Chapter 7: Findings, Conclusions, and Recommendations

7.1 Overview

The previous chapters of this report evaluate changes in water usage, dry weather runoff, water quality, and customer attitudes and awareness related to irrigation practices associated with the R3 Study. The intent of this chapter is to "integrate" these findings and outline their context as they relate to the interests and goals of the study participants and provide guidance for future efforts to improve water quality in the San Diego Creek watershed and in other areas of the county and state. Information is provided on:

- Findings and conclusions related to study methods for the water conservation, runoff reduction, water quality, and customer acceptance evaluations
- Findings and conclusions related to key results from the four study evaluations
- Recommendations related to future planning and policy

7.2 Study Methods

As noted in Chapters 3 through 6 of this report, study assumptions and methods demonstrated varying degrees of success. This section presents findings and conclusions regarding the degree of reliability of certain evaluation approaches and provides a foundation for future studies to build upon.

7.2.1 Water Conservation

Findings and conclusions regarding the study method for the water conservation evaluation portion of the R3 Study focused on three major areas.

First, the empirical effort used in the study quantified the change in mean water consumption and the shift in seasonal consumption. The models were not extended to document how water savings vary across households, for example, how savings are decreased/increased among lower/higher water use households. Such information could be useful in future studies.

Second, the study evaluated only about one year of post installation data. Thus, the statistical models can say little about the persistence of water savings. Additional follow-up quantification of water savings in subsequent years would be desirable.

Third, the modeling effort did not estimate the effect of self-selection by the participants in the education-only group. Thus, no attempt was made to extend the inference from the existing sample of participants to: 1) the rest of the service area; or 2) other service areas. The error component of the estimated models could be improved by specifying a function form to explain the variance. This should only be attempted after all major data issues have been resolved.

7.2.2 Runoff Reduction

As discussed in Chapters 2 and 4, significant measurement and data quality issues were associated with the enacted real-time measurement of urban runoff. The technology employed involved custom configurations and numerous needed calibration adjustments. Debris build-up was an early, ongoing, and possibly unavoidable issue that interfered with the calibration of the flow meters. Some of the original locations selected were more prone to this type of problem, and the flow meters were necessarily relocated. Although flow-monitoring problems required data from two of the three control sites to be discarded, the data from the other three sites (two treatments and one control) was sufficiently accurate to allow for the determination of meaningful statistical results.

To minimize the data collection issues experienced during the R3 Study, it would be helpful to install a V-notch weir in the storm drain. (See figure 7-1.) This would enable low flows to be captured and measured more precisely. It should be noted, however, that installation in an underground drain (as opposed to the surface drain shown on the figure) would require protective gear to be worn by the data collectors. Full gear (breathing apparatus) could become cost prohibitive for an aggressive (bi-weekly) monitoring program.

Figure 7-1
Detail of Diversion V-notch Design of Weir Installed in Large Drainage Pipe
(Note: Black sonic sensor hanging directly over V-notch to measure water flow levels.)

7.2.3 Water Quality

As discussed in Chapter 5, two independent reviews of water quality measurements were conducted as part of the R3 Study. Because of the variability of the data and limitations in sample quantities, the first review, which used parametric statistical techniques, provided less definitive results that the second review, which used more robust data analysis techniques. For some of the parameters reviewed, the robust analytical techniques were able to identify and measure differences in water quality across time and between study treatments.

7.2.4 Public Acceptance

As discussed in Chapter 6, pre- and post- intervention surveys were given to both the retrofit group and the education group. The pre-intervention survey was given to assess and document the prevailing landscape maintenance attitudes and behaviors of both participating groups. The post- intervention survey was given to determine 1) whether or not there was an acceptance of the ET controller as a way of managing landscape irrigation and 2) if exposure to the educational materials and monthly landscape maintenance tips had led to a change in irrigation practices and landscape management behaviors in either study group.

The survey responses indicate that, while 82 to 90 percent of the retrofit and education-only group reported to have read the educational materials, reading these materials did not cause their landscape maintenance habits to change. These responses suggest that future surveys should be designed to capture a measurement of the changes in the study subjects' consumer attitudes and behaviors in greater detail.

Future projects could benefit from using a marketing research firm specializing in the use of polls and surveys to measure residential consumers' attitudes and behaviors. The wording of each pre- and post- intervention survey question can be very carefully crafted in order to target, capture, and quantify each specific pre- and post- intervention behavioral change that is being measured. Identical or one-to-one correspondence between the pre- and post- survey questions is another effective marketing research technique. By documenting customers' changing responses, over time, to identical questions, behavioral shifts can be tracked and quantified.

7.3 Study Results

Key results of the four R3 Study evaluations are summarized below. Because the water conservation and runoff reduction evaluations were interrelated, the results from these evaluations are discussed together below.

7.3.1 Water Conservation and Runoff Reduction

As discussed in Chapter 3, water consumption by residential customers in the retrofit group was reduced by 41.2 gallons per day per household, with a reduction for the education group of 25.6 gallons per day per household. In contrast, whereas the runoff flows for the retrofit group were reduced during the study, flows in the education group increased (Chapter 4). There are three related explanations for this dichotomy: 1) the inclusion of small to medium size "common area" landscapes in the retrofit group and the exclusion of this group from the education group; 2) differences in irrigation scheduling between the residential homes in the two groups; and 3) proximity and relative flow volumes of the landscapes to the storm drain system.

7.3.1.1 Dedicated Landscapes

The retrofit group common areas averaged 0.8 acres in size and encompassed 15 sites/irrigation controllers including city landscape medians, HOA greenbelts, and a park. It is estimated that these sites account for more than 75 percent of the total area under treatment in the Site 1001 area. More specifically, these 15 sites totaled about 12 acres. The remaining 112 irrigation controllers installed on single-family residential lots are estimated to encompass 3.5 to 4 acres. The proportion of residences receiving educational materials including irrigation scheduling information was chosen to match the number receiving retrofit treatment. However, the total treated acres for the two groups varied considerably.

As was the protocol for all retrofit sites, irrigation schedules for these sites were established based on valve-by-valve evaluations of plant, soil, and irrigation system parameters. These schedules resulted in significantly more start times and shorter run times than that observed in these areas prior to the study.

More specifically, prior to installation of the retrofit treatment, each valve was turned on for two minutes to determine the flow. In this brief period, runoff was observed for many of the valves. This relates to the predominant clay soils, where runoff can exceed 90 percent of applied water after short periods due to the low infiltration rates. It is believed that the more frequent, short duration irrigation schedules developed by the treatment irrigation technology is the primary mechanism to reduce runoff from irrigation sites. In addition, these sites were closely monitored and incorporated suggested BMPs such as weekly meter readings. These sites were also used to develop the protocol for the midweek scheduling changes for all of the retrofit area and when to terminate a rain pause for the region.

In contrast to the retrofit group, the controllers on comparable common area landscapes in the education group are assumed to have continued with typical irrigation schedules that likely result in higher levels of runoff. If this is the case, and the common areas account for a similar percentage of irrigated area, this could explain the observed differences in runoff between the retrofit and education groups.

7.3.1.2 Differences in Irrigation Schedules

In addition to the runoff differences likely stemming from the inclusion of the nonresidential landscapes in the retrofit group, irrigation scheduling differences also existed for the residential homes between the retrofit and education groups. The education group households received a suggested irrigation schedule that provided the number of days per week to run the irrigation system, the number of minutes per cycle (start time), and a maximum of three start times. As noted above, short run times and multiple start times are believed to be the key element in reducing irrigation runoff.

Although the post-study survey indicated that about 60 percent of those in the education group changed their controller's irrigation schedule at least "sometimes," it is not clear how closely they followed the suggested schedule, including the recommendation on start times. Inasmuch as programming many controllers for multiple start times can be challenging, it is possible these instructions were generally overlooked. In contrast, the weather-based irrigation controller used on the retrofit homes automatically reduced the run time for slope, soil, and sprinkler precipitation rate. This will likely reduce runoff even in the absence of direct water savings. This difference may also be a consideration in the dissimilar runoff results in the two treatment sites.

7.3.1.3 Proximity to Storm Drains and Flow Volumes

The final consideration is the location and relative flow volumes of the common area landscapes relative to location and flow volumes of the residences. The common area landscapes were typically located closer to storm drain catch basins (and the study flow monitors) than most residential lots and also had much higher flow volumes on the individual irrigation valves. Runoff from most residential lots had to travel a signficant distance through surface street gutters before reaching catch basins and were subject to both evaporation and seepage in route. In addition, the limited drainage associated with many residential back yards could have further reduced the quantity of water reaching the storm drain from these areas in both the retrofit and education groups. Consequently, the reduction in runoff from treated retrofit common area landscapes and the presumed lack of similar reductions for the education group common areas, combined with the high valve flow volumes, likely explain the differences in observed runoff for the two treatment groups.

7.3.2 Water Quality

As described in Chapter 5, water quality samples were taken twice per month, resulting in a total of 39 samples over an 18-month period. One of the simplest and most straightforward methods to review these samples is to compare them to established water quality objectives for the San Diego Creek watershed. The subsections below address water quality and flow, and runoff water quality.

7.3.2.1 Water Quality and Flow

Chapter 5 of this report also describes issues with the reliability of study flow data during certain study periods and with certain monitoring locations. Because of the temporal relationship of these issues, integrating the water quality and flow data to determine changes in the mass loading of water quality constituents is difficult from a statistical standpoint. However, certainly, the water quality and flow data from the study provide some useful qualitative insight into the impacts of the interventions and may be instructive for future water quality improvement efforts.

7.3.2.2 Runoff Water Quality

Analyses utilizing ore robust statistical methods suggest that the intervention did result in changes in water quality. TN levels in the retrofit neighborhood following intervention were found to be significantly lower than levels before intervention, whereas no detectable differences were noted before and after intervention in the education neighborhood. Relatively large observed reduction in TN flux in the retrofit neighborhood could be influenced by seasonal factors, and the extent to which the ET controller contributed to the reduction is unknown.

7.3.3 Public Education

Data issues discussed previously make it difficult to quantify the impact of public education on reduced water usage and reduced dry season runoff. However, pre- and post-surveys of the retrofit + education and education only groups showed a positive response to the concepts of the irrigation tips. More than 70 percent of the retrofit group participants indicated that they liked the ET controllers, and the group also found that controller irrigation either maintained or improved the landscape. However, it appears that the savings in water use per year is not large enough for the water customers to be willing to pay for an ET signal.

7.4 Recommendations

The application of data from this study will influence future programs and efforts to improve water quality. The application of the irrigation management program focusing on using automatic real-time weather-based irrigation scheduling not only resulted in reductions in onsite/customer water use, but also reduced runoff. With the quality of runoff essentially unchanged, this reduction in runoff should result in a decrease in the total mass of non-point source pollutant loading to the watershed. The relative cost-effectiveness of this program should be evaluated in comparison to other existing or proposed BMPs to improve watershed water quality.

Although not directly determined from the study, the results suggest that the common area landscape sites will provide the most cost-effective application of the water management program. Additional empirical verification of this relative cost-effectiveness supposition is likely warranted.

An additional issue related to the water management program is the availability and viability of the irrigation controllers tested as a part of the study. Although the tested controllers operated reasonably well, occasionally glitches occurred, which necessitated either telephone or onsite intervention by study personnel. For the number of controllers installed for the study, these maintenance issues were manageable. However, the wide-scale use of these controllers would require a significant commitment from the water purveyor or the controller manufacturer to address maintenance issues. At this time, it is not believed that the controller manufacturer has established infrastructure to support a large number of controllers. In addition, the viability of the tested water management program is completely dependent on the regular transmission of data signals from the controller manufacturer to adjust irrigation schedules. Assurances on the long-term viability of signal transmission are imperative to the expansion of the tested program.

In contrast to the water management program, the educational program implemented as a part of the R3 Study reduced customer water use, but did not reduce measured runoff from the study area. Consequently, again assuming no change in runoff quality, this treatment would not appear to provide pollutant mass loading benefits to the watershed. However, the relationship between the observed water savings for the treated portion of the study area and increased runoff for the entire study area is unclear. Because of the clear relative cost advantages of educational programs, additional and more focused studies should be conducted to more fully understand this relationship and determine the viability of educational programs in reducing non-point source pollution.