Tony

Interim Report

on

Edwards Aquifer Saline-Zone("bad-water line")
Monitoring Program
(TWDB Contract No. 96-483-184)

Submitted to
Texas Water Development Board
Research and Planning Fund Grants Management Division
Austin, Texas

by
Glenn Longley
Marshall Jennings
Nisai Wanakule
Rita Setser
Robert Ourso

Edwards Aquifer Research and Data Center
Southwest Texas State University
San Marcos, Texas

November 17, 1998

Acknowledgements

This project has been under the general direction of Dr. Glenn Longley, Director, EARDC. Staff associated with the project have included Nisai Wanakule and Marshall Jennings, EARDC. Graduate students who have contributed to the project include Robert Ourso and Rita Setser. EARDC is indebted to the USGS for its assistance in setting up the initial instrumentation used in the project and also to Phil Nordstrom, TWDB, Contract Manager for the project, for his continuing advice and support. EARDC is very appreciative of the volunteer assistance of Jon Cradit, Cave Steward for Ezell's Cave, and his colleagues as well as the Cities of New Braunfels, TX, Converse, TX, and Atascosa Rural Water Supply Corporation.

Introduction

The Edwards aquifer is a source of water supply for various water-use sectors including irrigation, agriculture, industrial, and municipal. The aquifer has been designated a "sole source" drinking water supply for approximately 1.3 million people in the San Antonio region, by the Environmental Protection Agency. Currently, most of the municipal water supplies for the cities in the aquifer region are totally dependent on groundwater. More importantly, those cities' wells are located within a few miles of the saline zone interface of the Edwards aquifer --- also called the " bad-water line", Schultz (1993).

The "bad-water" line is commonly referred to as the boundary line that separates freshwater from saline water to the south and southeast of the Edwards aquifer (see Figure 1). It is defined as the salinity front which has total dissolved solids (TDS) of 1,000 mg/l. A knowledge of flow hydraulics, including occurrence, sources, and mechanisms controlling flow patterns, for this saline front is limited due to lack of wells drilled into the frontal region. Hence, new drilling programs described below are in progress.

Some wells located beyond the "bad-water" line have TDS concentrations of 6,000 mg/l, whereas TDS concentrations of freshwater wells usually range from 250 to 350 mg/l. Some wells near the "bad-water" line have reported decreased water quality during droughts and Harden (1968) has documented apparent saline water intrusion during the great drought of the 1950s. In testimony before the Texas Water

Commission (TWC), Harden (1992) reported that only 21 wells were sampled near the "bad-water line" in 1956, including 15 wells in Bexar county. Eight of the 21 wells showed deterioration in water quality. One well increased from about 40 to 300 mg/l of chloride concentration, while another well had increases of chloride from about 400 mg/l to over 4,000 mg/l. Harden (1992), in the late 1960s, also looked at a group of more than 130 wells and found water quality variations in about 60 wells. In 39 of the 60 wells, he found a correlation between water quality and artesian pressure. Eleven of the 60 wells showed variations that influenced use of the water for drinking water purposes. He pointed out that the Edwards aquifer was far less "stressed" in the late 1960s than it was in 1956 when 50 feet of artesian pressure reduction occurred for 5 months, leading to cessation of spring flow at Comal Springs. Harden (1992) concludes that the way to decrease the possibility of bad-water encroachment is to regulate withdrawals to maintain adequate spring flows.

According to Grant Snyder, Hydrogeologist with the Edwards Aquifer Authority (EAA), in 1985-86, the Edwards Underground Water District (EUWD now EAA), in cooperation with the San Antonio City Water Board (now San Antonio Water System or SAWS), Texas Water Development Board (TWDB), and the U.S. Geological Survey (USGS) began the construction of a series of 7 observation/monitor wells in a transect across the Edwards aquifer "bad-water" line in the San Antonio area. The wells were constructed to characterize the hydrogeology in the vicinity of the "bad-water" line and to support monthly water-quality data collection at the wells.

In 1989- 91, EUWD continued to construct monitoring wells at two additional transect locations at New Braunfels and San Marcos, Texas. In 1993, a single well in south Medina County was constructed near the community of Yancey, Texas, Waugh, 1993. This study significantly altered the perceived location of the "bad-water line" as freshwater was discovered in the Edwards aquifer much farther down dip than previously known. EUWD, sometimes in cooperation with the USGS, has sponsored several key studies of the saline-front including Poteet et al, 1992; Schultz (1992,1994); and, Perez (1986). Numerous other work is identified in ***Edwards Aquifer Bibliography, Through 1997,*** EAA Report 98-01, available online at http://www.e-aquifer.com/.

According to John Waugh, SAWS, the San Antonio Water System, in cooperation with the Texas Water Development Board, USGS, the Edwards Aquifer Authority, and other local, regional, and state universities, has initiated a 10-year project to expand the network of wells that monitor the "bad-water line". According to Waugh, a total of 36 new wells will be drilled along the boundary between the fresh and saline water zones. Additionally, 22 current wells will be reworked and equipped to monitor water levels and water quality on both sides of the boundary.

The SAWS work is the result of a Mayor's Citizens Committee on Water Policy that recommended in 1996 that a comprehensive study of the "bad-water line" and the potential movement into the freshwater portion of the Edwards aquifer, be conducted. The first phase of the SAWS study for drilling monitoring wells near Kyle, Texas in Hays County, was approved by the SAWS Board and endorsed by the San Antonio City Council in October, 1997. As of September, 1998, four wells have been drilled and completed near Kyle, Texas and represent the beginning of a network of 58 wells to be established along the "bad-water line" between Kyle and Uvalde, Texas. Waugh indicates that scientists will be analyzing geologic, hydrologic, and water-quality data from the wells in coming months. With the drilling and completion of these first wells, SAWS and its partner agencies will begin to monitor changes in the network, in both water level and water quality in the aquifer for, perhaps, the next 50 years. The project is designed to provide conclusive data concerning the possibility of movement of the "bad-water line" as well as provide a sentinel system to warn of any sudden changes that may preceed possible movement.

Background of the Present EARDC Monitoring Network

During the drought of 1996, concern was expressed once again for possible movement of the "bad-water line" into the freshwater zone of the Edwards aquifer, because of a lowering of artesian pressure. After much discussion and several seminars on viewpoints among regional scientists concerning saline-zone issues in the Edwards aquifer region, a proposal was submitted to the TWDB by the Edwards Aquifer Research and Data Center, in cooperation with the USGS and the Guadalupe-Blanco River Authority (GBRA). The GBRA's role in the proposed project was to analyze for event-driven water quality samples using its laboratory facilities at Seguin, Texas.

The proposed project was designed to strengthen and enhance the existing monitoring program undertaken by the EAA and provide a bridge to the coming 58-site network of SAWS. The two-year project, including data collection at 6 sites along the "bad-water line", was approved by the TWDB more or less at the height of the drought of 1996. The project included daily monitoring of temperature and specific conductance at two spring sites, three well sites, and a cave lake, using phone telemetry. Occasional measurement of dissolved oxygen and pH were also taken. In July, 1998, the project was extended for another two years to conclude by September, 2000.

Methodology

It was decided to place monitoring instrumentation at critical points along the "bad-water line" from San Marcos, Texas to just south of San Antonio, Texas. Six sites (site numbers correspond to locations on Figure 1) were located:

1. Deep Spring (AQU), (one of about ten major spring openings in San Marcos Springs). Deep Spring is located about 26 feet under the surface of Spring Lake at San Marcos, Texas. (Figure 2a).
2. Southwest Texas State University Flowing Well (SWT), located just behind the Freeman Aquatic Biology Building in San Marcos, Texas. (Figure 2b).
3. Ezell's Cave Lake (EZE) at San Marcos, Texas. The cave lake, representing the water table of the Edwards aquifer, is located about 40 meters below the land surface about one mile south of Spring Lake.
4. Comal Spring # 3 (COM) also known as the "gazebo spring run," New Braunfels, Texas.
5. Gib Sprawl Well (CON), Converse, Texas.
6. Atascosa Rural Water Supply Well # 1 (ATA), off Loop 1604 West, Southwest of San Antonio, Texas.

The purpose of the water quality monitoring of <u>specific conductance, (us/cm)</u> and <u>water temperature, (degrees C),</u> was to provide a consistent set of measurements collected by a telemetry system that reports daily. It was decided to place the continuous monitoring measurements on the

EARDC home page, http://www.eardc.swt.edu/, and include a convenient graphing method. The web page was also designed to include "event-driven sampling data" at the 6 monitoring sites, plus an additional network of wells included in EAA and SAWS sampling programs.

Instrumentation

The instrumentation selected by EARDC includes three components:

- *A 12V datalogger recording system* (Figure 3).
  The datalogger system is a Campbell Scientific, Inc. (CSI) Model CR10 and includes a 12V power supply. The power supply was supported by a 10-watt solar panel. The recording system was located in a environmental container provided by CSI.
- *A 12V modem and cell phone transmitter system* (Figure 3).
  A CSI 12V modem and Motorola cell phone with Yagi directional antenna was selected for use. A 2- inch conduit of about 10 feet in height supported the environmental container as well as the antenna and solar panel.
- *A water-quality sensor system including probes for specific conductance and water temperature.*
  CSI provided the water-quality probes that are enclosed in a sealed cabling system that links directly to the CR10. The Ezell's cave instrumentation included dissolved oxygen (D.O.), pH, and turbidity sensing, in addition to specific conductance and water temperature sensors. The multi-probe monitor is a Hydrolab H 20 system with a wired phone. The Ezell's system was made available to the EARDC "bad-water line" monitoring program by the National Park Service, Tucson, Arizona, the USGS-Texas District, and the Nature Conservancy of Texas.

Additional instrumentation and instrumentation software needed to make the real-time recording system functional includes:

- *An office PC with internal modem and UPS*
- *CSI software including a CR 10 program unique to each site and CSI PC 208 software for Windows 95 for communication between each site and the office PC.*
- *A PC lap-top for use in field calibration of sensors at each site.*
- *A Yellow Springs Instruments, Inc. YSI 600R multiprobe meter for independent calibration of field sensors.*

In operation, the instrumentation at each site records time and senses the probes at hourly time intervals and stores the data on the CR 10 datalogger. The antenna at each site is oriented toward a nearby cell-phone tower operated by GTE. Once each day (about 6 pm), each field site is "turned on" by its datalogger. This is done to conserve power and to minimize phone costs. The office PC has been programmed to call each site in turn during a time-window of about 15 minutes. When a connection is made with the site phone system, the data is returned to the calling office PC over the GTE cell network and filed as CSI PC 208 files. Occasionally, no cell phone connection is established between a field site and the calling PC (5 tries are made). In this case, the data stored on the CR10 is returned during the next calling cycles, in succeeding days. Such files are easily converted to most spreadsheet software.

Special CR10 programming was necessary at the Converse (CON) and Atascosa (ATA) well sites. These wells are pumped only a few hours per day and generally are not pumped on week-ends. Therefore, a float-switch was provided in the flow cells containing the sensors at these sites. When the well is being pumped, the float-switch activates the CR 10 datalogger and information is collected.

During periodic visits to the field sites, corrections are made to sensor values and the data files are adjusted as described below. Also, additional measurements are made for D.O. and pH using the YSI 600R.

Data Management

Periodically (eventually daily), an EARDC staff member imports the CSI text files into a database program called Filemaker Pro. Within this database program, a conversion script is run in order to flag any irregular data and to prepare the data for uploading to the EARDC server. After completion of the conversion process, the database file is exported as comma delimited text and this file is transferred to the EARDC server.

After transfer to the server, an additional conversion program is run on the data files to assure compatibility with the operating system. Finally the data files from each field site are loaded into a database management program (DBM) on the EARDC web page, where queries from end-users can be answered. The database management program is an elaborate system written by Nisai Wanakule and includes both continuous and event-driven "bad-water line" database access. Selected steps in the data management process are shown in Figure 4.

Data and Information on EARDC Web Page

The end-user is now able to access data at all field sites via the world wide web. The browser is directed to the URL of the EARDC "Bad-Water Line Monitoring Homepage (http://www.eardc.swt.edu/bwl/) and the end-user is able to choose data files and/or graphs. By clicking on the appropriate link, a common gateway interface, or CGI program, is activated which retrieves the requested data from the appropriate DBM file for a given field site then displays it. The end-user is given a choice of either viewing the data in a tabular format or viewing a time series graph of the requested data. One of the features of the graphing option is the ability to control the output format. By making selections on an HTML form provided in the program, various parts of the graph may be modified in subsequent displays. The site by site data may then be rapidly visualized.

GBRA Laboratory Analyses

As mentioned, the GBRA laboratory to analyze event-driven samples taken at field sites for common constituents, nutrients, selected field parameters, and dissolved organic carbon.

Common constituents and nutrients include:

Alkalinity as CaCO3, mg/l; Total Hardness as CaCO3, mg/l; Dissolved Calicium as CaCO3, mg/l; Dissolved Magnesium as CaCO3, mg/l; Dissolved Sodium as Na, mg/l; Dissolved Potassium, mg/l; Dissolved Chloride, mg/l; Sulfate, mg/l; Fluoride, mg/l; Silica, mg/l; and Total Dissolved Solids, mg/l.

Field parameters include: pH in standard units, Specific Conductance, us/cm; Water Temperature, degrees C.

Other information includes: the date and time of sampling, total depth in feet (if a well), pump or flow period prior to sampling in minutes, and current flow rate in gal/min, or spring flow rate in cfs.

The data for event-driven sampling is triggered by Comal Spring Flow falling to 150 cfs. One event was sampled between May 28 and May 31, 1996 and the data is available on the EARDC web page. A total of 23 wells and springs were sampled in order to establish baseline values for water quality parameters. An event was scheduled for 100 cfs, but Comal Spring flow recovered before the samples could be taken.

The 1996 data reflect normal water-quality conditions, with most parameters remaining reasonably constant and not substantially different from historical values.

In the summer of 1998, Comal Spring flows once again began a decline as a result of a long, hot and rainless period. However, flow returned to normal levels after rains. The lowest Comal Spring flow occurred in late-July and was 168 cfs, well above the 150 cfs trigger.

Results

Monitoring data have been collected and stored in the EARDC web-based DBMS since about May, 1996. Some sites have periods of missing records and this is especially true of ATA and CON sites. Occasional pH measurements at all sites appeared constant at about 7 pH units; temperature varied slightly with time of year at COM, SWT, AQU and was between 22 to 24 deg C; water temperature at CON and ATA were about 27 degrees C. All specific conductance values, at all sites fall within the range typical for freshwater in the Edwards aquifer indicating that salt water intrusion has not occurred during the 1996 - 1998 observations reported in this interim report.

Future Work: 1998 - 2000

Water-quality monitoring will continue at all six sites and the databases will be maintained on the EARDC server/web page system. Field visits will be made every one to two months based on need. Visits will be made for sensor calibration and site maintenance. At each visit, YSI multiprobe readings will be taken. At Ezell's Cave Lake site, visits will be made about monthly in order to provide routine maintenance of the Hydrolab H 20, probe. The Ezell's visits will be made with a cave steward.

An additional site, unrelated to the "bad-water line" monitoring activity but of the same kind of instrumentation, will be added to the EARDC DBM system. This site is Lower Glen Rose Monitoring Well and Rain Gage at Wimberley, Texas (WIM). WIM has a CR10 datalogger/cell phone installation with a Delta Corp. pressure transducer for water-level sensing and a Weathermeasure tipping bucket rain gage. A special EARDC web page is being created for this field site.

Also planned for late 1998 (or early 1999), is a test of a new method for estimating aquifer properties at saline wells in the Edwards aquifer. The method, ***Methods of Conducting Air-Pressurized Slug Tests and Computation of Type Curves for Estimating Transmissivity and Storativity,*** by Earl A. Greene and Allen M. Shapiro, USGS OFR 95-424. Earl Greene will visit EARDC to oversee the tests and will also give a talk to a group of local hydrogeologists on his pump-test method.

References

Cederberg, J.R. and R. T. Ourso. 1998. Water-Quality Assessment of South Central Texas -- Monitoring of the Freshwater/Saline-Water Zone in the Edwards Aquifer, July 1996 to December 1997., USGS Fact Sheet, 4 p.

Harden, R.W. 1968. Review of Water Quality Changes in the Edwards Reservoir, Especially Near the Bad Water Line -- File Memo, William F. Guyton and Associates, 23 p.

Harden, R.W. 1992. Prepared Testimony for Texas Water Commission Hearing in San Antonio on June 30, 1992, 6p. + exhibits

Poteet, D., Collier, H., and McClay, R.W. 1992. Investigation of the fresh/saline-water interface in the Edwards Aquifer in New Braunfels and San Marcos, Texas, Edwards Underground Water District Report 92-02.

Perez, R. 1986. Potential for Updip Movement of Saline Water in the Edwards Aquifer, San Antonio, Texas, USGS WRI Report 86-4032, 21p.

Schultz, A.L. 1992. Using Geophysical Logs in the Edwards Aquifer to Estimate Water Quality Along the Freshwater/Saline-water Interface -- Uvalde to San Antonio, Texas, EUWD Report 92-03, 47 p.

Schultz, A.L. 1993. Defining the Edwards Aquifer Freshwater/Saline-water Interface With Geophysical Logs and Measured Data --- San Antonio to Kyle, Texas, EUWD Report 93-06, 81 p.

Schultz, A.L. 1994. 1994 Review and Update of the Position of the Edwards Aquifer Freshwater/Saline-water Interface From Uvalde to Kyle, Texas, EUWD Report 94-05, 31 p.

Waugh, J.R. 1993. South Medina County Observation Well Project, EUWD Report 93-11, 10 p.

FIGURES

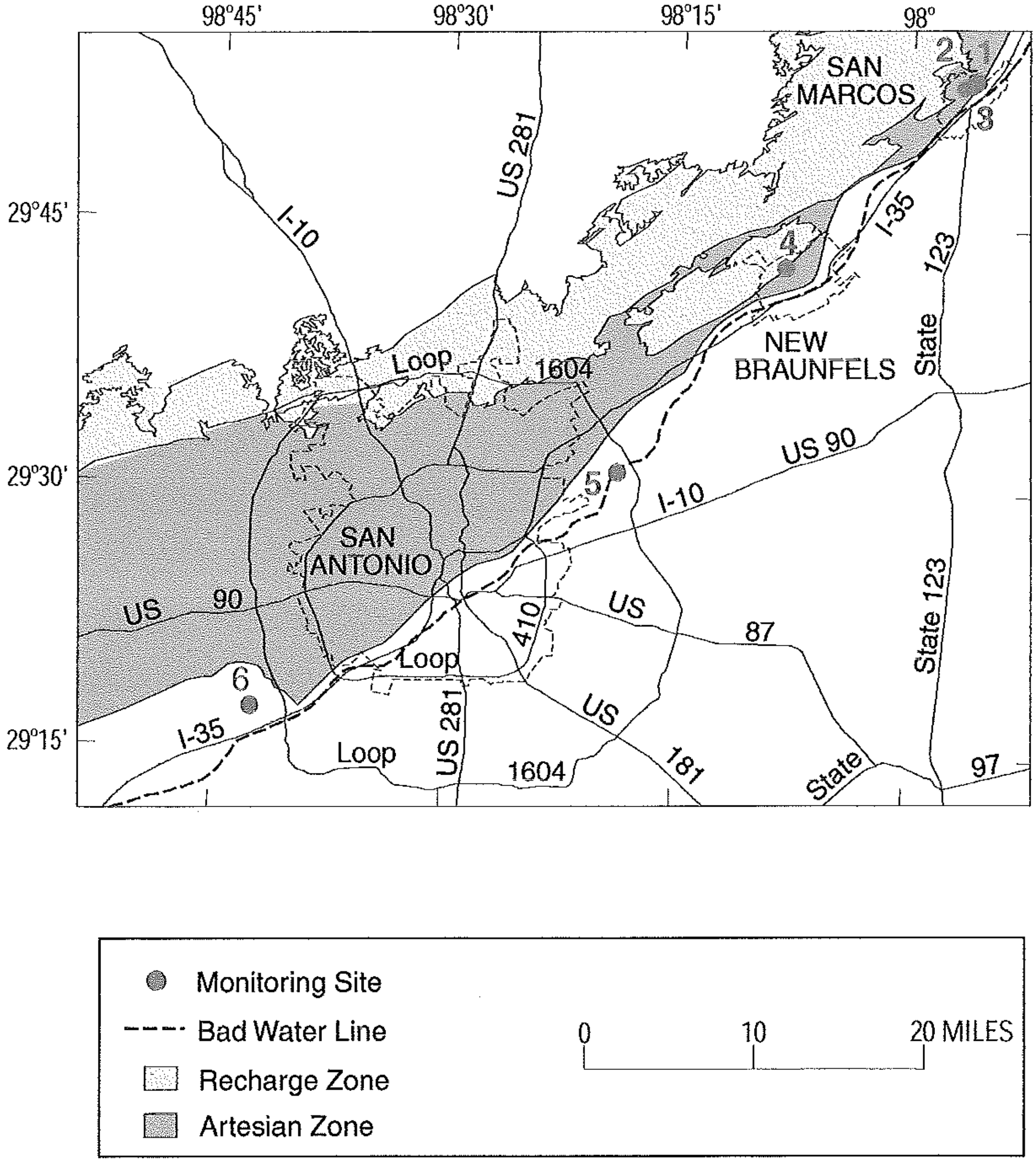


FIGURE 1. LOCATION OF BAD WATER LINE MONITORING SITES
(modified from U.S. Geolgocial Survey)

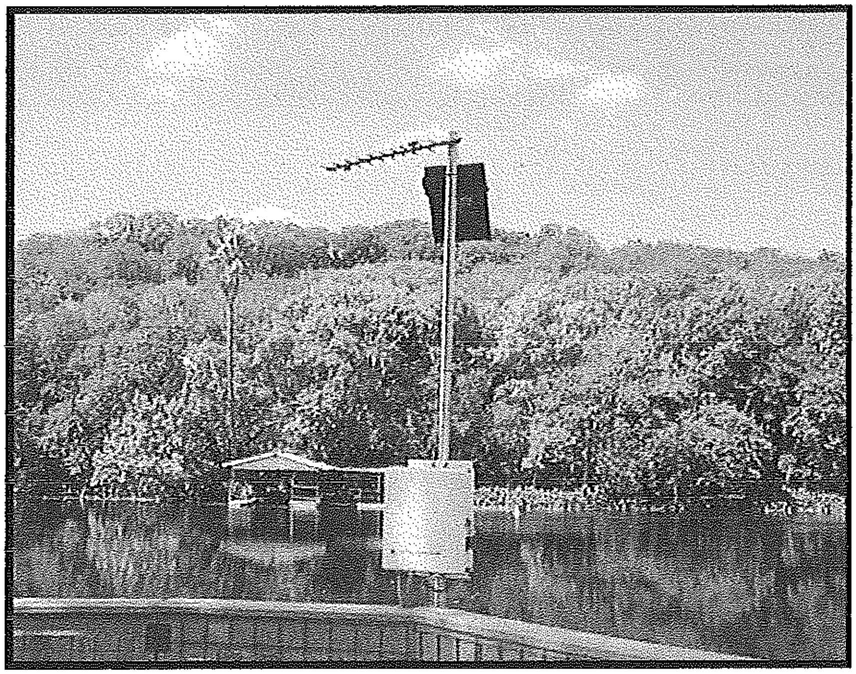


FIGURE 2a. VIEW OF DEEP SPRING

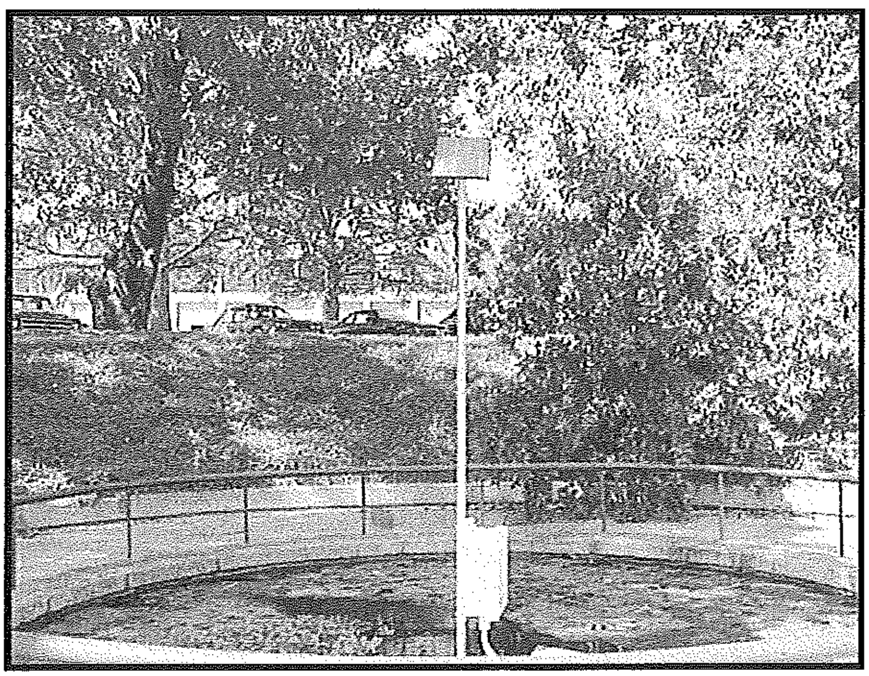
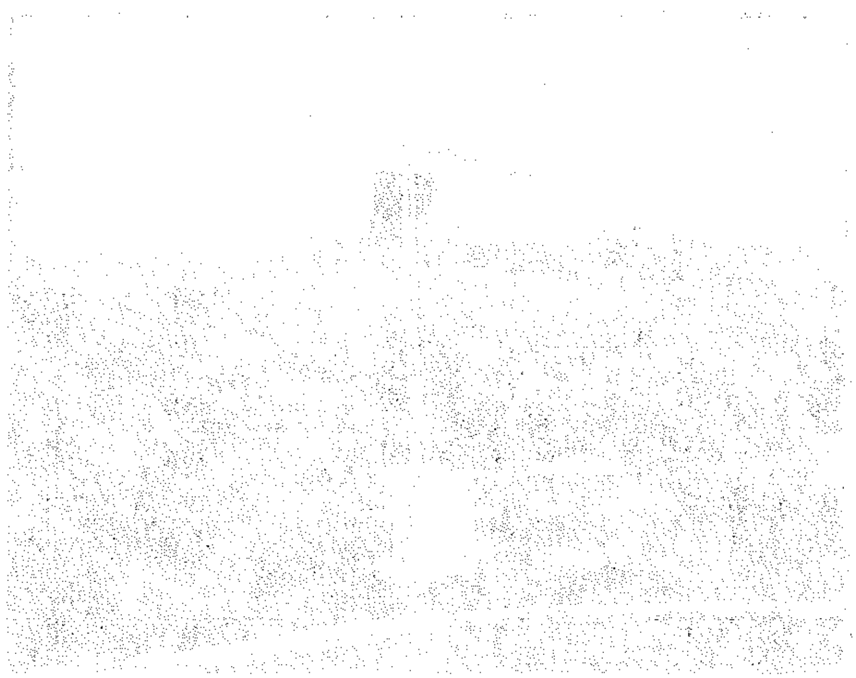
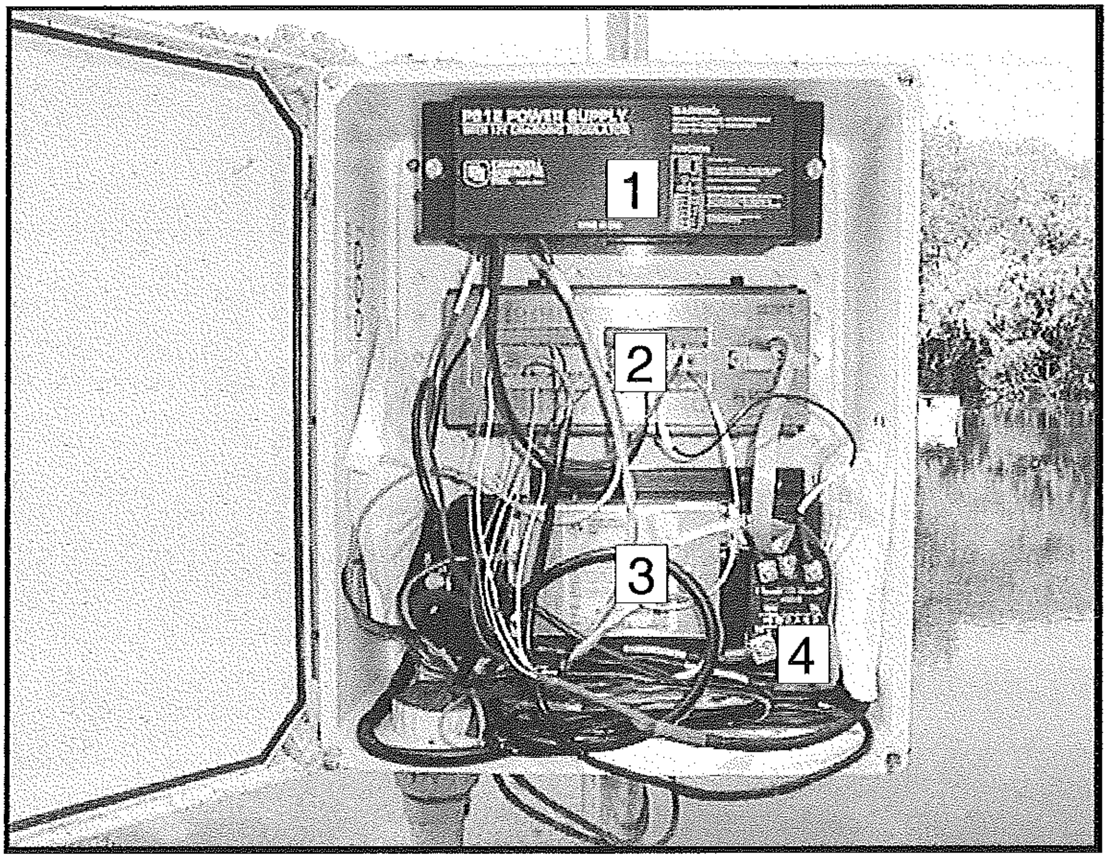


FIGURE 2b. SOUTHWEST TEXAS STATE UNIVERSITY FLOWING WELL

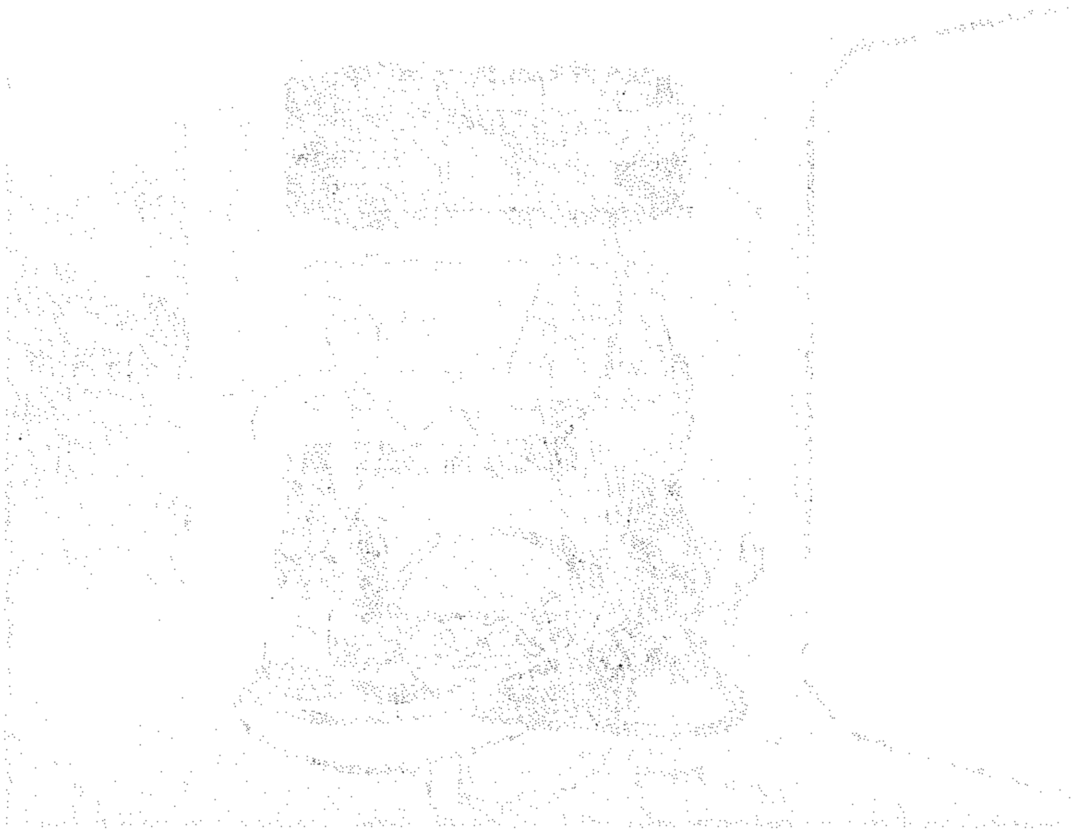
(photographs by Rita Setser)





1. Power supply
2. Campbell Scientific CR 10 Datalogger
3. Motorola Transceiver
4. 12 volt modem

FIGURE 3. DATA LOGGER AND TELEMETRY SYSTEM



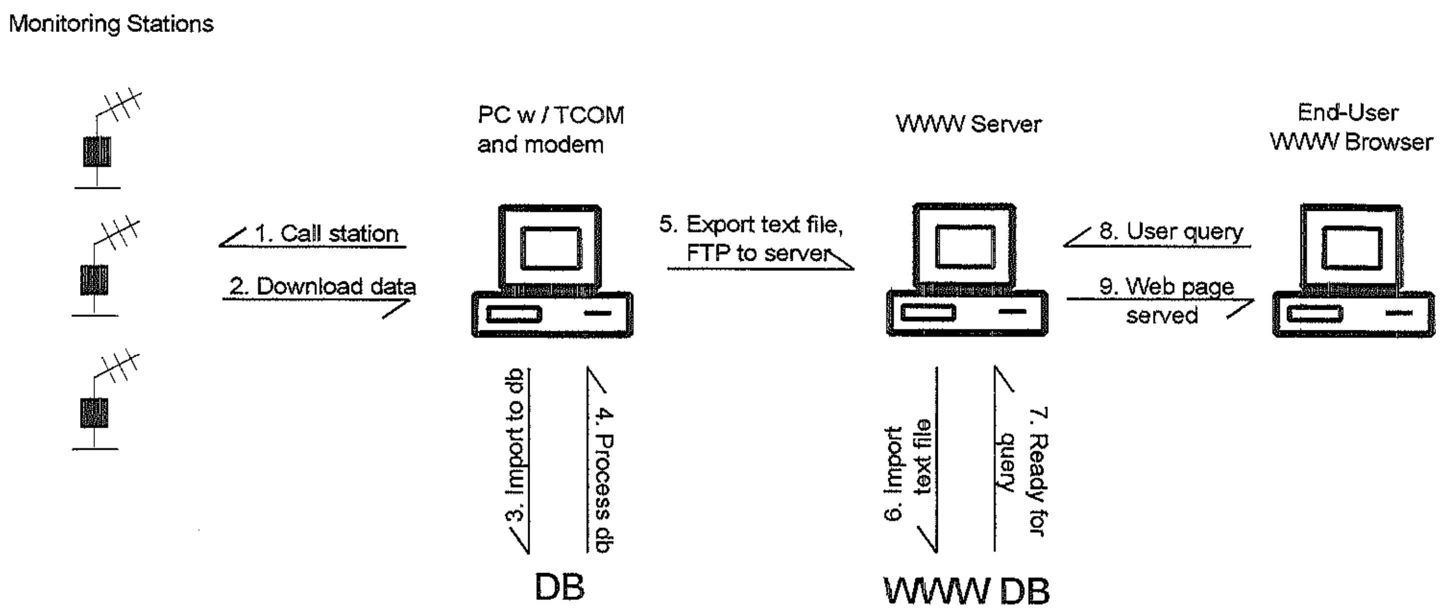


FIGURE 4. DATA AQUISITION, PROCESSING AND DISPLAY