time clock based on when and how much to water. This is derived from factors such as soil type, root zone depth and local weather conditions. According to University of Florida research in conjunction with the St Johns River Water Management District, setting residential irrigation controllers with respect to historical turfgrass seasonal water needs resulted in a 30% reduction of water use (Haley et al. 2007). During this study as well as Phase I (the WWIPP survey) it was observed that the homeowners did not have a clear understanding of when and how much to irrigate (Haley et al. 2007; Haley and Dukes 2009). A useful tool that has been developed to aid the homeowner in properly setting their irrigation time clock, based on seasonal plant water needs, is the Urban Irrigation Scheduler, which is located on the Florida Automated Weather Network Website (http://fawn.ifas.ufl.edu/tools/ urban_irrigation/).

Following the steps of community-based social marketing, a program aimed at encouraging irrigation scheduling is outlined below. The first step is to understand the behavior better, which can be accomplished with the behavior matrix presented in Table 2.

Using enforcement to "regulate" a behavior is not always helpful. For example, within the Southwest Florida Water Management District (SWFWMD) irrigation is only permitted certain days. Therefore a common misconception on the part of the homeowner, when irrigating less frequently, is to set longer cycle lengths during their given watering day. According to University of Florida research in conjunction with the SWFWMD, it was found that homeowners often deviate from the watering day restrictions (Dukes and Haley 2009).

Promotion of economic self-interest in relation to outdoor water use can also provide little impact. According to Phase I results, there was a trend of increased water application with increased property value. Conversely, the smaller the irrigated area, the more water applied when normalized with respect to application depth. A primary cause for the increased use in both homes of higher property value or smaller irrigated area is likely due to the minimal impact water cost has on excessive use (Haley and Dukes 2009).

Both internal and external barriers can hinder the success of the program. For this example, internal barriers may include a lack of knowledge regarding: plant water needs, irrigation time-clock functionality, and available resources (i.e. Urban Irrigation Scheduler). External barriers may include: willingness, policy change, other irrigation technology, climactic conditions, and influence by homeowner's association, neighbors, or landscape professional. One way to remove an external barrier is to educate the landscape professionals and/or homeowner associations.

The following steps help promote an effective program:

Written commitments are more successful than oral commitments. Signing a pledge can be added into the program as an initial step, it will actively involve the participant and help them view themselves as environmentally concerned.

Prompts such as a self-explanatory laminated run time card to be attached near the irrigation time clock or other location temporally and spatially close to the behavior. Additional prompts could include seasonal telephone, mail, or email reminders to change their irrigation run time. For a more wide range program media reminders could also be utilized such as television, radio, and newsprint.

A standard pattern of behavior can be created through report cards issued to program participants. Based on their utility water use data, the outdoor use can be determined. A report card style indicator, for landscape water management, has been found to be very effective in engaging conservation behavior. Messages, mottos, or slogans are most effective when to the point. It can be a printed window decal, refrigerator magnet, or hose nozzle. The message is to set your irrigation clock based on seasonal plant water needs. The slogan could be "Set by Season, be Water Wise".

In this program, incentives will be non-monetary and related to the desired behavior. The primary incentive will be the irrigation evaluation and subsequent individualized run time card. This will be beneficial for both educational and monitoring purposes. As budget permits, homes will receive an outdoor water conservation kit similar to that from Phase I (Figure 3), which includes a rain sensor, water saving hose nozzle, and appropriate literature to reinforce the importance of these devices.

A program evaluation is the best way to determine both the impact of the program and how well the program itself was facilitated. The evaluation should include multiple time steps of data collection as well as comparison with a control group.

If the rain sensor incentive were included in Phase II, as mentioned in the rain sensor scenario, the participant would also be provided with installation instructions and window decal (Figure 3). Additionally, during the irrigation evaluation interview, any home noted as having a rain shut-off device would also receive the decal. The biggest reasons rain shut-off device ordinances are currently ignored are due to lack of awareness and lack of enforcement. The window decals could raise awareness and eventually ease enforcement. The rain shut-off decal can act as a prompt to encourage irrigation water conservation awareness, involving homeowners to view themselves as environmentally concerned.

Model Development

The ideal selection of a model based on social-psychological theories of behavior and change will try to capture both internal and external dimensions of pro-environmental behavior. An example of an internal influence can be irrigation scheduling knowledge, while and external factor can be watering day restrictions. The motivation for conservation and drivers of behavioral change can be understood more clearly using conceptual models. More specifically, models can demonstrate social and psychological influences of the typical homeowner as well as pro-environmental consumer behavior. A model used with the collected data in Phase I can help to develop suggestions that can be incorporated to implement change in outdoor water use behavior for irrigation conservation.

Methods

Model Development

A logic model visually displays the progression of actions and outcomes that describe what an evaluation hopes to accomplish, Figure 4. There are five main components: inputs, outputs, outcomes, assumptions, and external factors. The logic model and subsequent impact theory model, Figure 5, along with the process theory model, Figure 6, address an educational program that would help homeowners appropriately set their irrigation time clocks to manage their landscape. According to Rossi et al. (2004), the logic model is a familiar depiction of program theory because it lays out the rational path from program services to participant outcomes. Additionally, the logic model will make it easy to identify appropriate future evaluation questions and can be further refined into the corresponding domains (Israel 2001). A logic model can be used as the basis for the future evaluation design and can be developed with stakeholders to represent a harmonious view, clarifying evaluation questions to determine relevant and important program impacts. As an added benefit to an evaluator, the logic model may bring to light issues that stakeholders may have otherwise neglected to notice. The models developed here are based off of established Florida Yards and Neighborhoods theory models (Israel 2001).

Participant Program Plan

Program activities can be observed in detail with the process theory model, Figure 6, this began with solicitation of participants in the target area following IRB protocol. Once contact was been made with the participants, the homes were given an irrigation system evaluation interview. This interview established their current irrigation habits and baseline information regarding their irrigation system and lawn/landscape. Homes were contacted at monthly/seasonal intervals encouraging the reprogramming of their irrigation time clock. Additionally, utility data will be obtained from Tampa Bay Water (TBW) online database. This data was used to monitor the proposed outcome, reduction of water use, and as a feedback loop.

The previous utility data, up to 60 months where available, was obtained for all participating homes, including the 12 months following the commencement of the campaign. To determine the effectiveness of the campaign on outdoor water use conservation, an equal number of nonparticipant households of similar value and parcel size were randomly selected as a control group for comparative analysis (Israel and Hague 2002).

Participant solicitation

The program was initially solicited via mail-out advertisement or personal communication. As part of the campaign advertisement and in compliance with UF-IRB regulations, address information was collected. For this study the advertisement directed the interested participant to a web survey as an initial criteria questionnaire. The chosen participants will then be contacted by telephone by University of Florida research personnel.

Contact list

The primary contact list contained 250 addresses, advertising of the program was sent in multi-waves to reach at least 100 households. Address lists were ascertained from the Pinellas County Utilities (PCU) customer service database. Initial contact has been made with these homes during Phase I. The water source is known for all homes. Although further data analysis was conducted on homes to identify a subset of higher water users the contact list was expanded due to poor response rate.

IRB documentation

Following IRB submission requirements, this research study was granted IRB protocol exemption (#2009-U-0386) based on interaction level of participants in accordance with 45 CFR 46.

Irrigation evaluation interview

As follow-up to the web-survey the researcher, via telephone or other preferred method of communication if noted, contacted participating homes. At this time the participant were asked a series of questions regarding their landscape layout, irrigation system, irrigation practices, indoor water use, and household demographics. These questions helped to verify existing information gathered on the home from property appraisal parcel information, aerial imagery, and Phase I responses if applicable.

Newsletter Correspondence

The newsletter distribution was either seasonally or monthly based on the frequency the participant selected during the recruitment survey. Current frequency distribution includes: monthly newsletters (n=34) and seasonal newsletters (n=15).

In the case of the monthly newsletter, each participant was always given a run time schedule for the month. It was not noted if the schedule grid is the same as a previous month, the goal was for grid to prompt the homeowner into a habit of checking their clock regularly. Typically, there was at least mild variation in run times even from month to month.

In the case of seasonally scheduling, there were always obvious changes to be made compared to the previous schedule. Aside from the run time matrix, the seasonal newsletter was the same as the monthly newsletter for the first month of each season (e.g. March = spring, June = summer, September = fall, December = winter).

The reclaimed water (RCW) participants received the newsletters with a slightly different scheduling matrix due to the variation in watering days and billing. Instead of runtimes listed by zones, the run times were only listed by equipment type (spray head versus rotor head).

Irrigation schedules

Irrigation schedules were provided for participants based on their unique irrigation system and landscape. The Urban Irrigation Scheduler on the Florida Automated Weather Network website (http://fawn.ifas.ufl.edu/tools/urban_irrigation/) and EDIS Document AE-220 (http://edis.ifas.ufl.edu/AE220) were used to standardize recommendations based on equipment type. These documents suggest irrigation run times based on two-day-per-week watering restrictions. However, since potable and well source irrigation is limited to one-day-per-week in the study area, the two-day-per-week runtimes (following the 80% replacement recommendation) was increased by 30%. Homes irrigating with reclaimed water were permitted three-days-per-week of irrigation, however in this case the recommended runtimes remained the two-day-per-week runtimes, as this provides adequate irrigation.

Program Evaluation

The program evaluation, conducted to measure the program outcomes, was conducted during October 2010, at the latter section of the newsletter distribution and data collection period. This evaluation supplied information that will aide in program improvement if the District were to extend or expand the program. However, since outcomes are affected by events and experiences that are independent of a program, the changes in the levels of outcomes may not always be directly interpreted as program effects.

Water Use Data

Potable source participant impact can be measured by comparing water use to nonparticipants. The water use of the potable source participants was utility data where indoor and outdoor use was separated to determine the irrigation use estimates. Utility water use data was collected from the single main meter for billing purposes and acquired from the TBW GovNet online database, Figure 7. This data combines both indoor and outdoor water consumption and the irrigation use was estimated as a fraction of the total use following appropriate methodology and assumptions. The data separation techniques most reliable for this program considers the minimum month method and/or the metric referred to as the indoor use metric, IUM (Dziegielewski and Kiefer, 2009). Where the lower of the two methods was considered the actual indoor usage.

The most widely employed technique for indoor and outdoor utility data water use separation is the seasonal versus non-seasonal use metric using the minimum month method (Dziegielewski and Kiefer, 2009; Vickers, 2001). This method uses the underlying assumption that residential water demand fluctuates over time due to weather variability, consequently allowing for seasonal and non-seasonal components of water use to be detected. The seasonal water use, also known as the weather sensitive water use, is considered nearly all water used outside the home. Furthermore, the seasonal use varies based on the months of the year. In contrast, non-seasonal water use refers to water use that is assumed to be constant throughout the year and typically embodies the indoor use.

The minimum month method was developed around the basic assumption that during the month of the lowest water consumption, seasonal or outdoor water use equals zero. Thus, the non-seasonal or indoor water use was assumed to be constant. Indoor water use (IU) is the volume of the single lowest month, $V_{Min\text{-}M}$ (Dziegielewski and Kiefer, 2009).

$$IU = Q_{Min\text{-}M}$$

Where:

IU = indoor (non-seasonal) water use in gallons per month

$Q_{Min\text{-}M}$ = minimum monthly water use in gallons per month

The outdoor water use for each month in a given year can be calculated as the difference between the total water use and the indoor use.

$$OU = Q_{Tot} - IU$$

Where:

OU = outdoor (seasonal) water use in gallons per month

Q_{Tot} = monthly water use in gallons per month

The second, and more detailed, approach considers the per capita water use based on the number of occupants that reside in the household. This metric is referred to as the indoor use metric or IUM_c (Dziegielewski and Kiefer, 2009), where the subscript *c* denotes per capita use. Where household occupancy data was not readily available, the indoor use metric IUM_a was used, where the subscript *a* denotes account (also referred to as household). In this case, estimates are used for the average number of persons per household.

$$IUM_c = U * M$$

$$IUM_a = IUM_c * N_a$$

Where:

IUM_c = per capita indoor water usage in gallons per person

U = average frequency of events (e.g. toilet flushing, clothes washing, showering, bathing, faucet use, dishwashing, etc.) per person

M = average use in gallons per event

IUM_a = average household indoor use in gallons per account

N_a = average number of persons in household

The coinciding outdoor usage metric (OUM_a) is the difference between the average annual rate and the indoor usage metric.

$$OUM_a = Q_{Annual} - IUM_a$$

Where:

OUM_a = average household outdoor use in gallons per account per month

Q_{Annual} = average annual household use in gallons per account per month

IUM_a = average household indoor use in gallons per account per month

This technique requires certain assumptions to be made regarding household characteristics. The indoor and outdoor usage metrics (IUM_a and OUM_a) were calculated with actual characteristics self-reported by the households in the participant data set.

Water use data analysis is presented for the entire study period for both potable participants (n=21) and nonparticipants (n=100) Additionally, newsletter click counts and self-reported questionnaire data were evaluated. However, the outdoor water use of the RCW participants cannot be measured, as these homes are not outfitted with water meters on the RCW line. Therefore, only the newsletter opening rate and self-reported data can be collected. The RCW participants (n=28) are not included in the response rate count because they were routed to the WWIPP program online survey from their response to another SWFWMD RCW project advertisement.

Irrigated Area Estimation

Property information was gathered from the Pinellas County property appraisal public records (www.pcpao.org) for each home included in the analysis. These records included information on the comparable sales, the property size, total gross living area (i.e. gross structural footprint), and residential extras (e.g. pool, enclosure, patio, shed, etc.).

The irrigated area was determined using this available property information. The irrigated area was calculated by subtracting the gross structural area and residential extras from the property size. From the Pinellas County public geographic information system (GIS) records (www.gis.pinellas.org), the residential parcels are outlined and an aerial layer from Jan/Feb 2006 was overlaid (Figure 8). Using the GIS layers, the irrigated areas were outlined with a polygon tool to determine the estimated irrigated area. The aerial estimated irrigated area was then compared to the calculated irrigated area from the property appraisal information.

The irrigated area was used to convert the billing data, provided in gallons of water used per month, into a normalized depth of water applied at each home.

$$I_{applied} = CF * OU / IA$$

Where:

- $I_{applied}$ = depth of water use applied across the irrigated area (in/month)
- OU = volume of outdoor water use (gallons)
- IA = irrigated area (square feet)
- CF = conversion factor; where 1 cubic foot = 7.4805 gal and 12 in = 1 foot

Theoretical Irrigation Requirement

Actual monthly irrigation estimated means were compared to theoretical irrigation estimate. Evapotranspiration for the landscape was calculated with the ASCE-EWRI equation (2005).

$$ET_L = ET_o * K_L$$

Where:

- ET_L = overall estimated landscape coefficient evapotranspiration (in/d)
- ET_o = reference evapotranspiration for short surfaces (in/d)

K_L = landscape coefficient.

$$K_L = (Kc_{turfgrass} * A_{turfgrass}) + (Kc_{ornamental} * A_{ornamental})$$

Where *Kc* is the crop coefficient for either turfgrass or ornamental plantings and *A* is the turfgrass or ornamental planting area (%). This theoretical estimation used an average turfgrass area of 75%, which is appropriate for the study area (Haley and Dukes 2009). Additionally, the irrigation requirement for the ornamental plant beds was considered to be negligible, since ornamental plant beds require little or no supplemental irrigation once established in Florida (Moore et al 2009; Shober et al. 2009; Wiese et al. 2009; Scheiber et al. 2008). The $Kc_{turfgrass}$ values were interpolated between north and south Florida warm season turfgrass values from Jia et al. (2009) as the study location is in between these two regions.

To compare the actual irrigation water estimate applied to the residential landscapes, a theoretical irrigation water requirement was calculated using a daily soil water balance (Dukes 2007).

$$I_{calc} = ET_c - P_e - D - R_O$$

Where:

I_{calc} = calculated net irrigation requirement (in/d)

P_e = effective rainfall (in/d)

D = drainage below the root zone from excess rainfall (in/d)

R_O =surface runoff (in/d)

Effective rainfall is the portion of rainfall beneficial to plants; this excludes precipitation resulting in runoff or drainage below the root zone. Effective rainfall was estimated using the soil water content on a day-by-day basis to determine the storage available or rain lost to D or R_O.

To determine the amount of irrigation required, drainage, runoff and effective rainfall, the upper and lower boundaries were determined using the soil water holding capacity of the soil. The upper boundary is referred to as field capacity (FC), and is the amount of water the soil can hold after gravitational drainage. Only the rainfall considered effective is the amount of input until FC is reached. Additional rainfall was considered excess and resulted in runoff or drainage. For the sake of minimal plant stress the lower boundary is the readily available water (RAW) (Dukes 2007).

$$RAW = (FC - PWP) * RZ * MAD$$

Where PWP is the permanent wilting point, RZ is the root zone and MAD is the maximum allowable depletion. Based on the soil survey data for the Astatula soil series and urban land for Pinellas County, the FC was taken as 11% and PWP as 4%, resulting in an available water content of 7%, which is appropriate for the area (Lewis et al. 2006). For St Augustinegrass, the RZ was assumed to be 8 in (Shedd 2008) and MAD was assumed to be 0.5 (ASCE-EWRI 2005). It was assumed that once the soil water content exceeded field capacity, drainage and or runoff occurred from excessive rainfall.

Once the soil hydraulic properties were used to define the upper limit of water storage, I_{calc} was determined assuming ideal irrigation conditions such that D and R_O were zero for the theoretical irrigation estimate.

$$I_{calc} = ET_c - P_e$$

Irrigation, I_{calc}, was simulated when the amount of soil water at the beginning of the day was at or below the lower boundary, RAW. Applied net irrigation was the amount necessary to reach the upper boundary, FC. Gross irrigation (I_{gross}) was estimated by dividing I_{calc} by an efficiency factor. An ideal irrigation efficiency factor of 80% was used in this project to simulate ideal irrigation based on uniformity potential of irrigation systems in Florida (Dukes et al. 2008).

Data Analysis

Data analysis was performed using SAS software (SAS 2004). Univariate data analysis was used to describe the data set sample with mean, standard deviations, and percentages. The level of measurement was reported as frequency statistics from the survey responses. The bivariate analysis was used for the evaluation of the independent variables and the hypothesis testing between the independent and dependent variables.

Positive and negative correlations were based on Pearson's correlation coefficient. The multivariate analysis enables assessment of the direct and indirect effects for related variables. An analysis of variance was used to determine main effect differences through

PROC GLM and means comparisons were performed with Duncan's Multiple Range Test at a 95% confidence level.

Results

Model Development

The major outcomes of the participant program, with respect to the input investments and output activities are identified in Figure 4. From this model the assumptions and external factors can be identified. For the homeowner irrigation scheduling program, relevant assumptions include: homeowner willingness to interact with irrigation time clock, their want to be in compliance with policy, and a want to conserve water. The External factors that may influence participation were identified as: willingness to participate, influence by homeowner's association or neighbors, policy change, other irrigation technology, and climactic conditions. These assumptions and external factors needed consideration upon development of the experimental design and program evaluation. Figure 5 elaborates on the impact of the Phase II participant program. The primary long-term outcome is to reduce irrigation water consumption and therefore reduce the groundwater demand. According to this model, homeowners are encouraged to practice irrigation scheduling which will reduce over watering and increase watering restriction/ordinance compliance. The feedback loop acknowledges the continued follow-up with the participants at various intervals over the 12-month program period. The impact model in Figure 5 also shows how the external factor, outlined in Figure 4, may hinder the programs desired outcomes. The selection of participants may have an effect based on the demographic and property attribute, as well as the preexisting practices, knowledge, and skill. The impact model also displays how the external factors can cause positive results that do not stem from the program directly. For example, if a homeowner installs a "smart" controller the same outcomes could be observed.

The process theory model, Figure 6, provides even more detailed insight by breaking the model into: "who", "how", "what", and "what-if". The program organizational half of the model refers to "who" and "how". Here the roles and responsibilities of the researcher are drawn out following a sequential order, form development, to solicitation, to continued monitoring, and finally evaluation. The service utilization half of the model shows the "what" and "what-if" scenarios. In this case, what the homeowner should do as a program participant and how the same outcome could or could not occur if any step was removed. The objective of the service utilization plan was to come up with a sufficient plan that will initiate the sequence of outcomes specified in the logic and impact theory models, Figures 4 and 5.

Program Participation

Current program participation included: 21 participating homes with potable water and 28 participating homes with RCW in the Pinellas County target area. Additionally, a nonparticipant comparison group (n=100) was included for water use analysis purposes.

Response rate

WWIPP Phase I yielded a 25% response rate (Haley and Dukes 2008). In anticipation of a similar or grater response rate, initially 100 advertising letters was projected as sufficient in the WWIPP Phase II scope of work. As the response to the advertising letters yielded less than desired rate the contact list increased from 100 to 250, of these 244 ended up being viable addresses, yielding a final response rate of 8.6% with 21 respondents to the advertising letters.

Click rate

The newsletter click count averaged 91% per newsletter issue. This high level of response concurs with the expressed interest and consequential motivation of the participant group. Conversely, the because the group of program participants was motivated, this result may be more likely to overstate the benefits of the program, if extended to a wider audience such as the entire District, in light of the low overall coverage rate (n=49).

Evaluation Results

The evaluation design was considered to be non-randomized partial coverage because only a small section of the target audience (domestic irrigators within the SWFWMD jurisdiction) was reached with the program. The evaluation looked at attitudinally-based questions from the primary and follow-up questionnaires as well as compared perception and knowledge questions of the participants with nonparticipants responses from WWIPP Phase I. Response rate of the program evaluation questionnaire was 92% (n=45).

Attitudinal questions

As part of the program evaluation, all participants were asked to self-report (n=45) their expected use of knowledge gained from the program. The expected uses are presented in Table 3. The primary objective of the program was to promote the use irrigation scheduling. From the self-reported expected behavior change, 93% of participants plan continued fulfillment this objective aim. In WWIPP Phase I only 69% of the participants actually fulfilled this aim based on self-reported data.

Knowledge score was calculated from the response to questions on preliminary and follow-up surveys regarding a broad spectrum of the landscape and irrigation system characteristics discussed in the subject matter of the program newsletters (Figure 9). Initially these questions were only part of the preliminary RCW survey, but were provided to all program participants in the follow-up questionnaire. The knowledge score was tallied and ranges from 0 to 70. The original question formats were presented as measures using a point Likert scale on the survey instrument. The answer options ranged from 5 to 1, rating level of familiarity with each characteristic, where 5 represents the highest level of knowledge.

Based on the follow-up survey responses, there was a gain in knowledge by the program participants for all characteristics listed in Figure 9 aside from: plant root depths, where the follow-up survey yielded less understanding; and soil type, where the responses remained approximately equivalent. Greatest increases in knowledge score were reported for the irrigation system characteristics regarding zone locations and sprinkler head types.

Both irrigation zone locations and sprinkler head types were an integral part of the irrigation evaluation interview. The participant was asked to record this information in efforts to obtain the proper run time recommendations for their "unique" system. The exercise yielded a positive principle in increased learning and retention. Therefore, the program did promote active learning with interactive information provided regarding water conservation research results (Kyam, 2000). Furthermore, by incorporating hands-on interaction with the irrigation system, cognitive learning was enhanced (Korwin and Jones, 1990).

Participants were asked to rate their level of familiarity to certain lawn and landscape characteristics, Figure 10. The level of familiarity was self reported rated from 5 to 1, where 5 represents the highest level of knowledge from preliminary survey responses and the RCW group only. The opinions of the effectiveness of water conservation ordinances, practices, and programs are illustrated in Figure 11.

Satisfaction

The satisfaction level of the participants of WWIPP Phase II was measured using a point Likert scale, with answer options ranging from very satisfied (5) to very dissatisfied (1). Figure 12 presents the average satisfaction score for the overall program newsletters, ease of understanding, accuracy, and relevancy. The overall satisfaction score of the program was 4.7.

Water Use Analysis

To determine any effect on outdoor water use by the participant homes during the study period, the estimated outdoor use was compared to: a nonparticipant group during the same period, a theoretical irrigation need, and the estimation of outdoor water use for the participant group prior to the study, shown in Table 4 and Figures 13 thru 15. A reliable method of observation of program impact is to observe the water use over the same period of time by two separate groups; in this case, comparison during the study period for the participant group versus a similar group of nonparticipants. The monthly average outdoor water use for the participant group (0.91 in/month, Table 4) was significantly different ($p=0.027$) than the nonparticipant group (1.15in/month) resulting a 20% less use (Figure 13).

Additionally, from the graphs of Figures 14 and 15, it is apparent that the theoretical irrigation need was greater than the estimated irrigation applied by both the participant and nonparticipant groups for the majority of the 2010 study period. In fact, the entire sample population was statistically ($P<0.025$) lower than the theoretical irrigation need (Figure 13). Therefore, during these months, all groups resulted in some under-irrigation relative to the theoretical estimate. Overall the ratio of estimated irrigation application to theoretical irrigation need during the study period was 0.6. This water use trend is consistent with similar water use analysis in the same area (Haley and Dukes 2009).

The water use of the potable participant group was compared to itself at two time intervals: the average of up to 60 months prior to and the 12 month period following the commencement of the program. A correlation existed between a decrease in water use and an increase in knowledge score calculated from the program evaluation. A higher water use knowledge score was negatively correlated with the change in water use of the participating household. However, the water savings of the participant group compared to itself at the two time periods were not significant when observing the water use.

Conclusions

The WWIPP Phase II program was developed in response to primary conclusions drawn during WWIPP Phase I. The "misunderstanding of irrigation scheduling and seasonal plant water needs" is addressed in each newsletter by providing suggested seasonally appropriate run times. The WWIPP Phase I respondents exhibited "interest in improving conservative water habits", each newsletter provides information and tips on increasing efficient irrigation.

Long term WWIPP Phase II success will be measured by a change in first attitude and second behavior. Initial attitude changes were quantified by the preliminary and follow-up questionnaire self-reported data. Actual behavioral would result in a measurable decrease in irrigation water use. The goal of the evaluation was to determine the success of the program, areas of improvement, and steps the District would need to take in order to implement the campaign on a larger scale.

The WWIPP Phase II program aimed to capture outdoor water use savings by educating homeowners on irrigation principles through monthly/seasonally newsletters that focused on principles of irrigation scheduling. The participation in the study showed a decrease in potable outdoor water use compared to a nonparticipant group and a correlation existed between an increase in knowledge and decrease in water use over time.

Evident by a low water use ratio, the sample population of both participants and nonparticipants are water conservative. This may either stem in part from effective measures by SWFWMD or the local utilities. Additionally, the participant households have displayed interest in outdoor water reduction by program interest and are enticed by non-monetary incentives. Populations such as these would be candidate for community prompts such as the rain shut-off device decal.

This program could serve as a pilot test for a larger conservation campaign. If the WWIPP Phase II program were to be implemented on a larger scale, the following steps should be taken.

1. Advertising
    a. Solicit program participation to a wider audience
    b. Sign-up form link located on SWFWMD or Utilities websites
    c. Mail outs included in utility bill stuffers
2. Target high water users or neighborhoods with known over irrigation practices
3. Monetary incentive for participant to increase participation would broaden appeal
    a. Requires cooperative effort with Utilities
4. Data collection – would be beneficial to have this data directly available
    a. Parcel information
    b. Aerial imagery
    c. Household size (number of people) verification
    d. Water use data (potable homes)
5. Surveys
    a. Create a single recruitment survey that will auto generate the newsletter frequency distribution (monthly vs. seasonally)
    b. Auto generate follow-up emails or instruments based on number on months participant is active in the program
6. Newsletters
    a. Provide monthly or seasonal run times by zones based on equipment type
    b. Ideally the run time matrix lists minutes per zone for each zone at a participating home. However on a larger scale this matrix would require more advanced programming and greater involvement by program administration.

c. Alternatively run times can be listed based on equipment type only. Similar to that of the RCW newsletters in the WWIPP Phase II or the FAWN Urban Irrigation Scheduler

The following points of improvement were identified as part of the program evaluation. These points should be addressed if the program were expanded into or implemented on a larger scale on the future. The primary aims would be to increase participant count to further test the impact and feasibility of the program. As well as target general populations as subsets of a larger area that are known to have high water use.

To al lesser degree additional areas of improvement would include the consideration of variations to run times matrix for future larger scale implementation. The selection of participants may have an effect based on the demographic and property attribute, as well as the preexisting practices, knowledge, and skill. The impact of external factors should be addressed; these can cause positive results that do not necessarily stem from the program directly. For example, if a homeowner installs a "smart" controller the same outcomes could be observed. Finally, if implementing on a larger scale over a multiple years, it may be beneficial to have at least a total of 24 newsletters (2 versions per month) that can be cycled through.

Table 1. Wind tunnel matrix for the four trial scenarios

Current plans, actions, or law	Scenario plan 1 Rain sensor incentive/ citation	2 Irrigation scheduling incentive/ citation	3 "Smart" choices	4 Alternative action
Current/Previous Technology Testing in Florida	+	+	++	- -
Community Based Social Marketing	++	++	+	+
Ordinance/Restrictions Compliance	++	++	- -	+
WWIPP Participant Program Scope	++	++	-	-

Table 2. Matrix of perceptions for irrigation behaviors

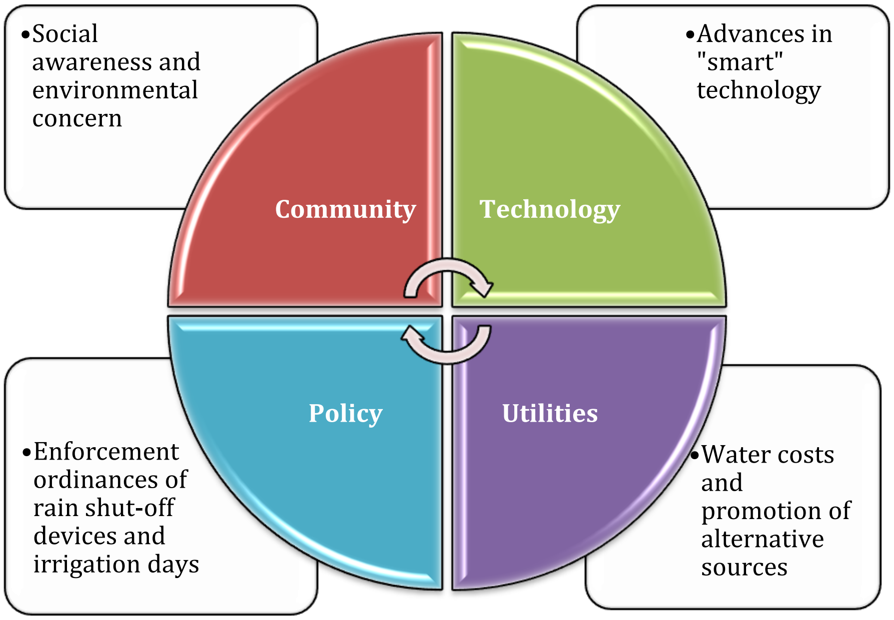
Behavior Type	Behavior	Perceived Benefits	Perceived Barriers
New	Irrigation scheduling	In touch w/ water use ↓ Water use Saves money Good for environment ↓ Weeds in lawn	↑ Effort Misunderstanding ↓ Turf quality
Competing	"Set & Forget"	No time or effort Lawn won't suffer ↑ Turf quality	↑ Water = ↑ Cost Not in touch
Competing	Manually irrigate	In touch w/ water use ↓ Water use Saves money Good for environment	↑ Effort May not know when to
Competing	Does not irrigate	No time or effort ↓ Water use Saves money Good for environment	↓ Turf quality ↑ Weeds in lawn

Table 3. Response percentages for continued use of evaluation objectives

Aim description	Phase I (n=251)	Phase II (n=45)
How often do plan to continue your watering schedule adjustment during year?		
Monthly	14%	20%
Seasonally	55%	73%
Neither	31%	6%
Do you water your lawn (turfgrass) and landscape (bedded area) for different lengths of time? To the best of the systems ability.		
Yes	44%	90%
No	53%	8%
Don't know	3%	2%

Table 4. Comparison of estimated irrigation application by month and season.

	Participants During Study (n=21)	Participants Prior to Study (n=21)	Nonparticipants (n=100)	Theoretical Need
Estimated Irrigation Applied (in/month)				
Jan	0.67	0.77	0.92	0.49
Feb	0.56	0.65	0.79	0.77
Mar	0.96	1.02	1.11	1.18
Apr	0.86	0.98	1.17	1.92
May	1.20	1.38	1.66	2.53
Jun	1.07	1.23	1.47	1.79
Jul	1.02	1.07	1.14	1.99
Aug	1.18	1.18	1.19	0.95
Sep	1.12	1.21	1.35	1.72
Oct	0.73	0.83	0.98	1.77
Nov	0.98	1.05	1.16	0.90
Dec	0.59	0.68	0.81	0.64
Estimated Irrigation Applied (in/month by season)				
Winter	0.67	0.77	0.92	0.49
Spring	0.56	0.65	0.79	0.77
Summer	0.96	1.02	1.11	1.18
Fall	0.86	0.98	1.17	1.92
Estimated Irrigation Applied (in/month)				
Monthly Average	0.91	0.92	1.15	1.39
Estimated Irrigation Applied (in/year)				
Annual total	10.94	12.05	13.75	16.62



External influences (scenario options):
Enforce rain shut-off ordinance
↑ Population
↑ Water demand
Technology shift

Internal influences (current activities):
Rain shut-off device required
Irrigation day restrictions
Potable water cost increase
Low cost for alternative sources
↑ # of homes with irrigation systems

Figure 1. Cluster diagram of community, technological, political, and water purveyor influences.

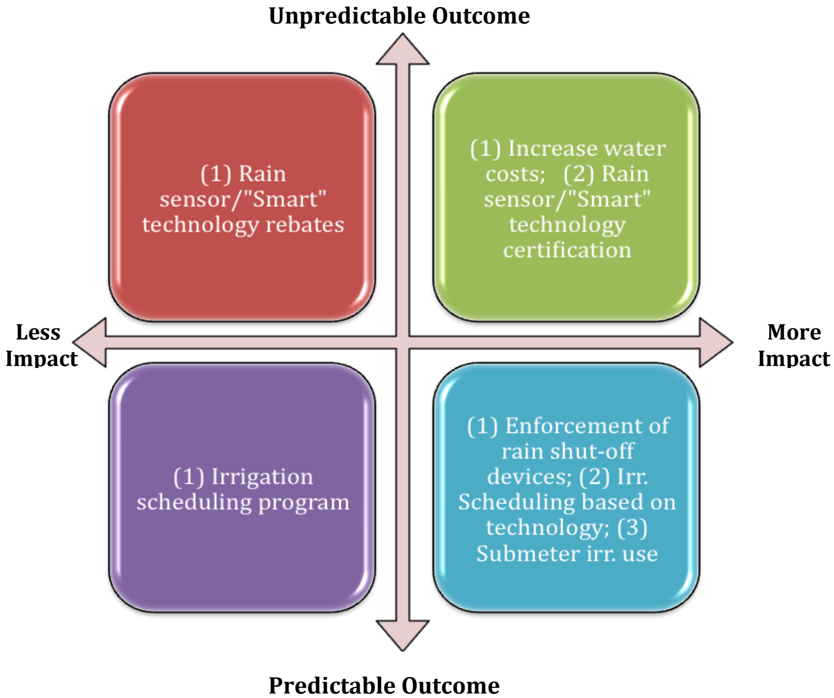


Figure 2. Impact versus outcome diagram of possible irrigation water conservation activities.

Figure 3. Rain shut-off device window decal.

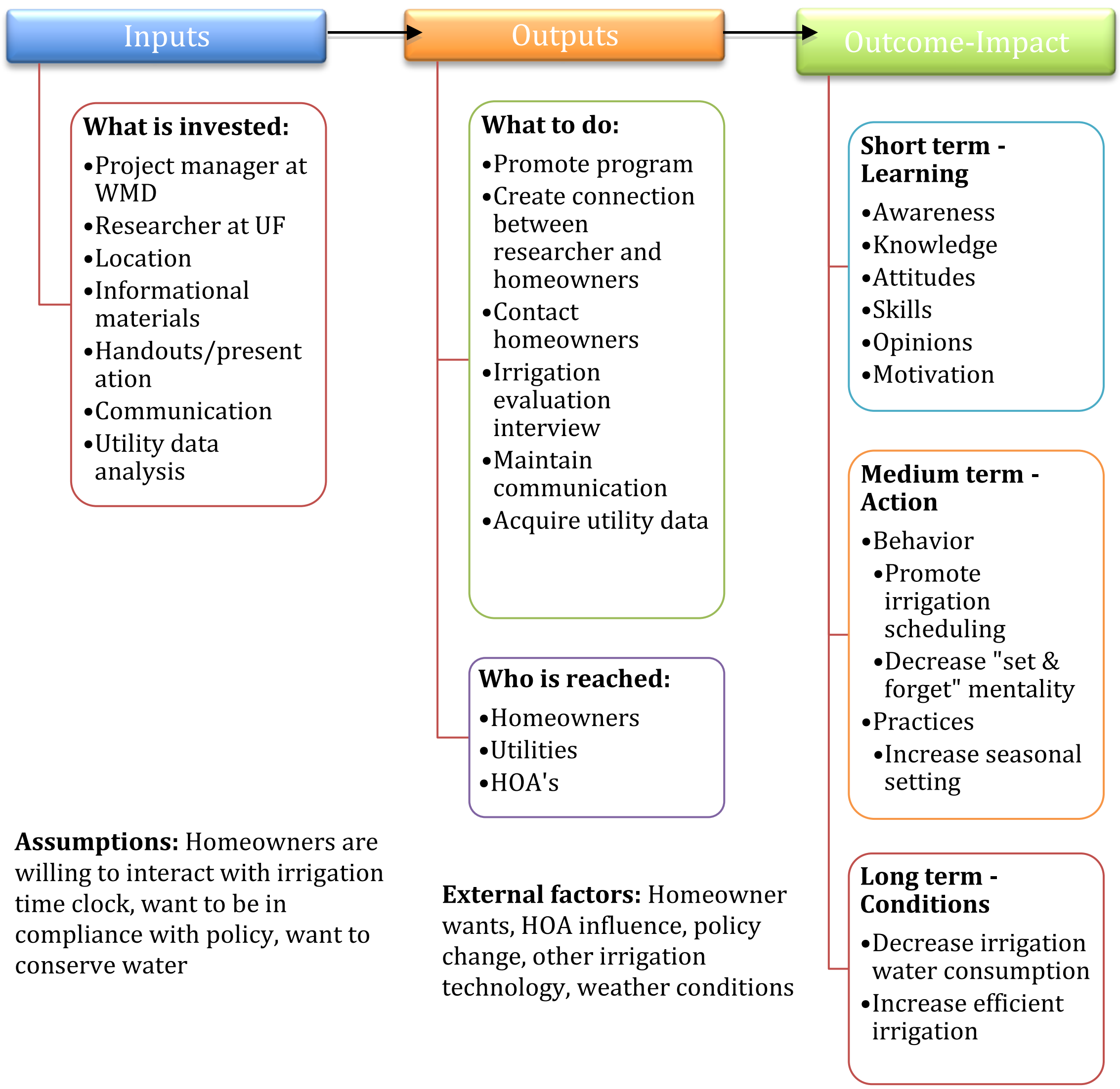


Figure 4. Logic model for household irrigation scheduling program.

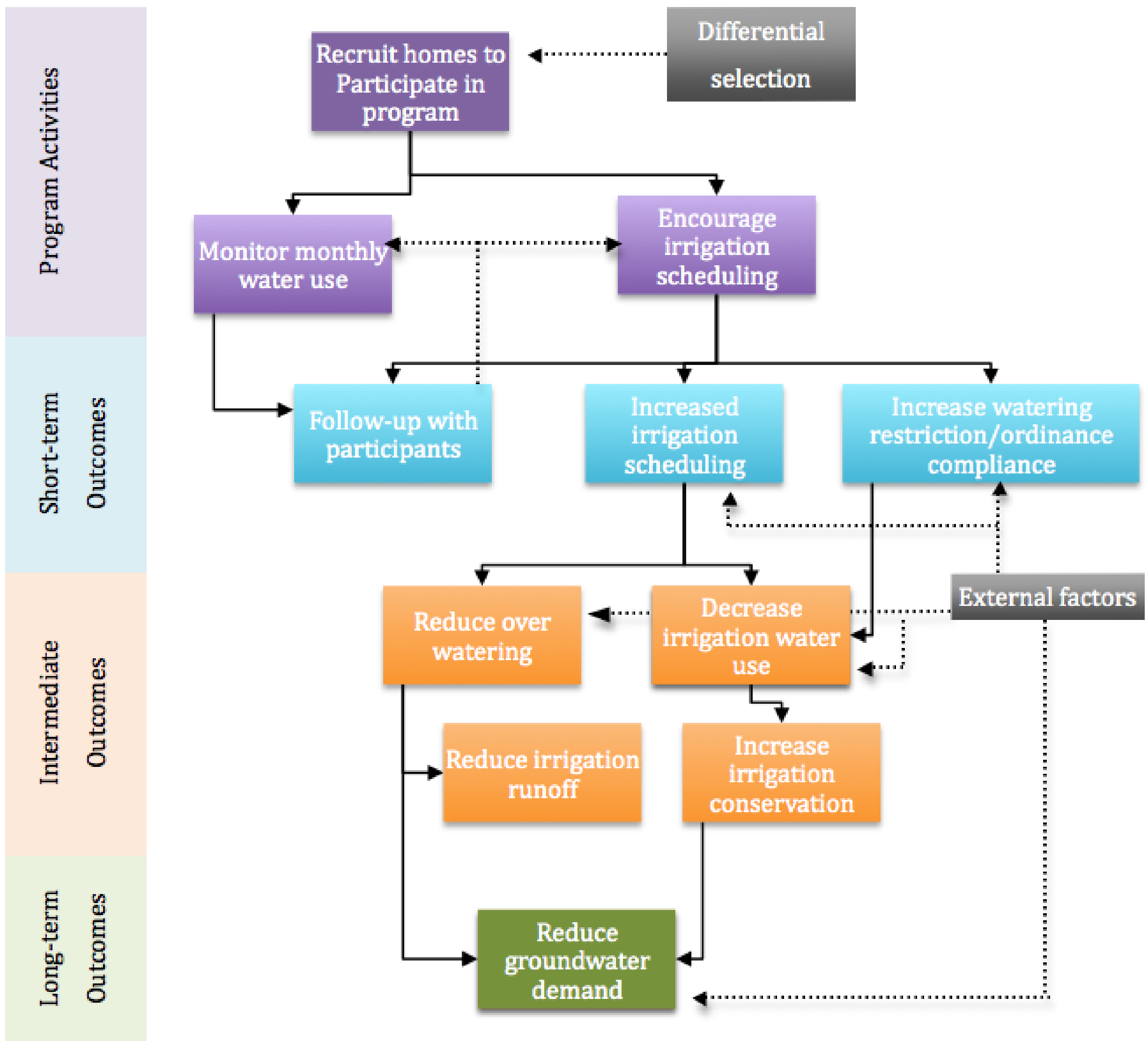


Figure 5. Impact theory model for homeowner irrigation scheduling program.

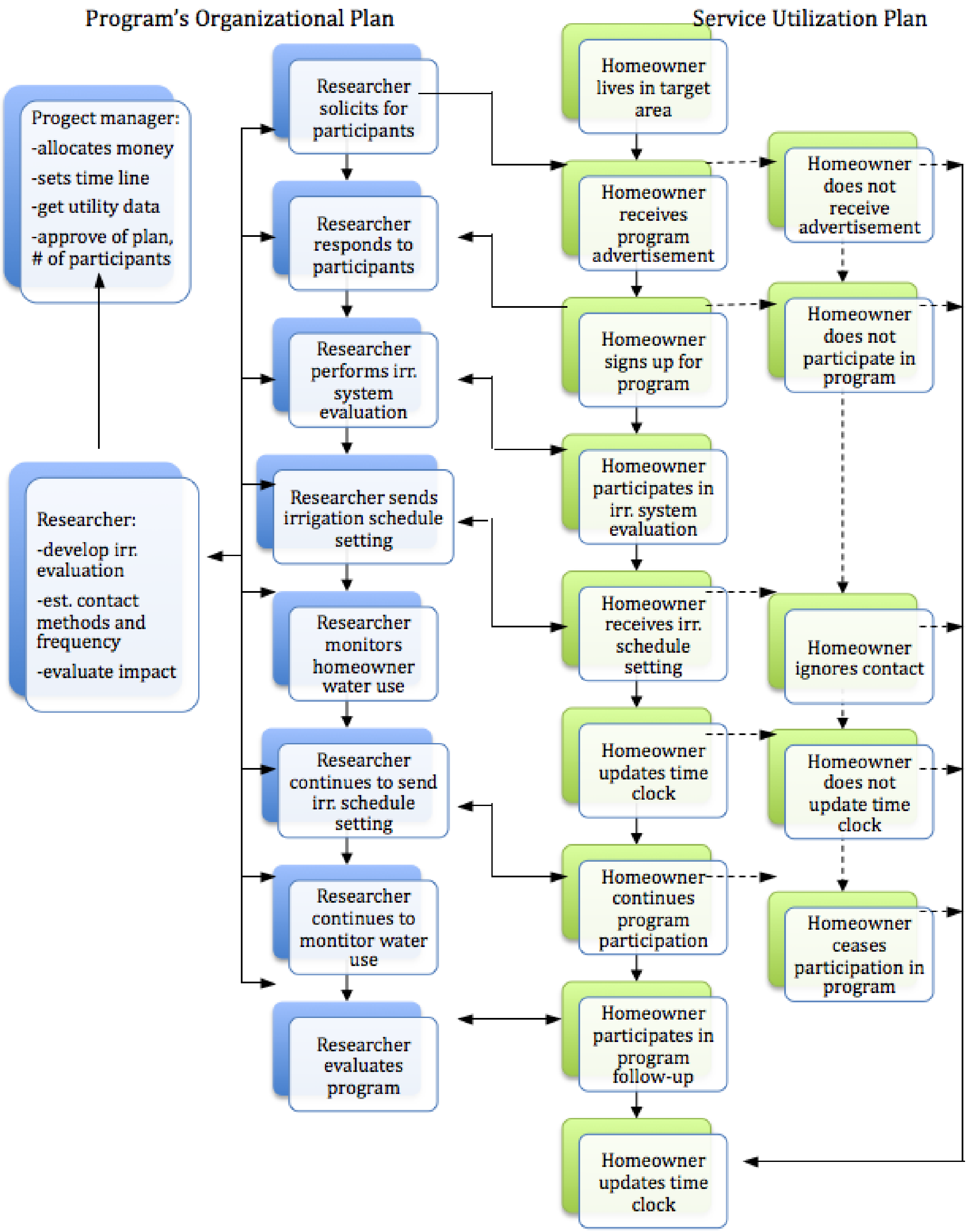


Figure 6. Process theory for household irrigation scheduling program.

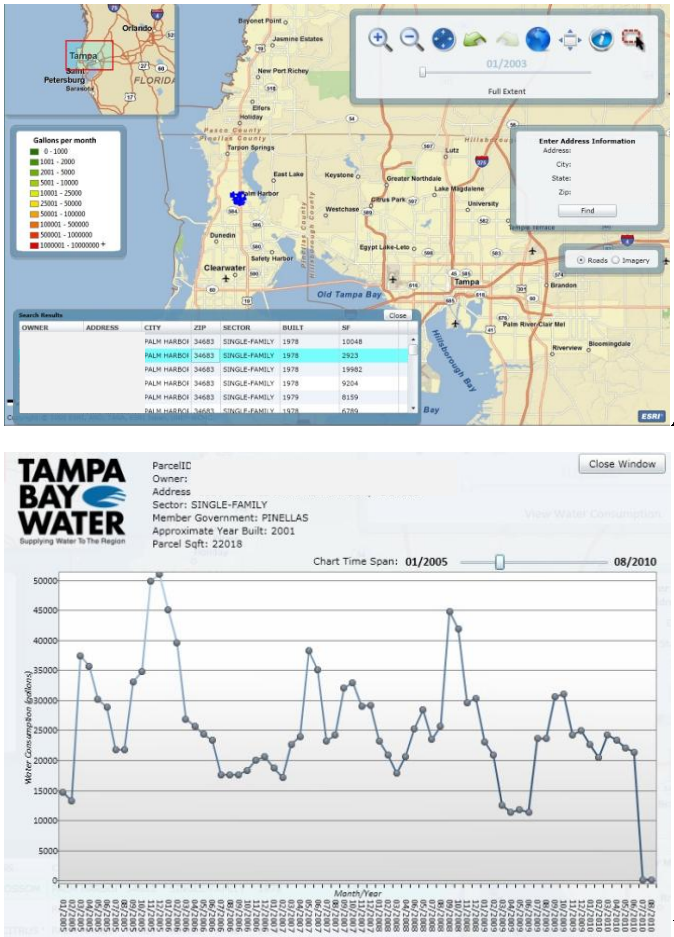
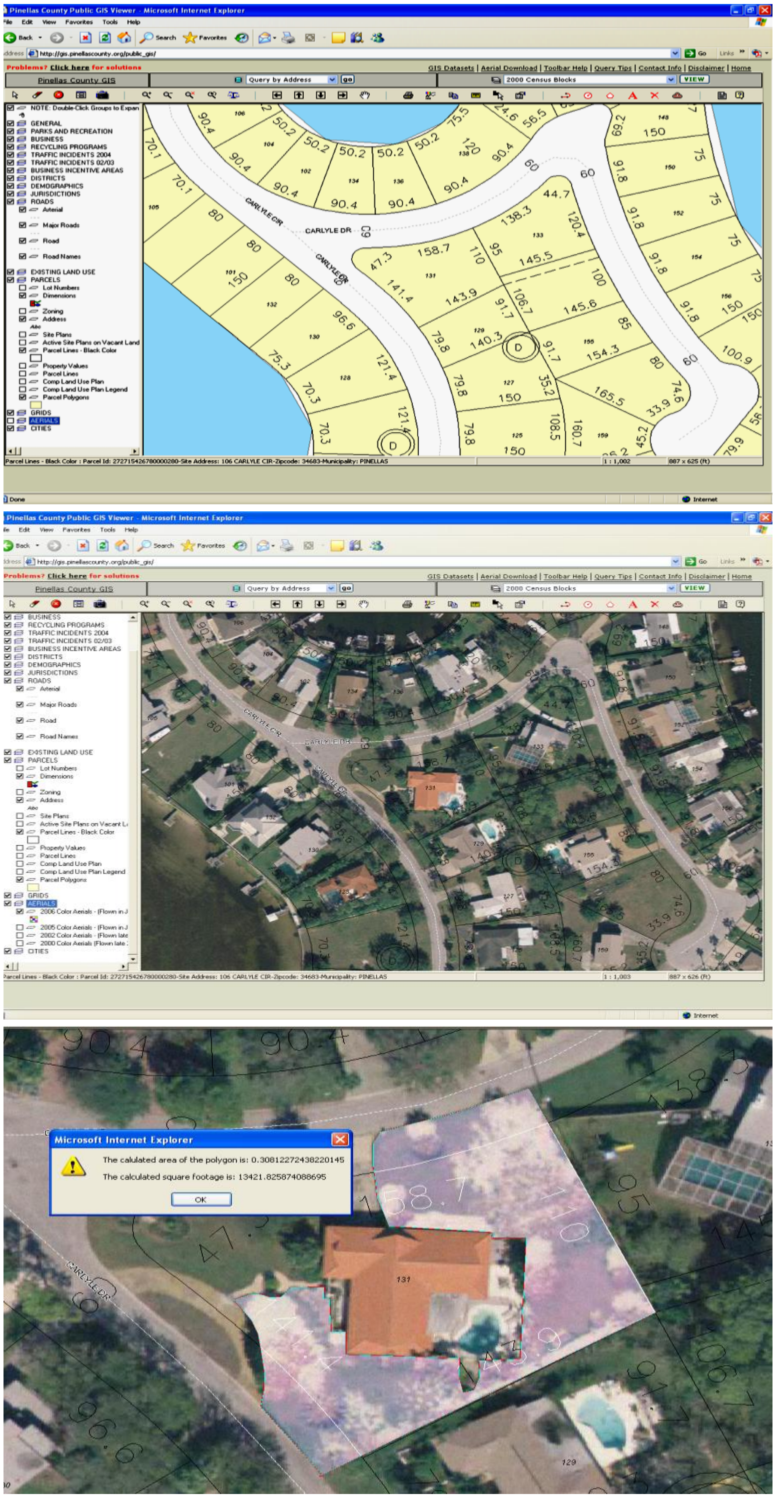


Figure 7. Screen shots from the Tampa Bay Water GovNet online water use database. A) Default map showing parcel selection tool icons. B) Parcel water consumption report display.



A

B

C

Figure 8. Property information data collected from Pinellas County public GIS server. A) Parcel map. B) Parcel map with areal imagery overlay. C) Calculated area using polygon tool.

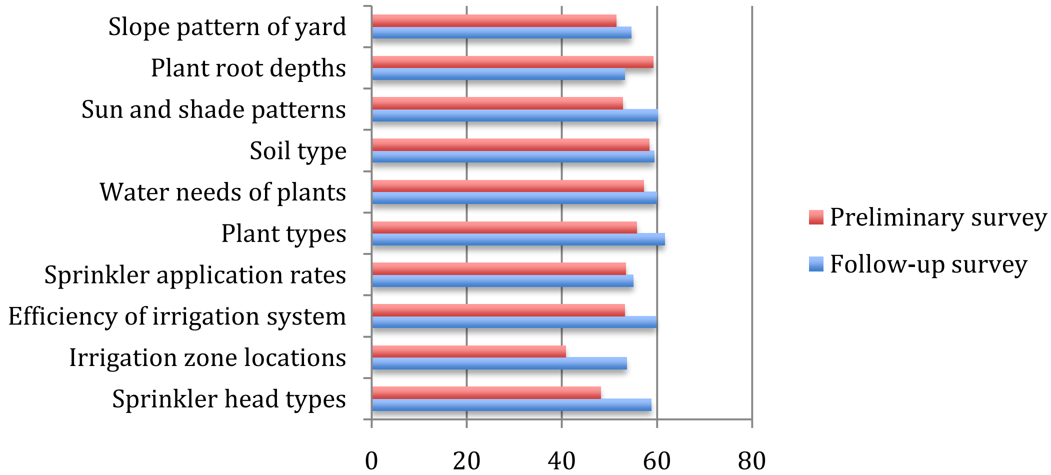


Figure 9. Knowledge scores from preliminary (RCW group only, n=28) and follow-up (all participants, n=45) surveys for landscape and irrigation system characteristics.

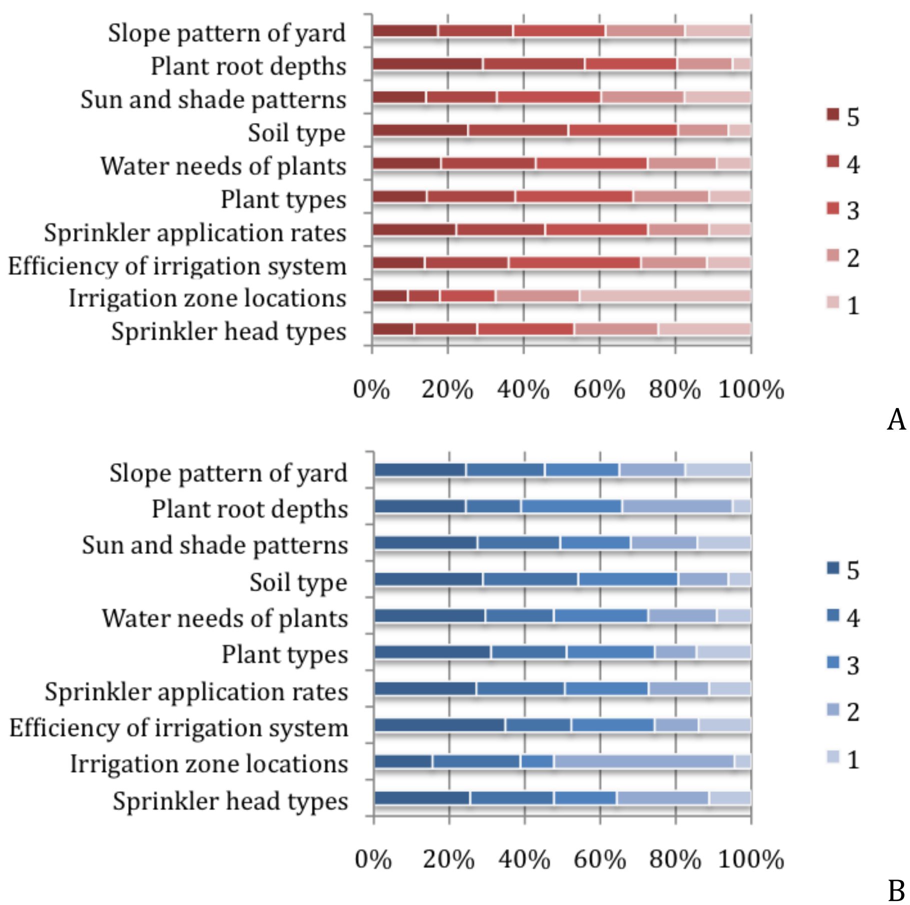


Figure 10. Level of familiarity of lawn and landscape characteristics rated from 5 to 1, where 5 represents the highest level of knowledge from (A) preliminary survey responses, RCW group only (n=28); (B) follow-up survey responses for all participants (n=45).

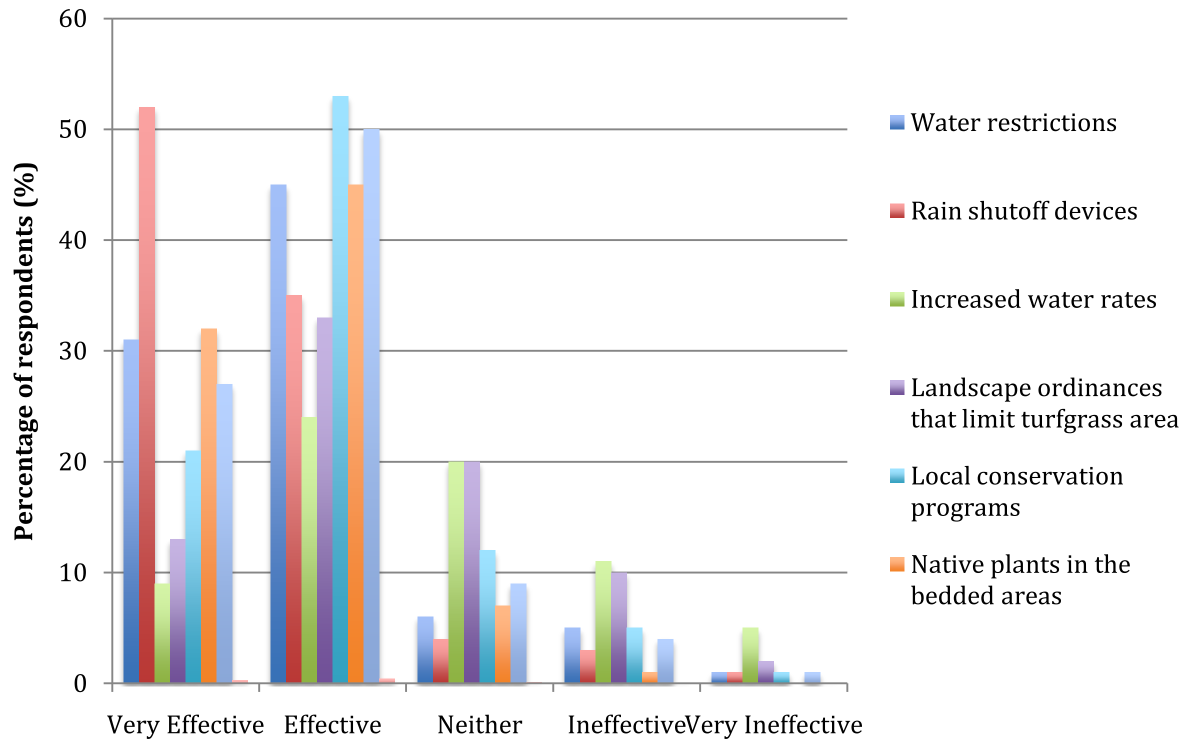


Figure 11. WWIPP Phase II respondent opinion of effectiveness of various water conservation methods (n=45)

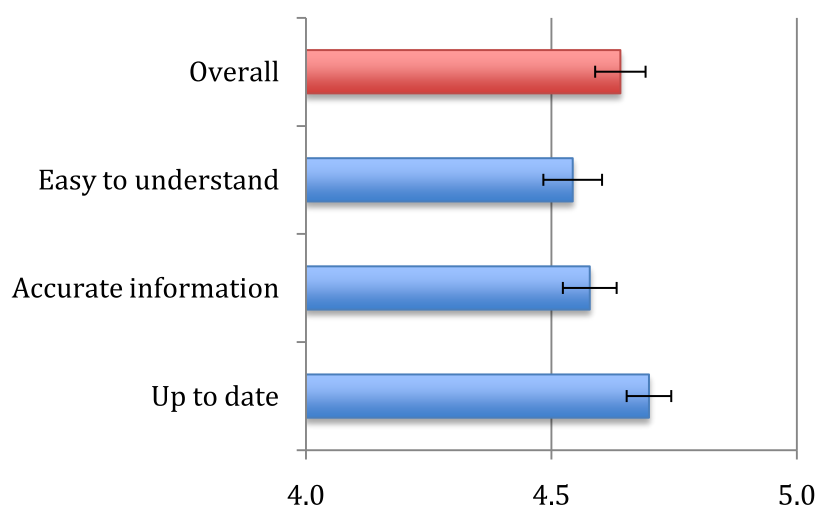


Figure 12. WWIPP Phase II program satisfaction scores with standard error bars (n=45)

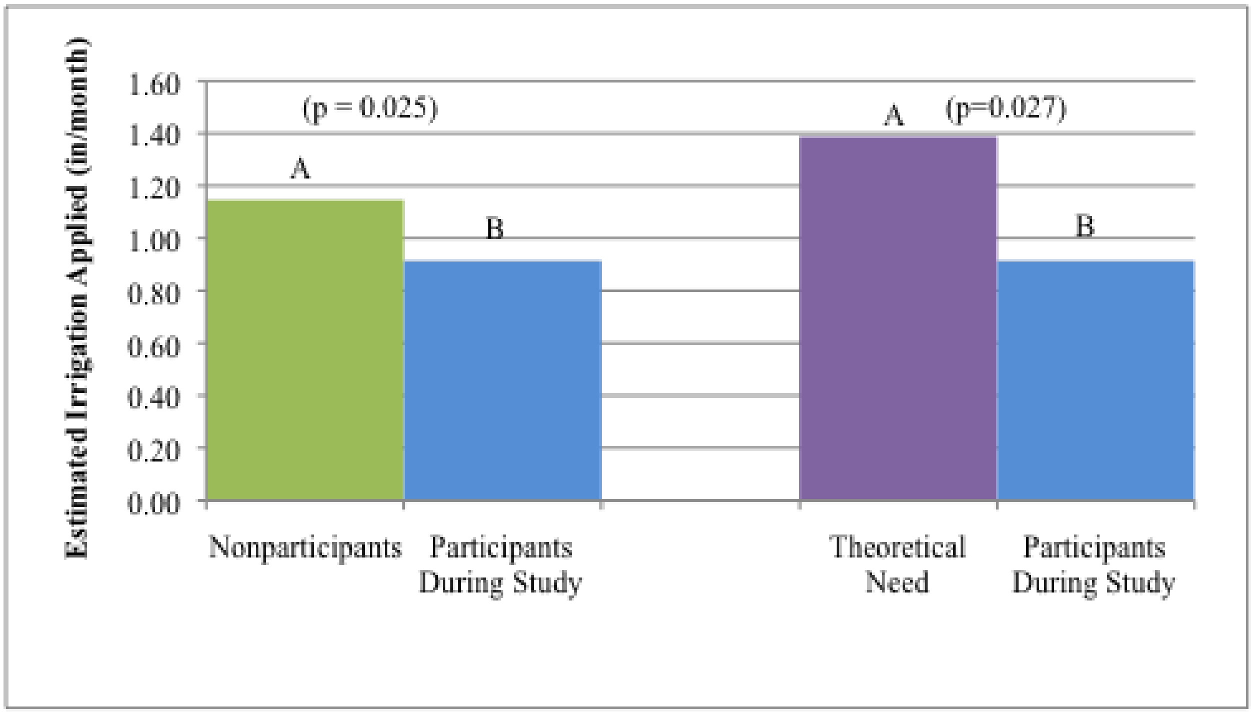


Figure 13. Comparison of outdoor water use during the 2010 study period. Upper case letters denote significant differences at the 95% confidence level based on Duncan's Multiple Range Test.

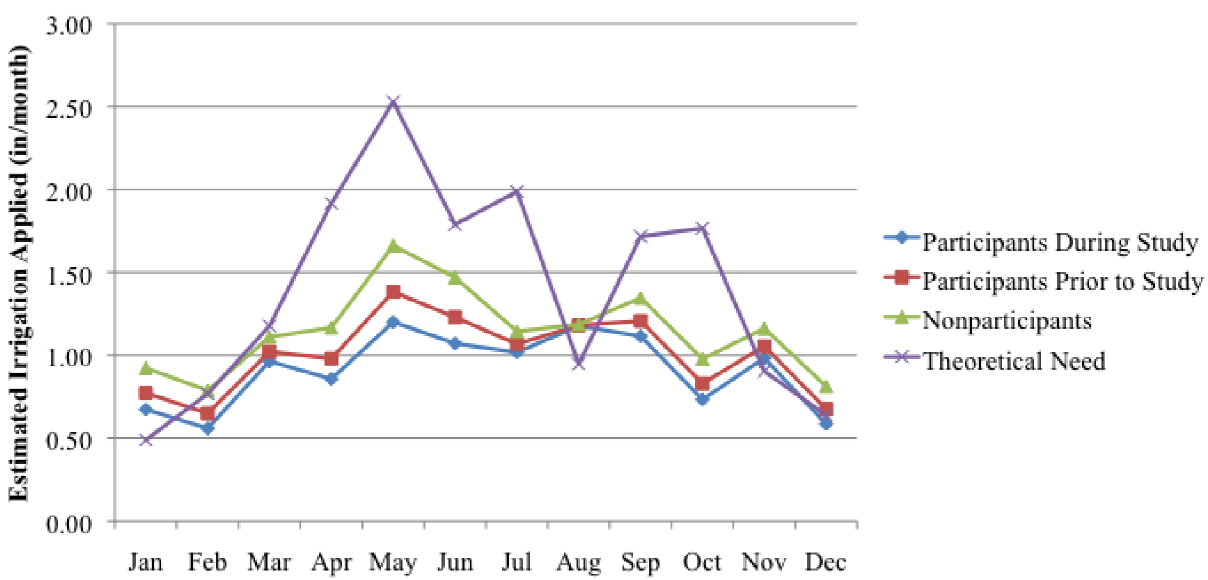


Figure 14. Comparison of estimated irrigation applied monthly.

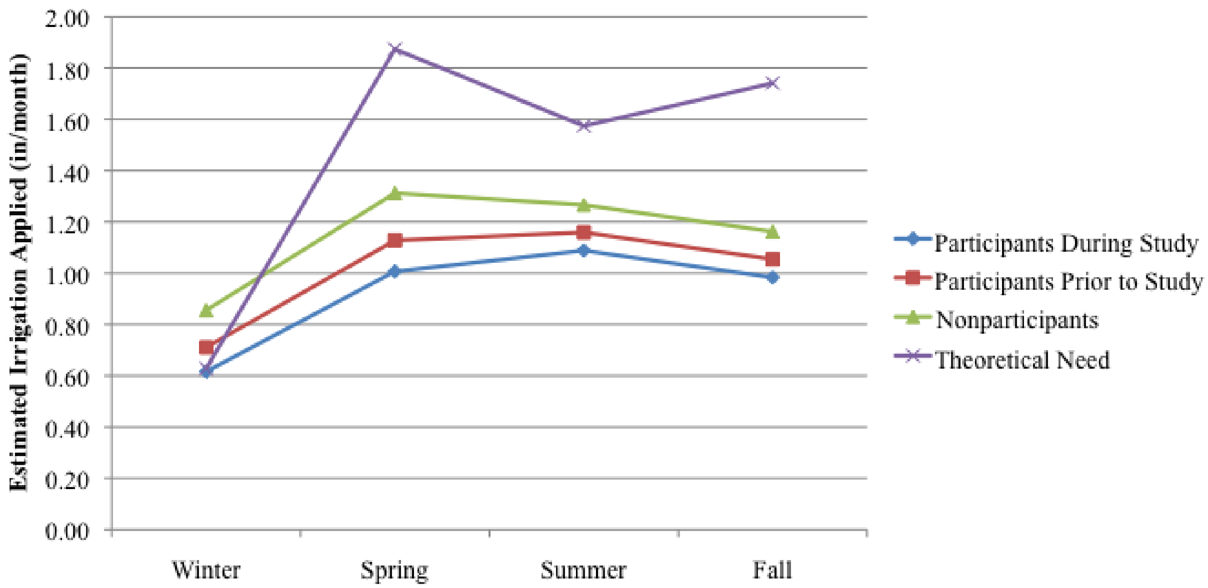


Figure 15. Comparison of estimated irrigation applied per season.

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