On-Farm Water Measurement in LCRA's Garwood Irrigation Division

Final Report for TWDB Grant Contract 0903580955

August 2012

Stacy Pandey, Water Conservation Coordinator, Sr.
Lower Colorado River Authority

On-Farm Water Measurement in LCRA's Garwood Irrigation Division

Final Report for TWDB Grant Contract 0903580955

August 2012

Stacy Pandey, Water Conservation Coordinator, Sr.
Lower Colorado River Authority

Table of Contents

LIST OF TABLES

LIST OF FIGURES

Executive Summary

The Garwood Irrigation Division has the most senior water right in the lower Colorado River basin, and water use in the Garwood system accounts for about 17 percent of total Lower Colorado River Authority (LCRA) water use throughout the basin in a dry year. These factors make this irrigation division a critical area for LCRA to concentrate agricultural water conservation program funds to improve water use efficiency within the Garwood canal system. The Garwood measurement project had three goals, 1) to improve water management within the system, 2) improve the ability to track water loss and verify savings from other conservation programs, and 3) to implement billing based on water use.

As a result of this project , more than 400 standardized water delivery and flow management structures were installed in the Garwood canal system. The Garwood measurement project also increased the mileage of new canals that are managed by LCRA by 80 percent, almost doubling the area of the Garwood canal system managed by LCRA instead of individual landowners. Of the 139 miles of new canals that are now managed by LCRA, 85 miles have been cleaned or rehabilitated through this project. Installation of 35 walk bridges and measurement piers at every delivery structure allow staff to collect accurate daily water measurements.

Volumetric pricing was implemented in the 2012 irrigation season after two test seasons of daily water measurement throughout the Garwood canal system. Irrigation contract holders in Garwood are now billed based on a combination of a base acreage rate and an additional fee for the volume of water delivered, similar to the rate structures that have been in place in LCRA's other two irrigation divisions since the early 1990s. The project also included customer communication such as bi-weekly water use reports to irrigation contract holders, farmer advisory committee meetings, and implementation of a conservation monitoring program.

The revised estimated project savings of between 4,900 and 5,600 acre-feet per year is almost 2,000 acre-feet higher than estimated savings of 3,400 acre-feet in the original proposal. It will take several years of data to establish a consistent and reliable savings figure. However, based on regression methods, there already appears to be a substantial statistically significant difference between predicted and actual use that is likely due primarily to this project.

The Garwood measurement project has been a successful and timely project in many ways despite substantial potential barriers to success. The construction phase of the project was completed on time and under budget even though the miles of canals that needed to be cleaned were under-estimated by almost 30 percent, and it was not possible to hire an additional staff person to assist with daily measurement. The implementation of volumetric pricing was completed one year ahead of schedule, in spite of increased scrutiny of agricultural irrigation water use and the complete curtailment of water use in LCRA's other two irrigation divisions due to an historic drought. It will take several years to realize the benefits of using on-farm water use information to verify savings from other conservation programs that have been implemented in the Garwood Irrigation Division, such as precision land leveling. However, provisional 2011 on-farm water use data suggest that the canal system is almost as efficient as the Lakeside Irrigation Division canal system, which experiences approximately 20 percent water loss.

1 Introduction

The Garwood Irrigation Division, which was acquired by the Lower Colorado River Authority (LCRA) in 1998, is located in Colorado and Wharton Counties (see Figure 1). As part of the 1998 water rights purchase agreement, LCRA agreed to make up to 100,000 acre-feet of water available to Garwood customers. The water right associated with this irrigation division is the most senior water right in the lower Colorado River Basin with a priority date of Nov. 1, 1900. This water right is currently used solely for agricultural purposes, but municipal and industrial use is allowed from the existing water right.

The Garwood Irrigation Division has a service area of 90,000 acres and 175 miles of managed canals. The major crop is rice. This project added another 140 miles of canals to the system. Prior to project implementation, on-farm water deliveries were not measured. Only the main canals were managed by LCRA, and billing for Garwood water contracts with farmers was based on acreage alone. Existing Garwood delivery structures in the original canal section were already standardized and efficient, consisting of cast iron screw gates attached to concrete pipes; however, delivery points throughout the rest of the service area were not standardized and varied greatly.

In 2011, more than 18,500 acres of rice was planted, and approximately 14,500 acres of that was irrigated for a second crop. The Garwood Division signed 65 rice water delivery contracts in 2011. Total diversions for the Garwood Irrigation Division have ranged from 46,000 acre-feet per year to 117,000 acre-feet per year in the last 10 years. Water use in the Garwood Irrigation Division accounts for about 17 percent of total LCRA water use throughout the basin in a dry year. Since the water use in Garwood is a substantial portion of LCRA's total use, particularly in a drought due to its senior water right, it is a critical area for LCRA to concentrate agricultural water conservation program funds to improve water use efficiency.

1.1 Project Objectives

The Garwood measurement project had three goals, 1) to improve water management within the system, 2) improve the ability to track water loss and verify savings from other conservation programs, and 3) to implement billing based on water use. On-farm measurement at individual turnout structures in the Garwood Irrigation Division allows LCRA to calculate system water loss based on comparing river diversions to on-farm use. Additional check structures have improved water management by allowing staff to control canal levels more precisely, resulting in a more direct correlation between demand and supply. Volumetric billing gives customers an incentive to conserve by changing the current billing systems from the existing flat rate per acre structure to one that is based on a combination of a base acreage rate plus an additional fee for the volume of water delivered.

2 Scope of Work

2.1 Project Overview

In the proposal for this project, LCRA planned to add an additional 303 water measurement structures (delivery structures) and 128 check structures to existing canals and field laterals of the Garwood Irrigation Division. Additionally, the proposal included rehabilitation of 60 miles of canals. The project also included stakeholder/customer communication, and implementation

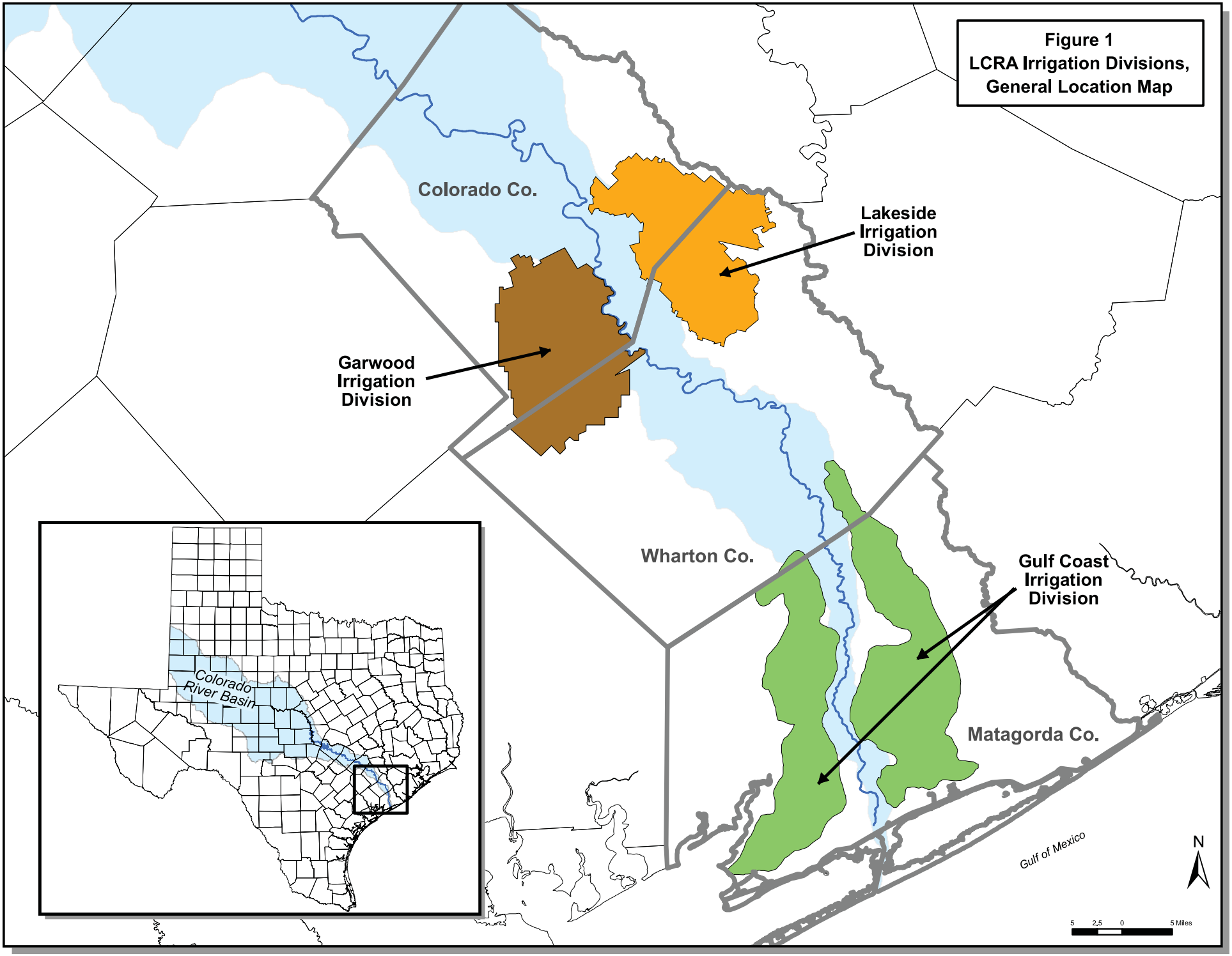


Figure 1
LCRA Irrigation Divisions,
General Location Map
Colorado Co.
Lakeside
Irrigation
Division
Garwood
Irrigation
Division
Wharton Co.
Gulf Coast
Irrigation
Division
Matagorda Co.
Gulf of Mexico
Colorado
River Basin
N
5 2.5 0 5 Miles

of a conservation monitoring program. As a result of the project, water contracts in the Garwood Division changed from the existing flat rate per acre structure to one that is based on a combination of a base acreage rate plus an additional fee for the volume of water delivered. The water savings from this project is estimated to be 3,400 acre-feet per year or a 4 percent reduction in Garwood's average annual water diversion.

2.2 Project Methods

2.2.1 Measurement Methodology

LCRA began using its current water measurement methodology in the Lakeside and Gulf Coast Irrigation Divisions in the early 1990s. The accuracy of this methodology was independently certified by the U.S. Bureau of Reclamation (USBR). Staff has experimented with using propeller flow meters on turf farms in the Gulf Coast Division and has found them to be unreliable due to large amounts of vegetation in the canal. Other types of meters appropriate for surface water flows are prohibitively expensive to install on each delivery turnout.

LCRA water coordinators measure flow at each turnout daily in Garwood using the current methodology in place in the other two LCRA irrigation divisions. Flow rates are determined by recording the size of the delivery structure opening and the height of the water on both sides of the canal structure to the nearest one-hundredth of a foot. Water coordinators use portable velocity probe flow meters to determine the rate of flow at pipe turnouts. These meters take instantaneous readings averaged over a 30 second to 1 minute timeframe and are able to measure water velocity as slow as 0.1 feet per second, reducing issues with accurate measurements at turnouts with slow flow. These meters are sent to the vendor annually for calibration testing and maintenance. LCRA receives a certificate for each meter to ensure that calibration tests were performed. This data is entered into a water accounting database, which includes information about the location, dimensions and type of each structure and automatically calculates daily flow and water volume delivered to each field. This information is sent to customers at least once a month. The irrigation divisions recently upgraded to new billing software, which replicates the functions of the original system in an updated platform, replacing old input screens with web-based forms.

2.2.2 Structural Components

Irrigation Division staff rode the entire canal system in the fall of 2008 to determine which intake structures were inadequate for accurate measurement. The locations of these structures were digitized in GIS. An updated map of the structures that have been installed as a part of this project is presented in Figure 2. Figure 3 shows a particular section of the South Canal in detail. Table 1 in the Appendix shows a list of all structures that have been installed. The number of proposed check structures was determined by the basic principle that one check structure would be needed for every quarter mile of canal, but many fewer check structure risers were needed (see following paragraphs).

Delivery Structures

Aluminum slide gates were used for the new delivery structures. They were attached to a high-density polyethylene (HDPE) plastic corrugated pipe with a smooth inside liner. Structure size

varies between 15-inch, 18-inch and 24-inch gates. The Irrigation Coordinator lifts the slide gate handle to desired opening and measures flow using a global flow probe meter on the downstream end of the HDPE pipe. A 10-foot by 20-inch wide measurement pier was built out of treated lumber to access each delivery structure. After the first season of water measurement testing in 2010, LCRA staff determined that 18-inch gates would be more efficient to operate than 15-inch gates in many of the locations originally planned to have 15-inch gates. Additionally, staff determined that a less expensive gate than originally planned would work.

Check Structures

Aluminum flash board risers were planned as check structures. However, following stakeholder meetings with customers and operational experience in the first season of water measurement testing in 2010, staff determined that the large aluminum slide gates used as delivery structures would work better as check structures. Both structures provide a similar function and are installed in the center of the canals to raise or lower the water levels and maintain a uniform water surface in the canal.

Several aluminum check structure were installed in 2010. This structure is attached to an HDPE poly plastic corrugated pipe. Structure sizes vary between 42-inch and 48-inch widths, 36-inch and 48-inch heights, and attach to either an 18-inch or a 24-inch HDPE poly plastic corrugated pipe. Two-by-six tongue and groove boards are placed inside the aluminum channels on the upstream side of the structure. The water level in the canal is controlled by the number of boards placed in the channels. Water flows are measured using a portable global flow probe meter on the downstream side of the HDPE pipe.

Walk Bridges

The original project budget included prefabricated aluminum walk bridges that would be installed over canals on an as needed basis. A preliminary site survey identified 65 areas where a walk bridge could be needed. Only 30 bridges ended up being needed, and the cost of those bridges was cut more than 50 percent during the construction phase by building the bridges in-house out of treated lumber. There will be some additional maintenance required long-term but the cost savings outweighs the future maintenance cost.

2.2.3 Project Action Plan

The project was organized into the following four phases:

Task 1 – Construction and Education. The initial construction phase included procurement of the materials, Garwood Division staff training and electronic data entry into LCRA's billing software, the Water Application Management System (WAMS). It also included development of a base GIS map of the Garwood Division with proposed structures (completed for project proposal) and identification of sites ready for construction in the fall and winter before the 2010 irrigation season. Stakeholder communication with existing farmer advisory panels was initiated.

Task 2 – Testing and Reporting. Installation of delivery structures and rehabilitation of canals proceeded ahead of schedule, allowing measurement of all structures in production during the 2010 crop season. Structures constructed in Phase 1 were operated in a trial mode, and water delivery data was reported to farmers. Based on operational experience delivering water to all structures in 2010, staff decided to install larger delivery gates and fewer check structures than originally planned.

Task 3 – Construction and Implementation. This phase of construction lasted two seasons. In the fall and winter before the 2011 irrigation season and the fall and winter before the 2012 irrigation season, remaining sites to be retrofitted with new structures were identified and structures installed. Canal laterals delivering water to those structures were rehabilitated. Operational results from Phase 2 were incorporated into operating procedures for tracking water delivery, making 2011 water measurement data more reliable than 2010 data. Water delivery data was reported to farmers on a bi-weekly basis.

Task 4 - Operations and Maintenance. Based on testing and reporting during the 2010 and 2011 irrigation seasons, staff was able to implement volumetric billing of the Garwood water delivery system 2012. All contracts for the 2012 crop year were based on volumetric billing. The GIS data set was updated in the summer of 2012. Analysis of water use data to calculate water conservation performance metrics will begin in the fall and winter of 2012 with the completion of the 2012 irrigation season since 2010 and 2011 data was provisional.

3 Project Results

3.1 Structural Components

Table 3-1 shows the number of structures that have been installed in each section of the canal since the beginning of the project in 2009. Of the 431 structures planned in the original 2009 budget, 416 have been installed. This lower number reflects a revised strategy of managing water flow with additional delivery structures that can function as check structures. Additionally, the number of walk bridges needed was reduced from an original estimate of 65 to 36. Walk bridges, and structure numbers were also decreased due to land leveling work that allowed customers to use permanent perimeter levees around the inside of fields as access roads. This gave irrigation coordinators better access to the delivery points. This reduction in walk bridges needed and the lower cost of the slide gates used to function as check structures is also reflected in the budget where almost $400,000 was budgeted for materials but just under $265,000 was spent for materials. Figure 2 shows the locations of the new structures that have been installed in the Garwood Canal System.

Miles
0 0.5 1 2
N
Colorado Co.
Wharton Co.
COUNTY ROAD 182
COUNTY ROAD 153
COUNTY ROAD 153
COUNTY ROAD 106
COUNTY ROAD 108
COUNTY ROAD 111
CRANEK
COUNTY ROAD 209
COUNTY ROAD 147
OLD BOENISCH
COUNTY ROAD 109
COUNTY ROAD 116
ROMAN
CEDER POST RANCH
COUNTY ROAD 112
FM ROAD 1693
FM 950
MAIN
LIONS PARK
MANSFIELD
GOLD
FM ROAD 113
COUNTY ROAD 109
COUNTY ROAD 237
COUNTY ROAD 243
FM ROAD 122
COUNTY ROAD 122
COUNTY ROAD 121
FM ROAD 533
COUNTY ROAD 113
OLD NRDA
COUNTY ROAD 115
COUNTY ROAD 121
COUNTY ROAD 116
STATE HWY 71
COUNTY ROAD 110
COUNTY ROAD 114
COUNTY ROAD 378
COUNTY ROAD 373
COUNTY ROAD 375
COUNTY ROAD 377
COUNTY ROAD 217
COUNTY ROAD 396
COUNTY ROAD 383
COUNTY ROAD 379
COUNTY ROAD 389
COUNTY ROAD 381
COUNTY ROAD 394
FM ROAD 25

Legend

New Structures by Canal Section
- New Walk Bridges
- Relift
- South
- West

Canals
- New LCRA managed canal segments
- Relift, South and West

Figure 2
Garwood Irrigation Canal System
Structures Installed 2009-2012

Map Document: (V:\WaterCo\Project\Irrigation\irrigation_districts\Garwood\Garwood_structures_GRANT_REPORT.mxd)
7_12 – 7:24:37 AM

Table 3-1. Planned and installed measurement structures and walk bridges in each section of the Garwood Canal System.

Canal System	Measurement Structures						
	Planned Measurement Structures	Planned Check Structures	Installed 2010	Installed 2011	Installed 2012	Walk Bridges Installed	Total Installed
Relift Canal	47	22	23	42	41	6	106
West Canal	145	58	47	103	46	9	196
South Canal	111	48	32	56	26	21	114
Total	303	128	102	201	113	36	416

3.2 Canal Rehabilitation

Figure 2 also shows the Garwood canal segments LCRA is now managing as a result of this project. The Garwood measurement project increased the mileage of new canals that are managed by LCRA by 80 percent, almost doubling the managed area of the Garwood canal system. Those canals were managed by individual landowners prior to project implementation. Of the 139 miles of new canals that are now managed by LCRA, 85 miles have been cleaned or rehabilitated through this project. This represents 25 additional miles of cleaning that was not anticipated; therefore the labor budget was substantially higher than expected. Some additional canal laterals were not originally anticipated to be used because they were fields that have been out of production for 15-20 years. These fields have been put back in production to meet criteria required to grow organic rice (at least five years of no chemical use). Also, several land tracts were sold or divided, splitting the original field between more than one customer, which requires additional measurement points farther away from the original end of the LCRA managed canal segment. All of the excavator work was done by LCRA staff, and the total project was completed under budget for approximately $930,000. Fortunately, the dry weather created ideal conditions for canal cleaning. In a wet year, rain water would have to be pumped out of the canals to complete the earth moving work, and significant time/scheduling delays would have been caused by waiting for canals to dry out to complete the work. This could increase labor and equipment rental costs by 25 percent. .

3.3 Volumetric Pricing

In the 2012 irrigation season, irrigation contract holders in Garwood were billed based on a combination of a base acreage rate and an additional fee for the volume of water delivered, similar to the rate structures that have been in place in LCRA's Lakeside and Gulf Coast Divisions since the early 1990s. In the original proposal, volumetric billing was planned for 2013, so it was implemented one year ahead of schedule. Staff also educated customers by delivering bi-weekly water use reports throughout the 2010 and 2011 irrigation seasons and consulted with individual landowners as needed to work through issues. As a result, the measurement methodology was refined in 2011, and staff felt comfortable going ahead with volumetric based billing in 2012.

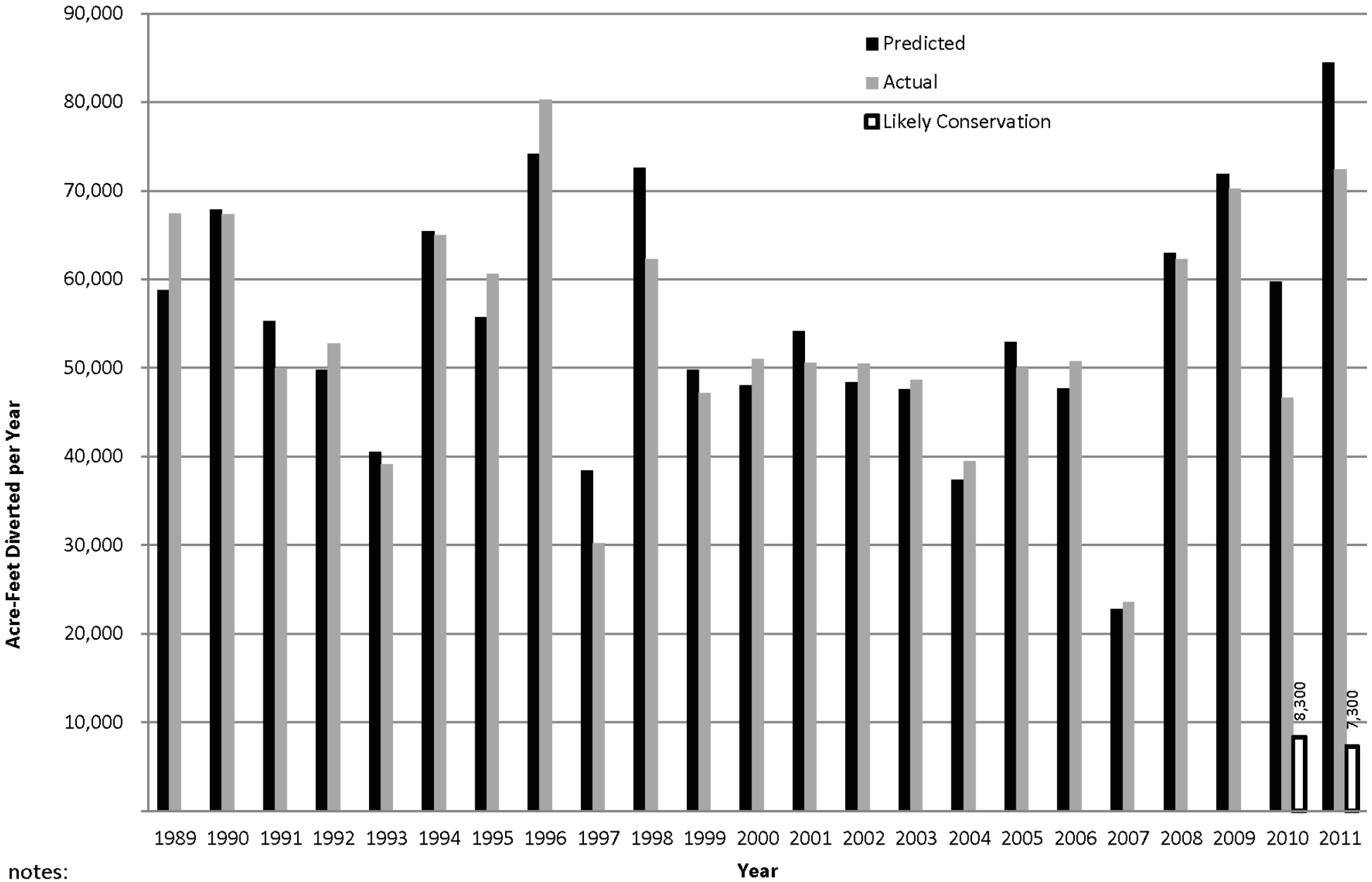
In addition, in 2013, irrigation division staff plans to implement the same two-tier, high-use surcharge pricing structure that was implemented in Lakeside and Gulf Coast in 2010. This surcharge structure allows LCRA to charge up to three times the regular rate for the highest use tier. This will provide even more incentive for customers to use their water efficiently.

Volumetric pricing and modifications to the way LCRA manages the Garwood canal system to enable volumetric measurement also effectively eliminated the use of feeder streams used to maintain water levels in a field by establishing an on/off method. Using this method, a customer takes a sizable stream in a field for a shorter period of time (three to five days), and then the water is turned off for three to five days. The water is managed and distributed throughout the system daily. This procedure results in less water being lost to evaporation.

3.4 Water Savings

In the original project proposal, staff estimated that the amount of water conserved through this project would be approximately 3,400 acre-feet per year. This estimate was based on a comparison between the Lakeside Division water use per acre after water measurement began and volumetric billing was implemented in 1993 and average historical Garwood Division water use per acre. The original project proposal also noted that Irrigation Division staff believed that actual savings would be substantially greater than the calculated estimate stated in the previous section due to wasteful water management practices observed in Garwood.

Figure 3 shows that the results of a regression analysis comparing predicted versus actual use in Garwood, taking weather variability into account. Provisional data available for 2010 and 2011 indicate savings between 7,300 and 8,300 acre-feet likely attributable to conservation measures implemented in Garwood during that time period. This includes a substantial amount of precision land leveling. The estimated savings for land leveling in Garwood for 2010 and 2011 is approximately 2,400 and 2,700 acre-feet a year. Therefore, at least 4,900 and 5,600 acre-feet per year of savings in 2010 and 2011 respectively is likely attributable to the Garwood measurement project, which is the only other known active conservation project in the Garwood Irrigation Division. As indicated previously, this data is provisional and Irrigation Division staff emphasized that 2011 was a test year so water measurement was not completely reliable.



notes:
2011 Climate data is provisional
Volumentric measurement started in 2010

Figure 3 **Actual versus Predicted First Crop Diversions in the Garwood Irrigation Division using Regression Methods**

4 Conclusions

The Garwood measurement project has been a successful and timely project in many ways, even though there were substantial potential barriers to success. The construction phase of the project was completed on time and under budget even though the miles of canals that needed to be cleaned were under-estimated by almost 30 percent, and it was not possible to hire an additional staff person to assist with daily measurement. It was a significant effort to bring all canals up to the LCRA standards needed to take accurate daily measurements of the entire canal system. Before this project began, many canal laterals and delivery structures were in poor shape and improperly sized to deliver water in a timely fashion to adjoining fields. In a few cases, the time to fill a field decreased from 10 days to less than one day. The original proposal included an additional staff member in the Garwood Division to take on the additional labor required for daily measurement of all delivery structures during the irrigation season, but creative shifting of resources and schedules, utilizing Lakeside Irrigation Division irrigation coordinators as well as existing Garwood Irrigation Division staff, avoided the need for hiring additional staff.

The operations and maintenance phase of the project to implement volumetric pricing was completed one year ahead of schedule during the middle of a historic drought. This shift to volumetric pricing could not have come at a more critical time given the scrutiny of agricultural irrigation water use following the severe drought in 2011 and the subsequent curtailment of irrigation water use for rice farming in LCRA's two other irrigation divisions. The successful and smooth implementation of volumetric pricing is a testament to the experience of Irrigation Division staff. It was a substantial effort to install all delivery structures needed to take control of and measure all water use in 2010, but necessary to alleviate perceived equity issues among irrigation contract holders if only limited sections of the system were measured during test years. Irrigation Division staff worked closely with individual land owners to gain their acceptance of and confidence in an entirely different way of operating the canal system, effectively eliminating the use of feeder streams by establishing an on/off watering schedule for each field.

The revised estimated savings of between 4,900 and 5,600 acre-feet per year is around 2,000 acre-feet higher than estimated savings of 3,400 acre-feet in the original proposal, and is probably conservative. It will take several years of data to establish a consistent and reliable savings figure, but it is encouraging that there appears to be a substantial statistically significant difference between predicted and actual use that is likely due primarily to this project.

The Garwood measurement project had three goals, to implement billing based on water use, to improve water management within the system and to improve the ability to track water loss and verify savings from other conservation programs through the use of on-farm water use data. The first goal has clearly been achieved following the commencement of volumetric pricing in 2012. Preliminary regression analysis results, provisional on-farm water use data indicating an approximate system-wide water loss of 20 percent (similar to the Lakeside Irrigation Division), and anecdotal staff experience all suggest that the second goal has been achieved. Collection of reliable on-farm measurement data in 2012 indicates that the last goal has been reached, although it will take several years to realize the benefits of using that information to verify savings from

other conservation programs, such as precision land leveling, that have been implemented in the Garwood Irrigation Division.

5 Acknowledgments

The successful completion of this project would not have been possible without the hard work of many LCRA staff, particularly the entire staff at the Garwood Irrigation Division with the assistance of many Lakeside Irrigation Division staff under the leadership of Randy Epps, Irrigation Operations Superintendent. When conservation staff was developing the HB 1437 short-term strategy report update for 2009-2014, irrigation division staff made the case to prioritize this project above others. Creation of the maps in GIS would not have been possible without Sandy MacMurtrie's assistance and Jerome Emmel's work coordinating the gathering of structure information. John McLeod, who was the initial project manager, helped write the grant proposal and set the framework for the project structure and reporting. John Hudec and David Smith both assisted as project managers. Shauna LaFrance took care of the overall project accounting and financial reporting to TWDB.

The following irrigation division staff members assisted with construction activities, water measurement or structure mapping: Brandon Mathis and Jeff Wied (crew leaders), Jerome Emmel (Planner/Scheduler), Tony Brown, Pat Korenek, James Till, Walter Weaver (Garwood Irrigation Coordinators), Mike Kasper and Steve Navarro (Equipment Operators), Greg Contreras, Tim Jones, Alex Ramirez, and Chad Sunderman (Lakeside Irrigation Coordinators), and Larry Harbers (Senior Technician).