California Urban Water Conservation Council

Evaluation of Potential Best Management Practices - Residential and Small Commercial Weather-Based Irrigation Controllers

Prepared for

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VII. Residential and Small Commercial Weather-Based Irrigation Controllers

1. Background

Irrigation accounts for a large proportion of total urban water demand. It is also a key driver of peak demand, and a significant source of urban runoff. Most studies and green industry professionals also believe that over-watering is widespread among the region's urban landscapes. All these factors combined suggest that conservation activity in this arena is likely to yield rich dividends on a number of different fronts.

Several approaches have been tried in the past to improve outdoor water use efficiency, such as, behavior modification through education, surveys/audits, conservation rate structures, and ordinances (e.g., day-of-week irrigation limits, Model Landscape Ordinance), and through application of modern technology (e.g., weather-based controllers, drip irrigation, gray-water reuse). Strategies based upon behavior modification, or application of new technology, are by no means mutually exclusive—in fact using them in concert usually leads to significant synergies.

Our goal in this section is to summarize key aspects of what we know about weather-based irrigation controllers. Weather-based controllers attempt to match irrigation to plant evapotranspiration (ET) needs, hence they are also referred to as ET controllers. Large, expensive, ET controllers for use in commercial landscapes have been available for some time. Recently, however, smaller, inexpensive units for use in residential settings have also started to appear on the market, opening up a conservation tool that heretofore was unavailable. Several of these newer, smaller, units have been extensively field tested during the last several years. Here we summarize what has been learned through these field studies and make recommendations about how best to integrate ET controllers into the existing framework of conservation PBMPs.

<u>Types of Weather-Based Controllers</u>

Weather-based (ET) irrigation controllers are available for as little as a hundred to several thousand dollars[41]. The technology underlying the different makes and models can be grouped into three broad categories, and within each category one may find ET controllers that either completely replace the existing controller, or make the existing controller "smarter" by piggybacking on it.

(1) *Controllers independent of broadcast signals*. The controller estimates irrigation schedules based upon on-site sensors. Some models may embed in their internal memory historical ET data for a given location, which is then modified on a real-time basis by on-site sensors. Some models may use a single sensor (temperature and/or solar radiation); others may incorporate additional sensors (rainfall and/or soil moisture).

[41] *Options for Weather-Based Irrigation Control for Residential and Small Commercial Sites Workshop*, 2003, Handbook prepared by California Urban Water Conservation Council; co-hosted by East Bay Municipal Water District and Santa Clara Valley Water District.

(2) *Controllers dependent upon broadcast signals*. The controller receives a signal broadcast from an off-site location indicating the level of ET, which is then used for estimating irrigation requirements. The customer may be required to subscribe to this signaling service, apart from purchasing the controller. The frequency with which signals are sent can vary (daily, bi-weekly, or as-required). Some models may also have the ability to integrate additional on-site sensors, such as rain collectors, to improve scheduling precision for the individual site.

(3) *Controllers with remote programming ability*. The controller is capable of both sending and receiving signals. Remote programming ability may be labor saving in large applications, and the controller can be designed to signal back if and when unauthorized tampering takes place. The latter feature makes these types of controllers especially useful in pay-for-performance programs.

The simplest controllers have embedded historical ET data and a single on-site sensor. Such models do not require a signal service subscription. In principle, additional on-site sensors could be integrated with embedded ET controllers to improve their accuracy, albeit at increased cost. At the other extreme are controllers with both a send and receive capability, making them remotely programmable and tamper proof. Any of these technologies will "work"—in the sense that each will modify irrigation schedules taking weather into account. The key is figuring out which technology model is most suited and cost-effective for a given setting.

Behavioral Assumptions—Implications For Program Design

The design of ET controller retrofit programs can greatly affect both the level of water savings, as well as the level of customer satisfaction. When residential ET controllers first became available, hope existed that a "hang it on the wall and walk away" approach would work, allowing water agencies to adopt fairly low-cost programs to distribute this new technology. Key to this expectation was the assumption that homeowners probably irrigate near optimum during the peak summer season but usually fail to properly scale irrigation up or down during the off-summer seasons (Figure 6). In such a scenario, simply transferring summer schedules from the existing to the retrofitted controller, or estimating a baseline schedule using simple rules of thumb, could be expected to generate marked savings. However, if excess irrigation is actually due less to inattention, and more due to a lack of knowledge on the customer's part (Figure 7), then savings depend to a greater extent on getting the baseline schedule right, which, in turn, implies a higher level of customer service during the retrofit phase and thereafter.

Water agencies should carefully assess which of the above two worlds its customers inhabit, before embarking on an ET controller retrofit program. In the context of ET controllers, we believe a mythology has arisen claiming that most residential customers alter their irrigation schedules no more than 2-4 times a year. Southern California's larger single family homes, especially in Irvine (see the two Irvine studies cited later), have been found to display a fairly sharp seasonal pattern—in other words, a pattern more like Figure 7 than Figure 6. While it is tempting to explain away these counterintuitive findings by attributing them to Irvine's steeply inclining rate structure, it is also possible that these patterns are more general, which is why agencies must carefully assess this issue.

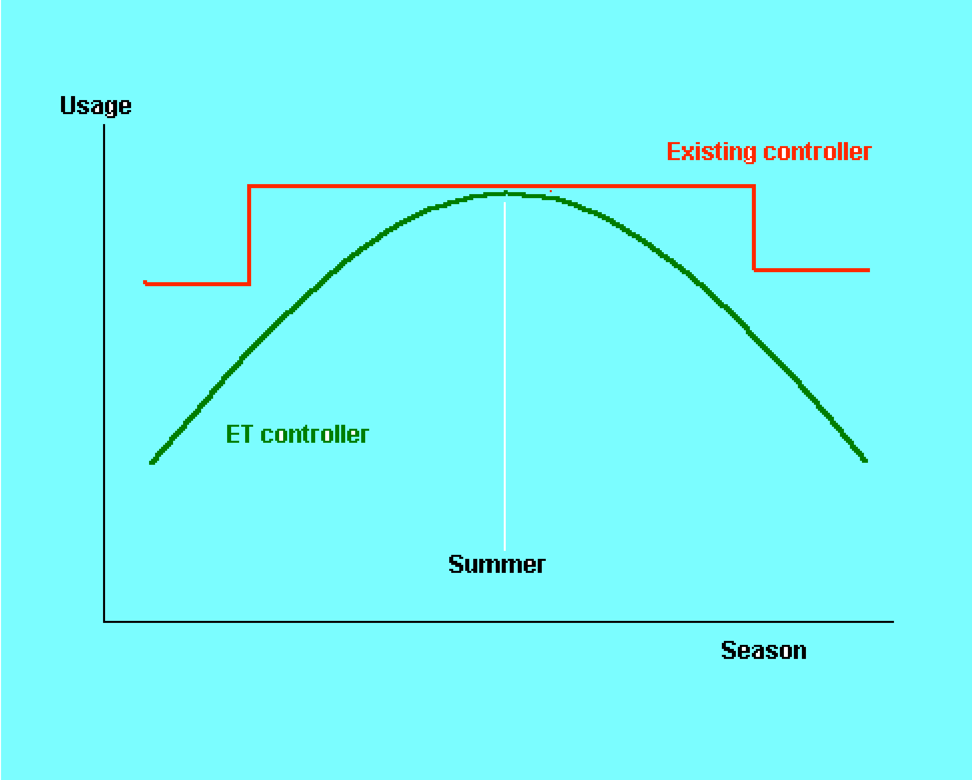

Figure 6. Peak summer schedule relatively accurate, customer inattentive

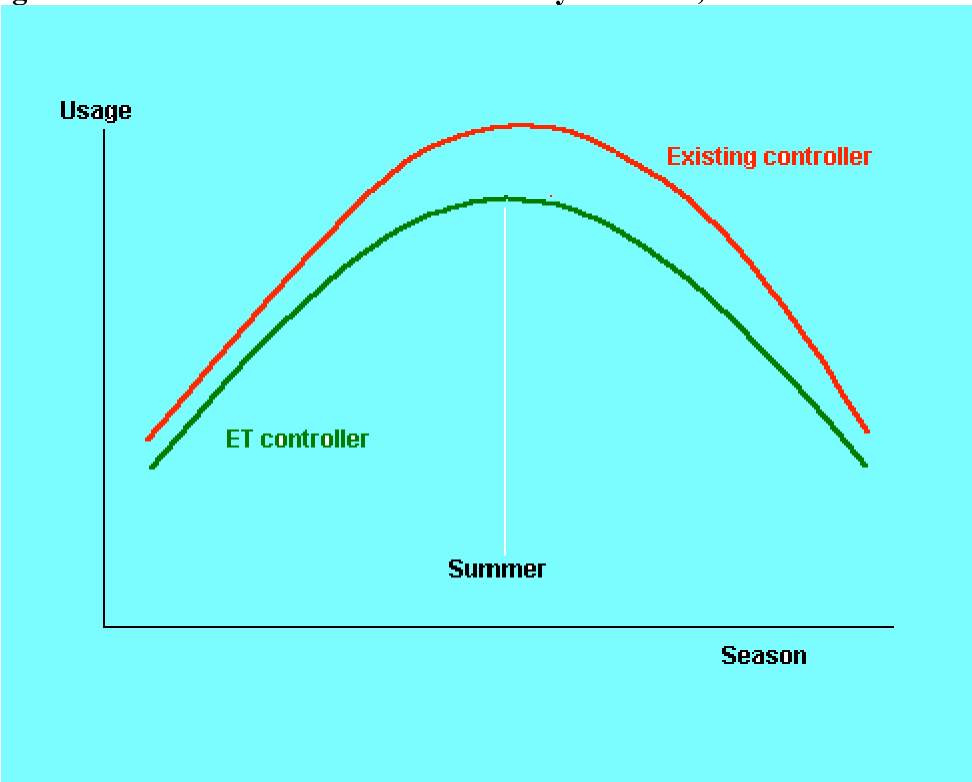

Figure 7. Customer relatively attentive, but not knowledgeable

2. Technological Efficacy

Several studies[42] have now been completed documenting the efficacy of ET controllers. The key findings of these studies are as follows.

Two studies performed in Irvine, California (Hunt et al., 2001; Diamond, 2003), and one in Denver, Colorado (Aquacraft, 2001 and 2002), specifically examine the efficacy of a broadcast-signal type controller (WeatherTRAK). A more recent study sponsored by the Metropolitan Water District of Southern California compares the performance of the above controller to two non-broadcast type controllers —a controller that modifies historical ET data using a temperature sensor (AquaConserve), and a controller that imputes ET by measuring solar radiation (WeatherSet). Although these studies do not suggest that all of the above controllers perform equally well, they do suggest that each has the potential of saving substantial amounts of water when correctly programmed with accurate baselines schedules in accordance with manufacturers' instructions. Additional studies are underway to fully understand the pros and cons of each type of controller technology. Technology vendors also continue to refine their products.

3. Water Savings Estimates

Assuming technological efficacy of the ET controller, water savings will become primarily a function of landscape size and the level of over-watering taking place prior to the ET controller retrofit. Studies that have evaluated water savings have come up with similar results, which is comforting. For example, Hunt et al. (2001) estimated that an ET controller program marketed to the top third (in terms of consumption) single-family homes in Irvine Ranch Water District's (IRWD) service area would reduce total residential consumption between 10 and 11 percent, or outdoor consumption by approximately 24 percent. A later evaluation of a follow-on program in IRWD's service area targeted at single-family homes also estimated a 10 percent reduction in total household consumption (Diamond, 2003). Both of these programs tested the performance of a broadcast-signal ET controller (WeatherTRAK). Addink and Rodda (2002) evaluated savings achieved by embedded historical-ET controllers (AquaConserve) in three agencies (Denver, Colorado; Sonoma, California; Valley of the Moon, California) and estimated that outdoor consumption in these three agencies declined by 21 percent, 23 percent, and 28 percent, respectively.

[42] Hunt, T., Lessick, D., Berg, J., Wiedmann, J., Ash, T., Pagano, D., Marian, M., and Bamezai, A., *Residential Weather-Based Irrigation Scheduling: Evidence From the Irvine "ET Controller" Study*, 2001 (http://www.irwd.com/conservation).
Addink, S., and Rodda, T. W., *Residential Landscape Irrigation Study Using Aqua ET Controllers*, 2002, (http://www.cuwcc.org/).
Aquacraft, *Performance Evaluation of WeatherTRAK Irrigation Controllers in Colorado*, 2001 and 2002, (http://www.aquacraft.com).
Diamond, D., *Project Review of the Irvine ET Controller Residential Runoff Reduction Study*, 2003, (http://www.irwd.com/reports).
Jordan, A., Lang, R., and Gonzales, M., *High Tech World Meets the Residential Irrigation Controller to Save Water in Santa Barbara County*, 2004 (forthcoming in AWWA conference proceedings).
Metropolitan Water District of Southern California, *Weather Based Controller Bench Test Report*, 2004.
The Saving Water Partnership, *Water Efficient Irrigation Study Final Report*, 2003, (http://www.cityofseattle.net/util/RESCONS/papers).

A more recent study of WeatherTRAK controllers in Santa Barbara found an even greater level of savings, mainly because the program targeted sites with very large landscapes (approximately 1 acre). Although not necessarily representative of the average California water agency, these findings underscore the strong relationship between landscape size and water savings as commonsense would dictate.

4. Customer Satisfaction and Outreach

Customer Satisfaction

Only two studies have examined this issue in some detail (Hunt et al., 2001; Aquacraft, 2001), and both report a high level of satisfaction with ET controllers. Unfortunately, both studies focus on the same broadcast-signal controller (WeatherTRAK), so it is difficult to compare customer satisfaction across different types of controllers.

Hunt et al. (2001) state that over 80 percent of study participants found overall performance of the WeatherTRAK controller to be either “good” or “very good”, and over 90 percent found the controller to be either “convenient” or “very convenient” to use. However, the customer service provided by the Irvine Ranch Water District during the course of this study probably exceeded that which would normally be provided by a water agency when implementing a controller retrofit program.

Aquacraft (2001) states that based on a total of 10 test sites: “Compared to the old controller 5 users rated WeatherTRAK as better, 2 as less, and 4 about the same. Six users would recommend the system to a friend.” Over 90 percent of study participants in both studies rated the appearance of their landscape as about the same, or better, than before.

In spite of such high levels of satisfaction with the technology, however, only one in four participants in the Irvine study (Hunt et al., 2001) and one in ten in the Denver study (Aquacraft, 2001) were willing to pay $4 or more per month for the signal fee associated with a broadcast-type controller like WeatherTRAK.

Customer Outreach and Programs

As mentioned earlier, when residential ET controllers first became available it was hoped that a “hang it on the wall and walk away” approach would be feasible, allowing water agencies to distribute this technology in a fairly low-cost manner. Field experience gathered since that time has dashed these hopes, however. Experience from Irvine (Hunt et al., 2001), and more recently from Santa Barbara (Jordan et al., 2004) demonstrates that savings and customer satisfaction greatly depend upon getting the baseline schedule right (requiring measurement of nozzle precipitation rates and so on; rules of thumb do not work), and upon educating the customer, and perhaps even their landscape caretaker, about proper irrigation scheduling and irrigation system maintenance, as well as about proper horticultural practices. These studies make a compelling case that ET controller distribution programs *must factor in a significant level of outreach effort in order to achieve water savings goals*.

5. Cost and Cost-Effectiveness

ET controllers both save water, but have the potential to reduce runoff. They also offer customers added convenience, which is of unknown value as of yet. The full lifecycle cost of a broadcast-signal ET controller, including unit cost, installation cost, and the monthly signal fee is quite high and would equate or fall below the water savings benefit only among some of the largest residential customers (Hunt, et al., 2001). The benefit-cost ratio is likely to be more favorable in the case of embedded historical-ET controllers since no signal fees are incurred, although it is still not clear whether the water savings are equivalent between the two ET controller technologies.

Although a comparative cost-effectiveness analysis of broadcast versus non-broadcast ET controllers has not been conducted to our knowledge, it is worth repeating what is known about the cost-effectiveness of broadcast-signal ET controllers. For example, in Irvine, Hunt et al., (2001) demonstrate that even if only the top-third of high water using single-family homes are retrofitted with WeatherTRAK controllers, the lifecycle water savings benefit to the customer would roughly equal $338 (customer savings are valued at $720 per acre-foot) compared to a total lifecycle cost of $528 (of which $353 represent signal fees) over a ten year product life cycle. Fortunately, this analysis also shows that the water savings benefit to IRWD is approximately $204, so that by offering a rebate IRWD can bring customer benefits in line with customer costs. In spite of the rebate, however, the overall benefit-cost ratio to the customer would still be close to one (or, by implication, the payback period roughly ten years), which is not the sort of incentive that makes individuals rapidly adopt new technology.

Several conclusions follow from the above discussion. First, targeting of high-water users to some extent is necessary to have a sensible program. Second, ET controllers should be marketed as much for their lifestyle and convenience features as for their water savings so that customers are drawn to this new technology. Green industry professionals should also be co-opted through outreach efforts to expand and transform the market for ET controllers[43]. Finally, a serious attempt must be made, whether through conservation rates, or through education, to sensitize customers to the consequences of bad irrigation habits, which we expect will make them significantly more open to new technologies such as ET controllers.

6. Summary

<u>Market</u>

Existing studies paint a positive picture about the technical efficacy of residential and small commercial weather-based irrigation controllers. In addition, their water savings potential rivals that of ultra-low-flush toilets on a per household basis.

[43] Bennett, D., and Smith, J., *Bringing Smarter Sprinkler Clocks to Market*, 2003, (http://www.cityofseattle.net/util/RESCONS/papers).

According to the California Department of Finance, there were roughly 7 million single-family detached homes in the state in 2003. We estimate conservatively that roughly only a quarter of these have automatic irrigation controllers and a landscape size large enough to justify weather-based irrigation controllers. Exact figures are difficult to come by at this stage, but assuming that on average landscape areas planted with turf and shrubs in these households works out to roughly 2,000 (turf equivalent) square feet, and that roughly 17 inches of irrigation per year are applied over and above what is necessary (based upon findings from Irvine, and author's preliminary estimate from another evaluation in progress), then the theoretical savings potential in this sector works out to roughly 114,000 acre-feet per year. Including the savings potential of other attractive sites, such as homeowner associations, parks, and other small commercial sites would raise this estimate even more.

We estimate the total cost of generating these savings to range roughly between $270 and $810 per acre-foot for non-broadcast and broadcast-type controller technologies (cost data underlying these estimates are taken from Hunt et al. [2001]).

Given the large likely market, and the possibility of making a significant impact on residential outdoor water use for which at present few other reliable tools are available, we believe that this technology easily merits designation as a PBMP. We also believe that costs of weather-based irrigation controllers will continue to decline over time, as the technology matures and demand expands, and that benefits (water savings, runoff reduction, customer convenience) will be better quantified by future studies, all of which could considerably improve the cost-benefit calculus.

Issues of Concern

Water agencies, however, need to consider several issues before adopting this technology to a full best management practice in its own right. For non-broadcast type controllers, technological efficacy still remains bit of an issue. For broadcast-type controllers, other issues remain on the table including: (1) location and coverage of urban weather stations, which obviously affects the accuracy of ET measurements transmitted to broadcast-type controllers; (2) how to ensure that customers continue to subscribe to the fee-based signaling service; (3) the amount and structure of the rebate and whether the initial purchase should be rebated or the signal service, or both; (4) whether signal service costs should be billed directly to the customer or along with the water bill. Finally, irrespective of the kind of controller at issue, the question remains whether weather-based controllers should be integrated with residential audits. Field experience both suggests that targeting of high water users is necessary, and that a good bit of effort is required up front to establish accurate baseline schedules to maximize water savings.

Manufacturers and Technology Advancements

Different manufacturers and vendors are continuing to pursue different ET controller technologies as well as different business models, which will influence how rapidly these controllers can be disseminated. Almost all manufacturers appear to have proprietary technologies, which deters water utilities to some extent, since none wants to be locked into working with just one technology or one vendor. Ideally, the industry would establish technical standards for both the signaling service and the receivers, such that customers could freely choose between different controllers and different signal vendors, mixing and matching as necessary. But since we do not yet detect solid moves by the industry in that direction, we expect absence of technical standards to act as bit of a dampener on the rate of (ET controller) market transformation and expansion in the short run.