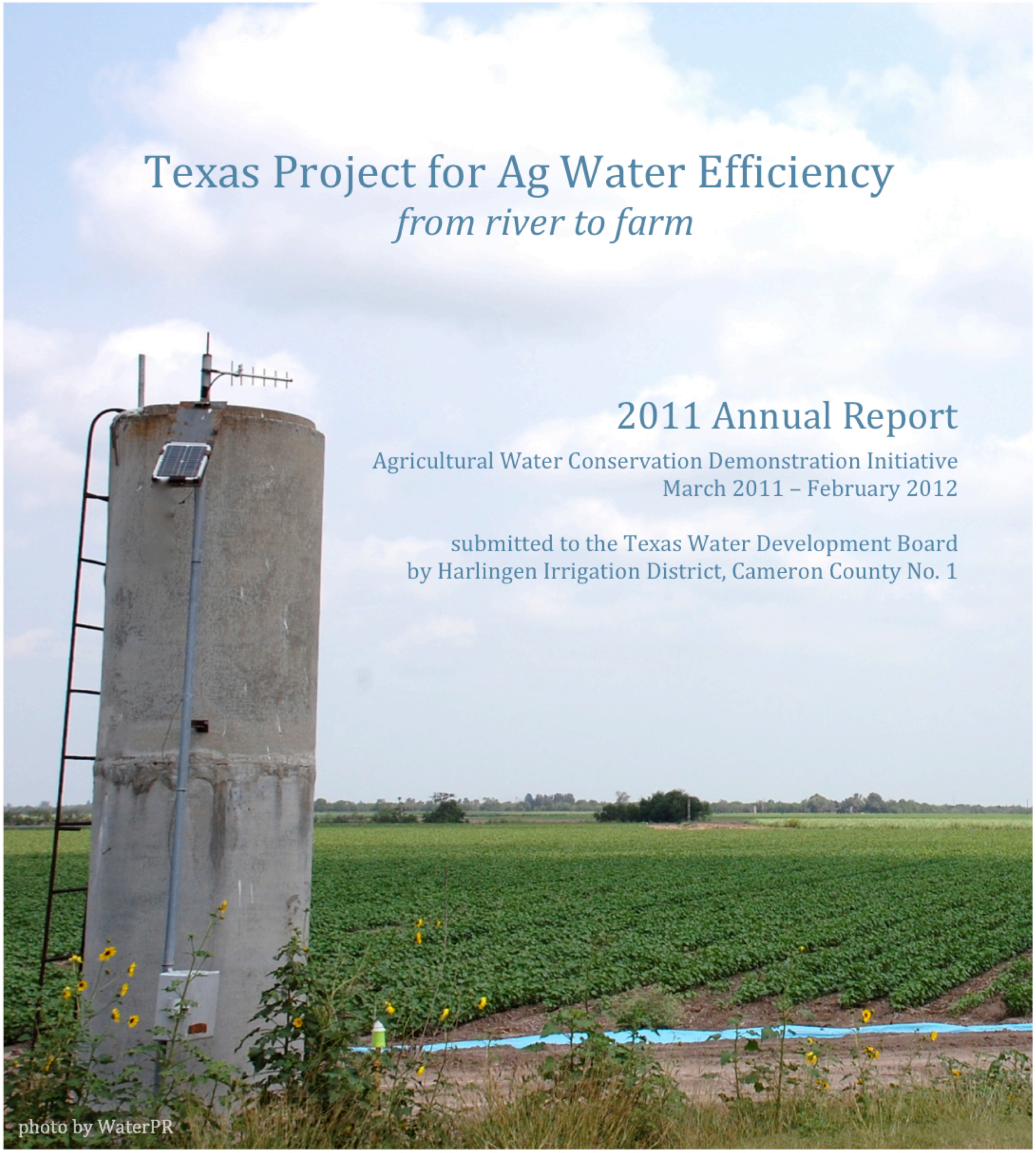
Texas Project for Ag Water Efficiency
from river to farm

2011 Annual Report

Agricultural Water Conservation Demonstration Initiative
March 2011 – February 2012

submitted to the Texas Water Development Board
by Harlingen Irrigation District, Cameron County No. 1



New technology adapted to a decades-old conveyance and distribution system:
solar-powered telemetry system monitors and allows for remote adjustment of on-farm delivery
via irrigation efficient poly-pipe in the field. HID's ADI project at work.

30 July 2012

Comer Tuck
Director, Conservation Division
Texas Water Development Board
1700 N. Congress Ave.
Austin, TX 78711

Re: TWDB Contract #2005-358-013

Dear Comer:

The Harlingen Irrigation District, Cameron County No. 1, is pleased to submit this 2011 Annual Report of activities and achievements associated with its Agricultural Water Conservation Demonstration Initiative grant for the period March 2011 – February 2012.

For the past seven years, the District and its partners in the ADI project have been researching and collecting and verifying data on techniques and tools for maximizing efficiencies in agricultural water management and use. Assured of our results, we are now ready for the ultimate phase of our project: disseminating our findings on agricultural water efficiency and conservation to agricultural producers, irrigation districts, and policy makers.

With this annual report, we are introducing the new name and tag line for our project:

Texas Project for Ag Water Efficiency
from river to farm

A logo is forthcoming and various elements of a multi-media campaign are being developed, with the goal of having factual information in easy to understand formats readily available as Texas prepares to debate water issues in the upcoming 2013 legislative session. With agriculture consuming the largest share of water in the state, this information is critical to ensuring that the process results in sound policies and programs. HID is honored to have had the opportunity afforded by this grant to contribute to the discussion.

Very best regards,

Tom McLemore
Project Manager
Harlingen Irrigation District
301 E. Pierce Ave.
Harlingen, TX 78550

Foreword: A message from the General Manager

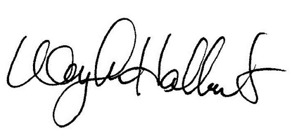
Over the past seven years the Harlingen Irrigation District with funding from the Texas Water Development Board has been demonstrating different types of irrigation practices in real on-farm situations. We have demo sites in center pivot, side roll, drip, emitters, flood, border flood, surge, and the traditional furrow flood with poly pipe. Through cooperation with the Texas AgriLife Extension-Farm Assist Program we have been able to show the expense of the water savings and the effect these procedures have had on yield, demonstrating to the farmer how water conservation increased or decreased his bottom line.

But these demonstrations have gone beyond just determining if, when, and how much water can be saved through various new irrigation technologies. As we conclude our studies and analyze our results, we find that the recommendations we have to make are not necessarily what we expected when we began. We have found that the most important component of all the data we collected on each practice is not the practice itself but rather the management of the practice, i.e., the tools that allow our farmers to be the most efficient they can be. That realization has allowed us to focus on how to make the farmers better managers of their water resources instead of trying to make them change completely the way they do business.

As a district, this changes our direction completely. Generally districts can't afford to make the infrastructure changes that would allow for wholesale changes in the way we irrigate in the Rio Grande Valley. Only in isolated situations and with specific crops can the farmer afford to install sophisticated water conservation systems. We can however seek to find ways to provide the proper tools to our farmers that will make them as efficient as possible in the practice that best fits their operations. The challenge for the district is to invest its time, monies, and energy into tweaking policy and operations to give our agricultural community the best opportunity and encouragement to make water conservation a daily practice on the farm.

As we move forward to publicize the results of this 10-year Agricultural Demonstration Initiative, we are compiling the results of our on-farm demonstrations for development into user-friendly graphics that illustrate the water savings that may be achievable through various irrigation technologies. But given the high costs of many of these technologies, we believe the best course of action is to focus attention on water efficiency through water management, beginning at the most critical point: district operations.

Sincerely,



Wayne Halbert
General Manager
Harlingen Irrigation District

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Agricultural Water Conservation Demonstration Initiative: 2011 Annual Report

From flood to drought: such is the way of life for irrigation in Texas.

In 2010, the Lower Rio Grande Valley experienced its worst flooding in years, as Hurricane Alex roared through the Lower Rio Grande Valley. Amistad and Falcon reservoirs reached unprecedented levels after being inundated with floodwater from Mexico following the hurricane and a separate tropical storm in late June and early July 2010.

One year later, the Valley – as well as the rest of Texas – was suffering through the worst one-year drought in the history of the state. The statewide drought index value surpassed all previous values; according to State Climatologist John Nielsen-Gammon, more than 40 years had passed since anything close to the severity of the 2011 drought has been experienced across Texas.

Throughout these extreme conditions, the Harlingen Irrigation District's Agricultural Water Conservation Demonstration Initiative is proving that the impacts of flood and drought can be overcome by efficient systems and processes for delivering and applying irrigation water.

Ag Water Use & Opportunities for Conservation

Agricultural producers in the four counties of the Lower Rio Grande Valley (Starr, Hidalgo, Cameron, and Willacy) each year pump just over one million acre-feet of river water on 432,553 acres of irrigated cropland. The two biggest categories of irrigated crops are sugarcane and citrus, both of which are high-value crops with water needs well in excess of rainfall amounts typical for their growing seasons.

In 2011, the Texas Project for Ag Water Efficiency closely studied potential strategies for reducing irrigation water to these crops without compromising their value. The studies found significant opportunities for water conservation at minimal cost to producers. If applied uniformly throughout the Valley, these strategies could conserve from 69,000 to 90,000 acre-feet of water annually: between seven to nine percent of the total amount of water used for irrigation in the region.

Conservation Strategies for Citrus

2011 serves as an exceptional example of the extreme level of irrigation water used by citrus growers in the Lower Rio Grande Valley under severe drought conditions. In 2011, most citrus growers in the region saw four inches of rainfall, most of it at the very end of the growing season and thus of little benefit for citrus growth and yield production. Typically, citrus in the Valley requires about 45 inches of water per year.

"Large-pan" flood irrigation traditionally has been the strategy of choice for citrus growers in the region. During 2011, the Texas Project for Ag Water Efficiency tested alternative methods of irrigation, including microjet sprinkler spray, single and dual line drip, and "narrow" border flood (described in full in Appendix A.) The results were impressive: growers using narrow border flood irrigation best met the 45-inch water requirement (41 inches applied via irrigation, plus 4 inches of precipitation). Every other irrigation methods exceeded this crop requirement, with the highest water use occurring with traditional flood irrigation. Producers using this method on average applied an additional 62 inches of irrigation water, far exceeding the yearly irrigation crop demand by approximately 17 inches of water in the 2011 growing season.

The entire LRGV citrus industry consists of about 28,000 acres of citrus. Extrapolating the 2011 results to this potential universe, we conclude that switching to alternative irrigation practices for citrus throughout the Valley could generate substantial savings in water – up to 49,000 acre-feet – if the entire industry converted from traditional flood to narrow border flood irrigation. Furthermore, switching to narrow border flood irrigation would be the easiest and most cost effective alternative irrigation practice for citrus growers currently using traditional flood irrigation methods.

Conservation Strategies for Sugarcane

Sugarcane during the 2011 growing season received 20 inches of rainfall, 53 inches less than the 73 inches of water needed to produce a crop. However, in sampling several irrigation events, our researchers found that some farmers were applying more water than needed to make up the rainfall deficit and/or irrigating too often, applying from 60 to 80 inches of water during the entire sugarcane season. This exceeds the volume needed to bring in the crop by some 7 to 27 inches.

More than 15 inches of water per acre can be conserved if farmers use available tools to calculate crop water demand by, for example, monitoring crop evapotranspiration and by applying water more efficiently to the crop. With more than 40,000 acres of sugarcane under cultivation in the Lower Rio Grande Valley, between 20,000 and 90,000 acre-feet of water could be saved with proper irrigation management: calculating irrigation scheduling, using proper flow-rates per furrow, and decreasing runoff loses.

"The 2011 growing season was one of the driest years on record, with very minimal rainfall. Some citrus growers using TFd [traditional large-pan flood] irrigation had 10 separate flood irrigation events. A TFd irrigation event will commonly use a 6 inch irrigation application, thus 5 acre-ft/acre of water was applied in TFd irrigation fields this past growing season. Although growers using BFd [border flood] irrigation also applied 10 flood irrigation events this past year, the total water applied may have saved as high as 2.5 acre-ft/acre of water this past year.

If the entire citrus industry faces water restrictions in the future due to continuous drought conditions in the Lower Rio Grande Valley, growers can easily transition to BFd irrigation and save a substantial amount of water and preserve citrus production until rain replenish the reservoirs again. This field management practice can be implemented at relatively low cost to the grower, without the need to invest in an irrigation system that is costly such as drip or microjet spray. The results of this research study suggest that during extensive drought season like that of 2011, if all growers changed from TFd to BFd irrigation practices were could save 45,000 acre-ft of water a year."

Appendix A, On-Farm Irrigation of Citrus Crops

The Harlingen Irrigation District was awarded the 2011 Environmental Excellence for Agriculture for its ADI achievements to date in promoting efficiencies in water delivery and application to help meet future water demands in Texas while maintaining and even increasing farm profitability. The award is highlighted on the District's website, www.hidcc1.org.

The District also was recognized for its innovation and technological advances in the area of irrigation flow control and water usage measurement in *A Catalogue of Good Practices in Water Use Efficiency*, prepared by the Stockholm International Water Institute for the 2030 Water Resources Group. The District's project was cited as one of nine global "good practice" projects included in a report presented to the World Economic Forum in Davos, Switzerland, in January 2012. The Catalogue highlights agricultural, municipal, and industrial water efficiency and conservation projects that can be replicated elsewhere: it defines a "good practice" project as one that "demonstrably improves the efficiency or productivity of water use (through water savings and/or yield increase). It will have been implemented in the field and will have demonstrated or have the potential for transferability to other appropriate settings."

The District issued a press release on its recognition (see Appendix G). The release was publicized in the March 2012 issue of *Irrigation Leader,* the February 2012 issue of Texas Water Resources Institute's *Conservation Matters*, the March 2012 issue of NRS Consulting Engineers' *Texas Water News*, on WaterLookOut.org, and on KRGV-TV, Harlingen's ABC affiliate. The press release also is posted on the District's website.

During 2011, 6 cooperators maintaining 16 demonstration sites participated in the project. (Details on all demonstration sites are provided in Appendix B.)

About the ADI

The Agricultural Water Conservation Demonstration Initiative (ADI) is now entering its eighth year of showcasing efficient process and tools in the management, delivery, and application of irrigation waters.

ADI is a project of the Harlingen Irrigation District-Cameron County No. 1, with funding from the Texas Water Development Board. HID's Tom McLemore serves as project manager. Other HID personnel active in the project include assistant project manager Heather Jones, tasked with administrative and budget activities, and field technician Danny Allen, who works with the cooperators in the surge demonstrations and maintains monitoring equipment and meters.

Participants in the 10-year project include Delta Lake Irrigation District, Texas A & M University-Kingsville, USDA-Natural Resources Conservation Service, Rio Farms, Inc., Texas AgriLife Extension Service and agricultural producers in Cameron, Hidalgo and Willacy counties.

Subcontractors on the project and their areas of expertise are as follows:

- Dr. Shad Nelson (Texas A&M University-Kingsville): drip, micro-jet, and flood irrigation in citrus and vegetables demonstrations
- Dr. Juan Enciso (Texas A&M Extension Service) and Xavier Peries (Texas AgriLife Extension Service): LESA/LEPA and other sprinkler demonstrations
- Dr .Steven Klose and Alan "Mac" Young (Texas AgriLife Extension Service FARM Assistance program): demonstration site economic evaluations
- Dr. Al Blair (AW Blair Engineering): technical assistance and contracting services
- Linda Fernandez, Karen Ford, and Sharon Mineo, WaterPR: event coordination, public outreach/education

A project advisory committee of growers, demonstration co-operators, scientists and representatives of grower organizations meet as needed to provide guidance and expert perspective. Committee members include Danny Allen (cooperator), Sam Morrow (grower), Enrique Perez (Cameron County Extension Service), Andy Garza (Texas State Soil & Water Conservation Board), and Drs. Blair, Enciso, Klose, and Nelson.

Major Achievements to Date

District Operations

As of year-end 2011, HID has completed the major steps toward improving its system to better serve its producers through more efficient management of the 52,000 acre-feet of water it delivers for irrigated agriculture in the Lower Rio Grande Valley.

The District's 40 miles of canal, 200 miles of pipe line, 37 auto-gates, and 36 re-lift pump houses are now fully integrated into a streamlined automatic system networked by telemetry stations and remotely controlled from a master computer system, accessible by canal riders and other personnel through any electronic communications device – cell phone, desktop, netbook. The automated system allows for precise delivery of water to producers and quick response to their needs. Plans detailing gate and telemetry construction and assembly using off the shelf, low-cost technology are available free of charge from the District.

The District has realized considerable benefits through its gate automation and telemetry projects funded by the TWDB and the US Bureau of Reclamation. The gates allow for more responsive and, thus, more efficient management of irrigation deliveries and have sharply curtailed losses in deliveries from canals overflowing into drainage ditches.

This is especially true in remote areas of the District, where lateral canals can easily overflow if the gate controlling the flow is not adjusted or shut in a timely manner. In the past, this situation could not be corrected until the canal rider physically inspected the canal. Now, with monitoring equipment strategically placed at selected points along the canal, staff are notified within minutes if the canal reaches a critical condition and can use the automated system to correct the condition immediately. This efficiency translates into considerable water savings.

Based on historical use of the lateral canal and the maximum number of irrigation heads that can be used in an irrigation period, the District estimates that one overflowing weir, if left uncorrected, can potentially lose six to 10 AF over a 24-hour period. The District's canal system has seven overflow weirs; we estimate that the automated gates are saving between 40 to 70 acre-feet of water per irrigation period.

Remote control of the canals also translates into considerable savings of staff time and effort. Now canal riders can make adjustments from a variety of linked-in devices rather than driving to remote points within the 88 square miles encompassed by the District.

Enhancements to the District's ADI website also are providing real-time data on rainfall and soil moisture content to assist producers in scheduling the timing and amount of irrigations.

Irrigation Techniques

Meanwhile, eight years of research into irrigation techniques on different crops grown by cooperating producers under various soil and field conditions have pinpointed where and how the greatest efficiencies can be achieved. At the top of the list for the Lower Rio Grande Valley is narrow border flood irrigation for citrus, which dominates the agricultural economy. Producers using narrow border flood irrigation of citrus groves are realizing improved yields while using less fertilizer and 30 to 50 percent less water.

Multi-year site- and irrigation-specific results for citrus growers cooperating in the ADI project are provided in Appendix B, On-Farm Drip, Sprinkler and Flood Irrigation in Multi-Year Crops.

Dr. Shad Nelson, Texas A&M University-Kingsville, an ADI partner leading the citrus studies, is building on these results with plans for a Demonstration Research Irrigation Park that will provide field day opportunities

"An economic assessment was performed at comparing the citrus pack-out from traditional flood (TFld) and narrow border flood (NBF) irrigation. Grapefruit citrus growers using border flood irrigation (raising berms in the center of tree rows) had higher percentage of fruit yield classified for sale in the fresh market category than traditional large-pan flood irrigators. Texas grapefruit growers make their income on fruit going to the fresh market, rather than fruit downgraded to be used and sold for the juice market. The method of irrigation that is used by the grower will directly influence soil nutrient availability for crop growth. Traditional flood irrigator use between 30-50% more water than border flood irrigator during each irrigation event. The majority of feeder roots that actively support tree and fruit growth and development reside within the upper 18 inches of the soil. Traditional flood irrigation practices will commonly move applied fertilizer sources beyond these feeder roots. The increased yield and fruit quality for border flood irrigation are a result of being able to better manage the amount of applied fertilizer that will be in the effective root zone."

Appendix A, On-Farm Irrigation of Citrus Crops

to showcase production and water conservation for irrigated citrus. The park will allow for long-term assessment of alternative irrigation methodologies to counter traditional large-pan flood irrigation of citrus orchards. This project also is being funded by the Texas Water Development Board.

The 'DRIP' site will include such irrigation technologies as drip irrigation, micro-jet spray irrigation, and various forms of border flood irrigation. Alternative irrigation strategies – single vs. dual-line drip irrigation, water deficit irrigation, and partial root-zone drying – also will be demonstrated as possible means of conserving water while assessing their impacts on fruit yield, quality, and shape.

The park will be located on land donated by Rio Farms, Inc., in Monte Alto, Texas (near Edinburg) with funding from TWDB, Texas A&M University–Kingsville Citrus Center, and other external sources. The new center is expected to open in 2013.

For field crops, however, investments in more efficient irrigation technologies are less likely, because higher fixed and variable costs related to a surge valve or drip system reduce net returns per acre, according to economic analyses conducted by specialists from Texas AgriLife Extension Service's Financial and Risk Management Assistance (FARM Assistance) program.

The 2011 economic analyses – like those of previous years – continue to show limited financial incentive for producers to adopt conservation practices under existing conditions.

FARM Assistance specialists completed 3 whole-farm and 16 demonstration site analyses for 10 ADI participants in the 2011 project period. Individual studies have included irrigated cotton, corn, grain sorghum, sugarcane, vegetables, onions, citrus, and other crops. Irrigation methods demonstrated include furrow, surge, drip, micro-jet, flood and narrow-border flood.

The complete economic assessments of the FARM Assistance on-farm studies are provided in Appendix C.

This annual report does not include information on cooperators who had worked with Dr. Juan Enciso on a project using soil moisture sensors to schedule irrigation via drip and center-pivot irrigation systems. These efforts were funded through the Rio Grande Basin Initiative (RGBI) and the results then shared with ADI to augment our research into effective irrigation technologies. That funding, dependent on federal earmarks, has been suspended. However, no adverse impact to the project is anticipated.

Given that drip and center-pivot technologies are used in only about five percent of the irrigated area in the Lower Rio Grande Valley, Dr. Enciso recommends that new efforts focus on other, more fertile areas for additional research, including comparing surge versus continuous irrigation and developing guidelines for

"These [2011] demonstrations as well as the 2005-2010 demonstrations (cotton, grain sorghum, corn, seed corn, soybeans and sugarcane) have shown the potential for water savings but, under current 'per event' pricing structures, water savings do not necessarily translate into cost savings for producers. With no significant differences in yields, the additional fixed or variable costs related to a surge valve or drip system reduces the net returns per acre compared to furrow flood. An exception is onions where drip technology has shown water savings as well as economic incentives.

While the FARM Assistance analyses indicate limited existing economic incentives for adoption of conservation practices in field crops, these demonstrations clearly illustrate the value of water saving methods under conditions of limited water availability and/or volume pricing. . . . results indicate that incentives to invest in and adopt surge irrigation [over flood irrigation for cotton] would begin with just less than doubling of the current water price."

Appendix C: Economic Evaluations of Demonstrated Technologies

managing new efforts focus on other, more fertile areas for additional research, including comparing surge versus continuous irrigation and developing guidelines for managing furrow irrigation and using poly-pipe.

Dr. Enciso also is working to develop a program more focused on district management of water, especially measuring the volume and rate of water flow, information that will add tremendously to the body of knowledge that has been amassed during the seven years of this initiative.

Other On-Farm Technologies

Texas A&M researchers tested several on-farm technologies in the field and in the laboratory to evaluate their practical applicability. Major findings are as follows:

- Results in sugarcane indicate that better water management can enhance water savings in on-farm irrigation systems, both pressurized and non-pressurized.
- Using weather stations to monitor crop water needs throughout the growing season will maximize crop yield and reduce the risk of water plant stress.
- Soil moisture sensors can be important measures for computing water holding capacity and the timing of irrigation, but the sensors tested showed poor response during the wet-dry process.
- Preliminary results of circular flume calibration and multiple outlet hydraulic analysis indicate promising applications for enhancing on-farm demand.

The complete report is provided in Appendix D, On-Farm Technologies.

"Three weather stations were upgraded and sensors were sent for calibration to Campbell Scientific Inc. These sensors have not been calibrated for several years under/over estimated weather variables. Currently, weather stations are working and ready to be linked to a Crop Weather Program of the Texas Agrilife Research Center at Corpus Christi.

The Crop Weather Program for South Texas (CWP) is a web-based decision support system designed to assist agricultural research and crop managers [see http://cwp.tamu.edu/]. Mostly dedicated to cotton, CWP provides 24-hour easy access to historical and current weather data and a suite of calculators and numerical simulation tools that generate field-specific information about the crop and its environment. However, it can be used to other crops making small programming changes to the interface and main body of the program."

Appendix D, On-Farm Technologies

Reporting & Record-Keeping

HID continued to comply with all record-keeping and reporting tasks required under its contract with the TWDB. Three progress reports were filed during calendar year 2011; this document constitutes the annual report covering the period March 2011- February 2012.

Public Outreach

Since its inception, the project has incorporated outreach activities, including field days and on-site training at the Flow Meter Calibration Facility. Project partners have presented on study results at a variety of professional conferences and through academic journals. (A complete list of project papers presented and published during this annual reporting cycle appears in Appendix E.)

In 2010 and 2011, the project sponsored the Texas Irrigation Expo as a means of showcasing the results to date from improvements in district operations and new techniques and technologies for on-farm irrigation.

ADI partners making presentations at the Expo were:

- Robert Mace, Texas Water Development Board, *TWDB Conservation Initiatives in Ag Irrigation*.
- Tom McLemore, Harlingen Irrigation District, *HID's Conservation Projects: Why They Are Important to You*.
- Shad Nelson, Texas A&M – Kingsville, *Saving Water in Citrus Production Through Irrigation Management.*
- Mac Young, Texas AgriLife Extension Service, *Economics of Water Technologies in the Lower Rio Grande Valley*.
- Juan Enciso, Texas A&M University, *Drip, Flood, Sprinkler in Annual Crops & Grass*.

ADI project partner Al Blair of AW Blair Engineering was a sponsor of the Expo and staffed a booth along with HID demonstrating several of the technologies discussed. The Texas Water Development Board and Texas A&M Kingsville also had booths with material on their projects, as did the FARM Assistance program.

Appendix F provides full details on the planning, execution, and results of the 2011 Expo.

ADI Goals for 2012 & Beyond

The project will continue to compile data from both ongoing on-farm studies and new improvements to district operations. But after eight years of research and analysis, the next critical steps for ADI involve outreach and education.

Starting in 2012 and continuing through the term of the project, outreach and education will be the primary activity for ADI. HID has signed a multi-year subcontract with WaterPR to develop a comprehensive information campaign focused on making available to irrigation districts and on-farm producers the knowledge and tools developed by the project. The goal is to create evergreen material on concise components of the project packaged in easily accessible, multimedia formats (print, web, video), positioning the project as the go-to source for increasing efficiency in ag water delivery and application.

Immediate tasks already underway at report time include developing (1) a stand-alone identity for the project with nomenclature that will resonate with our target audiences and be easily remembered and (2) key communications materials. These will include basic informational brochure, an updated website, regular newsletters, and a series of informational video vignettes targeted toward specific audiences.

Our goals is to have this basic suite of communications materials ready in advance of the 2013 legislative session as resource materials for discussions of policy issues related to agricultural water management and use. The materials will present the facts of where, how, and at what cost the greatest efficiencies can be achieved.

The initial step of that effort has been completed. HID's ADI project now has a new name – *Texas Project for Ag Water Efficiency* – and a tag line that describes the range of this project – *from river to farm.*

Logo development is in process as part of the materials effort.

The ADI Flow Meter Calibration Facility also is being renamed to reflect both its association with the project and the comprehensive functions it can perform. The *Rio Grande Center for Ag Water Efficiency* will be promoted through the outreach campaign as a resource for districts and growers throughout the region and the state.

Appendices

A: On-Farm Irrigation of Citrus Crops
Texas A&M University – Kingsville Citrus Center; Shad Nelson, PhD

B: On-Farm Drip, Sprinkler and Flood Irrigation in Multi-Year Crops
Texas A&M University – Kingsville Citrus Center; Shad Nelson, PhD

C: Economic Evaluation of Demonstrated Technologies
Texas AgriLife Extension, FARM Assistance Program; Mac Young

D: On-Farm Technologies
Texas A&M University; Hugo Perea, PhD.; Juan Enciso, PhD.; Shad Nelson, Ph.D; Xavier Peries

E: Professional Papers & Presentations

F: 2011 Texas Irrigation Expo
WaterPR; Sharon Mineo

G: February 2012 Press Release on *Catalogue of Good Practices in Water Use Efficiency*

Appendix A: On-Farm Irrigation of Citrus Crops

Submitted by:
Texas A&M University-Kingsville, Citrus Center
Dr. Shad D. Nelson, SDN Consulting, Inc.

Evaluating alternative irrigation practices to traditional flood irrigation in citrus grove management:

A replicated research study was performed in April 2011 at the Texas A&M University-Kingsville Citrus Center in Weslaco, TX comparing two flood irrigation strategies. Traditional large-pan flood (TFd) irrigated plots consisting of 3 citrus rows were compared against Border flood (BFd) irrigation where raised berms were formed down the middle of each citrus tree row. Water meters were used to accurately determine the total amount of water applied in all plots. It was determined that for the same land area that TFd used 50% more water over BFd irrigation. BFd irrigation allows water to be channeled faster down the citrus row and underneath the tree canopy than TFd practices can. It was observed that BFd irrigation was able to apply water to where the trees needed the water on a faster time scale than that of TFd. The results of this replicated study complement previous findings observed at the on-farm field scale and suggest that BFd irrigation may actual use less water than microjet spray and drip irrigation. This is because drip and microjet systems require the systems to be turned on more frequently, such as weekly irrigation events as compared to flood irrigation that is performed monthly to maintain tree growth.

The 2011 growing season was one of the driest years on record, with very minimal rainfall. Some citrus growers using TFd irrigation had 10 separate flood irrigation events. A TFd irrigation event will commonly use a 6 inch irrigation application, thus 5 acre-ft/acre of water was applied in TFd irrigation fields this past growing season. Although growers using BFd irrigation also applied 10 flood irrigation events this past year, the total water applied may have saved as high as 2.5 acre-ft/acre of water this past year. If the entire citrus industry faces water restrictions in the future due to continuous drought conditions in the Lower Rio Grande Valley, growers can easily transition to BFd irrigation and save a substantial amount of water and preserve citrus production until rain replenish the reservoirs again. This field management practice can be implemented at relatively low cost to the grower, without the need to invest in an irrigation system that is costly such as drip or microjet spray. The results of this research study suggests that during extensive drought season like that of 2011, if all growers changed from TFd to BFd irrigation practices were could save 45,000 acre-ft of water a year.

Evaluation of drip irrigation and tile drains for young citrus grove establishment:

A new planting of 1-year old orange trees was planted in December 2009 in the Lower Rio Grande Valley at a drip irrigated demonstration site. Extensive land preparation was performed at this site prior to planting, with drain tiles installed throughout the field to drain water from the area. Several locations throughout the field site are known to have elevated salts and sodium problems that would limit citrus production. Tile drains were installed and buried to provide drainage and allow for the leaching of salts from the rooting depth of the orchard. The orange trees are established on a single-line drip irrigation system, receiving weekly irrigation and fertilization inputs as needed. The trees at this site have established very rapidly, and have surprisingly good yield production for only having been growing for 3 years. Typically if would take 5 years before adequate fruit production occurs to justify harvesting. Trees were harvested at the end of the 2011 with initial yields in the 5 tons per acre range. The rapid tree establishment and good growth are a testament to the value that some areas can lead to promising yields for citrus after good land preparation, drain tile implementation and drip irrigation system installation. Economic assessment of yield generation as these trees continue to mature will need to be compared against yield from young trees under conventional planting to determine whether such practices improve the growers production and overall net cash farm income.

Evaluation of compost source on water savings in citrus:

A five year study evaluating the value of compost application for water savings and impacts on yield of grapefruit trees resulted in improved soil physical properties, increase soil moisture status, higher root growth and better citrus yields after the first year of yard-waste/woodchip compost application. It was found that citrus growers could extend the time between irrigation events by applying compost underneath the mature citrus tree canopy. It was estimated that growers could reduce up to one flood irrigation per year by applying compost, which is equivalent to saving 0.5 acre-feet of water/acre annually. An economic assessment was performed to evaluate if the increase in citrus yield and reduction in water application would pay off for the citrus grower. It was found that compost application would still be an economically feasible and a slightly higher financial incentive to conventional or organic citrus growers.

Effects of altering on-farm irrigation management for improved fruit quality:

An economic assessment was performed at comparing the citrus pack-out from traditional flood (TFld) and narrow border flood (NBF) irrigation. Grapefruit citrus growers using border flood irrigation (raising berms in the center of tree rows) had higher percentage of fruit yield classified for sale in the fresh market category than traditional large-pan flood irrigators. Texas grapefruit growers make their income on fruit going to the fresh market, rather than fruit downgraded to be used and sold for the juice market. The method of irrigation that is used by the grower will directly influence soil nutrient availability for crop growth. Traditional flood irrigator use between 30-50% more water than border flood irrigator during each irrigation event. The majority of feeder roots that actively support tree and fruit growth and development reside within the upper 18 inches of the soil. Traditional flood irrigation practices will commonly move applied fertilizer sources beyond these feeder roots (Fig. 1a-d). The increased yield and fruit quality for border flood irrigation are a result of being able to better manage the amount of applied fertilizer that will be in the effective root zone (Fig. 2a-c).

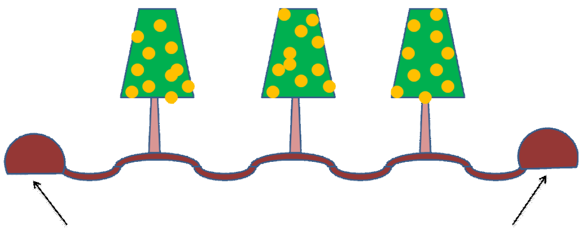

Fig. 1a. TFId with raised berms.

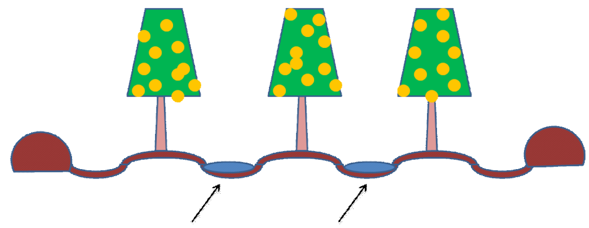

Fig. 1b. Lower soil elevation fills first.

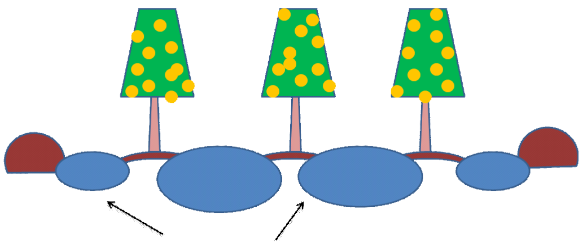

Fig. 1c. Nonuniform watering between rows.

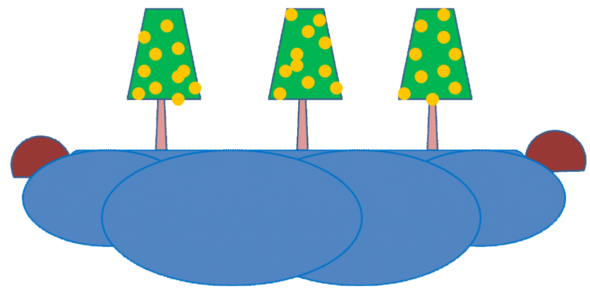

Fig. 1d. Deep percolation beyond rootzone.

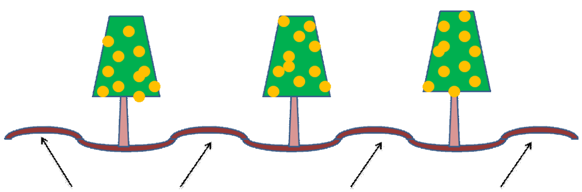

Fig. 2a. NBF with raised berms between rows.

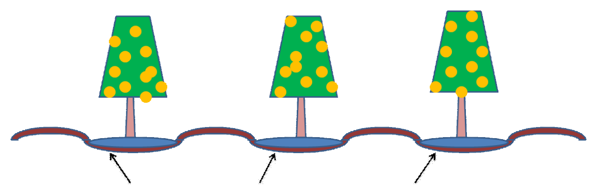

Fig. 2b. Watering under tree canopy.

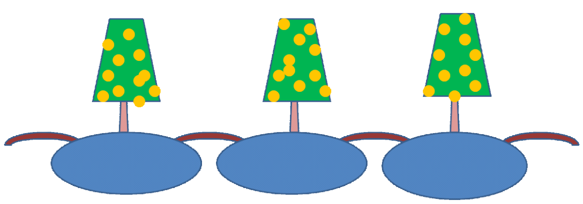

Fig. 2c. Targeting rootzone saves water.

Analyzing real-time soil moisture monitoring for irrigation water management:

On-farm soil moisture monitoring has been a integral part of the agricultural water conservation monitoring in the ADI program by citrus growers involved in the project. In the past 6 years, the growers would have to monitor in field soil water status by physically looking at sensors located at specific locations within various orchards. Soil moisture history needs to be downloaded to a laptop computer and a report showing the chart of soil moisture status would be provide to growers every month or every quarter of the year. The challenge observed by growers with this method is that they are looking into the past to try and determine the future if they want to alter irrigation timing. This spot check method has not led to any change in irrigation scheduling, so citrus growers continue to irrigate the way they have done for years. This year a couple citrus growers will have soil moisture data sent directly to their office in 'real-time' using remote technology. Growers involved in the ADI program will provide feedback as to whether having soil moisture status available at their fingertips on a minute by minute basis will lead them to schedule irrigation events for their citrus groves based upon soil moisture status and when the trees need the soil reservoir to be replenished.

Establishment of a Demonstration and Research Irrigation Park (DRIP) for citrus:

The North Farm of the Texas A&M University-Kingsville Citrus Center is land donated for citrus experimentation and demonstration projects by Rio Queen Farms. As part of this land, an on-farm irrigation park has been set aside for the establishment of long-term assessment of alternative irrigation methodologies to counter traditional large-pan flood irrigation of citrus orchards. The 'DRIP' site will include irrigation technologies such as drip irrigation, micro-jet spray irrigation, and various forms of border flood irrigation. Alternative irrigation strategies as single vs. dual-line drip irrigation, water deficit irrigation, and partial root-zone drying will be demonstrated as possible means of conserving water while assessing their impacts on fruit yield, quality, and shape.

Evaluating raised-bed plantings of citrus rows as a means of improving root health in drip irrigation:

Evaluation trials will be initiated after on-farm observations of citrus production in Morocco. Citrus established on high mounded raised beds under drip irrigation can provide a rooting area for citrus trees. Single line drip irrigation was shown to successfully grow varying citrus varieties and this may be a means of raising grapefruit citrus trees for the Lower Rio Grande Valley producers. Increased planting densities were shown to be effective using raised beds under drip irrigation leading to high citrus fruit production. Raised bed plantings of new citrus trees will be compared to conventional planting on flat ground. This demonstration area will provide citrus growers a first-hand look at alternative ways to grow citrus and low-flow irrigation strategies. Using drip irrigation on raised beds may reduce a predominant soil-borne pathogen problem, Phytopthora and root rot, commonly spread in traditional flood irrigation practices and leads to tree decline and death. Furthermore, high density planting of citrus may be useful for managing and getting ahead of another devastating disease 'citrus greening or HLB disease' that was encountered in Texas for the first time in January 2012. This disease has devastated the Florida citrus industry over the past five years and has led to the loss of thirty percent to complete destruction of groves throughout the state of Florida. This disease threatens the entire Texas citrus industry and alternative strategies are needed so that Texas' citrus does not reach that of Florida.

Leveraging of Project Resources:

The results on various on-farm management strategies, such as fertilization and water impacts on citrus, compost utilization on soil-water status and citrus yield, irrigation management and citrus pest control were published in the articles, presented at professional meetings, and were the catalyst to obtaining additional external grant funds to support the goals of the Agricultural Water Conservation Demonstration Initiative projects discussed above. The outcomes from Dr. Nelson's collaborative efforts with the Rio Grande Basin Initiative, Texas Water Resources Institute, Texas AgriLife Extension, Texas A&M University-Kingsville Citrus Center, Citrus Producers Board, and TAMUK graduate students are presented in the information that follows below. External grant dollars from funding sources besides that from the ADI as mentioned below have helped to provide the labor sufficient for data collection, analysis and results interpretation.

2011 External Grant Funds Supportive of ADI Projects:

$1,029,500	Total 2011 External Grant Funds Supportive of ADI Projects:
$2,000	TAMUK Council for Undergraduate Research (TCUR). TAMUK Oak Tree Survey and Citrus Water Management Projects. P.I. Shad Nelson, Co-PI: Juan D. Vargas. Oct 2011-Aug 2012.
$12,500	Texas Citrus Producers Board. Micro and Macro Nutrient Impacts at Improving Citrus Health to Combat Key Citrus Pests. P.I. Shad Nelson, Co-PI: M. Setamou, J.C. Melgar. Apr.-Aug. 2011. Project Yr 1 funding.
$25,000	Texas Citrus Producers Board. Micro and Macro Nutrient Impacts at Improving Citrus Health to Combat Key Citrus Pests. P.I. Shad Nelson, Co-PI: M. Setamou, J.C. Melgar. Sept. 2011 - Aug. 2012. Continued project funding support Yr 2.
$40,000	Title V/PPOHA Program proposal. 3D Printing for TAMUK Graduate Students. PD: L. Peel, Co-PIs: S. Ozcelik, H. Zhou, H. Li, K. Jin, F. Heidari, C. Montiel, P. Mills, L. McLauchlan, S. Nelson. 2011.
$150,000	$600,000 Total Award. USDA-NIFA HSI Collaborative Grants. BGREEN: BuildinG Regional Energy and Educational alliances: A Partnership to Integrate Efforts and Collaboration to Shape Tomorrow's Hispanic Sustainable Energy Leaders. PD: (UTEP) H.A. Taboada, J.F. Espirtu, W.Hargrove, S.Hernandez, J. Noveron; (TAMUK) PD: S.D. Nelson, G.Schuster, R.D. Hanagriff; (TSU-San Marcos); (NMSU)T.Jin, L.Sun, R.Richarson D.Valles, H.Sohn,N.Khandan, R.Acharya. 2011-2015. $150,000/yr x 4 yrs ($600,000 total) to TAMUK (2011-2015). Total Grant Award Distributed Through UTEP: $3,200,000 (2011-2015).
$800,000	$3,200,000 Total Award. USDA-NIFA HSI Collaborative Grants. STEP UP to USDA Career Success: Science, Technology and Environmental Programs for Undergraduate Preparation to USDA Career Success. PD: S.D. Nelson(TAMUK Lead), CoPDs: E. Louzada, R. Stanko, D. Ruppert; (DelMar College) J. Halcomb; (STC) Debbie Villalon; (TSTC) A. Duarte; (UTPA) M. Persans. 2011-2015. $396,000/yr x 4 yrs = $1,584,000 to TAMUK. $800K/yr x 4yrs (2011-2015).

Appendix B: On-Farm Drip, Sprinkler and Flood Irrigation in Multi-Year Crops

Submitted by
Texas A&M University-Kingsville, Citrus Center
Dr. Shad D. Nelson, SDN Consulting, Inc.

Clockwise from top left: Site: #07A – 2011, Site: #04 C -2010-2011, Site: #06D -2011, Site: #04 D -2011

1. Site #01A –2011

Site Description:

Acres:	49.0 (Blocks 106 & 107)
Soil type:	clay loam 0-6 inches, sandy clay loam 6-36 inches
Field characteristics:	15' x 24' spacing (115 trees/Acre)
Crop variety:	Rio Red grapefruit (tree age: 23 yrs)
Harvest season:	2011
Irrigation district:	None-Class B water owner
Irrigation system:	Bordered flood, polypipe
Fertilizer applied:	Mar '11: 300 lbs/ac 21-0-0-24

Sensor information:

Soil moisture: Irrometer data logger with Watermark sensors were placed at 6", 12", and 24" depths, sensor data is downloaded monthly and provided to grower for water management and irrigation scheduling as needed.

Irrigation schedule and amounts:

Total irrigation:	44 in. (11 separate irrigation events in 2011 due to very little rainfall throughout growing season)
Total rainfall:	4.0 in.
Total water input:	48 in.

Irrigation method: Border Flood

Over the past 5 years of data collection, this irrigation method has been shown to be the most effective water conserving irrigation method over traditional flood irrigation for mature citrus. The site is equipped with a 10 inch Turbine-type flow meter. Farmer uses 12" concrete outlet riser valve attached to poly-pipe. Farmer channels water more directly under the canopy (root zone) by using raised berms in between citrus tree rows. This method allows water to travel faster to the end of the row and grower will apply on average a 4-inch irrigation application amount using this method, as opposed to 6-inch irrigation event found in traditional flood irrigation practices. The grower will reform the raised berms each year after harvest season.

Observations made during the crop season:

This site was spared from flooding during June through October of 2010, as 90% of this grower's farm was under 2-4 feet of water after hurricanes and heavy rains went south through northern Mexico. Yield was reduced in this grower's grove to freeze impacting overall total yield, however, the ability to manage pest control and irrigation water during this intense drought year led to very good total packout with this grove having 85.6% packout for grapefruit, with all other fruit being eliminated and not sold as juice. Due to most of the water coming from irrigation in 2011, irrigation use efficiency (IUE) and total water use efficiency (WUE) were nearly equivalent and low compared to previous years where rainfall made up at least ¼ to ½ of the crop water needs.

Yield:	2011: 414.2 Tons or 8.45 Ton/ac total production; with 7.24 Tons/Ac packout yield.
Packout:	85.6%; Juice 0%; Shed Eliminated 14.4%
Water use summary:	IUE: 2011: 384.1 lb/ac.in., WUE: 2011: 352.1 lb/ac.in.

2. Site #01B – 2011

Site Description:

Acres:	14.5 (Blocks 216 & 216A)
Soil type:	clay loam 0-18 inches, loam 18-36 inches
Crop variety:	Valencia oranges (tree age: 9 yrs)
Harvest season:	15' x 23' spacing (124 trees/Acre)
Irrigation district:	None-Class B water owner
Irrigation system:	Border flood, polypipe (trees flooded for over 2 months)
Fertilizer applied:	Mar '11: 300 lbs/ac 21-0-0-24

Sensor information:

No soil moisture sensors for Valencia orchards. Turbine-type flow meter

Irrigation schedule and amounts:

Total irrigation:	40.0 in. (ten irrigation events)
Total rainfall:	5.0 in.
Total water input:	45.0 in.

Irrigation method:

Farmer uses 12" concrete outlet valve and attaches turbine meter to valve and poly-pipe. Farmer waters only directly under the canopy (root zone) by using raised berms in between rows (Oranges/Grapefruit). Farmer reforms raised berms after each harvest in order to channel water at a faster rate to the end of the bed as a water conserving irrigation method for flood irrigating mature citrus.

Observations made during the crop season:

Valencia oranges are located in same irrigation block as Rio red grapefruit site #01C with similar soil characteristics. Trees were submerged under water for approximately two months during summer 2010 due to hurricane and flooding along Rio Grande River. Loss of nearby orchards occurred, but these trees were saved, but expected yield totals are about 25% lower than yields observed in 2009 prior to 2010 flooding and 2011 freeze.

Yield:	2011: 203.8 Tons or 14.06 Ton/ac total yield; and 11.21 Tons/Ac packout
Packout:	79.8% ; Juice 0% , Shed Eliminated 20.2%
Water use summary:	IUE: 2011: 703.0 lb/ac.in. WUE: 2011: 624.9 lb/ac.in.

3. Site #01C-2011

Site Description:

Acres:	40.0 (Block 218=15 acres & Block 213=12 acres & Block 212=13 acres)
Soil type:	clay loam 0-18 inches, loam 18-36 inches
Crop variety:	Rio Red grapefruit (tree age: 9 yrs)
Field Characteristics:	15' x 24' spacing (115 trees/Acre)
Irrigation district:	None-Class B water owner
Irrigation system:	Border flood, polypipe (trees flooded for over 2 months)
Fertilizer applied:	Mar'11: 300 lbs/ac 21-0-0-24

Sensor information:

Soil moisture: Irrometer data logger with Watermark sensors were placed at 6", 12", and 24" depths, sensor data is downloaded monthly and provided to grower for water management and irrigation scheduling as needed. o

Irrigation schedule and amounts:

Total irrigation:	40.0 in.
Total rainfall:	5.0 in.
Total water input:	45.0 in.

Irrigation method:

Farmer uses 12" concrete outlet valve and attaches turbine-type meter to valve and poly-pipe. Farmer concentrates irrigation under the canopy (root zone) by using raised berms in between rows (Grapefruit). Farmer reforms raised berms after each harvest in order to channel water at a faster rate to the end of the bed as a water conserving irrigation practice for flood irrigating mature citrus.

Observations made during the crop season:

Rio Red grapefruit trees were submerged under water for approximately two months during summer 2010 due to hurricane and flooding along Rio Grande River. Yield expectations for 2010 are expected to be near zero for 2010-11 harvest. This season's yields are low due to this and freeze in 2011.

Yield:	Block 218 = 280.5 Tons or 18.7 Ton/ac total yield, with 17.2 Tons/Ac as packout Block 212 = 100.7 Tons or 7.8 Ton/ac total yield, with 6.5 Tons/Ac as packout Block 213 = 152.6 Tons or 12.7 Ton/ac total yield, with 11.2 Tons/Ac as packout
Packout:	Block 218 = 92.2%; Block 212 = 83.6%; and Block 213 = 87.9% packout; Juice 0%.
Water use summary:	IUE: 2011: Block 218 = 635 lb/ac.in. WUE: 2011: Block 218 = 564 lb/ac.in.

4. Site #01D-2011

Site Description:

Acres:	12 Acres (New Site as of Jan 2010)
Soil type:	silty clay loam 0-36 inches (hard pan at 18 inches)
Crop variety:	Rio Red grapefruit (tree age: 6 yrs)
Field Characteristics:	15' x 24' spacing (115 trees/Acre)
Irrigation district:	None-Class B water owner
Irrigation system:	Very Narrow bordered flood, polypipe
Fertilizer applied:	Mar'11: 300 lbs/ac 21-0-0-24

Sensor information:

Soil moisture: Irrometer data logger with Watermark sensors were placed at 6", 12", and 24" depths. This site was newly established in January 2010. Sensor data is to be downloaded monthly and provided to grower for water management and irrigation scheduling as needed.

Irrigation schedule and amounts:

Total irrigation:	40 ac.in
Total rainfall:	4.5 in.
Total water input:	44.5 ac.in

Irrigation method:

Farmer uses 12" concrete outlet valve and attaches turbine-type meter to valve and poly-pipe. Farmer concentrates irrigation directly under within the root zone by using raised berms in between rows and just outside of the young tree canopy (Grapefruit).

Observations made during the crop season:

There were two new locations at this site, one on low ground, the other on high ground. The low ground trees were completely destroyed in 2010 by flooding and high water reaching up to a height almost covering the tree tops, thus killing the trees. These trees have been removed and burned from the low site. The high silty clay site has young trees still alive but no real production from these trees.

Yield:	2011: n/a (young trees, production delayed by flooding)
Water use summary:	IUE: 2011: n/a lb/ac.in. WUE: 2011: n/a lb/ac.in.

5. Site #04 A – 2011

Site Description:

Acres:	16.5
Soil type:	sandy clay loam 0-24 inches, clay 24-36 inches
Crop variety:	Rio Red grapefruit (tree age: 19 yrs)
Field Characteristics:	15' x 24' spacing (115 trees/Acre)
Irrigation district:	Hidalgo 1
Irrigation system:	Drip Irrigation
Fertilizer applied:	20 gal./ac. 7-21-0 & 5 gal./ac N-32

Sensor information:

Irrometer data logger with 3 Watermark sensors also at 6, 12 and 24 inch depth under tree canopy and 12 inch sensor at drip line of canopy. To monitor lateral soil water movement from the drip tape, we installed WaterMark sensors at the 12" soil depth at 1, 2, and 3 feet away from the dripline. Grower has own meters.

Irrigation schedule and amounts:

Total irrigation:	48.0 ac.in
Total rainfall:	4.0 inch
Total water input:	52.0 ac.in

Irrigation method:

Single line Drip system; 5/8" polyethylene line with emitters every 48". 17 separate drip irrigation events occurred in 2009. Grower targets a 1.0 ac-in water application per irrigation event. Irrigated approximately 48 weeks in year due to lack of rainfall in 2011 growing season.

Observations made during the crop season:

This grower has decided to make a change to the number of drip irrigation lines placed under his mature citrus trees, due to our observations of lateral water movement not extending far enough to influence roots located near the dripline of the trees. Soil moisture sensors have confirmed this problem and grower is changing his practice. Very low rainfall has led to very high irrigation use throughout 2011 growing season, with weekly 1 inch irrigation events. Field harvested in two times with 349.01 Tons plus 238.6 Tons total yield in 2011. Very good harvest year to these trees.

Yield:	2011: 587.7 Tons Total Yield or 35.6 ton/ac and Average Packout: 77.0% and Juice: 18.0%
Water use summary:	IUE: 2011: 1,483 lbs/ac.in WUE: 2011: 1,369 lbs/ac.in

6. Site #04 B -2011

Site Description:

Acres:	30.0
Soil type:	clay loam, 0-6 inches, clay, 6 -36 inches
Crop variety:	Rio Red grapefruit (tree age: 19 yrs)
Field Characteristics:	15' x 24' spacing (115 trees/Acre)
Irrigation district:	Hidalgo 1
Irrigation system:	Microjet spray
Fertilizer applied:	20 gal./ac. 7-21-0 & 5 gal./ac N-32

Soil moisture sensor monitoring

Irrometer data logger with 3 Watermark sensors also at 6, 12 and 24 inch depth under tree canopy and 12 inch sensor at drip line of canopy. Decagon data logger EM-50 not downloading well after 5 years in the field, ECHO-10 probes at 6, 12 and 24 inches. This grower has own water meters.

Irrigation schedule and amounts:

Total irrigation:	48.0 ac.in
Total rainfall:	4.0 inch
Total water input:	52.0 ac.in

Irrigation method:

Microjet spray system. Single riser with 360 degree rotation spray emitter placed at the middle between trees to minimize spray on tree trunk. Grower applies approximately 1.0 ac-in. per irrigation event. Irrigated approximately 48 out of 52 week.

Observations made during the crop season:

Periodic rains throughout 2010 have assisted in water management, compared to 2009 season that had extensive drought period and lower yield than in 2008, as shown below.

Yield:	2011: 269.3 Tons Total Yield or 9.0 ton/ac and average
Packout:	68.3%; Juice: 27.5%
Water use summary:	IUE: 2011: 375 lbs/ac.in WUE: 2011: 346 lbs/ac.in

7. Site #04 C -2010-2011

Site Description:

Acres:	14.0
Soil type:	clay loam, 0-6 inches, clay, 6 -36 inches
Crop variety:	Rio Red grapefruit (tree age: 23 yrs)
Field Characteristics:	20’ x 25’ spacing (115 trees/Acre)
Irrigation district:	Hidalgo 1
Irrigation system:	Traditional Flood
Fertilizer applied:	1 lb N/tree/year in split granular applications

Soil moisture sensor monitoring:

Irrometer data logger with 3 Watermark sensors set at 6, 12 and 24 inches under center of tree canopy.

Irrigation schedule and amounts:

Total irrigation:	60.0 ac.in
Total rainfall:	5.0 inch
Total water input:	65.0 ac.in

Irrigation method:

Traditional flood with 5 rows per irrigation pan for Rio Red grapefruit with a 6 inch irrigation depth per irrigation. Irrigated field 10 times in 2011.

Observations made during the crop season:

Drought led to high water use and poor IUE due to high water application with 10 separate ½ acre-foot/acre irrigation events every 3-4 weeks, but good pest management in year to result in good packout.

Yield:	2011: 167.75 Tons grapefruit and 12.0 ton/ac total yield
Packout:	85.0%; Juice: 1.0%; 10.2 Tons/Ac packout
Water use summary:	IUE: 2011: 400 lbs/ac.in WUE: 2011: 369 lbs/ac.in

8. Site #04 D -2011

Site Description:

Acres:	35.0 (210 acres planted in 2009 as Valencia oranges)
Soil type:	sandy clay loam, 0-36 inches
Crop variety:	Rio Red grapefruit (tree age: 3 yrs)
Field Characteristics:	20' x 25' spacing (115 trees/Acre)
Irrigation district:	Delta lakes
Irrigation system:	Single line drip
Fertilizer applied:	Through drip system; New site established with 1-year-old trees March 10, 2009.

Soil moisture sensor monitoring:

Irrometer data logger with 3 Watermark sensors set at 6, 12 and 24 inches under center of tree canopy and one sensor placed 12" deep in the soil located one foot away from the drip tape to ensure lateral water movement.

Irrigation schedule and amounts:

Total irrigation:	50.0 ac.in
Total rainfall:	3.0 inch
Total water input:	53.0 ac.in

Irrigation method:

Single line Drip irrigation with emitters spaced every 2.0 feet.

Observations made during the crop season:

Trees at this new location are under stress due to high salt conditions. The Irrometer station was moved to a more northern section of the field where salt conditions are less pronounced and has helped in monitoring and irrigation management. Sensors placed 6, 12, and 24 inches below drip tape between emitters, plus another sensor located 12 inches deep and 1 foot away from drip tape to monitor lateral water movement. Site has tile drains installed prior to planting which has greatly helped in fast growth for these trees since planting, thus demonstrating how beneficial tile drains can be for citrus tree health, despite poor soil salinity. Excellent production for only being 3 year old trees. Grower is very pleased with this orchard's productivity and expects it to be 2 to 3 years ahead in production compared to other orange groves planted at the same time in South Texas.

Yield:	175 Tons total yield or 5.0 Tons/Ac
Water use summary:	IUE: 200 lbs/ac in.; WUE: 189 lbs/ac in.

9. Site #06D -2011

Site Description:

Acres:	10.0 ac
Soil type:	clay loam, 0-36 inches
Crop variety:	Rio Red grapefruit (tree age: 23 yrs)
Field Characteristics:	16′ x 25′ spacing (105 trees/Acre)
Irrigation district:	Hidalgo Cameron 9
Irrigation system:	Traditional Flood
Fertilizer applied:	Mar ’11: 220 lb/ac 46-0-0 urea

Soil moisture sensor monitoring:

No soil moisture sensors set up at this research site, field managed by research station farm manager with irrigation typically once every month. Each irrigation event provided a 6 inch water depth. Irrigated site 11 times in 2011.

Rain gauge:

Farm crew takes measurements by hand each day, thus providing very accurate rainfall data that can be used to double check rainfall records by nearby Texas Agrilife weather station or rains in Lower Rio Grande Valley.

Water Meter:

10” turbine-type flow meter

Irrigation schedule and amounts:

Total irrigation:	66 ac.in
Total rainfall:	5.5 inch
Total water input:	72.5 ac.in

Irrigation method:

Traditional Flood

Observations made during the crop season:

High level of water applied to this site with trees harvested prior to January 2011.

Yield:	2011: 170 Tons Total Yield or 17.0 Tons/ac and 80.0% packout; 10% juice.
Water use summary:	IUE: 200 lbs/ac in.; WUE: 189 lbs/ac in.

10. Site #07A – 2011

Site Description:

Acres:	7.3 (flood) Block N-O1
Soil type:	sandy clay loam, 0 – 36”
Crop variety:	Rio Red grapefruit (tree age: 6 yrs)
Field Characteristics:	15’ x 24’ spacing (121trees/Acre)
Irrigation district:	Hidalgo Cameron 9
Irrigation system:	Flood, conventional
Fertilizer applied:	Mar ’11: 220 lb/ac 46-0-0 urea

Soil moisture sensor monitoring:

Soil moisture equipment not at this research site other than Davis Instrument Rain gauge and Watchdog Data logger. Irrigation scheduling perform by farm manager based on ETc and duration since last irrigation event. Each irrigation equivalent to a 6 inch irrigation application. Ten irrigation events in 2011.

Rain gauge:

Watchdog Data logger attached to rain gauge stopped downloading in 2011, so rainfall is measured manually by Farm crew and is used for reliability.

Water Meter:

10” turbine-type flow meter

Irrigation schedule and amounts:

Irrigation performed using grower experience and estimations from ETc, typically irrigated at every 4-5 week intervals depending upon rainfall amount.

Total irrigation:	60 ac.in
Total rainfall:	4.0 inch
Total water input:	64.0 ac.in

Irrigation method:

Traditional flood; each irrigation is a 6 inch irrigation event. 10 irrigations in 2011. New farm management has really improved yields and production at this site, plus they are young trees (7 years old) just coming into top maturity and production.

Yield:	2011: 175.2 Tons Total Yield or 24.0 Ton/ac with 87.0% packout and 5% juice.
Water use summary:	IUE: 2011: 800 lbs/ac.in WUE: 2011: 750 lbs/ac.in

11. Site #28A – 2011

Site Description:

Acres:	8.5 (Lot #67)
Soil type:	Sandy Loam (up to 30-inch depth)
Crop variety:	Valencia Oranges (tree age: 7 yrs)
Field Characteristics:	115 trees/acre; no ground cover; drain tiles
Irrigation district:	
Irrigation system:	Micro-Jets (1 sprinkler/tree)
Fertilizer applied:	total NPK 129-0-184 (fertigation) or 23-0-16 per acre type 0-0-16 (100gal) and 28-0 0 (40gal)

Sensor and flow meter information:

Watermark (6, 12 & 24-inch depth) and irrigation sensors connected to 2 data loggers Water meter installed at the pump house.

Irrigation schedule and amounts:

Total irrigation:	48.4 inches/acre
Total rainfall:	4.0 inch/acre
Total water input:	52.4 inches/acre

Irrigation method:

Irrigation scheduling was based on soil moisture and past knowledge of when to irrigate. Water was provided by the district (pipeline) into a reservoir (sand media filtration and pump system).

Observations made during the crop season:

Irrigation in 2011 was performed on a regular schedule due to lack of ability to have data downloaded to grower. An automatic real-time monitoring station was set up in Feb 2012 to evaluate soil moisture monitoring in real time as a potential irrigation scheduling system for the grower.

Yield:	89.4 Tons Total Yield or 10.5 Tons/acre and 82.3% packout; packout yield of 8.7 Tons/Ac and 0% juice.
Water use summary:	IUE: 434 lbs/inch of water applied by irrigation WUE: 401 lbs/inch of water received (irrigation + rainfall)

12. Site #28B -2011

Site Description:

Acres:	8.5 (Lot #75)
Soil type:	Sandy Loam (up to 30-inch depth)
Crop variety:	Rio Red Grapefruits (tree age: 18 yrs)
Field Characteristics:	116 trees/acre; no ground cover; drain tiles
Irrigation district:	
Irrigation system:	Flood converted to drip in August 2006 (surface double line 30-inch emitter)
Fertilizer applied:	total NPK 1,063-0-378 (fertigation) or 97-0-34 per acre type 28-0-0 (330 gal) and 0 0-16 (115 gal)

Sensor and flow meter information:

Watermark (6, 12 & 24-inch depth) and irrigation sensors connected to data logger Water meter installed at the pump house

Irrigation schedule and amounts:

Total irrigation:	33.3 inches/acre plus 2 flood irrigation events of 6 inches each = 45.3 inches/acre
Total rainfall:	4.0 inch/acre
Total water input:	9.3 inches/acre

Irrigation method:

Irrigation scheduling was based on soil moisture and grower experience observing trees for signs of stress; water was provided by the district (pipeline) into a reservoir (sand media filtration and pump system)

Observations made during the crop season:

Irrigation by flood needed under this system during 2011 intense drought season to ensure that water in deep rooting zone was achieved.

Yield:	165.0 Tons Total Yield or 19.4 Tons/acre and 68.1% packout or 13.2 Tons/Ac packout and 0% juice.
Water use summary:	IUE: 857 lbs/inch of water applied by irrigation WUE: 787 lbs/inch of water received (irrigation + rainfall)

13. Site #28C – 2011

Site Description:

Acres:	8.0 (Lot #74)
Soil type:	Sandy Loam (up to 30-inch depth)
Crop variety:	Rio Red Grapefruits (tree age: 18 yrs)
Field Characteristics:	116 trees/acre; no ground cover; drain tiles
Irrigation district:	
Irrigation system:	Micro-Jets (1 sprinkler/tree)
Fertilizer applied:	total NPK 1240-0-528 (fertigation) or 144-0-61 per acre type 28-0-0 (385 gal) and 0 0-16 (300 gal)

Sensor and flow meter information:

Watermark (6, 12 & 24-inch depth) and irrigation sensors connected to data logger. Water meter installed at the pump house.

Irrigation schedule and amounts:

Total irrigation:	43.9 inches/acre plus 2 flood irrigation events of 6 inch each = 55.9 inches/acre
Total rainfall:	4.0 inch/acre
Total water input:	59.9 inches/acre

Irrigation method:

Irrigation scheduling was based on soil moisture and an average of an inch per acre was applied each time by Micro-Jet; water was provided by the district (pipeline) into a reservoir (sand media filtration and pump system)

Observations made during the crop season:

Soil moisture levels monitored by experience and readings on WatchDog dataloggers.

Yields for Blocks 74, 75, 76 were combined and harvested together a total yield of 485.2 Tons and packout total tons of 330.5 Tons (68.1% packout).

Yield:	155.3 Tons Total Yield or 19.4 Tons/acre and 68.1% packout or 13.2 Tons/Ac packout and 0% juice.
Water use summary:	IUE: 694 lbs/inch of water applied by irrigation WUE: 648 lbs/inch of water received (irrigation + rainfall)

14. Site #28D – 2011

Site Description:

Acres:	8.5 (Lot #73 and 76)
Soil type:	Sandy Loam (up to 30-inch depth)
Crop variety:	Marrs and Navel Oranges (tree age: 19 yrs)
Field Characteristics:	115 trees/acre; no ground cover; drain tiles
Irrigation district:	
Irrigation system:	Drip (surface double line 30-inch emitter)
Fertilizer applied:	total NPK 700-390-350 (fertigation) or 100-56-50 per acre type 28-0-0 (200 gal), 0-0-16 (200 gal) and 5-34-0 (100 gal)

Sensor and flow meter information:

Watermark (6, 12 & 24-inch depth) and irrigation sensors connected to data logger. Water meter installed at the pump house.

Irrigation schedule and amounts:

Total irrigation:	36.2 inches/acre including 2 flood event of 6 inch per acre each = 48.2 ac-in.
Total rainfall:	4.0 inches/acre (Jan-Dec 2011)
Total water input:	52.2 inches/acre

Irrigation method:

Irrigation scheduling was based on soil moisture and an average of 0.9 inch/acre was applied each time; water was provided by the district (pipeline) into a reservoir (sand media filtration and pump system)

Observations made during the crop season:

Irrigation was triggered at when 6" sensor reached an average of 100cb (0% AW), 12" sensor reached an average of 67cb (35% AW), and 24" sensor reached an average of 15cb (100% AW)

Yield:	114.8 Tons Total Yield or 13.5 Tons/acre and 80.7% packout; 10.9 Tons/Ac packout and 0% Juice.
Water use summary:	IUE: 560 lbs/inch of water applied by irrigation WUE: 517 lbs/inch of water received (irrigation + rainfall)

15. Site #:41A – 2011

Site Description:

Acres:	16
Soil type:	Harlingen Clay
Crop variety:	Cotton
Field Characteristics:	Laser leveled
Irrigation district:	Harlingen
Irrigation system:	Surge flood
Fertilizer applied:	

Sensor and flow meter information:

Watermark (6, 12 & 24-inch depth) connected to data logger.

Water meter installed at field turn out.

Irrigation schedule and amounts:

Total irrigation:	1 irrigation of 6.2″
Total rainfall:	10.8 inches/acre (Jan-Oct 2011)
Total water input:	17 inches/acre

Irrigation method:

The field was irrigated with surge flood as needed according to the water mark sensors.

Yield:	1,032 lbs per acre
Water use summary:	IUE: 166 lbs/inch of water applied by irrigation WUE: 60.7 lbs/inch of water received (irrigation + rainfall)

16. Site #:41B – 2011

Site Description:

Acres:	20
Soil type:	Harlingen Clay
Crop variety:	Cotton
Field Characteristics:	Laser leveled
Irrigation district:	Harlingen
Irrigation system:	Furrow flood
Fertilizer applied:	

Sensor and flow meter information:

Watermark (6, 12 & 24-inch depth) connected to data logger.

Water meter installed at field turn out. This field was irrigated from two sources. The North 12.7 acres and the south 8.6 acres

Irrigation schedule and amounts:

Total irrigation:	North 12.7 irrigation of 28.9”, South irrigation of 9.1”
Total rainfall:	10.8 inches/acre (Jan-Oct 2011)
Total water input:	North 39.7 inches/acre, South 19.9 inches/acre

Irrigation method:

The field was irrigated with furow flood as needed according to the water mark sensors.

Yield:	1,032 lbs per acre both fields
Water use summary:	IUE: 35 lbs/inch of water applied by irrigation North field IUE: 113 lbs/inch of water applied by irrigation South field WUE:25.9 lbs/inch of water received (irrigation + rainfall) North WUE: 65 lbs/inch of water received (irrigation + rainfall)

17. Site #44A – 2011

Site Description:

Acres:	37
Soil type:	Harlingen Clay
Crop variety:	Sugar cane 1210
Field Characteristics:	Laser leveled
Irrigation district:	Harlingen
Irrigation system:	Surge and Furrow flood
Fertilizer applied:	50 Gallons of 28-0-0-5

Sensor and flow meter information:

Watermark (6, 12 & 24-inch depth) connected to data logger.

Water meter installed at field turn out.

Irrigation schedule and amounts:

Total irrigation:	14 irrigations of 6” each
Total rainfall:	10.8 inches/acre (Jan-Oct 2011)
Total water input:	94.8 inches/acre

Irrigation method:

The field was irrigated with furrow flood on a 14 day schedule.

Yield:	6 Acres were harvested for seed the remaining acres yielded 39 tons of cane per acre
Water use summary:	IUE: 928 lbs/inch of water applied by irrigation WUE: 800 lbs/inch of water received (irrigation + rainfall)

Appendix C: Economic Evaluation of Demonstrated Technologies

Submitted by:
Texas AgriLife Extension, FARM Assistance Program
Mac Young, Extension Program Specialist II

Activities and continual progress regarding the FARM Assistance task of the ADI project of the Harlingen Irrigation District revolves around two primary objectives. The first is collaborating with project management team and coordinating the FARM Assistance program into the project concepts, including participation in management team meetings, planning sessions, producer meetings, and contributions to project promotional materials. Extension faculty also supported the overall project effort of recruiting project demonstrators. The second objective is the completion of the economic analysis for project demonstrations. Economic analyses for individual demonstrators range from conducting an evaluation of the site demonstration to providing the complete FARM Assistance strategic analysis service for the demonstration participant.

An overall economic summary of 2011 FARM Assistance activities are provided, including outreach and education publications produced. Summaries of each 2011 demonstration site analysis are included.

Economic Summary Overview

Texas AgriLife Extension Service's Financial and Risk Management Assistance (FARM Assistance) program works directly with ADI cooperators in the Lower Rio Grande Valley. FARM Assistance conducts economic evaluations on demonstration sites showing the financial benefit and/or viability of water conservation practices on the farming operations. Additionally, individual cooperators are offered FARM Assistance planning services for their entire operation, demonstrating the value of long-range financial planning to the farm manager. One ADI cooperator has indicated, "The FARM Assistance program has been an excellent tool in helping me evaluate the direction I need to proceed with my farm operation."

FARM Assistance specialists completed 3 whole-farm and 16 demonstration site analyses for 10 ADI participants in the 2011-2012 project period. Individual studies have included irrigated cotton, corn, grain sorghum, sugarcane, vegetables, onions, citrus, and other crops. Irrigation methods demonstrated include furrow, surge, drip, micro-jet, flood and narrow-border flood.

Economic analyses of the 2011 field crop demonstrations reflect some differences in the financial outlook for surge and drip irrigation technology compared to traditional furrow flood irrigation. These demonstrations as well as the 2005-2010 demonstrations (cotton, grain sorghum, corn, seed corn, soybeans and sugarcane) have shown the potential for water savings but, under current "per event" pricing structures, water savings do not necessarily translate into cost savings for producers. With no significant differences in yields, the additional fixed or variable costs related to a surge valve or drip system reduces the net returns per acre compared to furrow flood. An exception is onions where drip technology has shown water savings as well as economic incentives. While the FARM Assistance analyses indicate limited existing economic incentives for adoption of conservation practices in field crops, these demonstrations clearly illustrate the value of water saving methods under conditions of limited water availability and/or volume pricing.

In Focus 2011-2, "Furrow vs. Surge Irrigation in Cotton Assuming Restricted Water Availability in the Lower Rio Grande Valley," results indicate that incentives to invest in and adopt surge irrigation would begin with just less than doubling of the current water price. Specific results include:

- At $1.17/acre inch, Net cash Farm Income (NCFI) is $132/acre for furrow and $128/ acre for surge. Assuming $2.34/ acre inch, NCFI is $100/acre inch for furrow and $104/acre inch for surge. At $2.34/acre inch, the additional cost of a surge valve is covered by the water cost savings from using less water. The NCFI advantage under surge improves significantly as the price for irrigation water increases.
- Cumulative 10-year ending cash reserves grow to $1,395/acre for furrow compared to $1,353/acre for surge at $1.17/acre inch. At $2.34/acre inch, cumulative cash reserves grow to $1,091/acre for surge and $1,058/acre for furrow. Liquidity or cash flow improves with surge irrigation at higher water prices.

In citrus, economic analyses of the 2005-2011 demonstrations have shown water savings as well as economic incentives to adopt border flood, micro-jet spray and drip technologies compared to traditional flood. The economic incentives are especially evident when evaluating differences in fruit quality and yields.

Economic analyses of the 2011 citrus demonstrations continue to support the outcomes of a 2010 study evaluating flood, border flood, drip and micro-jet systems based on fruit quality and yields. In Focus 2010-4 "Assessing Irrigation Methods Based on Grapefruit Pack-Out," results reflect that border flood, micro-jet and drip have an advantage over traditional flood. Evaluating average 2005-2009 yields and pack-out percentages (fancy, choice, and juice) and average crop prices for each category, border flood on average had the highest 10-year net cash farm income and cumulative pre-tax cash flow followed by micro-jet and drip. Specific results include:

- Projected 10-year average NCFI for border flood was 1.2% more than micro-jet, 22.7% more than drip, and more than double flood.
- Border flood's advantage over conventional flood is largely reflective of higher average yields (21.1 tons/acre vs. 17.2 tons/acre).
- The NCFI advantage over micro-jet and drip is largely linked to costs of systems.
- Average 2010 cash costs were $2,000/acre for border flood, 4.8% less than drip and 6.1% less than micro-jet.
- Projected 10-year cumulative pre-tax cash flow balance for border flood was 3.4% more than micro-jet, 23.1% more than drip, and more than double that for flood.

Based on these findings, border flood may offer the best economical option for water savings and ease for producer adoption under current water pricing structures.

Economic Summaries by Site

Demonstration Site 01A

The Demonstration Site 01A analysis consists of a 10-year financial outlook (2011-2020) for the 50 acres of Rio Red grapefruit under narrow border flood irrigation. The orchard was assumed to have mature trees. The Rio Red grapefruit price is held constant at $160/ton. 2011 producer costs and overhead charges are producer estimated rates.

Total cash receipts average $3,525/acre over the 10-year period and cash costs average $1,928/acre, including $220/acre irrigation costs. Net cash farm income (NCFI) averages $1,597/acre due largely to the price being held at a constant $160/ton. The risk associated with prices and yields suggests some chance of negative NCFI. In a normal production year, NCFI could range as much as -$380/acre to $3,700/acre.

Demonstration Site 01B

The Demonstration Site 01B analysis consists of a 10-year financial outlook (2011-2020) for the 15 acres of Valencia oranges under narrow border flood irrigation. The orchard was assumed to be eight years old. The Valencia orange price is held constant at $150/ton. 2011 production costs and overhead charges are producer estimated rates.

Total cash receipts average $2,249/acre over the 10-year period and cash costs average $1,929/acre, including $200/acre irrigation costs. Net cash farm income (NCFI) averages approximately $319/acre due largely to the price being held at a constant $150/ton. The risk associated with prices and yields suggests a 5.33% chance of negative NCFI. In a normal production year, NCFI could range as much as -$667/acre to $1,267/acre. Reflecting the potential of negative NCFI, the probability of carryover debt is 11% in 2011 and then drops to 4% or less in 2013.

Demonstration Site 01C

The Demonstration Site 01C analysis consists of a 10-year financial outlook (2011-2020) for the 15 acres of Rio Red grapefruit production under narrow border flood irrigation. The orchard was assumed to have mature trees. The Rio Red grapefruit price is held constant at $160/ton. 2011 production costs and overhead charges are producer estimated rates.

Total cash receipts average $3,525/acre over the 10-year period and cash costs average $1,917/acre, including $220/acre irrigation costs. Net cash farm income (NCFI) averages $1,609/acre due largely to the price being held at a constant $160/ton. The risks associated with prices and yields suggest some chance of negative NCFI. In a normal year, NCFI could range from -$333/acre to $3,667/acre.

Demonstration Site 01F

The Demonstration Site 01F analysis consists of a 10-year financial outlook (2011-2020) for the 22 acres of onion production under furrow irrigation. Crop returns were assumed to be $2,000/acre in 2011-2020. 2011 production costs and overhead charges are producer estimated rates.

Total cash receipts average $2,008/acre over the 10-year period and cash costs average $1,405/acre, including $198/acre irrigation costs. Net cash farm income (NCFI) averages $598/acre due largely to crop revenue being held constant. In a normal production year, NCFI could range as much as $5/acre to $1,091/acre.

Demonstration Site 04A

The Demonstration Site 04A analysis consists of a 10-year financial outlook (2011-2020) for the 16.5 acres of Rio Red grapefruit under 2-line drip irrigation. The orchard was assumed to have mature trees. The Rio Red grapefruit price is held constant at $175/ton. 2011 production costs and overhead charges are producer estimated rates.

The analysis also includes the purchase and use of a 2-line drip system at a cost of $2,081 per acre. The 2-line drip system expense is evenly distributed ($208/acre/year) over the 10-year period with the assumption of no financing costs.

Total cash receipts average $3,500/acre over the 10-year period and cash costs average $2,680/acre, including $246.50/acre irrigation costs in 2011. Net cash farm income (NCFI) averages $810/acre due largely to the price being held constant at $175/ton. The risk associated with prices and yields suggests some chance of negative NCFI. In a normal production year, NCFI could range as much as
-$354/acre to $2,560/acre. The average probability of negative NCFI is 12.2% and the probability of carryover debt is 1% or less.

Demonstration Site 04B

The Demonstration Site 04B analysis consists of a 10-year financial outlook (2011-2020) for the 6 acres of Rio Red grapefruit under micro-jet spray irrigation. The orchard trees were assumed to have mature trees. The Rio Red grapefruit price is held constant at $175/ton. 2011 production costs and overhead charges are producer estimated rates.

The analysis also includes the purchase and use of a micro-jet spray system at a cost of $2,500 per acre. The micro-jet spray system expense is evenly distributed ($250/acre/year) over the 10-year period with the assumption of no financing costs.

Total cash receipts average $3,500/acre over the 10-year period and cash costs average $2,810/acre, including $316.01/acre irrigation costs in 2011. Net cash farm income (NCFI) averages $690/acre due largely to the pricing being held constant at $175/ton. The risk associated with prices and yields suggests significant chance of negative NCFI. In a normal production year, NCFI could range as much as -$483/acre to $2,443/acre. The average probability of negative NCFI is 19.5% and the average probability of negative cash reserves is 2% or less.

Demonstration Site 04C

The Demonstration Site 04C analysis consists of a 10-year financial outlook (2011-2020) for the 14 acres of Rio Red grapefruit under traditional flood irrigation. The orchard trees were assumed to have mature trees. The Rio Red grapefruit price is held constant at $175/ton. 2011 production costs and overhead charges are producer estimated rates.

Total cash receipts average $3,500/acre over the 10-year period and cash costs average $2,400/acre, including $245/acre irrigation costs in 2011. Net cash farm income (NCFI) averages $1,100/acre due largely to the pricing being held constant at $175/ton. The risk associated with prices and yields suggests significant chance of negative NCFI. In a normal production year, NCFI could range as much as -$58/acre to $2,840/acre. The average probability of negative NCFI is 2.6% and the average probability of negative cash reserves is 1% or less.

Demonstration Site 28A

The Demonstration Site 28A analysis consists of a 10-year financial outlook (2011-2020) for the 8 acres of Valencia oranges under micro-jet spray irrigation. The orchard trees were assumed to be mature trees. The Valencia orange price is held constant at $150/ton. 2010 production costs and overhead charges are producer estimated rates.

The analysis also includes the purchase and use of a micro-jet spray system at a cost of $1,000 per acre. The micro-jet spray system expense is evenly distributed ($100/acre/year) over the 10-year period with the assumption of no financing costs.

Total cash receipts average $2,218/acre over the 10-year period and cash costs average $1,660/acre, including $230/acre irrigation costs in 2011. Net cash farm income (NCFI) averages $558/acre for the 10-year period. The risk associated with prices and yields suggests a some chance of negative NCFI. In a normal production year, NCFI could range as much as -$625/acre to $2,500/acre. The probability of carryover debt is 35% or less in 2011 and then declines to 4% or less in 2016.

Demonstration Site 28B1

The Demonstration Site 28B1 analysis consists of a 10-year financial outlook (2011-2020) for the 5 acres of Marrs under 2-line drip irrigation. The orchard trees were assumed to have mature trees. The Marrs orange price is held constant at $120/ton. 2011 production costs and overhead charges are producer estimated rates.

The analysis also includes the purchase and use of a 2-line drip system at a cost of $1,000 per acre. The 2-line drip system expense is evenly distributed ($100/acre/year) over the 10-year period with the assumption of no financing costs.

Total cash receipts average $2,036/acre over the 10-year period and cash costs average $1,586/acre, including $230/acre irrigation costs in 2011. Net cash farm income (NCFI) averages $450/acre due largely to the price being held constant at $120/ton. The risk associated with prices and yields suggests a significant chance of negative NCFI. In a normal production year, NCFI could range as much as -$940/acre to $2,560/acre. Due to negative NCFI, the probability of carryover debt is 32% or less in 2011 and then declines to 7% or less in 2020.

Demonstration Site 28B2

The Demonstration Site 28B2 analysis consists of a 10-year financial outlook (2011-2020) for the 3 acres of Rio Red grapefruit under 2-line drip irrigation. The orchard was assumed to have mature trees. The Rio Red grapefruit price is held constant at $120/ton. 2011 production costs and overhead charges are producer estimated rates.

The analysis also includes the purchase and use of a 2-line drip system at a cost of $1,000 per acre. The 2-line drip system expense is evenly distributed ($100/acre/year) over the 10-year period with the assumption of no financing costs.

Total cash receipts average $2,640/acre over the 10-year period and cash costs average $1,770/acre, including $230/acre variable irrigation costs. Net cash farm income (NCFI) averages $870/acre due largely to the price being held at a constant $120/ton. The risks associated with prices and yields suggest some chance of negative NCFI. In a normal production year, NCFI could range as much as -$733/acre to $3,400/acre. The probability of carryover debt is 22% or less during 2010 and then declines to 4% or less in 2016.

Demonstration Site 28C

The Demonstration Site 28C analysis consists of a 10-year financial outlook (2011-2020) for the 8 acres of Rio Red grapefruit under micro-jet spray irrigation. The orchard was assumed to have mature trees. The Rio Red grapefruit price is held constant at $120/ton. 2011 production costs and overhead charges are producer estimated rates.

The analysis also includes the purchase and use of a micro-jet spray system at a cost of $1,000 per acre. The micro-jet spray system expense is evenly distributed ($100/acre/year) over the 10-year period with the assumption of no financing costs.

Total cash receipts average $2,641/acre over the 10-year period and cash costs average $1,771/acre, including $230/acre variable irrigation costs. Net cash farm income (NCFI) averages $871/acre due largely to the price being held at a constant $120/ton. The risks associated with prices and yields suggest some chance of negative NCFI. In a normal production year, NCFI could range as much as -$725/acre to $3,400/acre. The probability of carryover debt is 22% or less during 2011 and then declines to 4% or less in 2013.

Demonstration Site 28D1

The Demonstration Site 28D1 analysis consists of a 10-year financial outlook (2011-2020) for the 3.5 acres of Navel oranges under 2-line drip irrigation. The orchard was assumed to have mature trees. The early orange price is held constant at $120/ton. 2011 production costs and overhead charges are producer estimates.

The analysis also includes the purchase and use of a 2-line drip system at a cost of $1,000 per acre. The 2-line drip system expense is evenly distributed ($100/acre/year) over the 10-year period with the assumption of no financing costs.

Total cash receipts average $1,897/acre over the 10-year period and cash costs average $1,597/acre, including $230/acre variable irrigation costs. Net cash farm income (NCFI) averages $300/acre due largely to the price being held at a constant $120/ton. The risks associated with prices and yields suggest a significant chance of negative NCFI. In a normal production year, NCFI could range as much as -$971/acre to $2,486/acre. Due to negative NCFI, the probability of carryover debt is 47% or less in 2011 and then decreases to 16% or less in 2018.

Demonstration Site 28D2

The Demonstration Site 28D2 analysis consists of a 10-year financial outlook (2011-2020) for the 3.5 acres of Marrs oranges under 2-line drip irrigation. The orchard was assumed to have mature trees. The early orange price is held constant at $120/ton. 2011 production costs and overhead charges are producer estimates.

The analysis also includes the purchase and use of a 2-line drip system at a cost of $1,000 per acre. The 2-line drip system expense is evenly distributed ($100/acre/year) over the 10-year period with the assumption of no financing costs.

Total cash receipts average $2,037/acre over the 10-year period and cash costs average $1,586/acre, including $230/acre variable irrigation costs. Net cash farm income (NCFI) averages $451/acre due largely to the price being held at a constant $120/ton. The risks associated with prices and yields suggest a significant chance of negative NCFI. In a normal production year, NCFI could range as much as -$943/acre to $2,571/acre. Due to negative NCFI, the probability of carryover debt is 32% or less in 2011 and then declines to 7% or less in 2020.

Demonstration Site 32A

The Demonstration Site 32A analysis consists of a 10-year financial outlook (2011-2020) for the 64 acres of fifth year (fourth ratoon) sugarcane under furrow with poly-pipe irrigation. The price is held constant at $22/ton. 2011 production costs and overhead charges are producer estimated rates.

Total cash receipts reach $867/acre over the 10-yer period. It is assumed the crop is replanted in 2013 and 2019. Cash costs also reflect the sugarcane production cycle, requiring roughly $609/acre in 2011 (the fifth crop year), and $1,049/acre in the first replanting year (2013). Average NCFI generally follows the sugarcane production cycle producing $95/acre profit in the fifth crop year (2011). It averages approximately $122/acre per year for the assumed 10-year period. The risk associated with prices and yields suggests that, in a normal production year, NCFI could range as much as -$391 to $594/acre.

Demonstration Sites 41A & 41B

The Demonstration Sites 41A & 41B consists of a 10-year financial outlook (2011-2020) for 39 acres (26 acres of furrow and 13 acres of surge irrigated) cotton. It is not assumed the cotton acreage is rotated annually with another crop. The initial cotton price is $1.03/lb., including marketing loan deficiency payments. 2011 production costs and overhead charges are producer estimated rates.

The analysis also includes a $1,800 cost for a surge valve. The surge valve expense is evenly distributed over the 10-year period with the assumption of no financing costs.

Total cash receipts average $1,446/acre over the 10-year period for both irrigation methods. In addition to market receipts, total receipts include direct and counter-cyclical payments paid to base acres. Due primarily to the $180 per year cost of the surge valve, cash costs average $990/acre per year for the surge irrigation and $975/acre per year for the furrow irrigation. Excluding the surge valve cost per year, irrigation costs in 2011 including water, labor and poly-pipe were $72.92/acre for both the surge and furrow sites. NCFI averages $456/acre per year for the surge and $470/acre for the furrow. The risk associated with prices and yields suggests a minimal chance of negative NCFI. In a normal production year, NCFI could range as much as $462/acre plus or minus the average expected NCFI for both furrow and surge sites.

Demonstration Site 44A

The Demonstration Site 44A analysis consists of a 10-year financial outlook (2011-2020) for the 37.34 acres of first year sugar cane production under surge irrigation with poly-pipe. The initial price is $25/ton, including marketing loan deficiency payments, if applicable. 2011 production costs and overhead charges are producer estimated rates.

The analysis also includes the purchase and use of a surge valve at a cost of $2,200 and soil moisture equipment at $1,000. The surge valve expense is evenly distributed ($220/year) over the 10-year period and the soil moisture equipment is replaced every five years, with the assumption of no financing costs.

Total cash receipts average $980/acre over the 10-year period and cash costs average $490/acre, including $128.70/acre variable irrigation costs. In addition to market receipts, total receipts include direct and counter-cyclical payments paid to base acres. Net cash farm income (NCFI) averages $490/acre throughout the 10-year period. The risks associated with prices and yields suggest some chances of negative NCFI. In a normal production year, NCFI could range as much as $133/acre to $161/acre plus or minus the average expected NCFI for the site.

Appendix D: On-Farm Technologies

Submitted by:
Texas A&M University
Dr. Hugo Perea
Dr. Juan Enciso
Dr. Shad Nelson
Xavier Peries, Agronomist

Summary

The Agricultural Water Conservation Demonstration Initiative (ADI) project coordinates cost-effective technologies to optimize surface water use. In 2011, several technologies were tested on field and laboratory to demonstrate their practical applicability. In this year, on-farm irrigation systems, pressurized and non-pressurized irrigation systems, were evaluated; results in sugarcane indicate that better water management should improve water savings. Also, monitoring crop water necessities during the entire season by using weather stations will maximize crop yield and reduce a risk of water plant stress. Soil moisture sensors are important compute water holding capacity and the irrigation time. However, the sensors tested (Watermark) have poor response during wet-dry process.

Circular flume calibration and multiple outlet hydraulic analysis were performed to enhance on-farm demand. Preliminary results indicate promising applications on real farm irrigation.

Surface Irrigation Performance In Citrus

The border method of irrigation is the most commonly practiced surface irrigation method. There are many variations of the technique due to local farmer's preferences, available field sizes, irrigation stream sizes and natural topography. The term check border refers to relatively small borders with gentle slopes blocked at the lower end to prevent runoff and thus causing pounding. Check borders provide some additional advantages such as the opportunity for leaching of salts, efficient harvesting of rainfall water and minimizing erosion.

Recession phase of surface irrigation is important to evaluate irrigation efficiency, especially in border irrigation where greater water depth is infiltrated during this phase. The objectives here are to evaluate a citrus field surface irrigation at the Citrus Center of the Texas A&M University-Kingsville farm and to compare water savings on one and three grapefruit tree lines.

Figure 1 presents a field experiment setup; two treatments and 3 repetitions were performed. Two fields were irrigated simultaneously recording input flow rate, advance and recession of the water front during the entire irrigation event (Figure 2). Irrigation was cutoff after 5 inches of water was built up at the downstream end of the basin.

Figure 3 and 4 present the hydrographs for the two treatments. It was observed that water front in the one row treatment reaches the downstream-end of the border faster than the three line treatment. However, infiltrated water depth is lower and less uniform. In the three-line treatment, advance time is larger and infiltrated water is deeper than the one row experiment; infiltrated water might cover most of the root zone decreasing deep percolation loses. More studies on the infiltrated water may help to infer advantages of both treatments.

Figure 5 shows the advance of the water front for the six experiments. Advance curves are not similar for both treatments due to variable length of the border. Spatial variability of the soil on the infiltration parameters also plays an important role during the advance-recession phases. A detailed report of this experiment was presented by Dr. Shad Nelson from the Texas A&M University-Kingsville.

These results might be used to calibrate and run a model to obtain better understanding of the overland performance for the two treatments tested. However, we believe that border irrigation is a 2-dimensions phenomenon that may be approached by 1-dimensional analysis. If this hypothesis is true, a manuscript of this research will be presented and proposed to be published in a peer review journal.

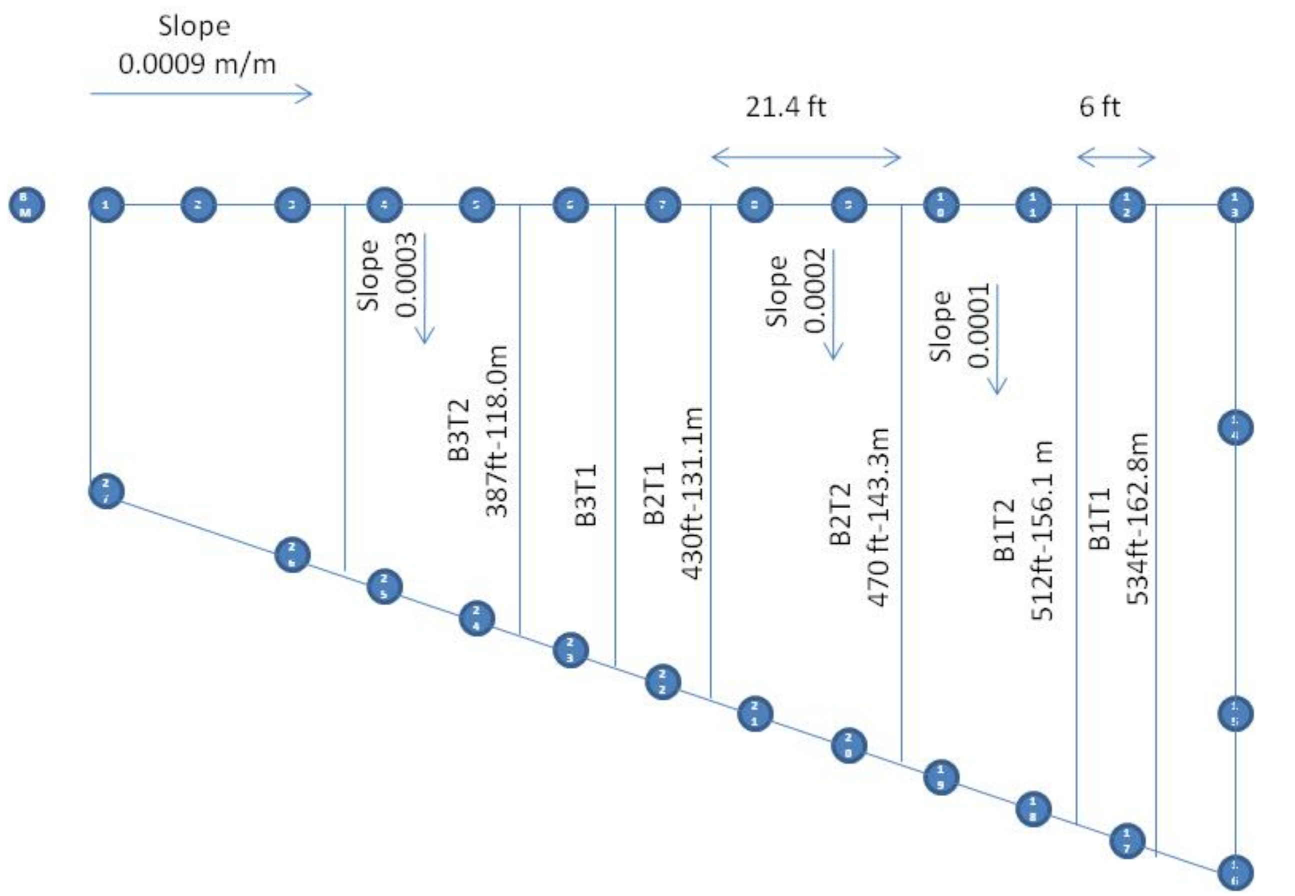

Figure 1 Field experiment setup for two treatments and 3 repetitions.

Figure 2 Water depth reading taken at the downstream end of the border.

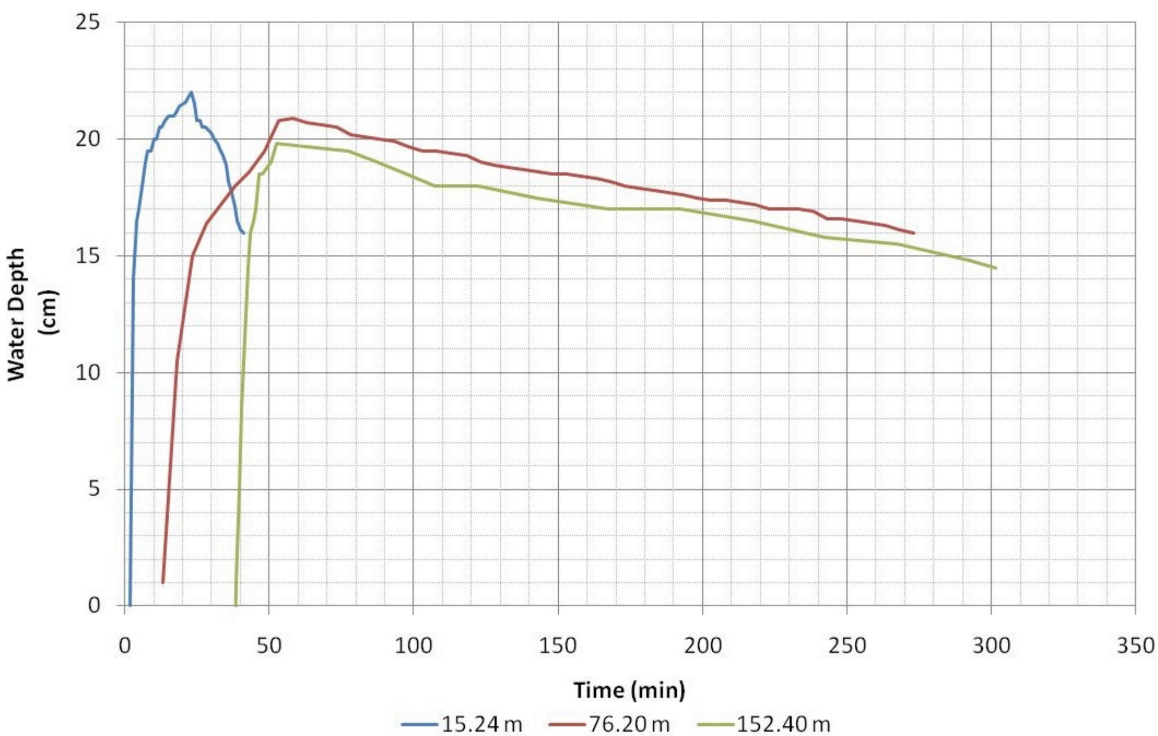

Figure 3: Hydrograph B1T1 at different location along the border 1.

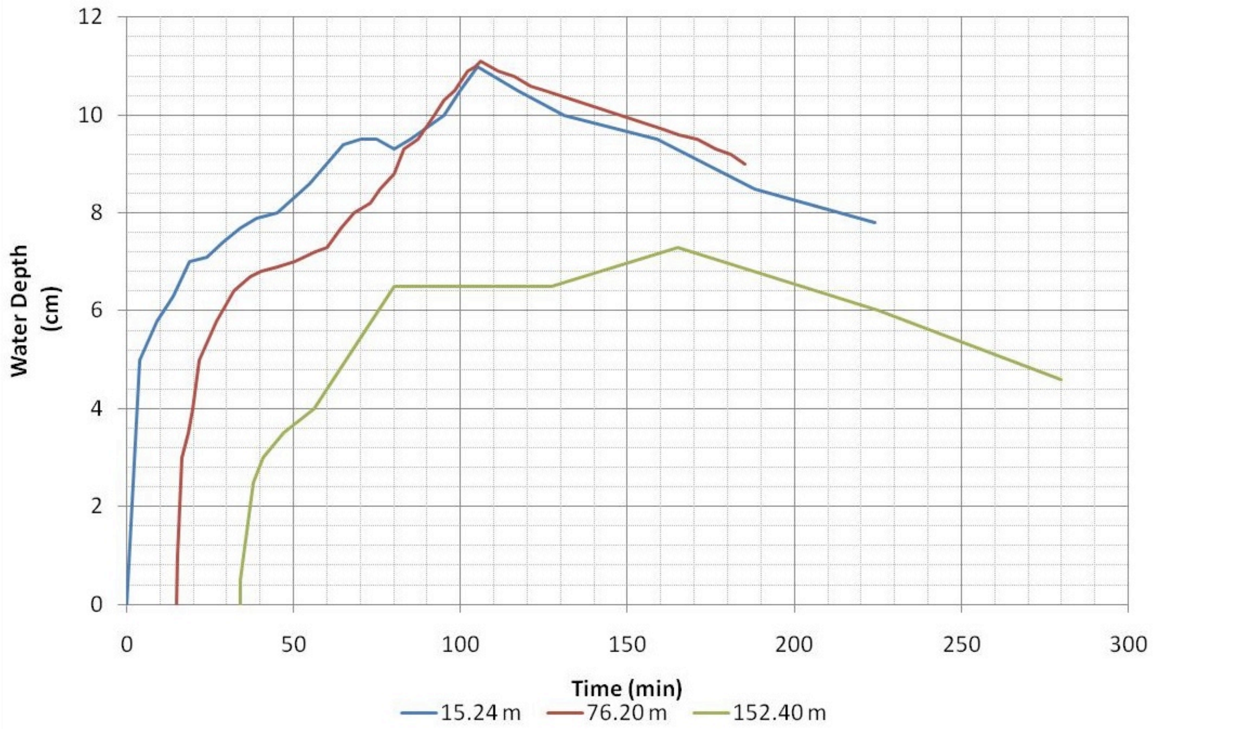

Figure 4: Hydrograph B2T2 at different locations along the border 2.

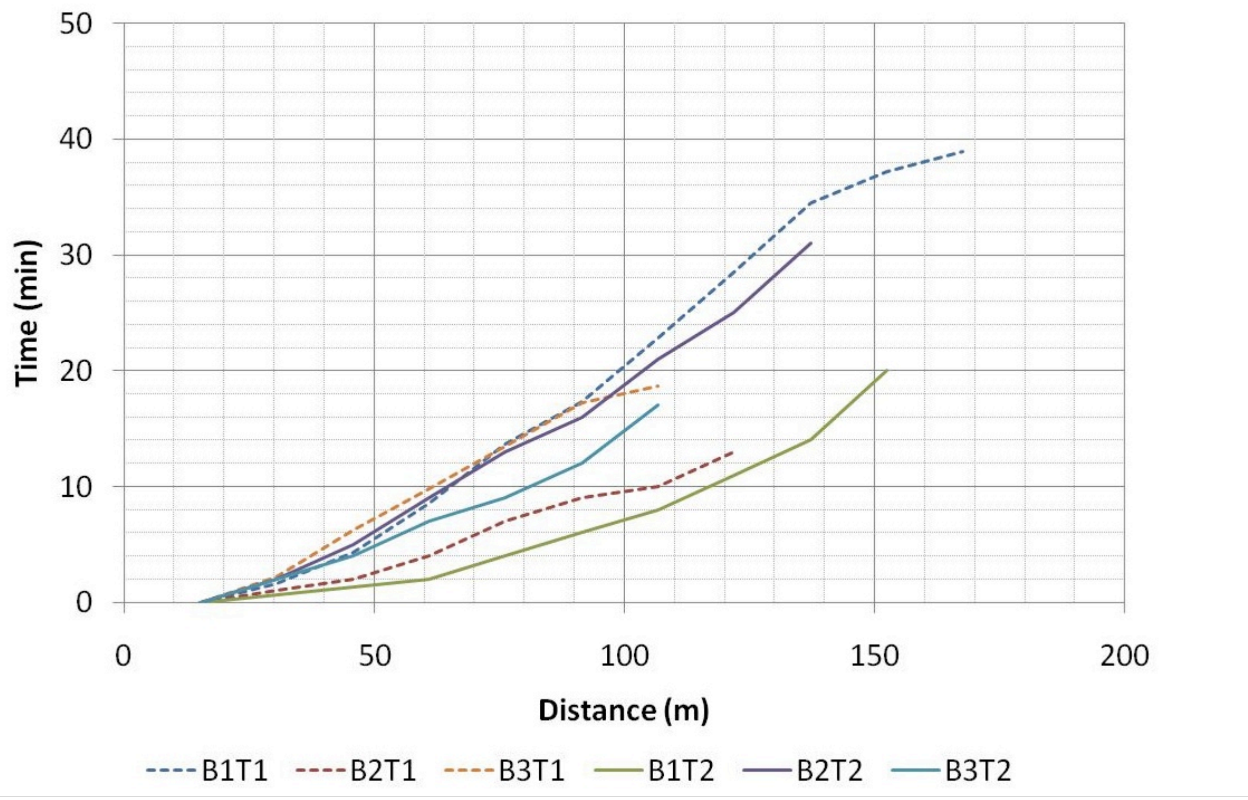

Figure 5 Advance curves for the six borders tested in the field.

Circular Flume Calibration

The usual discharge measurements structures in open channels are based on critical flow concepts. Constant discharge and steady flow condition for local contractions or local bottom elevation are important for accurately measuring flow rate. Bos (1976) provides a review off numerous geometric configurations which are normally used for permanent discharge recording.

Hager (1985) states that all flumes known to date consist of a local reduction of the channel width, the central part in the longitudinal direction being the flow zone, while contraction is achieve d by locally thickening the channel side walls. Other versions exchange the lateral constriction with a central body situated in the channel has not been related with discharge measurement. However, the channel geometry has been extensively studied in connection with piers of bridges or local constructions.

Three 6-inch diameter flumes were calibrated in laboratory by using a specially built structure. This device consists of a tank with a pressure sensor to monitor water depth level during the entire test (Figure 6). A globe valve at the bottom of the tank regulates flow rate and dissipates energy in the tank. A meter monitored water volume delivered to the flume over time. A set of three readings were taken before the flume and at 10 inches before the 2-inch vertical pipe (Figure 7). Sensors were placed at three different locations to measure the water depth variation.

Some authors assumed a 2nd degree polynomial to fit calculate to measured flow rate. However, the head-discharge functional form follows a power relationship.

$$Q = \mu\, h^{\gamma} \qquad (1)$$

Where μ and γ are power regression coefficients, Q is the flume discharge (gpm) and h is hydraulic head inside the 2” pipe (inches).

Power regression coefficients are shown in Table 1; correlation coefficients are very good for the three circular flumes. However, flume C underestimate measured discharge as shown in Figure 11; this underestimation might be due to construction flume problems. Despite this underestimation of the discharge for all hydraulic head tested, correlation is acceptable even when the three discharge readings from the flumes are put together (Figure 8).

Table 1: Power regression and correclation coefficients for the three circular flumes tested in laboratory.

FLUME	μ	γ	R^2
A	2.5824	2.4794	0.9965
B	1.2927	2.7858	0.9927
C	0.6927	3.4603	0.9895

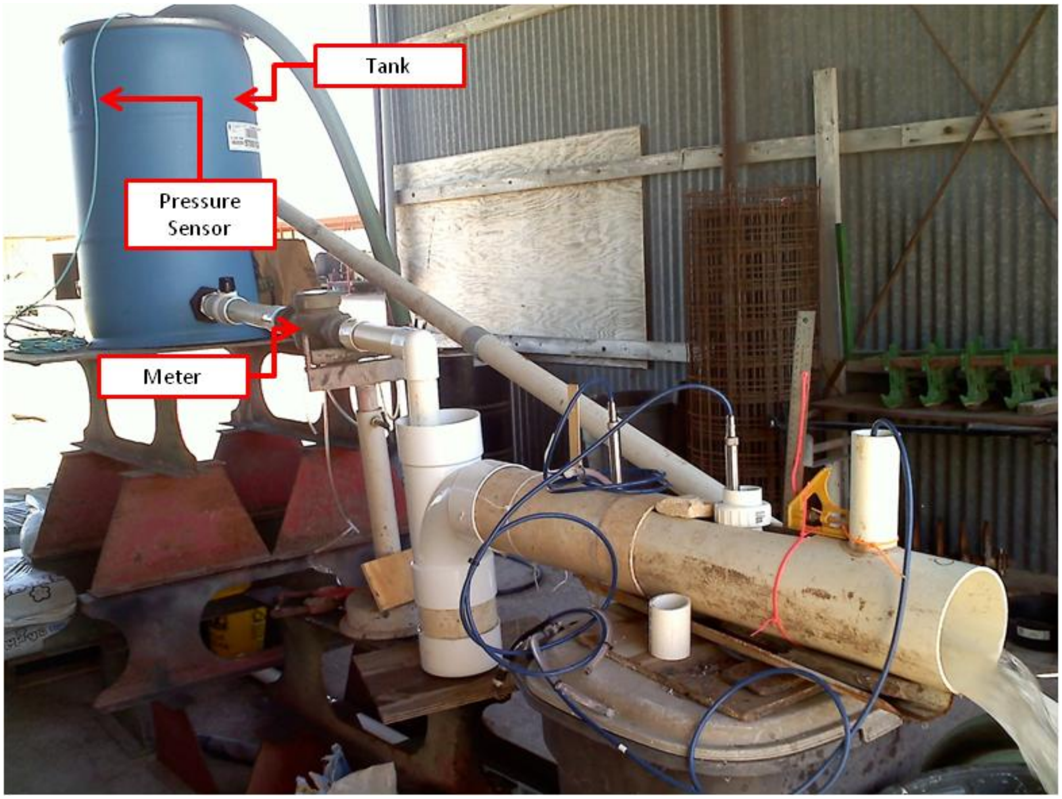

Figure 6: Device to calibrate circular flumes in laboratory.

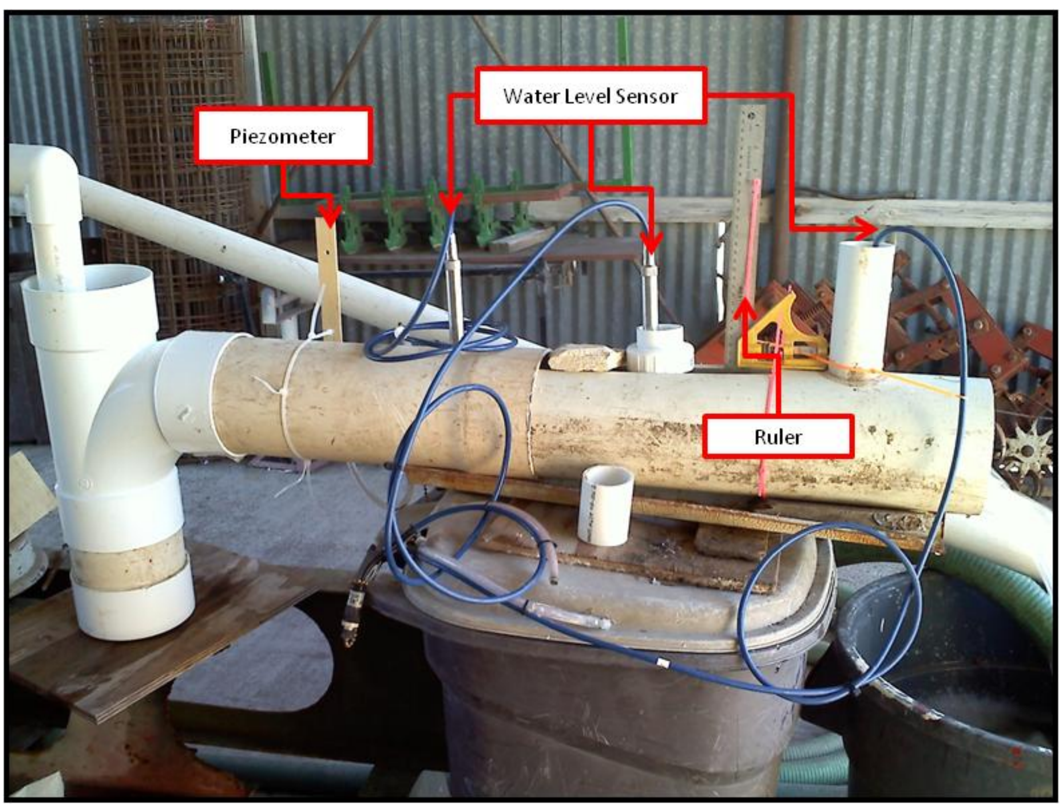

Figure 7: Location of sensors and ruler to compute flow rate over time.

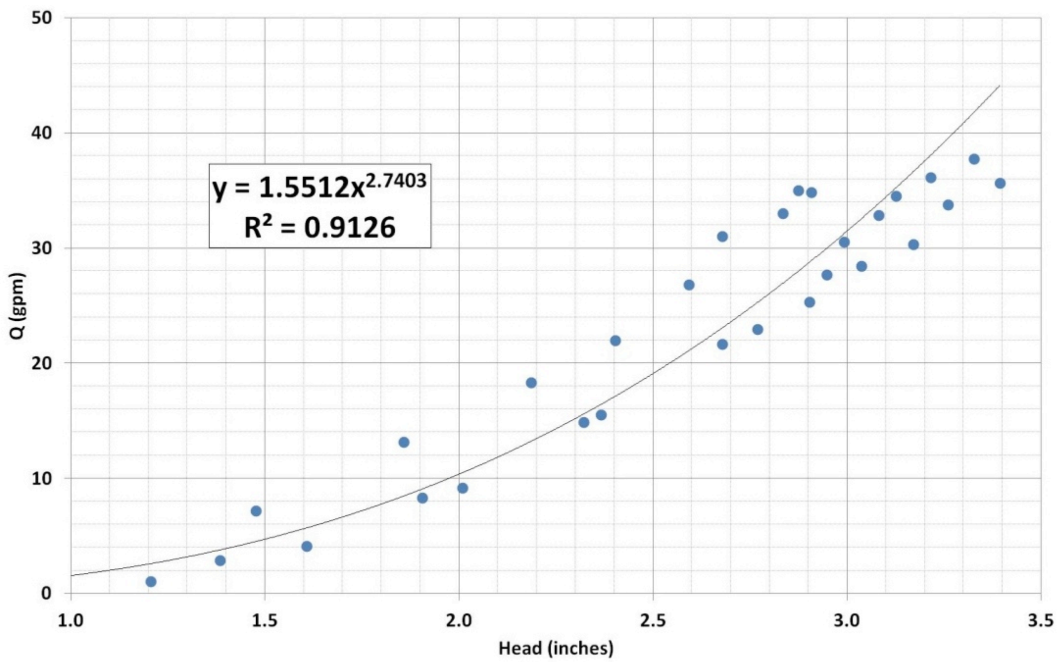

Figure 8: Circular Flume (Calibration)- Head-Discharge equation for a circular flume.

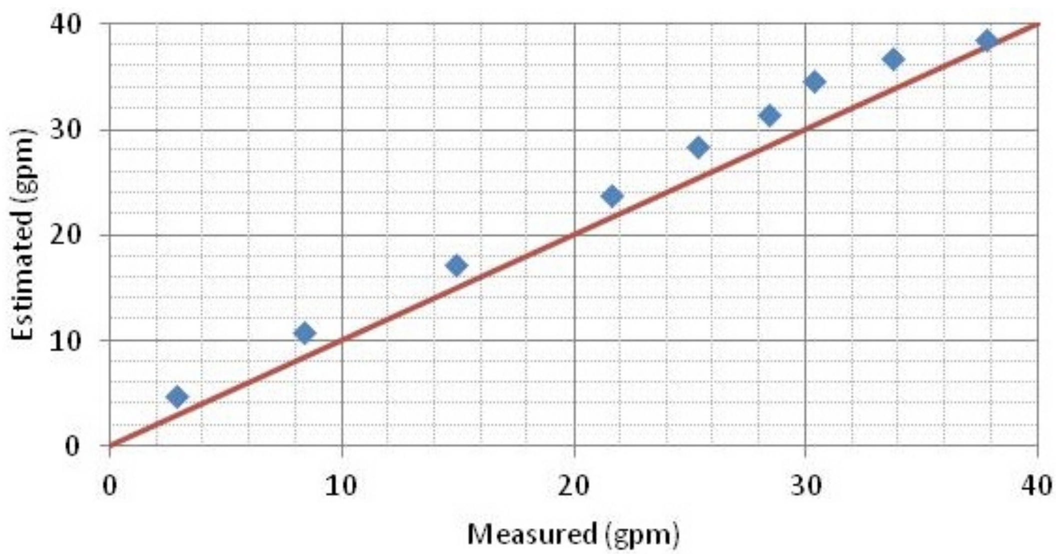

Figure 9: Measured VS Estimated discharge for flume A.

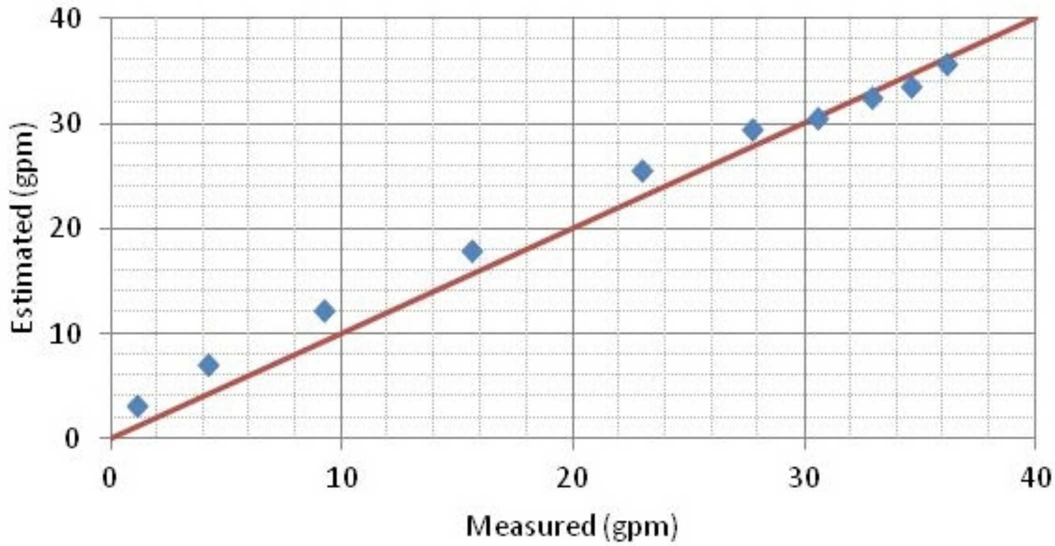

Figure 10: Measured VS Estimated discharge for flume B.

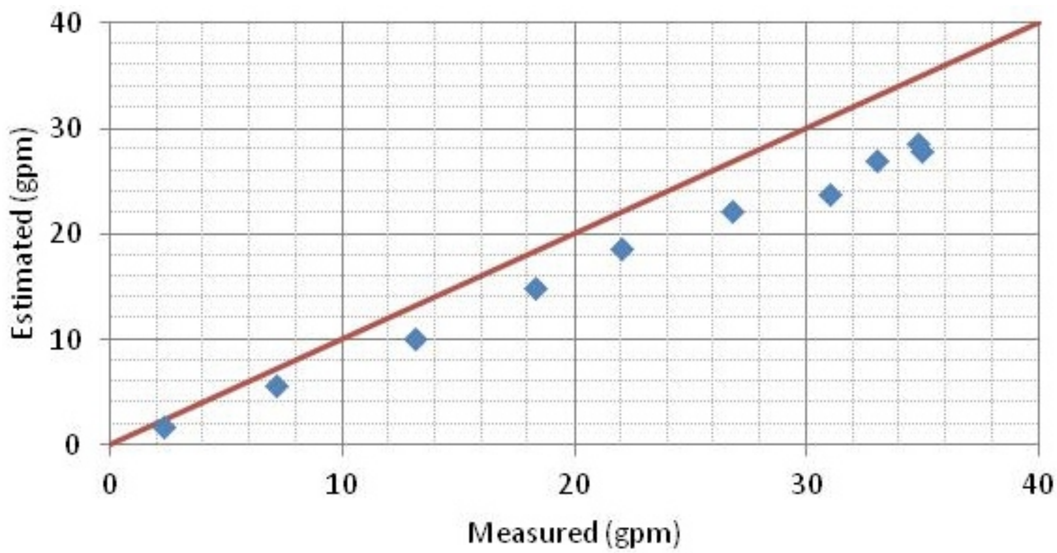

Figure 11: Measured VS Estimated discharge for flume C.

Multiple Outlet Hydraulic Analysis

Pipe with orifices is widely used to distribute water to furrowed-irrigated crops in the Lower Rio Grande Valley. Orifices are uniformly punched in the pipe wall to equal furrow spacing. Uniform water distribution is enhanced by delivering equal flow into each furrow; the velocity of the water decreases as soon as the flow passes through the orifice, reducing pressure head in the pipe. The pressure head reduction causes each succeeding orifice downstream to release a smaller discharge.

Inertia and friction forces determine the distribution of flow in the polypipe. Inertia correspond the change of velocity head; as fluid moves along a pipe, its longitudinal velocity decrease because part of it is discharged through the orifices. Therefore, the flow in the pipe line is decelerated, so it increases pressure, as predicted by Bernoulli's equation. Friction reduces pressure and relative magnitudes of friction and pressure determine whether static pressure at the dead end of the pipe increase or decrease. The Bernoulli's equation applied between two points is

$$Zo + ho + \frac{Vo^2}{2g} = Z1 + h1 + \frac{V1^2}{2g}\sum hl \qquad (2)$$

Where Z is the position head, h is the pressure head and $V^2/2g$ is velocity head.

The methodology for the hydraulics analysis is in progress. However, Table 2 and Figure 12 present preliminary results of the methodology programmed in Excel. A friendly user interface and a better hydraulic analysis need to be programmed and tested in order to release the program to public.

Table 2: Geometry of the orifice and polypipe input parameters for a hydraulic analysis.

Polypipe Input data						Orifice input data		
n=	60				No. of orifices in the polypipe	Do=	3.81	Orifice diameter (cm)
L=	82.5	m			Polypipe length			
q=	1.77	lps	0.00177	m^3/s	Flow rate	pi/γ=	0.10	m (Hyd. Press.@ orifice)
D=	38.1	cm	0.381	m	Polypipe Diameter	Calculations		
So=	0.010				Slope	e/D=	3.9E-06	Relative Roughness
p1/γ=	0.25	m	Hydraulic pressure @ beginning of the dripline			α=	0.016	
e=	0.0015	mm	Plastic Rougness			a=	1.352	m orifice separation
						Δx*So=	0.014	

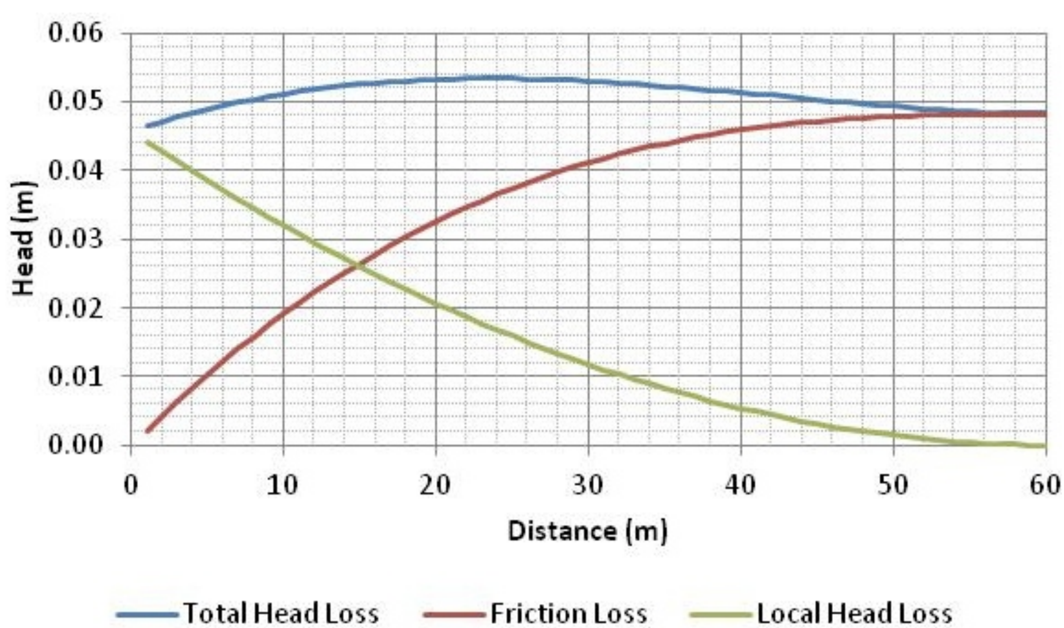

Figure 12: Friction and local head losses in a pipe with 60 orifices.

Soil Moisture Sensor (Watermark)

The Watermark soil moisture sensor (Larson Co., Santa Barbara, California) is sold as a qualitative indicator of soil moisture for applications such as irrigation scheduling. It consists of two concentric electrodes embedded in a porous matrix containing a soluble salt ($CaSO_4$), so that the water in the porous matrix is always gypsum-saturated. Lead wires are connected to the electrodes so that the electrical resistance of the porous medium can be measured. The device is encased in a synthetic membrane supported by PVC plastic. This presumably confers a life expectancy longer than that of gypsum blocks, which dissolve over time.

As temperature increases resistance decreases. Block resistance as measured in the soil should therefore be corrected for temperature, which implies normalizing the measured resistances to a reference resistance at an arbitrarily chosen temperature. Campbell and Gee (1986) reported a typical temperature sensitivity of 3%. The manufacturer of the Watermark sensors reports a temperature sensitivity of 1.8%. One calibration for soil matric potential, independent of soil type and assumed valid for all blocks, is provided by the manufacturer. It presents a nearly linear relationship between matric potential and resistance. Armstrong et al. (1985) calibrated a number of Watermark (model 200) soil moisture sensors in two soils and reduced the data to a single non-linear equation relating measured sensor resistance to matric potential and temperature.

Eighteen Watermark sensors were saturated with water and dried at room temperature to check the time of response and homogeneity of the matric potential reading. As a result, only 9 of them present acceptable values during the wet and dry stage (Figure 13). We observed that calibrations for soil matric potential were unique for each block. More serious, repeated calibration of selected blocks in the same medium produced different results. Consequently, no conclusions can be drawn about the water-specific nature of the block response. Watermark sensor is not suitable for accurate and reproducible measurements of soil water potential. Its use is appropriate in cases where relative indications of soil wetness is sufficient.

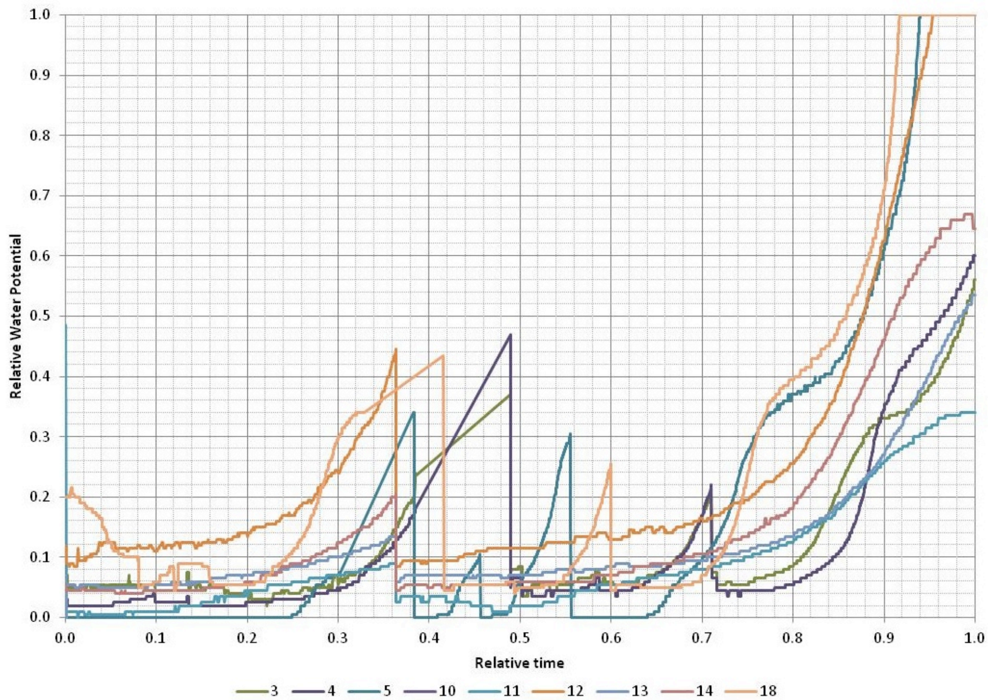

Figure 13: Wetted and dried phase for the water mark sensor.

Sugarcane Irrigation Scheduling

Sugarcane crop irrigated with drip irrigation was closely monitored by using daily weather parameters to estimate the reference evapotranspiration (ETr) and then potential evapotranspiration (ETp). The Penman-Monteith, a new standard method for ETr, was used. This method uses standard climatic data that can be easily measured or derived from commonly measure data. All the calculation procedures have been standardized according to the available weather data and the time scale of computation.

Three treatments and three repetitions were tested. An average of 20.3, 30.5 and 38.3 inches of water was applied for treatment 1, 2 and 3 with a standard deviation of 0.62, 0.10, and 0.043 inches respectively. Standard deviation values indicates that an efficient irrigation management of water was performed.

In addition, biometric data of sugarcane was taken during the whole crop season. These parameters were related to the physiological phase of the plant and plant density (Figure 14).

Preliminary sugarcane water requirement was computed using 10 years average data of temperature, precipitation, solar radiation and wind speed and direction. Then, evapotranspiration was monitoring daily during the entire season to irrigate when the plant most needed. Calculations are resumed on Table 3-6.

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Figure 14: Sugarcane data

Table 3: Climatic variable to compute water requirements in surgarcane.

Month	Temperature (°C)		Humidity	Wind	Sun	Rad	Eto
	Min	Max	(%)	(km/d)	(hr)	(MJ/m²/d)	(mm/d)
January	10.3	22.1	82	257	10.6	17.7	2.6
February	11.9	23.8	82	295	11.1	20.8	3.31
March	15.1	26.8	79	314	11.8	24.7	4.46
April	18.2	29.5	81	285	12.6	28	5.35
May	21.3	32.2	83	271	13.3	29.9	6.05
June	23.2	34	83	235	13.6	30.5	6.47
July	23.3	34.5	82	222	13.5	30.1	6.5
August	23.5	35.1	81	223	12.9	28.5	6.34
September	21.6	32.5	85	162	12.1	25.7	5.1
October	18.2	29.9	85	165	11.3	21.8	3.96
November	13.9	26.3	84	180	10.7	18.3	2.92
December	9.8	21.9	82	190	10.4	16.6	2.32
Average	17.5	29	82	233	12	24.4	4.62

Table 4: Daily precipitation.

Day	Precipitation (mm)												Total
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1	0.2	5.5	0.4	0.0	1.2	3.3	0.2	1.1	5.5	2.7	1.8	2.9	
2	0.6	2.2	1.0	0.0	0.3	0.1	0.3	0.9	2.9	1.5	4.5	0.3	
3	0.9	0.1	0.2	0.0	0.7	0.7	10.6	0.2	1.9	6.4	0.2	0.8	
4	0.0	0.5	0.0	0.8	0.1	0.0	11.4	1.4	1.4	2.2	4.7	0.6	
5	0.0	0.2	0.0	5.2	0.0	0.5	11.5	2.5	1.4	1.5	0.4	0.3	
6	0.1	0.0	0.0	0.1	0.0	1.6	3.1	2.4	0.8	9.5	0.6	0.1	
7	1.8	0.8	0.0	0.8	0.7	1.5	4.7	0.0	5.4	4.0	0.0	1.9	
8	0.2	0.0	0.1	2.3	0.2	7.8	3.1	0.1	8.3	1.3	0.0	2.0	
9	0.0	0.1	0.0	0.0	0.0	3.2	0.4	0.1	15.5	1.1	0.0	1.0	
10	0.1	1.6	0.0	0.0	0.0	2.4	0.0	0.1	8.0	1.5	0.0	0.1	
11	1.2	0.3	0.0	1.0	0.3	0.9	0.2	0.4	0.7	0.7	0.8	0.4	
12	0.4	0.1	0.5	0.7	0.0	0.0	1.0	0.2	2.0	0.5	0.3	0.2	
13	0.2	1.4	0.9	0.0	0.6	2.0	0.1	3.6	0.8	8.1	3.2	0.6	
14	1.9	3.3	3.6	0.0	0.2	3.3	0.0	2.4	7.2	2.9	0.1	0.0	
15	2.6	0.0	6.3	0.0	3.8	6.4	0.0	0.9	11.7	0.3	1.5	0.1	
16	1.1	0.0	0.0	0.0	1.8	0.0	2.5	2.0	5.1	0.3	5.8	1.0	
17	0.1	0.0	0.0	0.3	2.9	0.2	5.8	0.8	10.3	1.4	0.9	0.1	
18	0.5	0.4	0.1	0.0	2.7	1.7	7.4	4.4	13.8	0.6	0.1	0.0	
19	0.2	0.2	0.0	0.0	0.0	0.2	3.7	0.6	14.5	1.2	0.0	0.0	
20	0.0	0.2	0.0	0.0	6.4	0.1	11.4	0.1	0.2	1.9	1.1	0.0	
21	0.6	0.5	0.0	0.1	0.1	2.2	0.0	0.8	2.5	0.3	0.2	0.0	
22	0.5	0.0	0.5	0.3	0.1	13.4	0.3	2.4	5.0	0.2	0.0	0.7	
23	1.0	0.0	0.1	1.7	0.0	3.7	0.1	11.1	4.7	0.0	0.2	4.5	
24	2.9	0.6	0.0	3.3	0.0	0.1	0.7	0.6	12.1	4.5	0.4	2.0	
25	0.3	0.0	0.0	0.9	6.9	4.4	0.5	5.4	0.1	0.2	1.2	0.4	
26	0.0	1.6	0.3	0.3	0.1	1.8	4.4	0.9	1.2	4.4	3.0	0.6	
27	0.2	0.0	0.8	0.5	5.7	0.3	2.0	3.0	0.2	6.3	0.1	0.2	
28	0.0	0.3	3.6	0.5	1.6	0.0	0.2	3.1	1.1	1.0	0.1	0.0	
29	0.2		2.0	0.5	4.1	1.3	1.2	3.1	0.1	1.6	1.0	0.0	
30	0.4		0.0	0.7	0.3	0.1	0.0	4.2	0.0	0.8	0.3	0.0	
31	0.6		1.2		0.2		0.0	13.4		2.4		0.0	
Total Rain	19	20	22	20	41	63	87	72	144	72	33	21	613.5
Tot. Eff. Rain	18	19	21	19	38	57	71	60	107	63	31	20	523.8

Table 5: Crop water requirements for sugarcane.

Month	Decade	Stage	Kc	Etc (mm/d)	Etc (mm/dec)	Eff. Rain (mm/dec)	Irr. Req. (mm/dec)
Oct	2	Init	0.75	3.04	12.20	6.60	10.0
Oct	3	Init	0.40	1.45	15.90	19.50	0.0
Nov	1	Init	0.40	1.29	12.90	11.60	1.3
Nov	2	Deve	0.42	1.20	12.00	12.80	0.0
Nov	3	Deve	0.55	1.49	14.90	6.20	8.6
Dec	1	Deve	0.70	1.63	16.30	9.60	6.7
Dec	2	Deve	0.84	1.97	19.70	2.30	17.4
Dec	3	Deve	1.00	2.29	25.10	8.20	16.9
Jan	1	Deve	1.15	2.90	29.00	3.90	25.1
Jan	2	Mid	1.27	3.30	33.00	7.90	25.1
Jan	3	Mid	1.27	3.40	37.40	6.60	30.8
Feb	1	Mid	1.27	3.73	37.30	10.40	27.0
Feb	2	Mid	1.27	4.28	42.80	5.80	37.0
Feb	3	Mid	1.27	4.77	38.10	3.00	35.1
Mar	1	Mid	1.27	5.27	52.70	1.80	50.9
Mar	2	Mid	1.27	5.67	56.70	10.90	45.8
Mar	3	Mid	1.27	6.05	66.60	8.20	58.4
Apr	1	Mid	1.27	6.51	65.10	8.90	56.2
Apr	2	Mid	1.27	6.81	68.10	1.90	66.1
Apr	3	Mid	1.27	7.14	71.40	8.40	63.0
May	1	Mid	1.27	7.56	75.60	3.20	72.4
May	2	Mid	1.27	7.58	75.80	17.00	58.8
May	3	Mid	1.27	7.97	87.70	17.40	70.3
Jun	1	Mid	1.27	8.10	81.00	19.00	62.0
Jun	2	Mid	1.27	8.34	83.40	13.80	69.6
Jun	3	Mid	1.27	8.28	82.80	23.80	59.0
Jul	1	Mid	1.27	8.02	80.20	35.40	44.8
Jul	2	Late	1.26	8.25	82.50	27.10	55.5
Jul	3	Late	1.20	7.96	87.50	8.90	78.6
Aug	1	Late	1.14	7.46	74.60	8.50	66.0
Aug	2	Late	1.08	6.99	69.90	14.20	55.7
Aug	3	Late	1.02	6.21	68.30	37.00	31.3
Sep	1	Late	0.96	5.30	53.00	38.50	14.5
Sep	2	Late	0.91	4.60	46.00	45.20	0.8
Sep	3	Late	0.85	4.04	40.40	23.40	16.9
Oct	1	Late	0.79	3.44	34.40	26.90	7.5
Oct	2	Late	0.75	3.04	18.20	9.90	10.0
Total					1868.40	523.80	1355.0

Table 6: Water requirements summary

IRRIGATION SCHEDULE											
Date	Day	Stage	Rain (mm)	Ks (fract.)	Eta (%)	Depl (%)	Net Irr (mm)	Deficit (mm)	Loss (mm)	Gros. Irr. (mm)	Flow (l/s/ha)
10-Jan	86	Dev	0.1	1	100	66	79.8	0	0	114.0	0.2
09-Feb	116	Mid	0.1	1	100	67	80.3	0	0	114.8	0.4
01-Mar	136	Mid	0.4	1	100	67	80.5	0	0	115.0	0.7
18-Mar	153	Mid	0.1	1	100	67	80.2	0	0	114.6	0.8
02-Apr	168	Mid	0.0	1	100	69	83.1	0	0	118.7	0.9
16-Apr	182	Mid	0.0	1	100	69	82.3	0	0	117.6	1.0
29-Apr	195	Mid	0.5	1	100	69	83.1	0	0	118.7	1.1
10-May	206	Mid	0.0	1	100	66	79.7	0	0	113.8	1.2
23-May	219	Mid	0.0	1	100	67	80.6	0	0	115.1	1.0
05-Jun	232	Mid	0.5	1	100	68	81.5	0	0	116.4	1.0
19-Jun	246	Mid	0.2	1	100	71	85.7	0	0	122.4	1.0
02-Jul	259	Mid	0.3	1	100	66	79.6	0	0	113.6	1.0
15-Jul	272	End	0.0	1	100	65	78.3	0	0	111.9	1.0
30-Jul	287	End	0.0	1	100	68	82.2	0	0	117.4	0.9
11-Aug	299	End	0.4	1	100	67	80.5	0	0	115.1	1.1
04-Sep	323	End	1.4	1	100	66	78.7	0	0	112.5	0.5
16-Oct	End	End	0	1	0	25					

SUMMARY					
Total gross irrigation:	1851.5	mm	Total rainfall :	613.5	mm
Total net irrigation:	1296.1	mm	Effective rainfall :	533.3	mm
Total irrigation losses:	0	mm	Total rain loss:	80.1	mm
Actual water use by crop:	1859.4	mm	Moist deficit at harvest:	30	mm
Potential water use by crop:	1859.4	mm	Actual irrigation requirement :	1326	mm
Efficiency irrigation schedule:	100	%	Efficiency rain :	86.9	%
Deficiency irrigation schedule:	0	%			

Weather Stations

Three weather stations were upgraded and sensors were calibrated by Campbell Scientific Inc. These sensors have not been calibrated for several years under/over-estimated weather variables. Currently, weather stations are working and ready to be linked to a Crop-Weather program of the Texas Agrilife Research Center at Corpus Christi (Figure 15).

The Crop-Weather Program for South Texas (CWP) is a web-based decision support system designed to assist agricultural research and crop managers. Mostly dedicated to cotton, CWP provides 24-hour easy access to historical and current weather data and a suite of calculators and numerical simulation tools that generate field-specific information about the crop and its environment. However, it can be used to other crops making small programming changes to the interface and main body of the program.

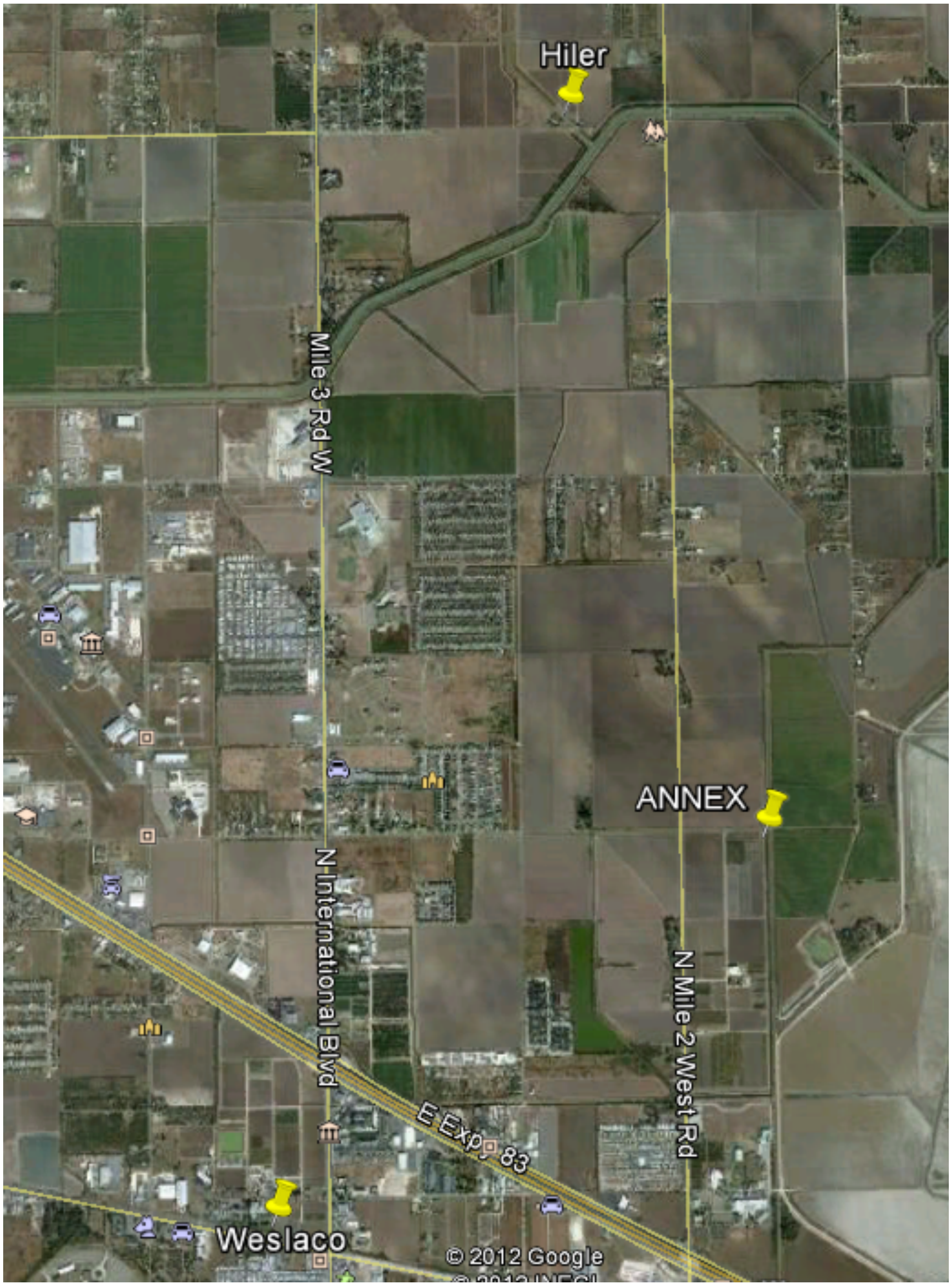

Figure 15: Location of the three updated weather stations.

Sugarcane Drip Irrigation Evaluation

Knowing the capacity of your irrigation system, or, how much water your irrigation system is capable of applying in a given time period is an important factor for irrigation system evaluation. Generally, this requires an evaluation of the irrigation system to determine the gross application rate and any losses or non-uniformities which might be occurring during application. The entire irrigation system should be in the best shape possible to achieve maximum uniformity and efficiency. A simple relationship can be used for any irrigation system to determine the gross amount of water being applied. This relationship states that the gross depth applied is equal to the flow rate of water in the irrigation system, multiplied by the total irrigation time, and divided by the area being irrigated.

Drip or trickle irrigation systems can be evaluated by using a graduated cylinder or measuring cup and measure the time it takes to catch a certain volume of water from each of several emitters throughout a system. This average system emitter flow rate can be balanced with the individual plant water requirements and the number of emitters per plant to determine the irrigation schedule.

Results of this evaluation have shown that evaluated drip irrigation system was working properly, in spite of some irregularities in several drip line (Table 7). Table 8 presents the field data for 32 emitters distributed in a sugarcane field. Volume of water in a time span was taken three times to make average.

Table 7: Results of the evaluation of the drip irrigation system

Parameter		Description
qavg	0.93	Average emitter flow rate
qstd	0.13	Emitter flow rate standard deviation
CUC (%)	86.49	Christiansen's Uniformity Coefficient
qlq	0.75	Average Low quarter emitter flow rate
AELQ	80.65	Application Efficiency of the Low quarter
qmax	1.11	Maximum Emitter Flow Rate
qmin	0.72	Minimum Emitter Flow Rate

Table 8: Drip irrigation evaluation data for sugarcane field.

SAMPLE	LOCATION	TIME (sec)	VOLUME (mL)	PRESSURE (PSI)	Flowrate $L\ h^{-1}$
1	E-1	120	35	8	1.05
2	B-1	120	37	8	1.11
3	E-2	120	35	8	1.05
4	B-2	120	35	8	1.05
5	E-3	120	35	8	1.05
6	B-3	120	35	8	1.05
7	E-4	120	30	8	0.9
8	B-4	120	30	8	0.9
9	E-5	120	30	8	0.9
10	B-5	120	30	8	0.9
11	E-6	120	32	8	0.96
12	B-6	120	32	8	0.96
13	E-7	120	25	8	0.75
14	B-7	120	27	8	0.81
15	E-8	120	24	8	0.72
16	B-8	120	24	7	0.72
17	E-9	120	24	7	0.72
18	B-9	120	24	7	0.72
19	E-10	120	35	7	1.05
20	B-10	120	37	7	1.11
21	E-11	120	35	7	1.05
22	B-11	120	35	7	1.05
23	E-12	120	35	7	1.05
24	B-12	120	35	7	1.05
25	E-13	120	30	7	0.9
26	B-13	120	30	7	0.9
27	E-14	120	30	7	0.9
28	B-14	120	30	7	0.9
29	E-15	120	32	7	0.96
30	B-15	120	32	7	0.96
31	E-16	120	25	7	0.75
32	B-16	120	27	7	0.81

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Appendix E: Professional Papers & Presentations

2011 Presentations at Professional Meetings:

1. The Economics, Finance and International Business Research Conference, Miami, FL. Dec. 9, 2011
    a. S. Nelson, M. Young, R. Hanagriff and S. Klose. An Evaluation of Flood Irrigation and Compost Use in South Texas Rio Red Grapefruit Production: Are There Economic Values?
2. 9th Annual Texas A&M System Pathways to the Doctorate Symposium, College Station, TX. Nov. 11, 2011
    a. De Leon, V., and S. Nelson. Impact of Organic Matter on Carbon Dioxide Evolution.
    b. Garcia, L., and S. Nelson. Nutrient Load Trends in Six Kleberg County Texas Streams.
    c. Vargas, D., and S. Nelson. The TAMUK Southern Live Oak Tree Survey.
    d. Field, K., G. Schuster, S. Nelson , K. Ong, and J. Woodward. Isolation of Organisms Causing Boll Rot from Feeding Insects of South Texas.
    e. Trevino, J., G. Schuster, S. Nelson, B. Bextine, and J. Munyaneza. Effects of Potato Planting Timing in Texas on Zebra Chip Incidence and Liberibacter Infection Rate in Potato Psyllids.
    f. Gomez, M., C. Simpson, S. Nelson, A. Volder, S. King, J. Melgar, and G. Schuster. Salinity Impacts on Growth and Physiology of Grafted and Non-Grafted Citrus Trees.
3. Annual Meeting of the ASA-CSSA-SSSA. Oct. 2011. San Antonio, TX
    a. Simpson, C.R., A. Volder, S.Nelson, G. Schuster, J.C. Melgar, J. Jifon, and S. King. Assessing the Impact of Salinity on Citrus Rootstocks in the Lower Rio Grande Valley.
    b. Williams, C.F., S. Castle, S.D. Nelson, and N. Prabhaker. Linking Soil Sorption to Plant Uptake of the Systemic Insecticide Imidacloprid in Viticulture.
4. Annual Meeting of the American Society of Horticultural Sciences. Sept 2011. Waikoloa, HI.
    a. S.D. Nelson, M. Young and J. Enciso. Relating On-Farm Level Irrigation Water Use to ‘Rio Red’ Grapefruit Pack-Out. HortScience 46(9):S139. (Abstr.).
5. Joint Phytopathological Society APS-IPPC meeting. Aug 2011. Honolulu, HI
    a. Tanner, J.D., M. Kunta, J.V. da Graca, M. Skaria and S.D. Nelson. Evidence of a Low Rate of American Seed Transmission of Citrus Tatter Leaf Virus in Citrus.
6. NACTA 2011 Annual Conference, June 2011, Edmonton, Alberta, Canada.
    a. S.D. Nelson, K. McCuistion, R. Stanko, and E. Louzada. The Power of Experiential Learning and Mentoring to Increased Underserved Minority Undergraduate Students into Graduate School. 2011 Abstracts: NACTA Journal. Vol. 55, Suppl. 1, No. 015, p. 8-9.
7. 65th Annual Meeting of the Subtropical Plant Science Society. Feb 9, 2011. Weslaco, TX.
    a. Esparza, M., Raygoza, J., Nelson, S.D. and Setamou, M. Effect of Soil and Foliar Calcium Sources on the Survival of Asian Citrus Psyllid. (1st place winner).
    b. Peddabhoini, N.P., Setamou, M., Saldana, R. and Nelson, S.D. Testing the Efficacy of an “Attract and Kill” Strategy for the Control of Citrus Leafminer in Texas. (3rd place winner).
    c. Nelson, S., Young, M., Enciso, J., and Peries, X. Evaluation of Compost Management in Citrus for Improved Crop Sustainability. (poster)
    d. Young, M., Nelson, S., Klose, S., and Enciso, J. Impact of Irrigation Method on Rio Red Grapefruit Pack-Out Economics.

8. 71st Annual Meeting of the Southern Region ASHS. Feb 5-8, 2011. Corpus Christi, TX.
    a. S.D. Nelson, and M. Setamou. Engaging Underserved Undergraduate Student Populations through Experiential Learning for Careers in Horticultural Sciences. HortScience 46(9):S15. (Abstr.).
    b. C.R. Simpson, S.D. Nelson, S. Cornell and M. Setamou. Evaluation of Salinity on Citrus and Watermelon Rootstock Seed Germination. (oral, 2nd place winner, PhD contest)
    c. M. Esparza, J. Raygoza, M. Setamou and S.D. Nelson. Impact of Plant Available Calcium to Reduce Asian Citrus Psyllid Survival in 'Rio Red' Grapefruit. (poster)
    d. S.D. Nelson, M. Young, M. Setamou, X. Peries and J. Enciso. Evaluation of Compost Management in Citrus for Improved Crop Sustainability. (poster)
    e. Nelson, S., Enciso, J., Peries, X., and Young, M. Water Use Efficiency and Water Savings in South Texas Grapefruit Production.

Published Newsletters:

Texas A&M University Kingsville Citrus Center Newsletter, http://kcc-weslaco.tamu.edu

Mar 2011 Evaluating Water Use and Yield from Various Irrigation Systems in Citrus Production.
S.D. Nelson, M. Young, and J. Enciso. Vol. 29. No. 1. Pg 2-3.

Farm Assistance Focus Series 2011-2, http://farmassistance.tamu.edu/

Mar 2011 Furrow vs. Surge Irrigation in Cotton Assuming Restricted Water Availability in the Lower Rio Grande Valley.
M. Young, S. Klose, and V. Reynolds.

2011 Referenced Journal Articles:

1. Nelson, S.D., L. Rock, M. Sétamou, and J. Lloyd-Reilley. June 2011. Flowering native plants able to withstand elevated abiotic salt stress. *In* (Eds. J.A. Pascual and F. Perez-Alfocea) Proceeding of the Fifth International Symposium on Seed, Transplant and Stand Establishment of Horticultural Crops. *Acta Horticulturae.* 898:103-111.
2. Nelson, S.D., M. Young, J. Enciso, S.L. Klose, and M. Setamou. 2011. Impact of irrigation method on water savings and 'Rio Red' grapefruit pack-out in South Texas. *Subtrop. Plant Sci.* 63:14-22. http://www.subplantsci.org/SPSJ/v63%202011/v63%202011.htm
3. Simpson, C.R., S.D. Nelson and H.A. Ajwa. 2011. Impact of soil texture and organic matter content on MITC volatilization from soil columns. *J. Agricultural Sci. & Techn. A* 1:194-198.
4. Williams, C.F., and S.D. Nelson. 2011. Comparison for rhodamine-WT and bromide as a tracer for elucidating internal wetland flow dynamics. *Ecological Engineering*. 37:1492-1498.
5. Nelson, S.D., C.R. Simpson, H.A. Ajwa, and C.F. Williams. 2011. Evaluating surface seals in soil columns to mitigate methyl isothiocyanate volatilization. In Integrated Pest Management and Pest Control. Intech-Open Access Publisher. ISBN: 978-953-307-926-4. (Book Chapter, Invited, accepted, in press).

Appendix F: 2011 Texas Irrigation Expo

Submitted by:
WaterPR
Sharon Mineo

Following the success of the 2010 Texas Irrigation Expo, the decision was made to hold the Expo again in 2011. The focus was expanded to encompass the general public as well as the previously identified targets – irrigation district board members and managers who can implement system-wide conservation strategies, such as lined canals and automatic gates, and producers who can implement on-farm techniques to reduce water usage. The new focus required a new format: tours were eliminated from the schedule, and the first full day of the Expo was targeted toward agriculture while the second half-day, a Saturday, was geared more to the general public. The format was designed to allow more options for all attendees.

In January 2011, venues were identified and narrowed down, and catering & AV initial budget numbers were determined. In February, a site visit was made to McAllen, the site selected by the ADI Committee, to tour the convention center, meet with staff there, and visit the Embassy Suites hotel, which had been identified as a venue of interest by committee members. WaterPR worked with the convention center staff and Tom McLemore at HID to reserve the venue and get a contract ready for signature by HID. During this time, we began updating our Valley media list, and looking into possible community outreach and advertising opportunities.

In March, the contract for the venue was finalized. We also performed other logistical updates, such as budget and task reviews. Pricing logistics were set for the sponsors, exhibitors, and lunch. Working with HID staff, we researched options for promotional items. The website was updated with the 2011 Expo info, and a "save the date" e-news blast was sent to all contacts. We also began layout of the print newsletter, and started work on posters for the Expo.

In April, we continued to follow up with the convention center as needed for venue logistics. We met regularly via conference call with the committee to discuss event plans. We procured an estimate for pipe & drape setup, and reviewed the hotel room block estimate. A possible children's activity for the Expo was identified (the Texas Farm Bureau's Mobile Learning Barn).

Promotional items and a sponsor/exhibitor brochure were finalized and delivered in time to be used at the Expo booth at Texas Water Day at the Capitol in April. Posters for the exhibit purchased by HID were created for the event as well. The posters were also designed to be printed as informational fliers to hand out about the general Expo and science contest. A press release and promotional e-mails were sent to announce the opening of sponsor, exhibitor, and general registration for the Expo, and the website was updated accordingly. A mailing list was prepped to send the brochure to last year's sponsors and exhibitors. Requests were sent to various organizations to include the Expo on their websites, calendars, and/or in member newsletters. An online general registration form was created.

A sponsor/exhibitor information packet was created and posted to the website, along with an online sponsor/exhibitor registration form. A printable version of the sponsor/exhibitor brochure was posted as well, for those not wishing to pay online.

In May, periodic check-in meetings with HID staff were initiated in order to improve communication flow. These meetings continued throughout the remaining duration of Expo planning. We continued to work on a final pipe & drape contract. A printable general registration form was posted on the website, as an alternative to online general registration.

The pop-up display design was updated for 2011, the new display ordered, brochure edits made in advance of a reprint, and event photos and other updates added to the Expo website. We researched advertising rates to develop a marketing plan for the Expo. We organized a brochure mail out to the 2010 sponsor and exhibitors as a follow up to the initial e-mails. Sponsor and exhibitor registrations were processed as they came in, and added to the tracking file. Potential presenters for the Expo were identified, and letters drafted to invite them to participate. Adjustments were made to the general agenda.

In June, the marketing timeline and advertising options were updated and reviewed. Another e-news blast was sent out to encourage sponsor and exhibitor registrations, resulting in three new exhibitors. We started exploring some options for a simple redesign of the HID newsletter. Sponsor and exhibitor registrations were processed as they came in.

In July, decisions were made about advertising to pursue for the Expo. We started pulling together a list of residential/commercial irrigators in advance of a potential brochure mailout. Web updates were made as needed.

Sponsor and exhibitor registrations were processed as they came in, and added to the tracking file. Hard copy packets were sent out to previous sponsors/exhibitors as needed, and were sent to future registrants. We continued to confirm and follow-up on speakers.

In August, updated hotel registration information was posted. The program was updated, and reception VIP invitations were sent out. Additional contacts were researched for outreach efforts. Web updates were made as needed. The HID newsletter was created and sent to HID to print and distribute. The Expo brochure was updated. Speaker follow up continued.

In September, a full meeting of the ADI group was held. The draft budget was updated, and Mobile Learning Barn confirmed. Reception VIP guest confirmation letters were mailed, and a reception invitation drafted. General registrations were processed as they came in.

Mail list updates and tracking continued. A general registration brochure was created. Advertising logistics and research continued, and advertising and story space were secured for the Irrigation Leader, plus e-banner ads for the Farmer Stockman. The website was updated, and another e-blast sent out. Sponsor/exhibitor tracking and communication continued, with materials sent out as needed.

In October, reception invitations were printed, and updated contacts sent to HID for mailing. General registration tracking continued.

The Expo was submitted to community event calendars, and an ad created for the November Irrigation Leader magazine. We reached out to radio stations about getting the event mentioned on-air, and sent information to farmers; markets around the state. We updated both the HID and Expo websites, and updated the brochures for a new print run. A banner ad was created and ran the week of October 21 in the Farmer Stockman e-newsletter; it ran again the week before the Expo. Rainwater harvesting contacts were identified, and marketing timeline was updated.

Confirmation letters were sent out to all speakers, with a form to fill out and return confirming their information.

In November, reception letters were sent to new speakers, and RSVPs tallied. General registration tracking continued. We worked closely with the convention center, caterer, and pipe and drape vendor on Expo logistics. Expo signage was drafted. A draft program for print was started. HID staffed an Expo booth at the San Antonio Farm & Ranch Show.

The second Farmer Stockman e-ad was run, outreach was sent to homeschoolers to attract families, another e-blast was sent to all contacts, a new press release was sent to outlets across the state, ads were created through the Texas Advertising Network targeting smaller newspapers, ads and interviews for KURV radio were set up.

Sponsor/exhibitor tracking and communication continued, with materials sent out as needed. Reminders were sent to all sponsors and exhibitors, with e-mail and phone follow up as needed. Potential sponsors and exhibitors were again targeted via e-mail and calls. Speaker follow up was continued with e-mails, calls, and letters, and speaker updates were tracked as materials came in. Bios were added to the website for those received.

In the first part of December, general registration and RSVP tracking continued. We worked closely with the convention center, caterer, and pipe and drape vendor on final Expo logistics. Expo signage, surveys, and programs were finalized and printed. Online registration was closed and final pre-registrant check-in list was created, along with name badges. Presentations were loaded onto the laptop. Last minute publicity tasks included final logistics for CC web and signage, radio spots, and a final pre-event e-blast. Sponsor/exhibitor reminder e-mails were sent, and tracking continued with last-minute exhibitors. Speaker reminder e-mails were sent and calls made as needed. We worked with speakers to obtain bios and presentations, and compiled bios into a script for speaker introductions.

We traveled to McAllen for three days of on-site work at the Expo, which was held December 9-10. On-site tasks included working with venue, catering, and pipe & drape vendors for setup, checking-in attendees, assisting exhibitors with move-in and move-out and speakers with audio-visual functions, and other tasks as needed.

At the VIP reception on December 8, remarks were made by special guests Carlos Pena, IWBC; L'Oreal Stepney, TCEQ; Thomas Michalewicz, US BOR; and Hon. Eddie Lucio, Jr., Texas State Senate, who presented awards to the science contest winners.

The agriculture-based program was held December 9, with a variety of speakers from the ADI project and others, including keynote speaker Deputy Commissioner Drew DeBerry of the Texas Department of Agriculture. Concurrently, TDA CEUs were offered for participants.

The Saturday program was geared more toward homeowners, with water conservation topics including rainwater harvesting and water-wise landscaping. Though poor weather conditions likely hindered attendance, those present were very engaged with the speakers.

Follow-up activities included adding walk-ins to the registration list, compiling surveys, updating the website with photos, presentations, and wrap-up, a final e-blast to direct folks to same, and thank you letters and e-mails to speakers, sponsors, and exhibitors.

The 2011 Expo counted more than 300 attendees, higher than in 2010. Although most were from Texas, 10 other states plus Mexico were represented. Respondents to the exit survey were overwhelmingly enthusiastic about the Expo, with almost all giving ratings of "very satisfied" or "satisfied" to each element cited in the survey. Comments included:

- "Everything was useful, enjoyable & beneficial about this event. The organization & topic of speakers was probably the best."
- "Excellent booths with good information; excellent speakers."
- "All the sessions were very educational."

Appendix G: February 2012 Press Release on *Catalogue of Good Practices in Water Use Efficiency*

Harlingen Irrigation District

ANNOUNCEMENT to NEWS MEDIA
For Immediate Release: February 16, 2012

Harlingen Irrigation District Touted as Global Leader for "Good Practice Projects" in Agricultural Water Efficiencies

A suite of water conservation initiatives developed and promoted by the Harlingen Irrigation District (HID) of Cameron County has been honored as one of nine global "good practice" projects included in a report presented to the World Economic Forum in Davos, Switzerland, last month.

A Catalogue of Good Practices in Water Use Efficiency, prepared by the Stockholm International Water Institute for the 2030 Water Resources Group, highlights agricultural, municipal and industrial water efficiency and conservation projects that can be replicated elsewhere. The Catalogue defines a "good practice" project as one that "demonstrably improves the efficiency or productivity of water use (through water savings and/or yield increase). It will have been implemented in the field and will have demonstrated or have the potential for transferability to other appropriate settings."

The District, which manages 52,000 acre-feet of water for irrigation use in agricultural operations in the Lower Rio Grande Valley of Texas, was recognized for its innovation and technological advances in the area of irrigation flow control and water usage measurement.

"This project has proved that proper management, regardless of the method of irrigation, actually can produce increased yields with less water," said HID General Manager Wayne Halbert. "Our results can be replicated across Texas and the entire world."

In 2004, HID was awarded a 10-year grant under the Agricultural Water Conservation Demonstration Initiative Program of the Texas Water Development Board to promote water conservation while maintaining or increasing profitability on farms. The District focused on developing a state-of-the-art water distribution network control and management system and promoting on-farm irrigation techniques in a large-scale demonstration of cost-effective technologies. The District's SCADA system (for "Supervisory Control and Data Acquisition") allows it to monitor and control processes distributed among various remote sites, facilitating communications between those sites and the central facility, and providing the necessary data to control processes. The data provided by the flow measurement devices are helping the District move to volumetric pricing of irrigation water.

– MORE –

Supporting the SCADA system are several other initiatives:

- A Flow Meter Calibration and Demonstration Facility – the first in Texas – that can simulate various options for irrigation systems, allowing for more informed decisions about irrigation techniques and, thus, water conservation. It also serves as a training center where operators can learn about pumps, automated controls, calibration of measuring tools, and water use data collection.
- Collection of on-farm flow measurement data through automatic meters installed throughout the District's 250-mile irrigation system. The meters are tied to a telemetry system that reports pumping and flows in real time.
- A demonstration of web-based information system that reports weather, real time flows, and a user accounting system.
- Design of low-cost automatic gates for irrigation canals and low-cost remote telemetry units to measure water levels and soil moisture.

HID has demonstrated it is possible to conserve water without losing money or affecting the quality of a crop. Surveys conducted in 2009 and 2010 showed that these innovative irrigation system controls and data streams achieved water savings of nearly 35 percent.

AW Blair Engineering, Texas AgriLife Extension Services, and Texas A&M University Kingsville provide consulting services for the various projects. Additional funding has been provided by U.S. Bureau of Reclamation, the North American Development Bank, and by the District along with its consulting partners, Delta Lake Irrigation District, Netafim and USDA-EQIP.

HID was honored with a Texas Environmental Excellence Award in 2011 for its water conservation initiatives.

The *Catalogue of Good Practices in Water Use Efficiency* is available on the District's website at http://www.hidcc1.org/node/16.

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