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The use of GIS as a Real Time Decision Support System for Irrigation Districts

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Texas Water Resources Institute
make every drop count

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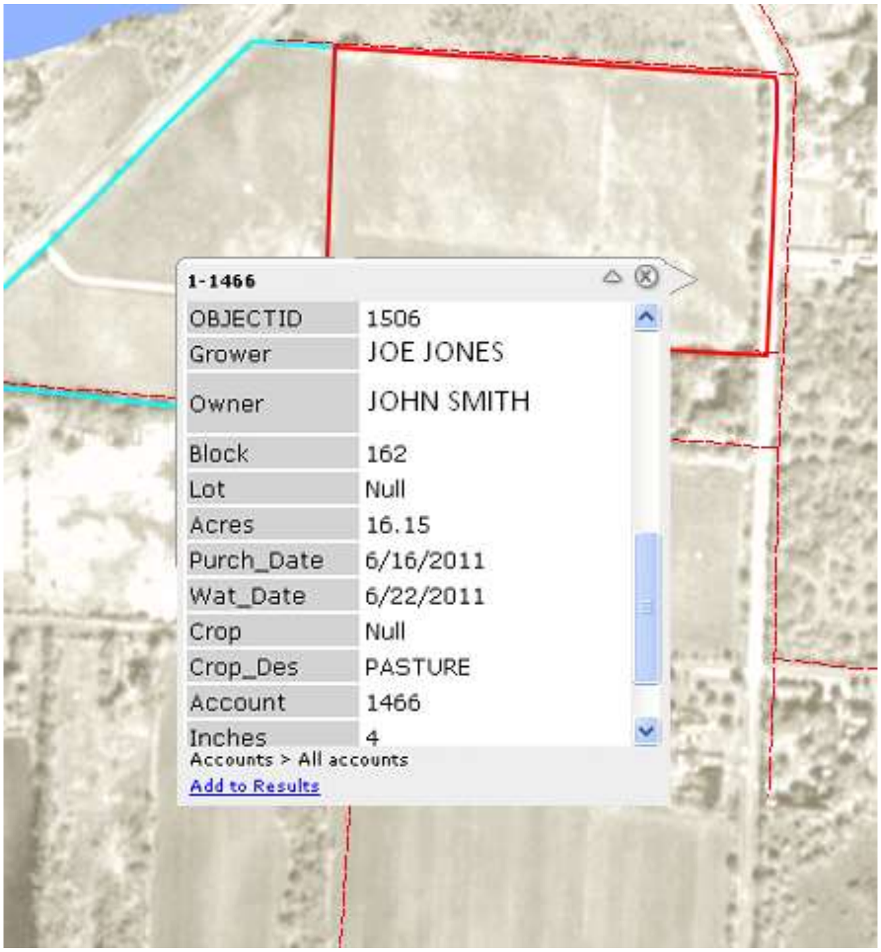

Rio Grande Basin Initiative
Irrigation Technology Program
Texas A&M AgriLife Extension Service

USE OF GIS AS A REAL TIME DECISION SUPPORT SYSTEM FOR IRRIGATION DISTRICTS

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EXECUTIVE SUMMARY

Most irrigation districts use GIS primarily for simple organization of spatial data. GIS is often put on a lower priority and managed by part-time personnel, which leads to datasets being out-of-date and disconnected from the water daily management. An effective use of GIS is integration with district operations as a real time decision support system.

In 2009 we started to develop a GIS tool that would work as real time decision support system for irrigation districts in the region of Texas along the Mexican border. We started collaborating with the Brownsville Irrigation District in 2009, and with the Cameron County Irrigation District #2 in 2010.

The objectives were to provide the districts with a simple tool that would improve the availability of pumps and gates data from the existing SCADA system, improve the management of water orders, and allow access of data by account holders through the internet. An important component of the project was to interact and train District personnel. The final product of the project is a website, where pump and gates operations and water orders information are displayed in real-time, along with links to related historical data and other information.

The on-line tool has three main components: 1) possibility to query real time and historic data from a new reorganized database created in our server; 2) status maps for display in real time of selected spatial information and alarms; 3) interactive maps for display of desired spatial information in real time and query historic spatial information. The main meaning of the status maps is to enable a friendlier and quicker access to the frequently used data. SCADA data include On/Off, current flow, upstream and downstream water level, and gate position. Water account data include pending orders, payment delinquents, and water balances.

One problem we faced in this project was to automatically transferring data to our server. The issue was solved by writing a specific code (SshSendFile.msi protocol) which bypasses the firewall protecting the TAMU server. Another issue was to involve of existing IT contractors in the project, as suggested by district managers. At the end this involvement resulted beneficial not only in terms of knowledge and future collaboration, but also in terms of minimizing any impediment to the current organization of the system. For example, it was helpful having contractors to set up of additional users and passwords, and to help deciding the best time of the day to extract and transfer files in case that the computer would be switched off at night.

The activity resulted in an expanded interest on the use of GIS as a real time decision support system by district personnel, the identification of solutions for limits in the existing database, and recommendations for further improvement. District managers adopted most of the new proposed strategies, promptly complied with many recommendations, and suggested further steps. Other districts showed interest to collaborate to set up similar projects.

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INTRODUCTION

Irrigation districts in Texas are aware that more is to be done in terms of efficiency and data management, and that GIS can be a useful tool. SCADA systems and online information are more being used and linked to GIS (Fipps and Leigh, 1998, Fipps and Leigh, 2003, Bonaiti and Fipps, 2010). The integration of these tools, though, is hardly achieved, and security is an issue when sensitive data are to be displayed online.

We are currently assisting several irrigation districts in the Lower Rio Grande River, which use GIS software and have detailed information on pumps and gates remote operations (SCADA) and water accounts, with the objective to improve the efficiency of daily water management. In this paper we present the studies of two districts that begun in 2009 and 2010. GIS was integrated to daily SCADA and water accounting information, and linked to the district website.

We present the activity carried out as follows:

1. Analysis of the current district database management, with final list of identified problems and recommended changes
2. Set-up of a Web GIS Pilot Project to improve data management and availability through the internet
3. Response from districts

STUDY AREA

The project was carried out in two irrigation districts in the Lower Rio Grande Valley: Brownsville Irrigation District (BID) and Cameron County Irrigation District No.2 (CCID2). The BID project started in 2009. This district is one of the smallest among the 28 irrigation districts in the Lower Rio Grande Valley (**Fig. 1**). The irrigated area is about 4,200 acres. The typical irrigation method is by flood irrigation, and the most common irrigated crops are soybean, grain, cabbage, orchard, corn, cotton, and pasture. Water is pumped from the Rio Grande River, and delivered to the fields by means of 9 re-lift pumps, 5 automated gates, and 129 miles of pipelines network under low pressure. Water is stored in resacas[1], which have a total surface of about 1 square mile (**Fig. 2**).

The CCID2 project started in 2010. This district is one of the biggest districts in the Lower Rio Grande Valley (Fig. 1). The district provides municipal water for San Benito, Rio Hondo and East Rio Hondo Water Supply Corporation (WSC), American Electric Power/Central Power and Light Company (AEP/CPL), and over 57,000 acres of irrigated farmland. Typical irrigated crops are sugarcane, cotton, corn, grain, pasture, and citrus, which are irrigated mostly with a flood irrigation method. The delivery network includes several resacas[1], with a total surface of about 1.4 square miles, a 3.2-sq miles reservoir,

[1] An area of river bed that is flooded in periods of high water; an artificial reservoir (Dictionary of American Regional English, 2011. [online] URL: http://dare.wisc.edu/?q=node/144)

106 miles of pipelines, 192 miles of open canals (mostly unlined), one pump on the Rio Grande, 15 re-lift pumps, and 10 automated gates **(Fig. 3**).

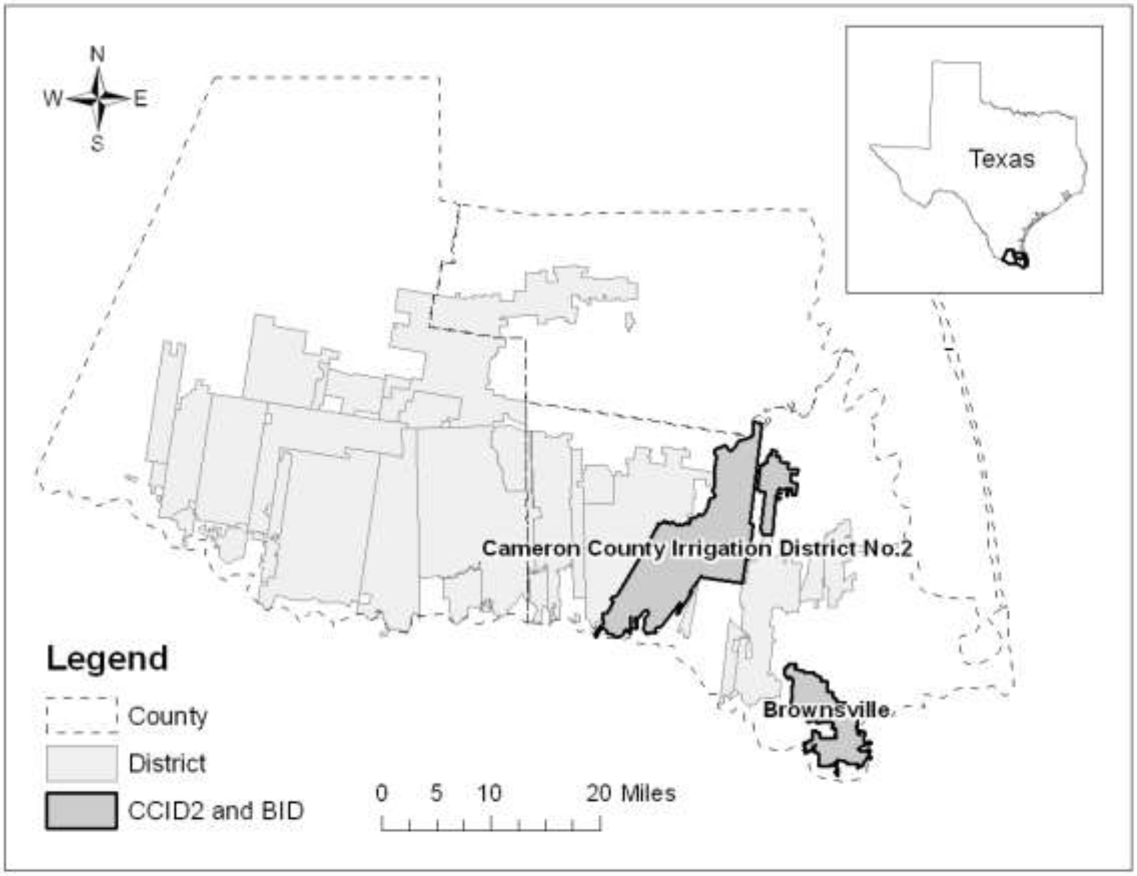


Figure 1. Brownsville Irrigation District (BID) and Cameron County Irrigation District No.2 (CCID2)

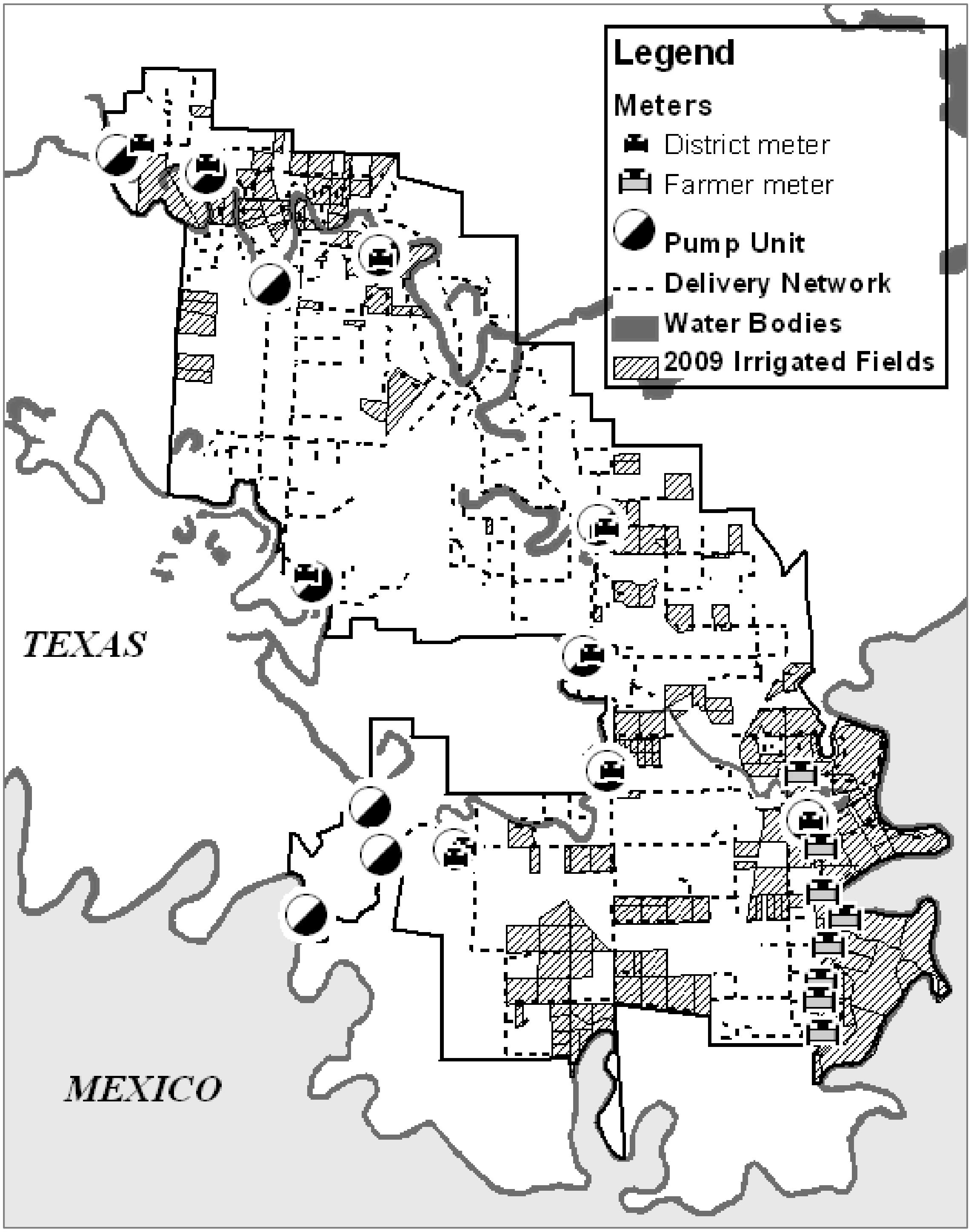


Figure 2. Pump stations and delivery network in BID.

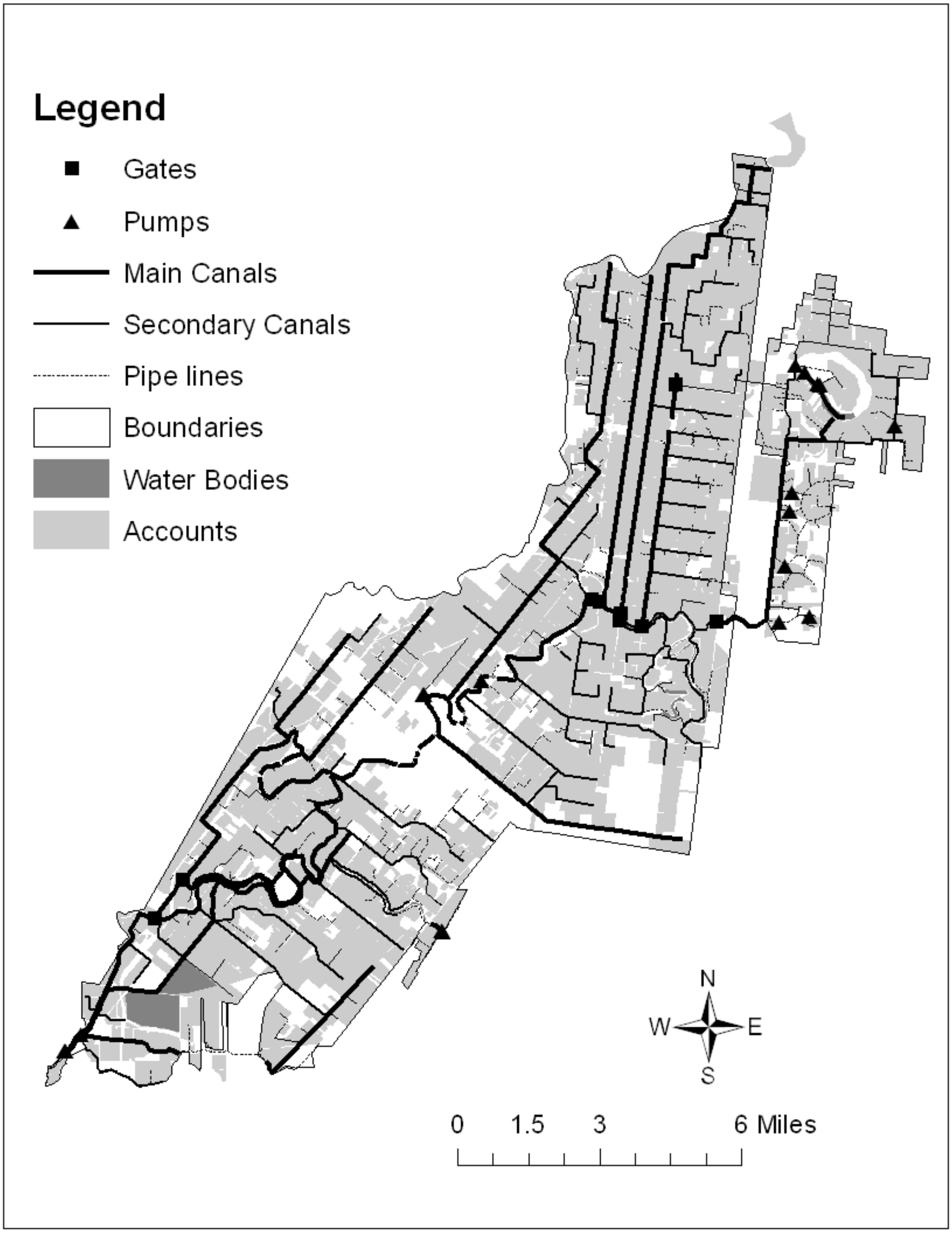


Figure 3. Delivery network and water accounts in the CCID2

PROJECT ACTIVITIES

Database analysis and recommendations

We examined the district's internal computer network to ascertain if and how computers are interconnected, how data is stored, what software is used for data acquisition and management, and what level of training does district personnel receive on the use of computer systems and associated software. Data recorded at the district office were identified, along with storage and use details. We also determined what type of information district personnel considered the most useful and what improvements were desirable. A detailed description of the analysis is reported in this chapter for both BID and CCID2, together with a summary of common problems and recommended changes identified for both districts.

Brownsville Irrigation District (BID)

The District's pumps and automated gates are equipped with remote terminal units (RTUs), and are operated remotely with a SCADA software, which is installed on a personal computer (PC1) disconnected from the internal network (Fig. 4). The SCADA unit polls the RTUs for water level in canals/resacas, equipment status (On/Off), flow rate, and cumulated flow.

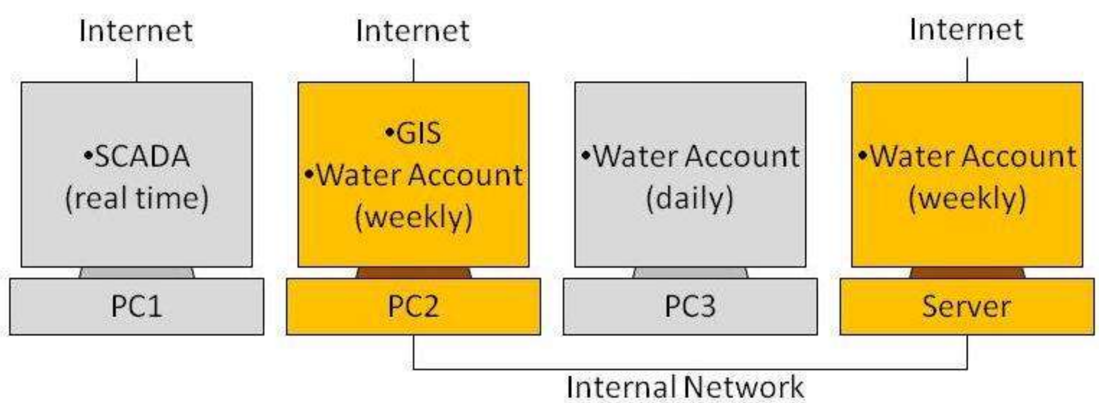


Figure 4. Scheme of gates, pumps and water orders database management communication in BID. Internal communication is missing between some sources of data (grey computers).

Water account information is stored in a server, and was is updated from a personal computer (PC2) with a database management software (FilePRO). In 2011 the district moved from FilePRO to a Microsoft Windows Access database. The District manages water orders by selling “water tickets,” which specify detailed information such as date of purchase and delivery, amount of water sold and delivered, name of land owner and grower, crop. Water volumes are estimated with the use of manual meters’ readings. The water accounts database is not updated in a timely manner, particularly the dates of order and delivery. Some water ticket information for a few of the largest farms is kept more current on a third computer (PC3).

GIS is mainly used to create maps representing total yearly water sales, and distribution network features. The GIS database is also managed and stored on PC2, and updates are added on an almost yearly base.

The most evident problem relatively to database management is a missing communication link between different sources of data. Internet access is, nevertheless, ensured to three out of four computers. Another important problem is that some modifications to database settings (e.g. output data formatting) can only be done by contractors, which leads to a strong dependency on the contractor and ties the hands of the District staff. A list of problems and recommended changes were compiled (Table 1) for the District, some of which were addressed before the end of the project, as it will be described in this chapter.

Table 1. Identified problems and recommended changes for BID.

	Problems	Suggestions
SCADA	1) District personnel do not know how to access stored data	Convert output into a text file format with the desired frequency
	2) No communication with the internal network	Connect to the internal network
Water account	3) Output data are in an encrypted format	Add routine that converts output in a text file format, or move to a different database product
	4) Update of water tickets is done weekly	Update water tickets information daily
	5) Irrigated fields (“locations”) are missing in the water account database	Add “location,” ensuring the use of the same code as in the GIS database.
	6) Daily updates of water sales are recorded in a standalone computer (no connection to the internal network)	Record data in the water account computer (PC2)
	7) Information on planting date, harvest date, and irrigation method are missing	Require the canal rider to record this information and update them daily in the database
GIS	8) Current shape files are not usable with available alphanumeric information and other IDEA Team shape files	Re-project to common spatial references; add fields to host new information; edit at scale equal or larger than 1:10,000; snap network and update it
	9) Water orders area differ from water account area (sub areas, mistakes on drawing, over selling, confusion of order between accounts, etc.)	Frequently update maps with information on location, turnouts, and cultivated parcels, encourage the identification of irrigated fields with grower
	10) “Locations” recorded by canal rider differ from water account boundaries	If the location is larger, use this name to identify the account; if it is smaller, use it to split account
	11) Daily updates of water sales are recorded in a standalone computer (codes are not compatible with GIS)	Modify files to meet GIS requirements, or record data in the water account computer (PC2)
	12) Water account number in the database includes a prefix number. This can lead to errors in data processing	Split water account number and prefix in two separate columns in the database table

Cameron County Irrigation District (CCID2)

The pump on the Rio Grande River and several gates (Rubicon technology) are equipped with remote terminal units (RTUs) for remote control. They are operated remotely with two SCADA units, which are installed on two separate personal computers (PC1 and PC2) disconnected from the internal network (Fig. 5). SCADA unit in PC1 polls the Rubicon gates RTUs for upstream and downstream water level, gate opening, and flow rate. This SCADA unit is also operated via the Internet by specialized district personnel using a laptop. Similarly, SCADA unit in PC2 polls the river pump RTU for equipment status (On/Off), flow rate, and cumulated flow.

Water account information is stored and updated in the server using a Microsoft Windows Access database. The district manages water orders by selling "water tickets," which specify detailed information such as date of purchase and delivery, amount of water ordered, name of landowner and grower, and crops grown.

The GIS database is managed with a third PC (PC3) and updates are added several times a year.

Also in the case of CCID2, the communication link between different sources of data is missing. Similarly to what we found in BID, SCADA outputs are in a proprietary format and information on crop management and delivered volumes is not complete. A list of the problems and recommended changes were compiled for the district. In the case of CCID2 we also added a priority order to our recommendations (Table 2).

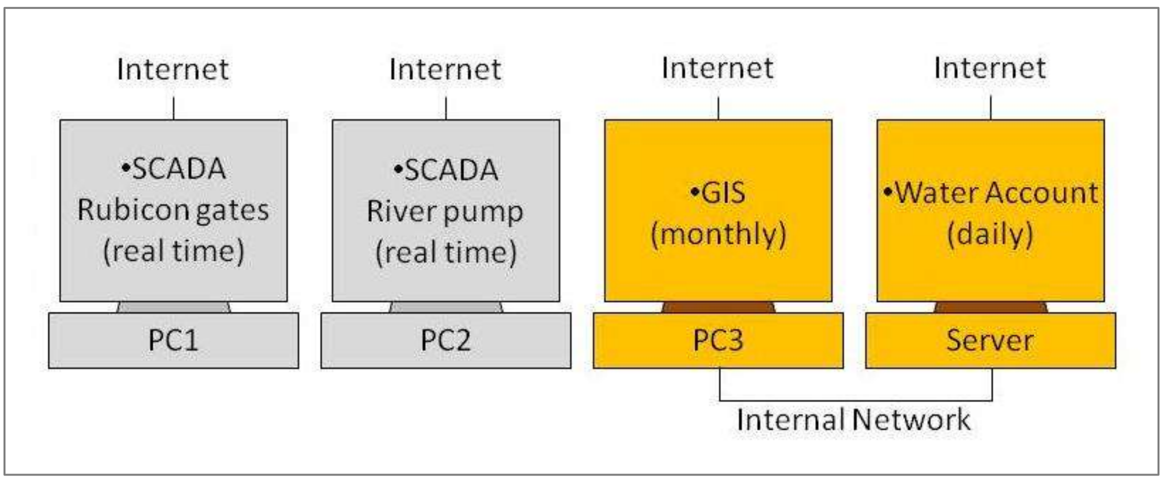


Figure 5. Scheme of gates, pumps, and water orders database management communication in CCID2. Internal communication is missing between some sources of data (grey computers)

Table 2. Identified problems and recommended changes for CCID2. Primary problems are also identified (*).

	Problems	Suggestions
SCADA	1. There is no communication with the internal network. Connection is needed to directly retrieve data without using Internet	Connect the computer to the internal network
	2. Rubicon and Eagle Automation output data are in a proprietary format*	A routine had to be added that converts Rubicon output in a text file format every 15 minutes. Convert also Eagle Automation output data
	3. There is no information on currently operated canals and gates, other than at Rubicon gates (open/close, flow, etc.)	Connect other key locations for irrigation management to the SCADA system
Water account	4. Property ID # (PID) is not updated. As a result link to map might fail*	Update PID
	5. Some crop management data are not available	Add planting and harvest date
	6. Delivered volume is missing (only ordered)*	Measure/estimate delivered volumes
	7. Status and date wanted for PID are missing, and cannot be displayed on map*	Ask more detailed information on PID when selling water tickets
	8. Currently irrigated PID/account is not identified*	Monitor begin and end of irrigation
GIS	9. The information is not up to date*	At least yearly update is needed
	10. Turnouts and command areas are not mapped*	Add turnouts and command areas
	11. Max capacity of gates and canals is not in database*	Add max capacity of gates and canals
	12. Maps are not properly drawn*	Add spatial references, snap beginning and ending points of canals and pipelines, add direction of flow to canals and pipelines, and edit at scale equal or larger than 1:10,000

A list of common problems and recommendations identified for both districts are reported in Table 3.

Table 3. Common problems and recommended changes identified for both districts

	Problems	Suggestions
General	Data are in standalone machines	Connect machines to the network
SCADA	Data are hidden	Use standard format
Water account	Format is encrypted	Use standard format
	Infrequent update	Update daily
	Irrigated fields ID are missing	Add irrigated fields ID
	Crop information is missing	Add crop information
GIS	Is not properly drawn	Correct data
	Is not up to date	Update at least yearly
	Irrigated fields are missing	Add irrigated fields

Web GIS Pilot Project

Based on the results of the database analysis, we set up as Web GIS Pilot Project to demonstrate the benefit of introducing a simplified web-based tool to manage SCADA and water accounts data. We followed these steps:

1) Set up common understanding and objectives
2) Ensuring suitable data format and features at District office
3) Transfer files in real time from the district computers to our server and storing and processing received files and creating gis projects
4) Set up web applications for data retrieval, which are personalized for district personnel and account holders

<u>Set up common understanding and objectives</u>

A challenging activity within the project was to identify solutions that would suit the district needs. As the district was not familiar with the proposed technology we had to design the project based on our knowledge of the district, rather than on a specific request. We therefore set up some preliminary activities to gain good understanding of the district activities, personnel skills, and potential for improvements.

An education and GIS training program was carried out to help district personnel and contractors to gain the basic knowledge required to collaborate in the implementation of the project. Several meetings were organized to foster discussions with the manager and district personnel and to identify expected outcomes. Discussion focused on improvement need for database organization and access. With some demonstration sessions we introduced the manager and district personnel to several new web applications. Sessions were also organized for the SCADA contractor upon his request (BID case only). Finally, we did several field visits with the canal rider in order to familiarize with the distribution network system. Visits resulted useful, and also gave the canal rider the opportunity to explain in detail his work methods. Table 4 summarizes the activities conducted in the BID case.

Table 4. Face to face education and GIS training program carried out in the first year at the BID.

	Meetings	Demonstrations	Classes	Field tours
NUMBER OF EVENTS	9	6	2	3
PEOPLE (counted for each event):				
• District manager and personnel	11	8	2	1
• Water account database contractor	1			
• SCADA contractor	1	2		
TOTAL	13	10	2	1
HOURS (hours x people)	28	10.5	5	7

Ensuring suitable data format and features at District office

The SCADA database was in a proprietary format in both districts, and required the intervention of the contractor to be converted into a format that could be used by others. Polling interval and method varied according to the contractor. The set-up of a routine creating output data every 15 minutes was a feasible solution for all contractors, and acceptable for the time step required by the district personnel in this project. In BID a routine was added by the SCADA contractor in PC1 to output and save data in a CSV file format every 15 minutes, with data older than a week being overwritten. In this way the size of the file is kept limited for faster transfer. In CCID2 a routine was added by the Rubicon contractor in PC1 outputs and saves gates data in a CSV file format every 15 minutes. At this district, data on PC2 have been not used due to unresolved problems with the contractor.

Water account database was also in a proprietary format in BID (FilePRO software). Therefore, the daily output was set up to be automatically converted to CSV format by the IT contractor. The large size of this file is not an issue since transfer is only needed once a day. In the case of CCID2 although Microsoft Windows Access is an open source database, the extraction of selected data was a process not performed on a regular basis. Some set-up time was required for the IT consultant to add a routine in the Server that automatically extracts selected tables as Excel spreadsheets on a daily base. The same procedure was set up at BID in 2011, once they moved to the Microsoft Windows Access database. Since the water account database consultant was the same in both districts, this was an easy step.

In general, we preferred to let the consultants deal with the processing of SCADA and water accounts databases at the districts offices, even when data was available in a known format. Over all this phase required a long time, but in our opinion this was a successful process because contractors were the only ones that knew exactly what data were available. Contractors tended to see us as competitors, so cooperation was lacking at times. This problem was resolved through negotiations that were facilitated by the districts' managers. As mentioned before, in one case we didn't reach an agreement.

Regarding the GIS database we did minor corrections, such as adding spatial references for correct display on the maps, updating of identification codes to enable connection with other databases, and add several water account detailed boundaries as demonstration (Fig. 6). A procedure was set up in collaboration with the District personnel for ensuring a more frequent update.

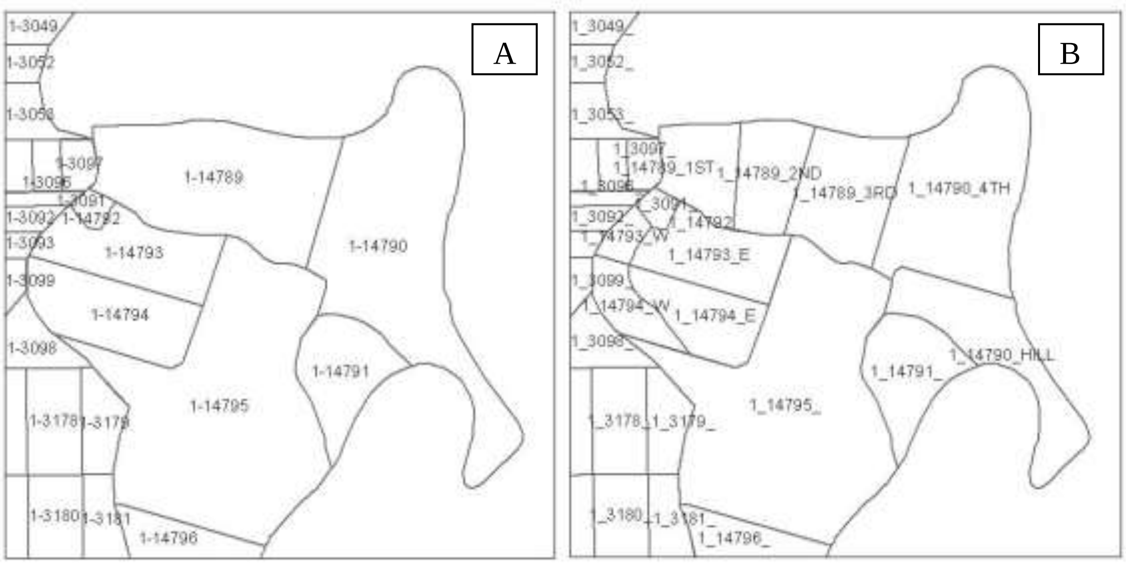


Figure 6. Water accounts were split in irrigated fields, to help the canal rider to verify if water is allocated correctly. A: existing map. B: modified map

Data transfer, storage, and processing

A new file transfer protocol (SshSendFile.msi) was installed individually on all machines with data to be transferred. The protocol enables the transfer of all output files through the TAMU firewall. SCADA data were set up to be sent every 15 minutes, while water account data are sent daily. Spatial data are manually transferred every time there is an update.

All received data are stored in the TAMU server, which works as a new simplified and reorganized district database. SCADA and spatial data are stored in a SQL Server database, while water account data are stored as Excel spreadsheets. To organize spatial data in the SQL server database we used the ArcGIS server software version 10.

Data is stored in such a way that received raw data is used for display in real time, as it is described in the following paragraph, and that another automated procedure validates data builds an historic database. This validation process is done mostly using Python and Visual Basic scripts. Additionally, Excel and ConvertXLS software are used to automatically convert spreadsheets to text files and vice versa. An example of validation processes is deleting data when outside of a set range. This method helped with most of our cases, as we often found numbers way too big (x 1,000), or numbers equal to 0 in cumulative recordings.

Web applications for data retrieval

Data is finally organized to be accessed, displayed and downloaded through the Internet, using dedicated web pages in the district website. These web pages are grouped together under a section called "Online Management" and can be used to:

- Query real time and historic data
- Display real time selected information via a status maps
- Display and query real time and historic data through interactive maps

Easy to use queries enable the user to access real time and historical data (pumps, gates, meters, and water orders). Results can be displayed on the web page screen or downloaded as Excel and PDF files.

In the case of BID we set up three (3) drop down menus: pumps, meters, and water accounts. The user can download the entire SCADA database for selected pumps and meters as Excel spreadsheets, and can download the water account information for each year as PDF report. For CCID we set up a demonstration web page that can be used to query SCADA recordings for a chosen number of days or for a specific date range (only flow rate for C Canal). The CCID2 set up is shown in Figure 7.

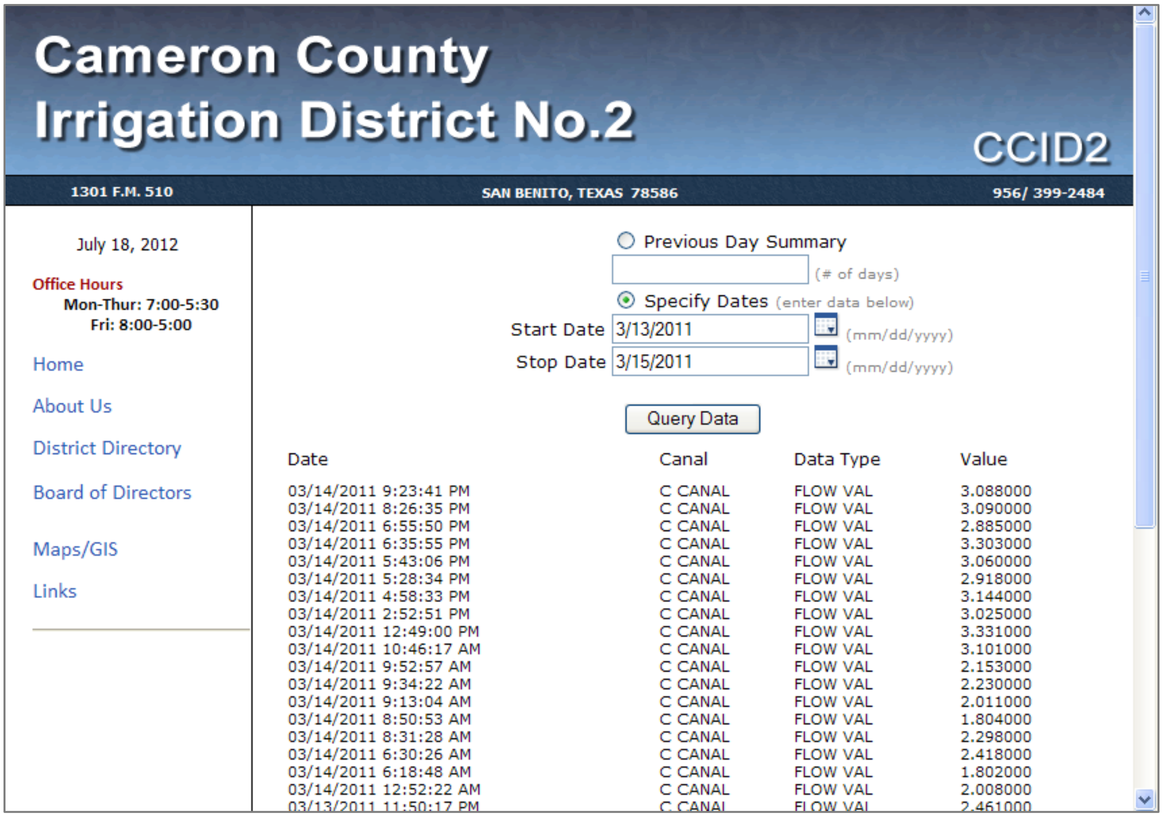


Figure 7. Example of historical data retrieval for CCID2 (C Canal).

A status map shows the most relevant information in real time, such as flow rate, water levels, total water orders, and alarms. Alarms are set to alert on specific problems (e.g. water levels), different per each district. In the status map a static background is chosen to easily identify key locations, and boxes are set to display the selected information updated in real time.

In our Pilot Project we set a status map for the entire BID district with real time data (flow rate and water level), and a demonstration for a limited area in CCID2 with automated Rubicon gates (flow rate, gate elevation, upstream and downstream water level, total water orders). In the case of BID, we also added two drop down menus that allow access to charts that summarize the last week of data for the SCADA Units (pumps and meters). The status maps set for BID and CCID2 are displayed in Figures 8 and 9.

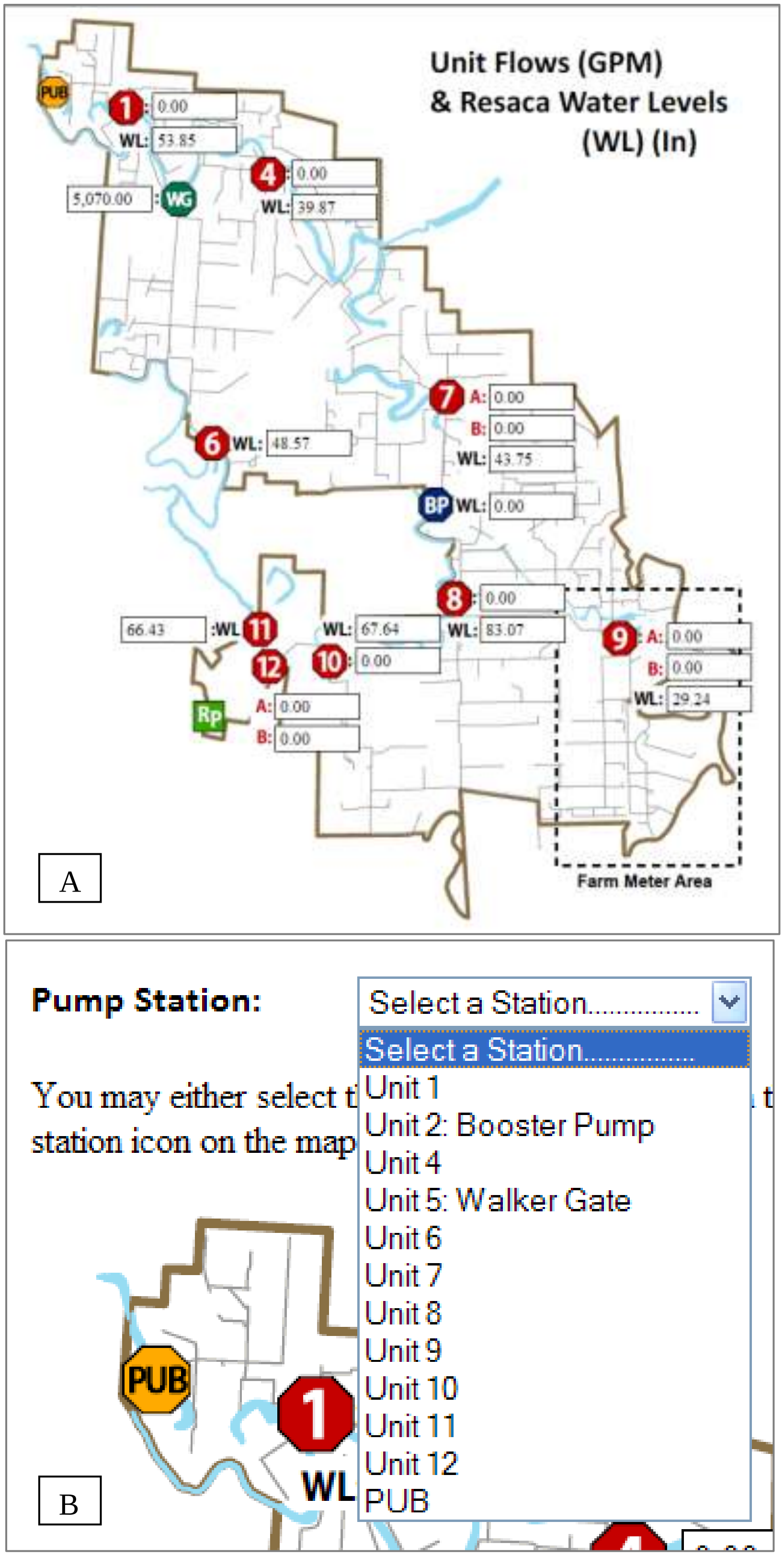


Figure 8. Status map set for BID, which displays flow rates and resaca water levels. A: entire status map. B: detail showing the drop down menu to pumps weekly charts

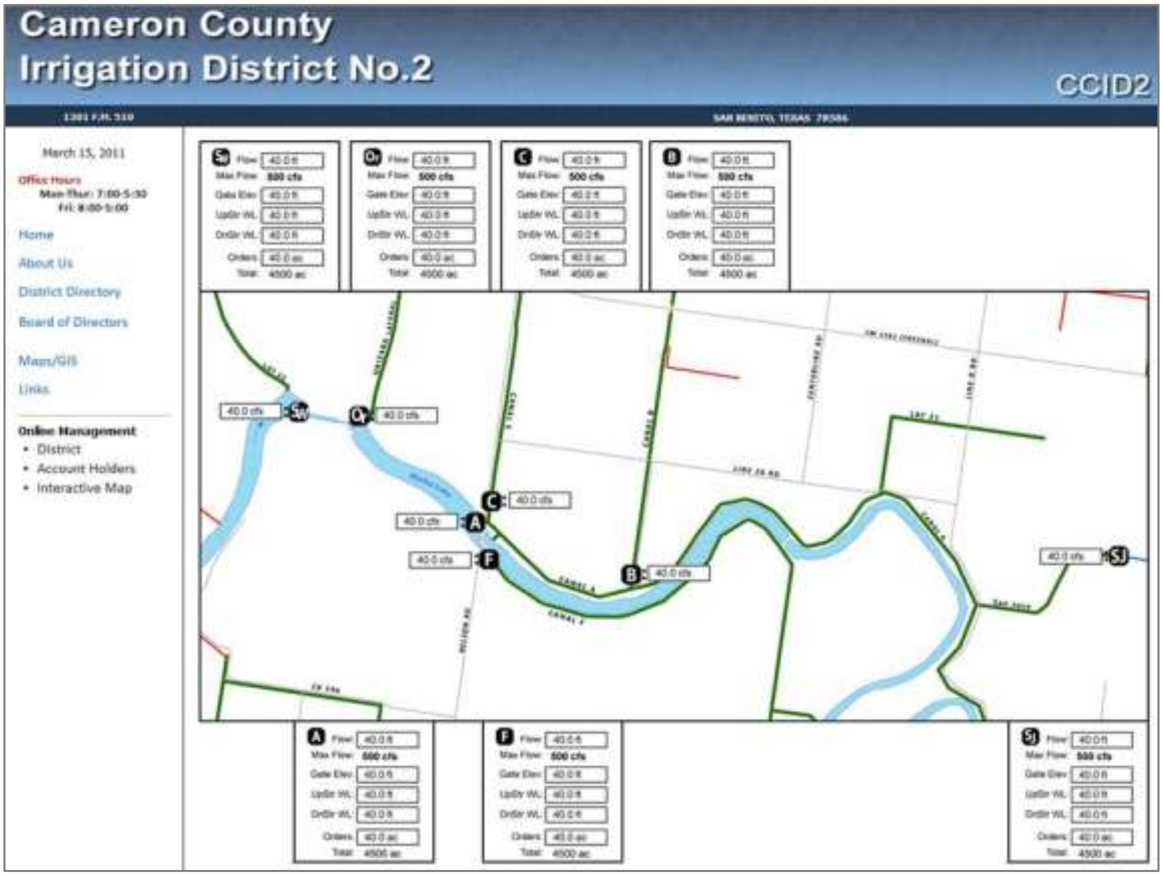


Figure 9. Status map set for CCID2, which displays information for the automated Rubicon gates in the Warley Lake resaca area (demonstration only).

An interactive map displays similar information as the status map, with the following additional features:

- Table of contents that displays information legend and allows to switch on and off the displayed information
- Personalized queries to the database, with display of results on the map
- Navigation tools to navigate the map and retrieve selected information (Zoom in/out, Pan, Full extent, Back and forward extent, Measure, Identify)
- Possibility to combine all background in one single layer and to cache it to improve navigation speed (Fig. 10)

We used ArcInfo, version 10, to create maps and to link SQL database information to the map (with the "Join" tool), and we used ArcGIS Server, version 10, to publish interactive maps as web pages.

Figure 10. Aerial photographs are combined in a single layer and cached using the ArcGIS Image Server extension

In our Pilot Project we set up two (2) interactive maps per each district, one for district personnel and one for account holders. District personnel can access all data, while account holders can access only their own information. In the case of BID, account holders can also access readings from selected water meters, which are updated every 15 minutes, without having to call the canal rider.

As we did for the status map we added links to the SCADA weekly charts (only a demonstration chart in the CCID2 case). Additionally we created links to the historic data web page. Examples of interactive maps available to district personnel and account holders are shown in figures 11, 12, 13 and 14.

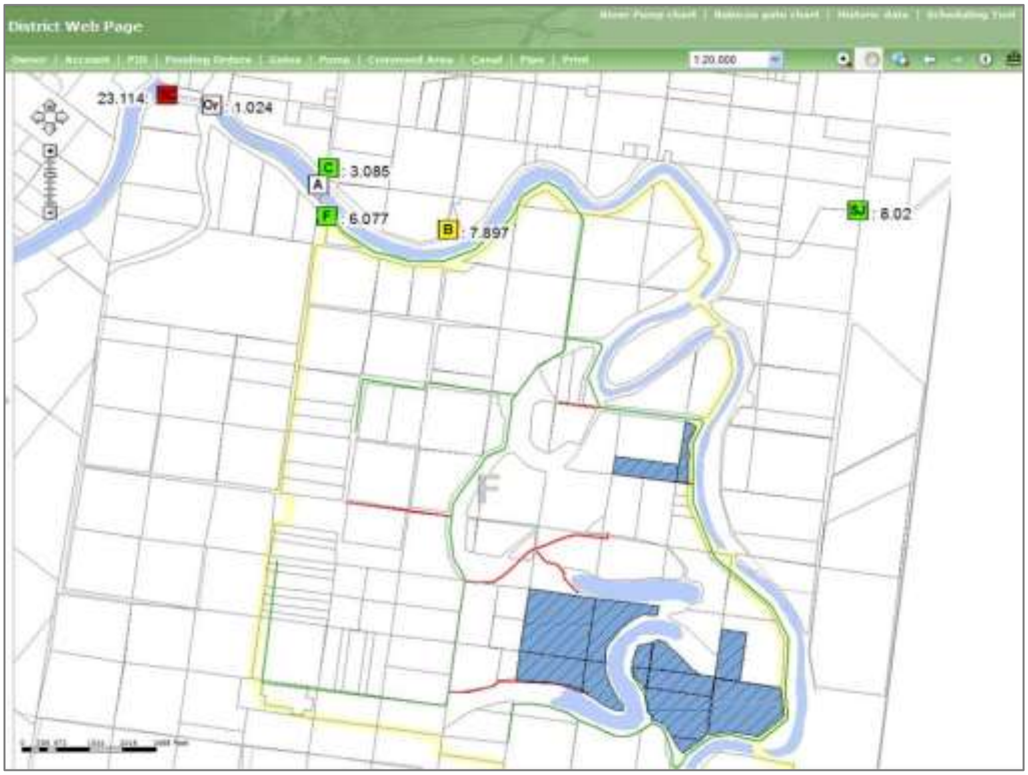


Figure 11. Interactive map for district personnel, showing current water orders, network, and gates alarms

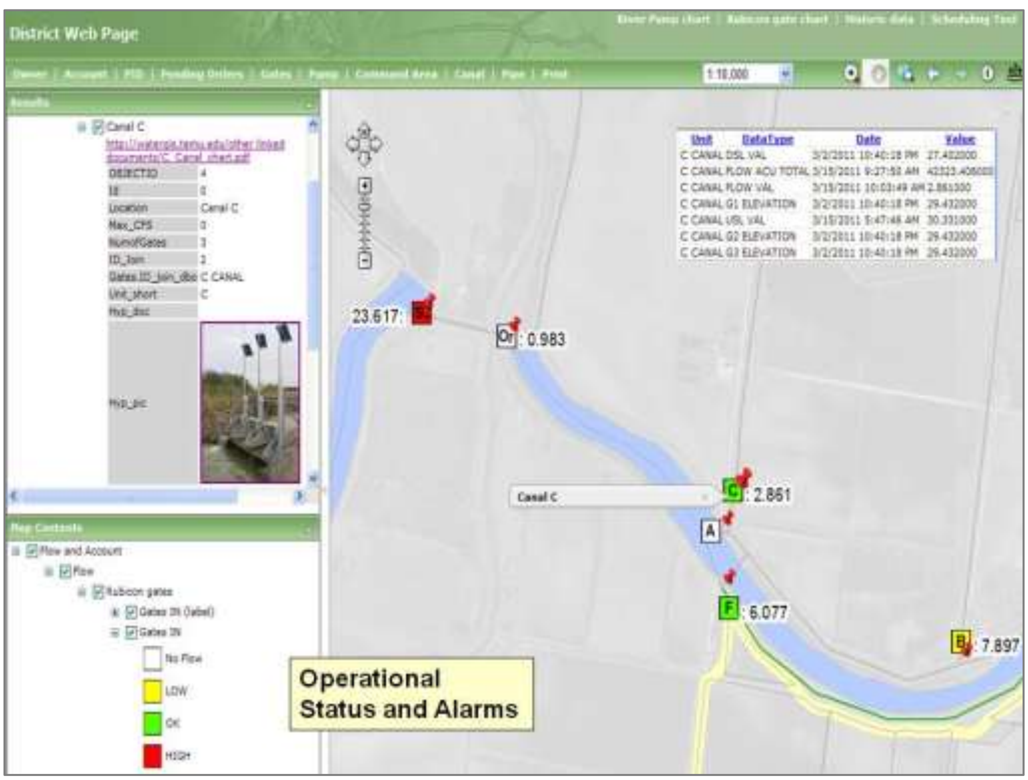


Figure 12. Interactive map for district personnel, with detailed information on gates status

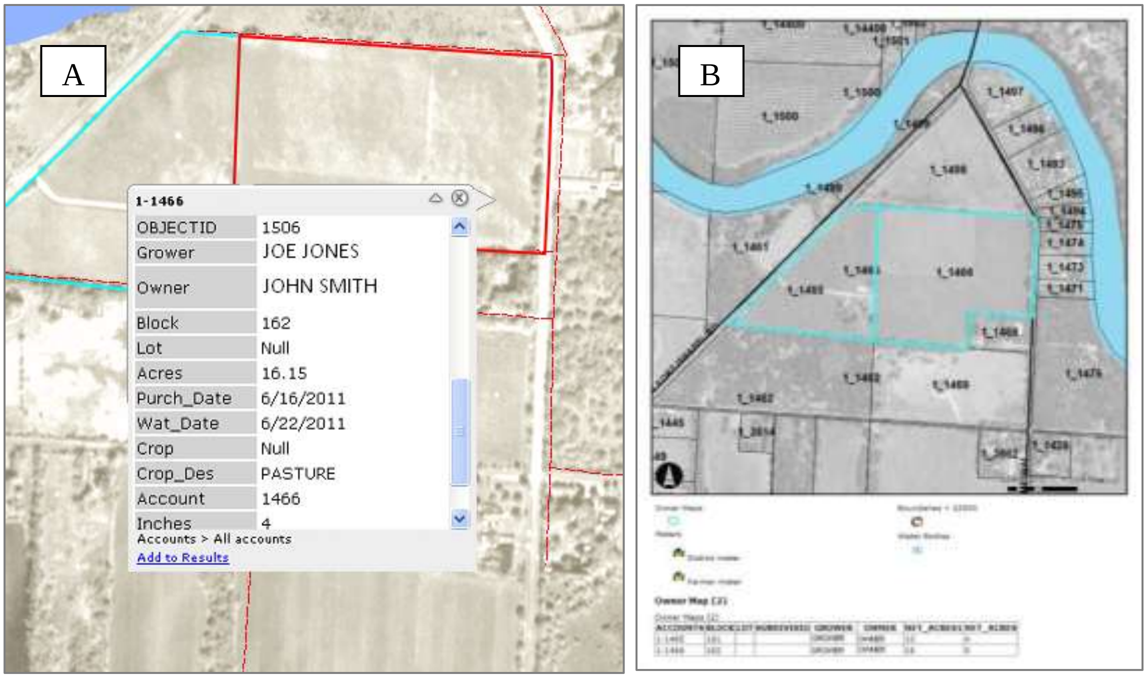
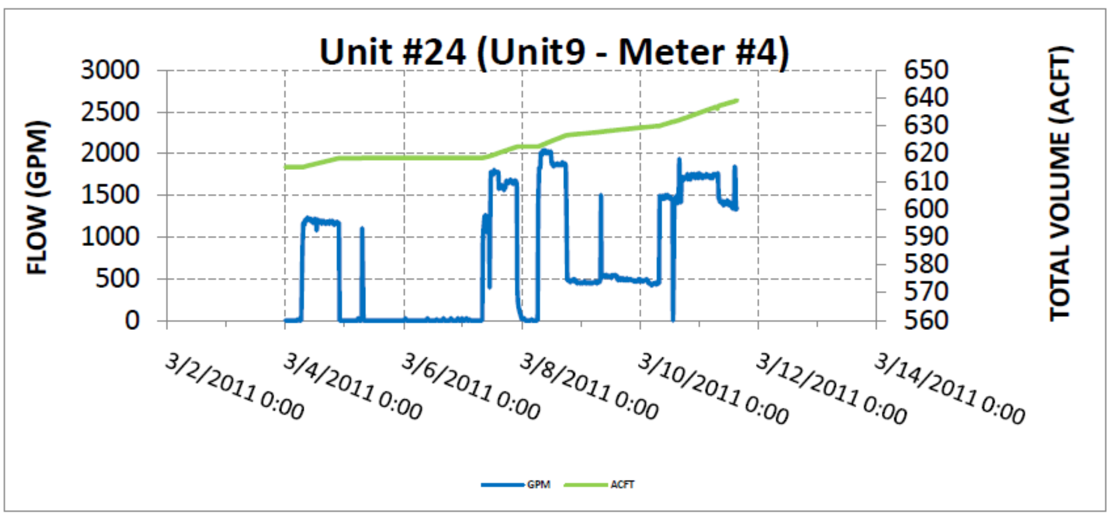


Figure 13. Account holders can identify their own fields and find related information on water account, and can print a report. A: detailed information. B: report



Tuesday 3/15/2011 8:46	GPM	ACFT
	1352	639.127

Date	GPM	ACFT
3/4/2011 0:00	0	615.1078
3/4/2011 0:15	0	615.1078
3/4/2011 0:30	0	615.1078
3/4/2011 0:45	0	615.1078

Figure 14. Account holder can access readings from selected water meters.

A summary of the data retrieval set up that we created with the Web GIS Pilot Project is shown in Table 5. As we said, features are differently available for district personnel and account holders (which can access their own data only), and have been set up slightly differently for BID and CCID2. As a result of the activities carried out with the Web GIS Pilot Project the set up of data communication improved too, as shown in Figure 15.

Table 5. Access to data through web application in the Web GIS Pilot Project (grower can access only its own data)

Map	Feature	District		Account Holder	
		BID	CCID2	BID	CCID2
Database query	**Telemetry/SCADA**				
	• On/Off	✓	✓ (1)		
	• Flow	✓	✓ (1)		
	Water Orders				
	• Water orders	✓	✓		
	• Irrigation Volumes	✓	✓		
	• Crops	✓	✓		
	• Account Balances Water/Money	✓	✓		
Status Maps	**Telemetry/SCADA**				
	• Alarms	✓	✓		
	• On/Off	✓	✓		
	• Flow	✓	✓		
	Water Orders				
	• Total Irrigation Volumes		✓ (1)		
Interactive Map	**Telemetry/SCADA**				
	• Alarms		✓ (1)		
	• On/Off	✓	✓	✓	
	• Flow	✓	✓	✓	
	• Find Name	✓	✓		
	• Find Type (pump, gate, etc.)	✓	✓		
	Water Orders				
	• Water orders	✓	✓	✓	✓
	• Irrigation Volumes	✓	✓	✓	✓
	• Crops	✓	✓	✓	✓
	• Account Balances Water/Money	✓	✓	✓	✓
	• Find Owner, Grower, Account #	✓	✓		
	• Find PID, Serving canal/pump		✓		

(1) Demonstration only

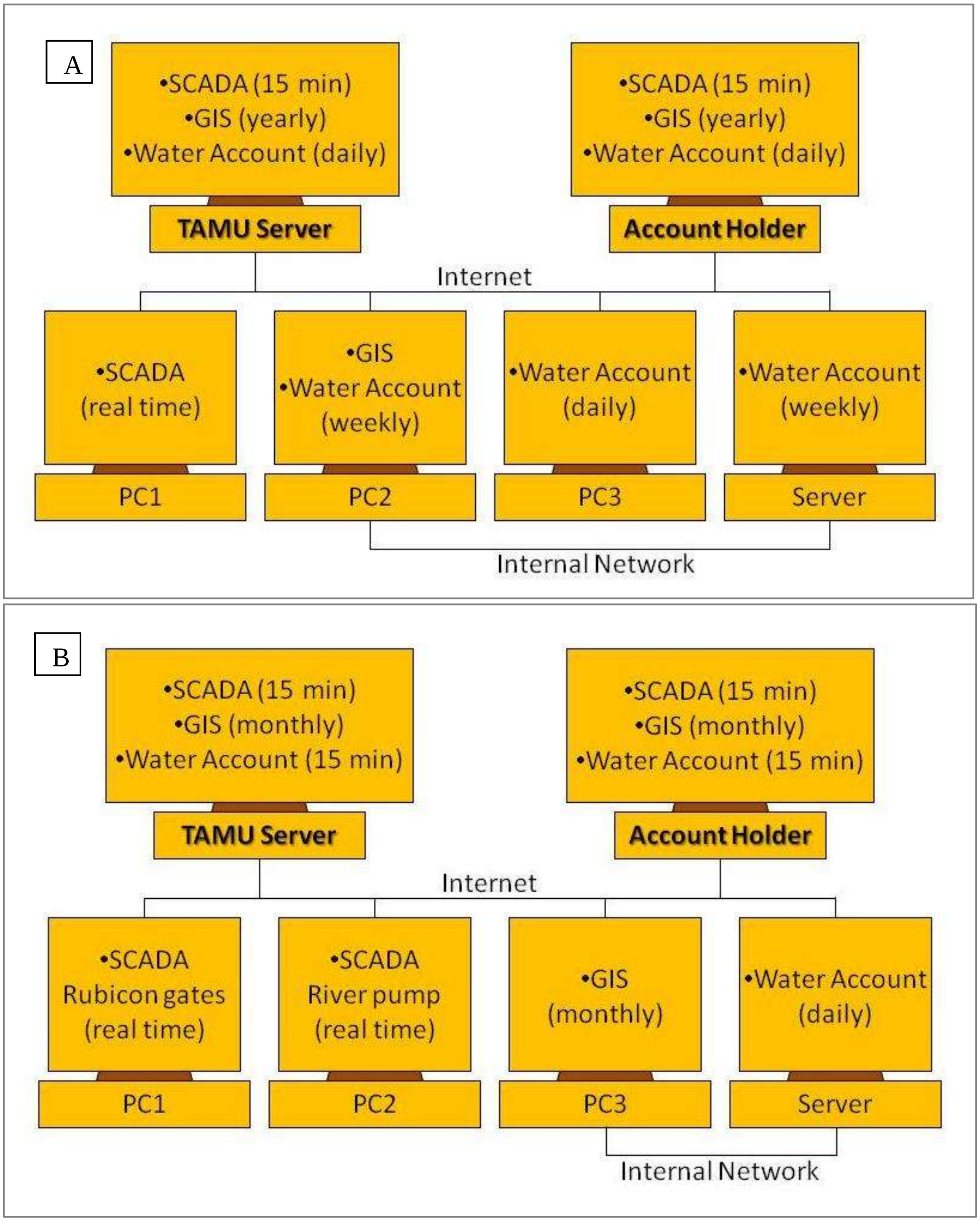


Figure 15. Database management final set up created in the Web GIS Pilot Project. A: BID. B: CCID2.

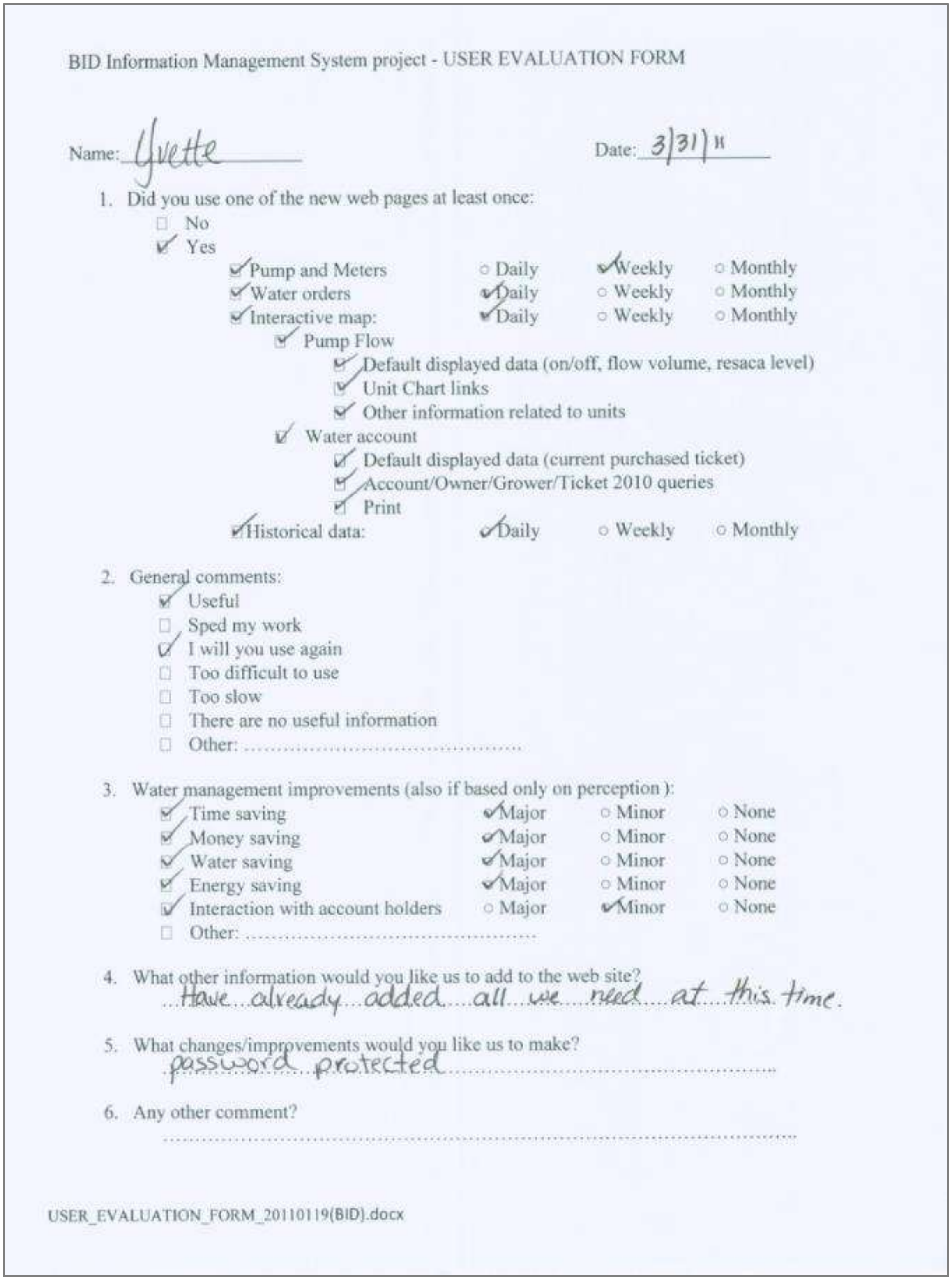
Response from districts

Overall, districts actively responded to make the changes required to complete the project and accepted some recommendations. In Table 6 we summarize the changes made by BID, the most drastic being moving from an old-fashioned proprietary water account database to an open source database. BID personnel also started a plan of periodical evaluation using a form provided by us (Fig. 16).

District personnel and managers had the perception that the changes introduced could save water and time. For example, the availability of flow meters readings to account holders reduces need of talk to the districts personnel. The district managers believe that if such information is readily available to account holders, irrigation would be more efficient, with reduction of total volumes delivered. Districts appreciated the activity and expressed the interest to engage in further changes and activity, such as introducing other crop management data, updating of all water account information daily, and ensuring maintenance of GIS to keep it always up to date.

Table 6. Changes carried out at BID following our recommendations

	Problems	Accepted suggestions	Change made by
SCADA	Output data are in a proprietary format.	Added routine that converts output in a text file format every 15 minutes.	BID
Water account database	Obsolete database software	Moved to a new open source database	BID
	Output data are in a proprietary format	Added routine that converts output in a text file format every day	BID
GIS	Irrigated fields (Locations) are not mapped	Added some locations to map	TAMU (demonstration only)
	Water account number in the database includes a prefix number. This can lead to errors in data processing	Split water account number and prefix in two separate columns in the database table	BID



BID Information Management System project - USER EVALUATION FORM

Name: Yvette　　　　Date: 3/31/11

1. Did you use one of the new web pages at least once:
   - ☐ No
   - ☑ Yes
     - ☑ Pump and Meters — ○ Daily ✓Weekly ○ Monthly
     - ☑ Water orders — ✓Daily ○ Weekly ○ Monthly
     - ☑ Interactive map: — ✓Daily ○ Weekly ○ Monthly
       - ☑ Pump Flow
         - ☑ Default displayed data (on/off, flow volume, resaca level)
         - ☑ Unit Chart links
         - ☑ Other information related to units
       - ☑ Water account
         - ☑ Default displayed data (current purchased ticket)
         - ☑ Account/Owner/Grower/Ticket 2010 queries
         - ☑ Print
     - ☑ Historical data: — ✓Daily ○ Weekly ○ Monthly

2. General comments:
   - ☑ Useful
   - ☐ Sped my work
   - ☑ I will you use again
   - ☐ Too difficult to use
   - ☐ Too slow
   - ☐ There are no useful information
   - ☐ Other: ……………………………………

3. Water management improvements (also if based only on perception):
   - ☑ Time saving — ✓Major ○ Minor ○ None
   - ☑ Money saving — ✓Major ○ Minor ○ None
   - ☑ Water saving — ✓Major ○ Minor ○ None
   - ☑ Energy saving — ✓Major ○ Minor ○ None
   - ☑ Interaction with account holders — ○ Major ✓Minor ○ None
   - ☐ Other: ……………………………………

4. What other information would you like us to add to the web site?
   Have already added all we need at this time.

5. What changes/improvements would you like us to make?
   password protected

6. Any other comment?
   ……………………………………

USER_EVALUATION_FORM_20110119(BID).docx

Figure 16. Evaluation form for district personnel, completed periodically

CONCLUSIONS

The project was developed in districts that were already feeling the urgency to upgrade their technologies, including GIS. Specific interests were to make best use of the large amount of available data, to adopt web applications, and to enable customers to access their data through the Internet.

Despite the efforts and will, these changes required a long time to be fully implemented due to a number of issues, such as identifying district needs, accurately designing the project, integrating the non optimal existing data, securing sensitive data, and involving contractors and consultants. Referring to contracts, they should be specific in non-propriety software in that any consultant should be able to modify in the future, and district personnel should be able to extract all data they need at any time. Nevertheless, collaboration with contractors resulted beneficial for the sound implementation of the project.

The activity produced some effects that looked promising for improved water management efficiency. The districts adopted most of the new proposed strategies, promptly complied with many recommendations, and suggested further steps. Other districts showed interest to collaborate to set up similar projects.

There was an overall feeling from the districts that the adopted changes would help save water and costs, and this was assessed by means of qualitative evaluations. Nevertheless, there is a need to quantitatively estimate such benefits. Water balances and reliable historical data might help to make these assessments in the future. An initial understanding of such benefits might be obtained with a description of improved services provided to growers (e.g. availability of flow meter readings on line reduces the number of calls to the canal rider).

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