Appendix B: Study Design

The Residential Runoff Reduction Study

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Introduction

In 1999, the Municipal Water District of Orange County (MWDOC) and Irvine Ranch Water District (IRWD), in partnership with other national, state, and local agencies and organizations began developing a project to accomplish two goals:

1) Measure changes in the dry weather volume and pollutant content of residential runoff associated with improved irrigation management practices.
2) Confirm residential irrigation water savings identified in a previous study evaluating an automated residential irrigation controller system (the "Westpark Study").

This Appendix presents detailed information on the general study design framework described in Chapter 2. Subjects discussed include watershed selection, flow monitoring, water quality sampling, ET controller operation and selection process, and controller installation and operation.

Watershed Selection

Five watersheds were selected for the study area, based on five criteria: 1) Isolation from other watersheds, 2) climate, 3) land use, 4) development age, 5) irrigation water management techniques.

Isolation from Other Watersheds:

A watershed consists of a region of land, which drains through a single point. The five study watersheds were located in the Northwood Village subdivision in the IRWD service area. Each watershed drains through a single point and is isolated from other sources of runoff. This enabled the runoff flow and water quality to be free of interference from other sources.

Climate

While most of Southern California and Northwood Village have a similar climate, the five watersheds share the same ET zone. They are located within 5 miles of CIMIS station #75, which provides local ET_o information. The ET_o (reference evapotranspiration, the amount of water utilized by plants and lost to evaporation) is the same throughout the Northwood region and most of the central section of the IRWD service area. The plant water requirements of ET_g, which is the standard of turfgrass for cool season turfgrass and is often referred to as simply ET, are the same for all five watersheds.

Due to the close proximity of the all the homes and the lack of any physical or geographical separation of the five watersheds, the study team relied on the CIMIS station #75 for ET_o data.

Land Use

The Northwood section of IRWD's service area was selected because the predominant land use is single-family residence. There are also local parks, common city streetscapes, two condominium associations and one homeowners association (HOA). Several of the watersheds contained townhouses, apartments or condominiums. However, these types of multi-family units were limited in each of the watersheds; no single watershed had a large number of multi-family units.

Development Age

Northwood's neighborhoods were created during two distinct periods of home development. The first phase of development began in the late 1970s and finished in the early 1980s. The second phase started in 2000 and continues to the present. The study excluded the newer section of Northwood for two reasons. First, the newer homes and their HOA are not typical of Southern California. Second, IRWD has monthly water bill information dating back to the late 1980s on homes in the older section of Northwood.

Irrigation Water Management Factors

In addition to ET_o, other basic factors of irrigation water management are precipitation rate, soil type, and plant type. This study implemented real time ET scheduling through a commercially-available signal and distributed educational material to improve water management. Other water management factors are described below.

Precipitation rates vary from irrigation valve to irrigation valve, and most of the homes applied the water with spray heads operating off the pressure provided by IRWD. The individual homeowners installed most of the irrigation systems after the purchase of their houses. The technology used in these irrigation systems was of the same approximate age and featured similar types of equipment. The irrigation systems installed in the study area were also representative of a common irrigation set-up presently in use in Southern California. .

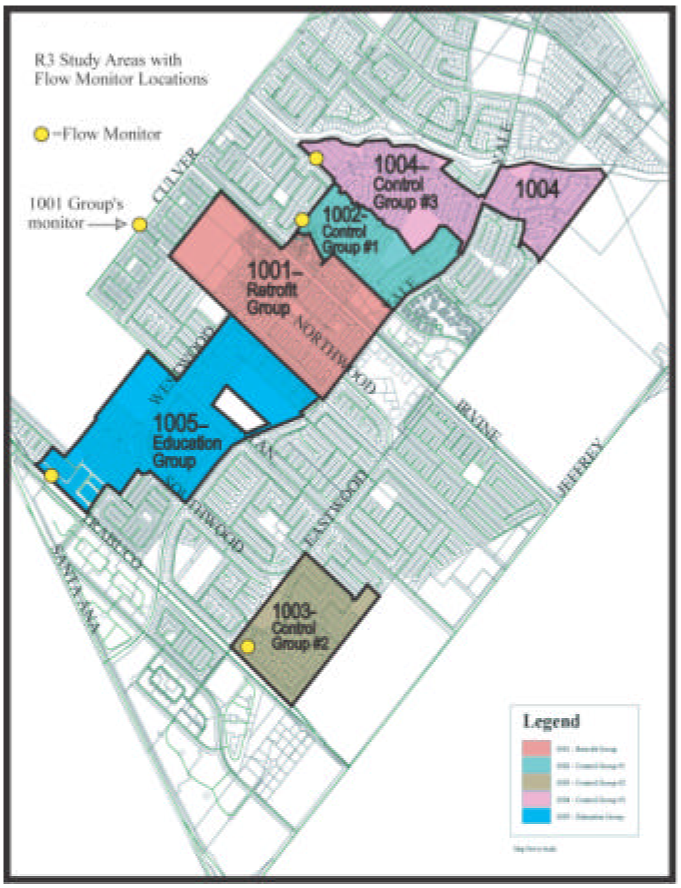
The soil type in the study area is not typical of Southern California and consists of heavy clay. Clay has the lowest infiltration rate and requires the highest level of water management.

The landscapes have sufficiently similar plant material. Although there was no data available to perform a numerical comparison, the study team field surveyed each of the potential watersheds. The majority of landscaping of all homes in the study area consisted of turfgrass. To varying extent, the outside edges, fence, building and walkways areas were lined with shrubs and plant materials other than turfgrass. The best estimate of the ratio of turfgrass to other landscaping is approximately 70 percent. While some of the homes in each of the watersheds may not have followed this construct, the vast majority of landscapes were laid out in this fashion, which allowed the study team to determine which plant materials were mostly consistently found throughout the five watersheds.

Results

After determining that large sections of Northwood were similar and after locating safe monitoring sites, the study team traced the storm drains. The selection of the monitoring site determined the shape and contents of the watershed. The study was able to isolate five watersheds with similar characteristics. The areas of the five watersheds are outlined and labeled in Figure B-1 below.

Figure B-1
Five watershed areas and their corresponding Control groups



Flow Monitoring

The two main criteria for the study's flow monitoring equipment were: 1) the monitor could not alter the pipe or channel and 2) the monitoring must be able to distinguish the seasonal flow changes and any flow change that resulted from the three different treatments (i.e., retrofit group treatment, education-only group treatment, and control group treatment).

Two technologies were suitable for this application: Manning's equation plus a level sensor, or velocity sensor and level monitor (area-velocity). The area-velocity method was chosen due to lack of slope information for the storm drain system. The selected equipment was a Sigma 950, manufactured by Hach. The equipment was battery operated, could record data every minute, and included an ultrasonic transmitter and a velocity sensor located in the storm drain. The ultrasonic transmitter established the water surface level and area, while the velocity sensor determined the velocity of the water in the pipe.

Flow was calculated by the equation: Flow = Area x Velocity. Because four of the five monitoring locations (see Figure B-1 above) were located in pipes, several variations on the ultrasonic transmitter / velocity sensor were tested before the combination of sonic and velocity wafer were selected.

Water Quality Sampling

The water quality sampling program quantified constituents found in residential runoff flows. Because a typical residential neighbor includes more than single-family lots, the concept of water management through an ET signal technology expanded to include common area landscapes.

The water quality sampling program consisted of two phases: 1) pre-study and 2) dry weather sampling.

Pre-study

Based on water level elevation provided by the flow monitors, the study team developed a plan for sampling water quality during dry weather runoff periods. In the early evening (7 to 10 pm) and again in the early morning (3 to 6 am), the water level would rise, indicating an increase in runoff flow. While the amount of change varied by location and date, the pattern was common to all of the watersheds.

The study team performed a weeklong test to determine the most representative sampling time. The team sampled all five study areas every day at 4 am and 7 pm. The constituents sampled were fecal coliform, nutrients, and trace metals.

The test results showed neither differences nor patterns in concentrations between sites, days, and sample times.

Dry Weather Sampling Duration

The final sampling program consisted of bi-weekly sampling of all five sites. During sampling weeks, all five sites were sampled for all analyses listed in Table B-1 on Tuesday, and three sites were sampled for pesticides two additional days. Toxicity samples were collected once per month at all five sites.

Table B-1
Routine Water Quality Analysis Responsibilities

Responsible Lab	Water Quality Parameter	Bottle Type
IRWD	NO_2, NO_3, NH_3, $T\text{-}PO_4$, TKN, $O\text{-}PO_4$, EC, pH, Trace Metals, Total / Fecal Coliform	(2) 1-L Cubitainer (1) 250 ml Sterile
SCCWRP	Toxicity (Sea Urchin Fertilization)	
SCCWRP	Pesticides	
MWL	MS-2 Phage	(1) 1-L (from MWL)
MWL	Enterococcus	(1) 250 mL (from MWL)

The study team collected the biweekly Tuesday samples beginning in January of 2001 and continuing through the next 18 months. The first months of sampling occurred before or during the installation of the ET controllers in the residences and the common landscape. The last 12 months, starting in July 2001 and finishing in June 2002, became the post retrofit samplings. The pesticide sampling continued for an additional six months through December 2002. Table B-2 provides outlines the water quality and data collection schedule for each group in the study.

Table B-2. Water Quality and Data Collection Schedule					
Sample Site	**Site ID**	**Cross Streets**	**Atlas Page**	**Parameter**	**Frequency**
Group A Education Site Control Site	1005 1003	Shadwell/Westmoreland Carver/Carver	84w – C1 105w – A1	Flow WQ	Weekly Bi-weekly
Group B Control Site Control Site Retrofit Site	1004 1002 1001	Hicks Canyon/Park Place La Paloma/Park Place Culver/Florence	83w – D2 83w - D1 84n – A3	Flow WQ	Weekly Bi-weekly

ET Irrigation Controller Operation and Selection Process

To meet the R3 Study objectives, it was necessary to install as many ET controllers as possible in the retrofit group. Providing the fullest coverage of the watershed with proper irrigation water management generated the best chance of changing the runoff flows. Since residential areas include landscapes other than those of the homeowners, these landscape areas were included in the water management component of the R3 Study. This represents a 3 to 1 ratio of medium-size landscapes to residential landscapes. A description of the installation process for both residential and medium-size landscapes follows:

Residential Landscapes

The IRWD staff attempted to reach as many of the 334 residences in the retrofit watershed as possible. These targeted residents received three letters which informed them of the following:

1) If selected to participate in the study, they would receive a free controller that would automatically adjust the landscape watering.
2) Their participation would be part of an environmental study aimed at preventing runoff from reaching the ocean.
3) They would be saving water without having to program an irrigation controller.
4) They were provided instructions for participating in the study along with a phone number to call to sign-up, as well as a form with a stamped and addressed envelope (for returning the form).

Additionally, IRWD staff hosted a function for the HOA in which staff demonstrated the ET controller to the residents and helped them to complete the sign-up form. Lastly, IRWD staff walked the Northwood neighborhood and hung flyers on the study candidates' front doors. These flyers contained statements from the homeowners in Westpark that had participated in the original ET Controller study. The flyers also described the ET controllers' overall customer satisfaction and ease with which the irrigation system worked.

In all, 137 residents responded to the various communication efforts by agreeing to participate in the study and installing the ET controller on their property. Of the 137 positive responses, 112 homes were equipped with proper automatic valves.

The installation of controllers began in April 2001 and continued through June 2001. A full team of IRWD staff worked weekdays, Saturdays and evenings to complete the installations. Additionally, educational materials were distributed to the retrofit group during installations.

Medium-size Landscapes

In addition to the single-family residences, the retrofit watershed contains 2 condominium complexes, and one HOA with three distinct land use types. The area also contained 12 city streetscapes. The City of Irvine agreed to change out the existing manual controllers with the ET controllers. All of the HOAs agreed to change out their controllers for the ET controllers.

The only major landscape not replacing its existing controller with an ET controller was the park-playground area of the school. The school landscape area consisted of a single meter with two separate controllers and more than 50 valves. This would require at least six ET controllers. Given the limitation in the controller and the high number of cycles that would be required to correctly irrigate the school site, IRWD was not confident that the ET controllers could be programmed in a manner that would avoid conflicting runtimes.

Controller Installation and Operation

The study evaluated the performance of the engineering of irrigation management techniques to reduce the consumption and residential runoff while maintaining the quality of the landscape. A typical irrigation controller is difficult to program and limited in the scope of the scheduling ability. Proper scheduling requires calculations based on real time ET data, landscape topography, and plant type, which are beyond the capabilities of typical controllers. The landscaper in the field is left to guess or rely on past experience as to the correct amount of water, the correct runtime to prevent runoff, and the correct days of the week to water.

The operation of the ET controller in this study was optimized by: 1) weekly maintenance, and 2) proper irrigation scheduling. IRWD staff programmed the controllers, which were operated by a combination of IRWD staff and HydroPoint consultants. (HydroPoint Data Systems, also known as HydroPoint, developed and supplied the ET controllers used in the R3 Study.)

During the prior study in Westpark, the programming was calculated based on a design precipitation rate suggested for spray heads. That study received numerous complaints that too much water was being applied and an effort was undertaken to conduct an area/flow measurement to determine the actual precipitation rate. These measurements indicated an average precipitation rate of 3.98 inches per hour while the design precipitation rate for the spray heads was 1.80 inches per hour. The measured rates varied from as low as 1.4 inches per hour to as high as 9 inches per hour. This suggested that standard settings in which a homeowner would program the controller are unlikely to efficiently run the irrigation. Because of this and other important factors, trained staff preformed the installations