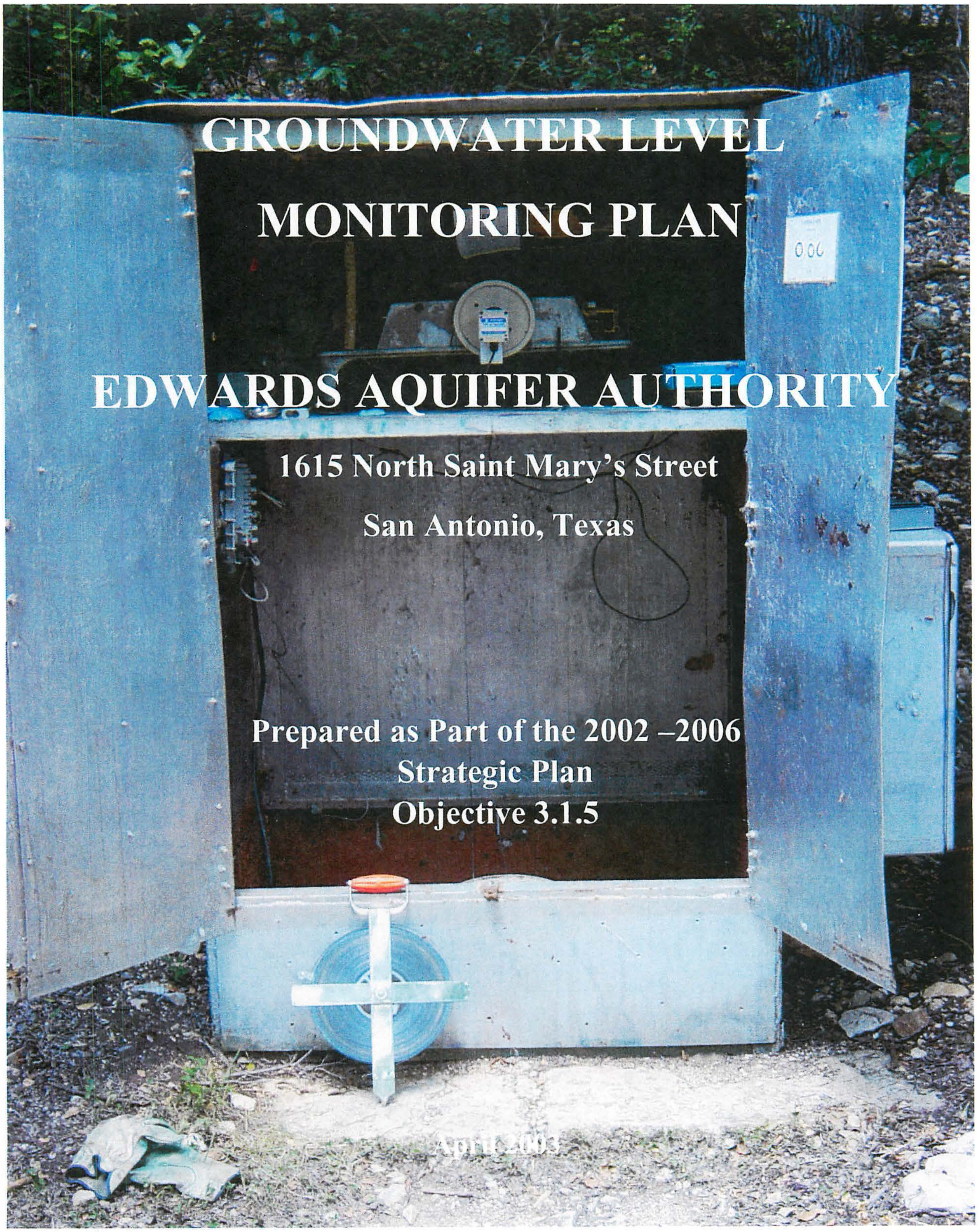

GROUNDWATER LEVEL MONITORING PLAN

EDWARDS AQUIFER AUTHORITY

1615 North Saint Mary's Street

San Antonio, Texas

Prepared as Part of the 2002 –2006
Strategic Plan
Objective 3.1.5

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APPENDICIES

ACRONYMS AND ABBREVIATIONS

bgs	below ground surface
DQO	data quality objective
EAA	Edwards Aquifer Authority
e-line	electronic water level measurement device
GW	groundwater
MSL	mean sea level
NAWQA	National Water Quality Assessment
psi	pounds per square inch
QA	quality assurance
QC	quality control
SOP	standard operating procedure
TWDB	Texas Water Development Board
USGS	United States Geological Survey

SECTION 1

INTRODUCTION

This section provides the objective and outlines the contents of the plan, and presents the importance of obtaining accurate groundwater level information. Also provided in this section are discussions of the various water level programs, and methodologies in use by the Edwards Aquifer Authority (the Authority).

1.1 PLAN OBJECTIVE

The objective of this plan is to provide a standard for the collection of water level data for the Authority. The plan includes data quality objectives (DQOs) and calibration requirements, as well as the field measurement and decontamination protocol. The plan also references methods used by other agencies, and includes a requirement for annual review.

Groundwater level data are of utmost importance in making basic evaluations of any aquifer. As such, the accuracy of these data are critical for assessments of groundwater gradients, and detecting potential relationships with surface water. Groundwater levels provide the primary source of information related to hydrologic stresses acting on aquifers and the relationship between hydrologic stresses and recharge, storage and discharge (Taylor 2001).

1.2 WATER LEVEL MONITORING NETWORK

Authority staff performs water level measurements on a regular basis throughout the jurisdictional area of the Authority. Water level data are collected from a network of monitor wells that can be categorized by their frequency of measurement as follows:

- Wells utilizing continuous / automatic recorders that collect data over a preset interval
- Wells measured monthly
- Wells measured two – three times per year (synoptic measurement)

In 2002, the Authority operated 39, continuous recorders and collected monthly measurements at 17 wells. Maps showing locations of all continuous recorder and monthly tape down wells for calendar year 2002 are located in **Appendix A** as **Figures A-1** and **A-2. Table B-1** in **Appendix B**, summarizes basic information for wells monitored under the continuous and monthly programs.

In addition, approximately 300 wells are measured two to three times annually as part of the synoptic water level project. **Figure A-2** located in **Appendix A**, shows the locations of all wells measured during the three synoptic events during calendar year 2002.

The Synoptic Program is designed to collect groundwater levels across the aquifer three-times annually. All synoptic levels are collected within a two-week period using steel tapes e-lines, and data from continuous recorders.

All continuous recorders are installed in Authority–operated monitoring wells. The monthly measurements and synoptic measurements are collected from a combination of Authority-operated monitor wells and private wells.

1.3 METHODOLOGY

Groundwater level data may be obtained by a variety of methods such as, steel tapes, electric line (electric water-level tape or e-line), float-activated recorders, pressure sensing devices, air-lines and other methods. The steel tape and e-line are manual measurement methods that provide an instantaneous reading of water levels. The air-line method is typically set up to provide an instantaneous reading of water column height above the bottom of the air-line however; the data is read from a pressure gauge rather than measured downhole. Pressure sensing devices, float-activated recorders and similar equipment generally are used to provide a near continuous record of water level changes over time.

The standard for measurement of accurate depths to water is the steel tape method. However, the e-line also provides very accurate readings (at relatively shallow depths) and the water level can be read directly from the calibrated line. In addition, in wells that are pumping, or have cascading water in the well bore, the e-line is preferable to steel tape since it does not require submersion below the upper few inches of the water surface. Generally speaking, the other methods listed are initially calibrated from data obtained using a steel tape. For example, when setting up a float-activated recorder, initial depth to water is determined using a steel tape or e-line. All continuous recorded data is checked on a routine schedule using a steel tape or e-line.

SECTION 2

DATA QUALITY OBJECTIVES

In order to obtain data of acceptable quality in the most efficient manner, the ultimate use of the data must be known. Specifically, DQOs must be defined. This section will provide a definition for the required DQOs, and provide guidelines for determining the validity of the data.

2.1 DEFINING DATA QUALITY OBJECTIVES

Data quality objectives, or DQOs, are used to specify the data type, quality, quantity, and ultimate uses of the data collected (AFCEE 2001). Groundwater level data are typically measured in units of feet to water surface. They are paramount in understanding and describing the overall condition of the Edwards Aquifer. Therefore, the quality of the groundwater level data needs to be reflective of its importance. Groundwater level measurement tools in use by the Authority provide this data to the nearest 0.01-foot. However, operator error, incorrect calibration, inaccurate vertical survey data, borehole deviations, and other issues may cause the true measurement to be less accurate than 0.01-feet. Groundwater level data are collected continuously by data recorders at multiple wells across the region and at least monthly by steel tape, e-line, or airline. This results in a large quantity of historical data that defines trends and helps to statistically reduce errors over time. Furthermore, the DQOs are influenced by the large aerial extent for which groundwater level data are collected.

The Authority measures water levels throughout an approximately 180-mile section (central section) of the Edwards Aquifer Region. Groundwater gradients can vary significantly over this distance, with the highest gradients typically located in the unconfined (Recharge Zone) portions of the aquifer. A relatively high gradient, combined with a large area of investigation mitigates the effects of small (<0.1-foot) perturbations in accuracy. However, this does not circumvent the need to obtain data that are as accurate as feasible.

The DQOs for groundwater level data obtained using a steel tape or e-line are summarized in **Table 2-1, Groundwater Level Data Quality Objectives**. Expected accuracy is dependent upon well depth and type. Obtaining successive measurements at each well defines the precision, or repeatability of the measurements. Since the equipment is accurate to 0.01-foot, repeated measurements that do not deviate outside this range implies that the user has obtained a level of precision equal to the instruments accuracy. However, several wells have minimal annular space available for measurement equipment to pass through, and repeated measurements may not fall within the acceptable range of variation. In these cases, a mathematical average is to be recorded and flagged in the field log. Data flagging conventions are discussed in Section 2.2.

DQOs for continuous recording equipment are based on their accuracy, and the amount of drift or deviation over the recorded time interval. Although each continuous recording device may have a stated accuracy of 0.01-feet, regular confirmation of continuous recorders must be obtained using a calibrated steel tape or e-line. This is due to the tendency of many recorders to drift over time. Bubbler and transducer recorders have an operational range that must be adhered to in order to maintain accuracy. Therefore, the deviation of each continuous recorder from the valid steel tape or e-line measurement is to be evaluated and recorded in accordance with Table 2-1, on a monthly basis.

Water level data may be obtained by using an airline if the length of airline is known, and an accurate pressure gauge is installed at the surface. The line is pressurized and a direct reading is taken from the pressure gauge. The reading in pounds per square inch (psi) is then multiplied by 2.31 to convert from psi to feet of water above the bottom of the airline. The corresponding depth to water is: ((depth to water = depth to bottom of airline) – (height of water above bottom of airline)). Airlines typically do not provide the degree of accuracy or precision of other devices discussed herein. The units of pressure on gauges are generally in tenths or greater gradations. As such, a maximum accuracy of 0.23-foot (0.1 psi X 2.31) would be associated with most airline measurements. Furthermore, significant changes in water temperature effectively change the fluid density, and should be compensated for when temperatures deviate more than a few degrees from 68-degrees Fahrenheit (Groundwater & Wells 1995).

2.2 DATA VALIDATION AND FLAGGING

Data validation is the process of ensuring the data are reasonable and have met the DQOs. For groundwater level monitoring, this can be accomplished in two basic steps. First, as the data are collected, they should be reviewed, and compared to historical data for similar conditions or to regionally similar data if no historical data are available. Second, prior to inclusion into the groundwater level database, the data should be checked again for agreement with historical conditions (such as previous water levels, or water levels taken under similar conditions). If the data review indicates the collected data are reasonable, and the data collector has not noted any anomalous issues associated with the data then they can be reasonably assumed to be valid water levels.

Some data may require notations to indicate potential issues with data quality. For example, if a groundwater level measurement is taken repeatedly without obtaining the desired precision (see Table 2-1) between readings, then an estimated value may be required. In this case, the data would be recorded as the mathematical average, and noted with the letter "J". The "J" or J-flag indicates the value is an estimated quantity based on the measurements taken.

In a worst case scenario, where the data are highly questionable, with an error margin greater than 0.5% (with a maximum value of 0.5-foot) the data would be recorded in the field log and noted with an "R" or R-flag. This indicates the measurement was taken, but the deviation from the DQOs has resulted in rejection of the data for use in groundwater gradient calculations. Maintaining a record of R-flagged data will assist in identification of wells that historically have anomalous data readings.

Water level measurements taken with an airline should be flagged in the field log with the letter "A", such that it will be readily apparent how the reading was taken. If the data are critical, such that they will be used with or compared to steel tape or e-line data, then (if possible) an additional measurement using a steel tape or e-line should be made to confirm the accuracy of the airline gauge.

Wells measured in close proximity to pumping wells, or wells that are pumping when measured, should also be flagged. The appropriate flag for this scenario is a "P" or P-flag. This will help to explain why the water level for such wells may appear anomalous when compared to other data. Data flags and definitions are summarized in **Table 2-2, Data Flagging Conventions.**

One final circumstance that must be compensated for when encountered involves turbine shaft wells that may have significant accumulations of lubricating oil above the water surface. When this is encountered the water level measurement should be adjusted by using an average adjustment factor of 0.86*. The height (or thickness) of the oil layer should be multiplied by 0.86, and the resulting value added to the value for the oil/water interface. This may require the use of a water paste to find the level of the oil/water interface. The example below can be used to clarify the procedure (modified from Hopkins 1994).

Measurements taken on a well containing a 10-foot thick layer of oil:

1) Depth to oil/water interface	=100 ft
2) Depth to top of oil layer	= 90 ft
3) Amount of oil in well	= 10 ft
4) Oil in well X 0.86	= 8.6 ft
5) Adjusted depth to water	=91.4 ft

Expected DQOs and flagging criteria are summarized in Table 2-1. The error margin for fully acceptable water level measurements is 0.05% or less of the depth measured when two or more concurrent measurements are compared.

* 0.86 Represents an average correction factor for hydrocarbon compounds in the compositional range of lubricating oils used in agricultural pumping wells.

Table 2-1 Groundwater Level Data Quality Objectives and Flagging Convention

Depth to Water (in feet)	Δ Between* Measurements (in feet)	Data Flag	Δ* Between Measurements (in feet)	Data Flag	Δ* Between Measurements (in feet)	Data Flag
0 – 100	≤ 0.05 *foot*	None	≥ 0.05 ≤ 0.50	J	≥ 0.50	R
100 – 200	≤ 0.10 *foot*	None	≥ 0.10 ≤ 0.50	J	≥ 0.50	R
200 – 300	≤ 0.15 *foot*	None	≥ 0.15 ≤ 0.50	J	≥ 0.50	R
300 – 400	≤ 0.20 *foot*	None	≥ 0.20 ≤ 0.50	J	≥ 0.50	R
400+	≤ 0.30 *foot*	None	≥ 0.30 ≤ 0.50	J	≥ 0.50	R

* Δ Represents the mathematical difference between concurrent measurements

Table 2-2 Data Flagging Convention

Flag	Definition
J	Measurement based on a numerical average
R	Data recorded, but results do not meet the DQOs
P	Data obtained from pumping well, or level appears to be influenced by a pumping well located in vicinity
A	Measurement taken with an airline

SECTION 3

EQUIPMENT CALIBRATION

This section will discuss the requirements for calibration of groundwater level measurement equipment. Equipment falls into two basic categories, manual measurement equipment and continuous recording equipment.

3.1 MANUAL MEASUREMENT EQUIPMENT

This section applies to steel tapes and e-lines. At depths of less than 500-feet, and relatively low downhole temperatures (<82° Fahrenheit), the effects of stretching and thermal expansion are negligible under the DQOs. Currently, the Authority does not obtain water level data at depths greater than 400 feet below ground surface (bgs). As such no special techniques are needed to compensate measurements taken with these devices under the current program.

While these instruments can generally be considered "calibrated," repeated use, damage, or stretching can lead to a loss of accuracy. Specifically a steel tape or e-line that is kinked, or that has been pulled with excessive force in order to dislodge it may no longer be within calibration. Therefore, in order to assess the condition and calibration of these devices, an annual (or more frequent if the device is suspect) calibration to a reference tape is required. The reference tape is to be a steel tape, stored in a controlled environment, and used only for calibrating other devices. The calibration procedure will entail making a side by side comparison of the "field" device, with the reference tape, for the full length of the device. This comparison is best accomplished by taking successive measurements in the same well with the two devices and comparing the results. If a deviation greater than 0.01-feet per 100-feet, or one-tenth of one percent is noted, the device is out of calibration. Tapes or e-lines that do not fall within the required calibration range are to be taken out of service until repaired, or destroyed if not repairable.

3.2 CONTINUOUS RECORDING EQUIPMENT

Continuous recording equipment is to be referenced to a water level obtained with a calibrated steel tape or e-line at the time of equipment set-up. Furthermore, a steel tape or e-line reference check will be performed on all continuous recording equipment monthly to ensure that no significant drift has occurred in the continuous measurement. If measurements indicate drift in the device beyond 0.01 ft/100 ft, then calibration adjustments should be made.

SECTION 4

STANDARD OPERATING PROCEDURE

This section outlines standard operating procedures (SOP) for decontamination of equipment and collection of water level data. Standard procedures are necessary in order to prevent possible contamination via the measurement device and to ensure that water level measurements are comparable.

In order to accomplish the required decontamination procedures, a list of supplies is provided below. All supplies may not be needed dependant upon circumstances encountered in the field. However, it is recommended that field personnel have all supplies available for gauging events.

4.1 SUPPLY LIST

1. Steel tape or electric line.
2. Blue carpenters chalk.
3. Tools for removal of the well cap.
4. Containers that can be sealed (such as 5-gallon buckets with lids) for storage of decontamination and rinse waters.
5. Alconox® or Liquinox® laboratory grade non-phosphate soap.
6. Potable water.
7. Distilled or deionized water.
8. Household bleach, unscented with no detergent additives and a standard 5.25% concentration of sodium hypochlorite.
9. Spray bottles.
10. Reagent grade methanol.
11. Supply of disposable latex, nitrile, or plastic gloves.
12. Eye wash bottle.
13. Safety glasses.
14. Plastic sheeting (4-foot by 4-foot, or larger).
15. Field data recording form.

4.2 STEEL TAPE

A steel tape graduated in 0.01-foot increments is to be used. The tape should be inspected for kinks, breaks, and other abnormalities on a continual basis. Do not use a tape that is in poor condition. If a weighted tape is used, the weight must be constructed of an inert material such as brass, stainless steel, or iron (lead weights may not be used). The weight is to be attached in a manner such that it will be held securely yet still allow the weight to separate from the tape should it become lodged in the well.

The procedure for decontamination and measurement using a steel tape is outlined below. Decontamination procedures are of utmost importance when gauging a well that is used for domestic or public drinking water. Introduction of bacterial or other contamination into wells of this type may cause persons using the water to ingest water borne pathogens or other contaminants. This situation is unacceptable, and preventable on the part of staff.

4.2.1 Procedure

1) During the decontamination process, wear new latex, nitrile, or plastic gloves and eye protection. If the steel tape has not been in contact with hydrocarbon compounds or other contaminants, clean the tape as follows:
   - A. Wash the tape in a mixture of Alconox® or Liquinox® soap and potable water;
   - B. Rinse the tape with clean potable water;
   - C. Rinse the tape with distilled or deionized water applied using a spray bottle; and
   - D. Rinse the tape with household bleach just prior to inserting the tape into the well. The bleach solution should be mixed using 2.5 ounces of 5.25% sodium hypochlorite (household bleach solution, such as Chlorox® brand) bleach to 5 gallons distilled or deionized water. This will result in a 200 mg/L bleach solution, which is adequate to disinfect equipment used inside a well. Do not use scented bleaches.

Note: The bleach, soap and potable water solutions are to be replaced daily. Bleach will degrade rapidly once mixed and exposed to contaminants, hence the need to replace it daily.

2) If the tape has contacted hydrocarbon or other contaminants, such as turbine shaft oil or naturally occurring crude oil, the contaminants must be removed from the tape prior to gauging any additional wells. In order to ensure that any residual hydrocarbon contaminants are removed, an additional step is added to the decontamination process. The tape is to be sprayed or wiped down with reagent grade methanol, prior to performing the final rinse with distilled water. Repeat the decontamination process if any residual contamination remains after this step.

3) Safety glasses must be worn whenever bleach solution or methanol is used. In addition, an eye wash station must be present on site when these solutions are used. Care must also be taken to prevent the bleach or methanol solution from contacting skin or clothing.

4) If the tape is not used immediately, then it must be stored in a new plastic bag (trash bag, or other appropriately sized bag), or securely wrapped in clean aluminum foil. This will prevent re-contamination of the tape prior to use.

5) Once the tape is thoroughly decontaminated, chalk the lower few feet of the tape by pulling the tape across a piece of blue carpenter's chalk. The wetted chalk mark will be used to identify that part of the tape that was in contact with the water surface in the well.

6) Lower the tape (and weight if applicable) into the well slowly until the lower end of the tape is submerged below the water surface. Knowing the approximate water level, based on previous readings will help the user to perform this step more efficiently. After contacting the water surface, continue to lower the tape until the next whole foot mark is opposite the measuring point (the measuring point should be clearly marked and described). This number is referred to as the "hold," and is equal to the total length of tape in the well. Record this number on the field log.

7) Rapidly wind the tape back on to the spool in order to facilitate reading the wetted chalk mark before it dries. Record the wetted chalk mark (also referred to as the cut) on the field log. The tape should never be removed from the well in a manner that will result in the tape contacting the ground surface. Always spool the tape back onto the reel when removing it from the well. Under rare circumstances when the tape cannot be placed directly back onto the reel, the tape is to be placed on clean plastic sheeting spread out on the ground.

8) Subtract the cut, from the hold (number obtained at the measuring point) and record this as the depth to water from the measuring point. The depth to water below the measuring point is defined as: (hold – cut = water level below measuring point)

9) In order to obtain the elevation of the water surface in feet above mean sea level (msl), subtract the number obtained for the water level below measuring point from the elevation for the measuring point and record this in the field log.

10) In order to ensure accurate data, the depth to water from the measuring point should be measured at least twice. Acceptable data criteria are outlined in the Data Quality Objectives Table in Section 2 of this document.

4.3 ELECTRIC LINE

An electric tape graduated in 0.01-foot increments is to be used. The line should be inspected for kinks, breaks, and other abnormalities on a daily basis. Do not use a line that is in poor condition.

The procedure for decontamination and measurement using an e-line is outlined below. Decontamination procedures are of utmost importance when gauging a well that is used for domestic or public drinking water. Introduction of bacterial or other contamination into wells of this type may cause persons using the water to ingest water borne pathogens, or other contaminants which is unacceptable, and preventable on the part of staff.

4.3.1 Procedure

1) During the decontamination process, wear new latex, nitrile, or plastic gloves and eye protection. If the E-line has not been in contact with hydrocarbon compounds or other contaminants, clean the tape as follows:
   - A. Wash the tape in a mixture of Alconox® or Liquinox® soap and potable water;
   - B. Rinse the tape with clean potable water;
   - C. Rinse the tape with distilled or deionized water applied using a spray bottle; and
   - E. Rinse the tape with household bleach just prior to inserting the tape into the well. The bleach solution should be mixed using 2.5 ounces of, 5.25% sodium hypochlorite (household bleach solution, such as Chlorox® brand) bleach to 5 gallons distilled or deionized water. This will result in a 200 mg/L bleach solution, which is adequate to disinfect equipment used inside a well.

Note: The bleach, soap and potable water solutions are to be replaced daily. Bleach will degrade rapidly once mixed and exposed to contaminants, hence the need to replace it daily. Scented bleaches are not to be used.

2) If the E-line has contacted hydrocarbon or other contaminants, such as turbine shaft oil or naturally occurring crude oil, the contaminants must be removed from the E-line prior to gauging any additional wells. In order to ensure that any residual hydrocarbon contaminants are removed, an additional step is added to the decontamination process. The E-line is to be sprayed or wiped down with reagent grade methanol, prior to performing the final rinse with distilled water. Repeat the decontamination process if any residual contamination remains after this step.

3) Safety glasses must be worn whenever bleach solution or methanol is used. In addition, an eye wash bottle must be present on site when these solutions are used. Care must also be taken to prevent the bleach or methanol solution from contacting skin or clothing.

4) If the E-line is not used immediately, then it must be stored in a new plastic bag (trash bag, or other appropriately sized bag). This will prevent re-contamination of the E-line prior to use.

5) Once the E-line is thoroughly decontaminated, test the circuit by placing the probe into a small container of clean potable water. If the tone sounds or the indicator needle deflects indicating a closed circuit, the equipment is ready for use.

6) Lower the probe end into the well slowly. Knowing the historical water level for the well being measured will assist the user in anticipating when to expect the probe to encounter the water surface.

7) Once the E-line indicates a closed circuit, record the reading on the line, adjacent to the measuring point. Record this number in the field log as the depth to the water surface from the measuring point. The measuring point should be clearly marked and described. The E-line allows for a direct reading of depth to water, therefore, the "cut" and "hold" values inherent to the steel tape are not used here.

8) In order to ensure accurate data, the depth to water from the measuring point should be measured at least twice. Partially rewind the line, and repeat the measurement process. Acceptable data criteria are outlined in the Data Quality Objectives table in Section 2 of this document.

9) Upon achieving acceptable data quality, respool the E-line. The E-line should never be allowed to contact the ground surface. In the rare event that the E-line cannot be respooled, a clean piece of plastic sheeting should be placed on the ground and the E-line can be allowed to accumulate on the plastic sheeting.

4.4 CONTINUOUS RECORDERS

Currently, the Authority uses continuous recording equipment that will record to either a paper chart, or store the data digitally to a "card" or other device which is downloaded on a monthly basis. Recorders that have electronic storage are currently set to take a water level measurement every 15-minutes.

Table 4-1 outlines the types of continuous recording equipment currently in use by the Authority.

Table 4-1 Continuous Water Level Recorder Equipment

Manufacturer and Model	Data Storage Method	Measurement Methodology	Operational Range (in feet of pressure head variation)
Stevens	Paper Chart	Float	50
OTT Orfamedes	Electronic	Bubbler	41
OTT Thalamedes	Electronic	Float	100
OTT Nimbus	Electronic	Bubbler	41
Insitu – MP Troll	Electronic	Pressure Transducer	231
Insitu – Mini Troll	Electronic	Pressure Transducer	200+

Continuous recording equipment is to be installed per manufacture direction, and calibrated to a steel tape or e-line. Prior to installation the downhole portion of the unit is to be decontaminated in accordance with the procedure below. Also, a safety cable or strap is to be used on all downhole equipment.

4.4.1 Procedure

1) During the decontamination process, wear new latex, nitrile, or plastic gloves and eye protection. If the down-hole portion of the equipment has not been in contact with hydrocarbon compounds or other contaminants, decontaminate as follows:
   A. Wash the in a mixture of Alconox® or Liquinox® soap and potable water;
   B. Rinse with clean potable water;
   C. Rinse with distilled or deionized water applied using a spray bottle; and
   F. Rinse with household bleach just prior to inserting into the well. The bleach solution should be mixed using 2.5 ounces of, 5.25% sodium hypochlorite (household bleach solution, such as Chlorox® brand) bleach to 5 gallons distilled or deionized water. This will result in a 200 mg/L bleach solution, which is adequate to disinfect equipment used inside a well.

Note: The bleach, soap and potable water solutions are to be replaced daily. Bleach will degrade rapidly once mixed and exposed to contaminants, hence the need to replace it daily. Scented bleaches are not to be used.

2) If the downhole device has contacted hydrocarbon or other contaminants they must be removed prior to placement in the well. In order to ensure that any residual contaminants are removed, an additional step is added to the decontamination process. The downhole portion of the device is to be sprayed or wiped down with reagent grade methanol, prior to performing the final rinse with distilled water. Repeat the decontamination process if any residual contamination remains after this step.

3) Safety glasses must be worn whenever bleach solution or methanol is used. In addition, an eye wash bottle must be on site when these solutions are used. Care must also be taken to prevent the bleach or methanol solution from contacting skin or clothing.

4) If the downhole device is not placed in the well immediately, then it must be stored in a new plastic bag (trash bag, or other appropriately sized bag), or aluminum foil until ready for use.

SECTION 5

PROCEDURES FOLLOWED BY OTHER AGENCIES

A literature review of procedures for water level measurement followed by the US Geological Survey, and the Texas Water Development Board was conducted during compilation of this document.

5.1 US GEOLOGICAL SURVEY

The US Geological Survey has been gathering water level data for over one-hundred years (Taylor 2001). The US Geological Survey has developed various guidance documents for taking water level measurements, as well as documents discussing the importance of monitoring groundwater levels over long time periods. US Geological Survey methods for collection of water level data do not deviate significantly for well depths and types similar to those measured by the Authority.

5.2 TEXAS WATER DEVELOPMENT BOARD

The Texas Water Development Board (TWDB) performs water level measurements based on their publication number UM-52, *Explanation of the Texas Water Development Board Ground-Water Level Monitoring Program and Water-Level Measuring Manual*, (Hopkins 1994). This manual is comprehensive, covering a wide range of conditions across the state as well as providing an excellent discussion of various measurement devices in use by the TWDB. The primary purpose of the TWDB manual is to provide a basis for consistency in taking water level measurements that fall under their jurisdiction.

SECTION 6

ANNUAL REVIEW

6.1 ANNUAL REVIEW OF MONITORING METHODOLOGY

In accordance with the guidance set forth under Section 3.1.2 of the 2002-2006 Edwards Aquifer Authority Strategic Plan, data collection efforts described in this plan will be reviewed by May 31, each year. The review will be directed toward ensuring that all data collection efforts herein are necessary, properly performed, and properly staffed. Furthermore, the review will ascertain if the methodologies in use are still appropriate for their intended purpose in addition to identifying and listing wells that exhibit anomalous data. The review process will include a listing of wells monitored under synoptic, monthly, and continuous recorded programs. The developed well list will be included as Appendix A in each updated plan.

Wells listed in **Appendix A, Figures A-1, A-2,** and **A-3,** will be subject to updates based on changes in monitoring requirements as well as condition, location and accessibility of listed wells. Wells found to be exhibiting anomalous data will be noted, and investigated after identification. Proposed remedies or alternatives for anomalous wells and data will be summarized in a letter report to the Aquifer Science Program Manager each year after the annual review process. Furthermore, the letter report will contain a summary of recommended updates to the Groundwater Level Monitoring Plan.

SECTION 7

SUMMARY OF GROUNDWATER LEVEL MONITORING PLAN

7.1 SUMMARY

This plan is intended as a guidance document for Authority staff to use when collecting groundwater level data. The importance of this data should not be underestimated, especially when collected properly, and validated in the field. Groundwater level data can be used to better understand aquifer response to stresses related to pumping, and recharge in addition to ascertaining groundwater gradient information, and surface water interactions that occur in the aquifer.

The primary aspects of this document are the use of DQOs, SOPs, and conducting annual reviews of the plan itself to ensure the adequacy of the plan as conditions and data needs change. The use of DQOs will ensure that data collected are consistent, and appropriately flagged when suspect. Incorporation of SOPs into the plan will also contribute to consistent measurements, as well as prevent accidental cross contamination of wells. While the annual review process will help the Authority to maintain an accurate groundwater level data-set, as well as identify and correct anomalous and erroneous data points from future data-sets.

SECTION 8

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APPENDIX A

Groundwater Level Monitoring Well Maps for:
Continuous Recorder, Monthly Tape Down, and Synoptic Wells

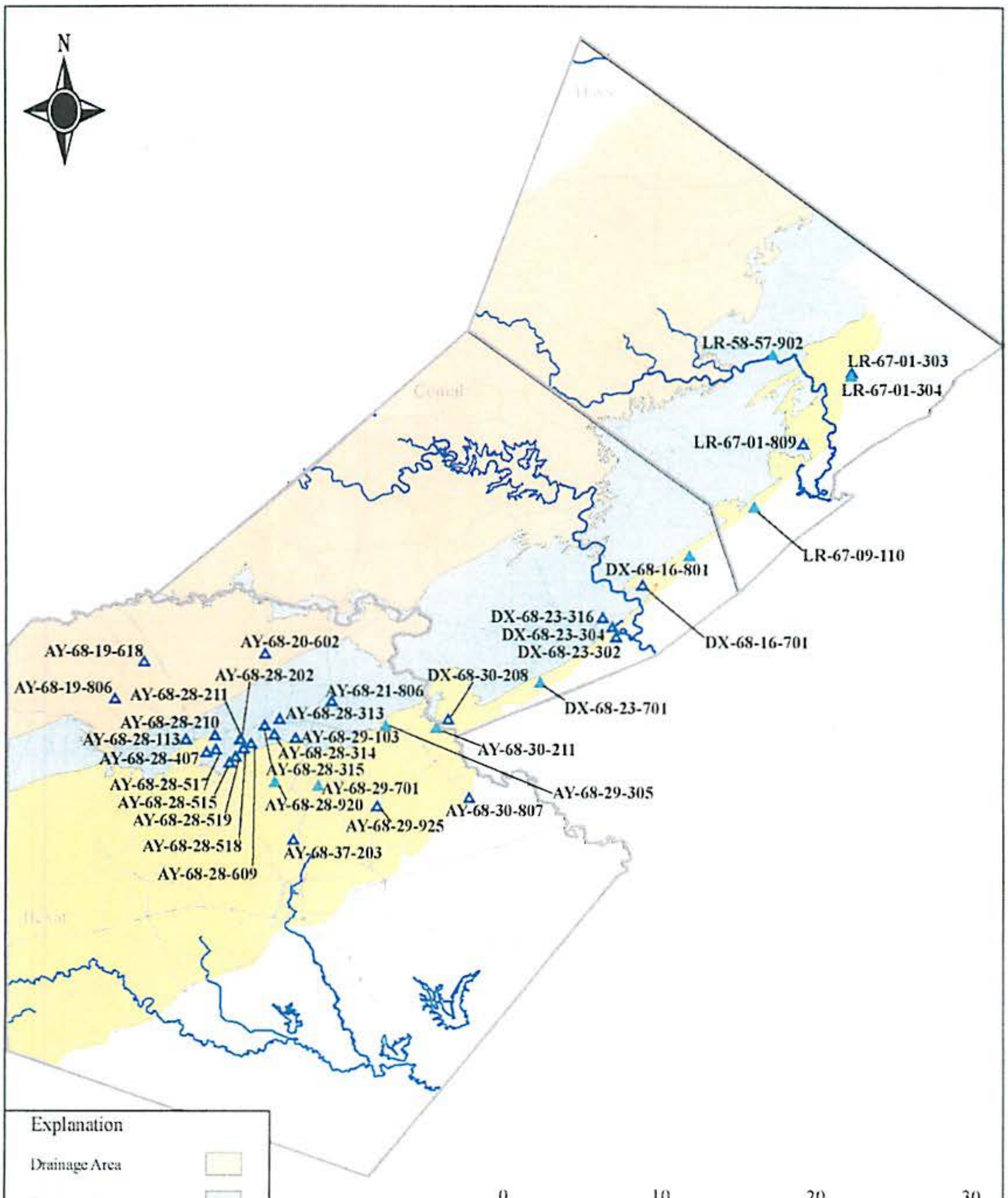

Figure A-1

Year 2002 Edwards Aquifer Authority Water Level Observation Network Bexar, Comal and Hays Counties

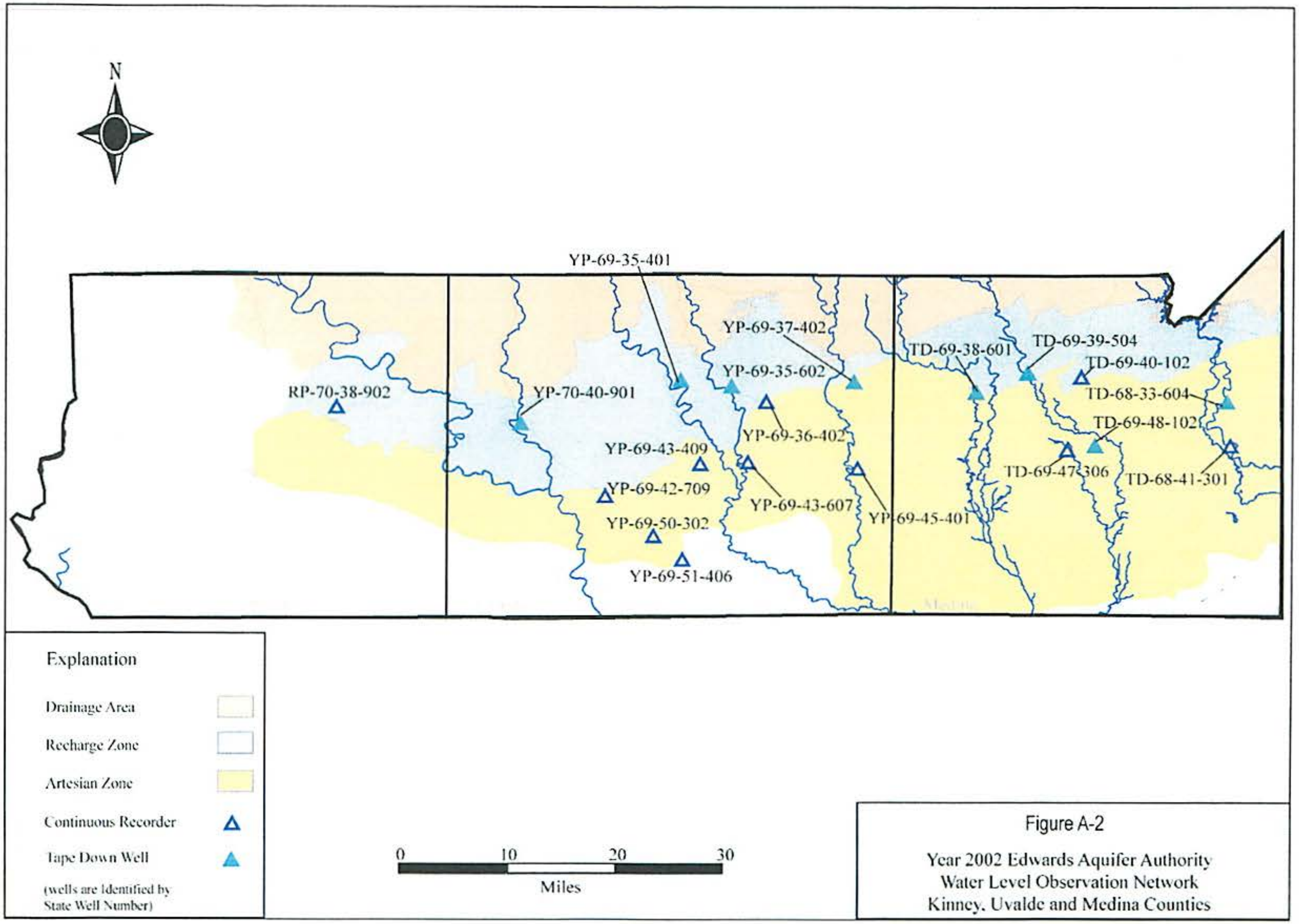

Figure A-2

Year 2002 Edwards Aquifer Authority
Water Level Observation Network
Kinney, Uvalde and Medina Counties

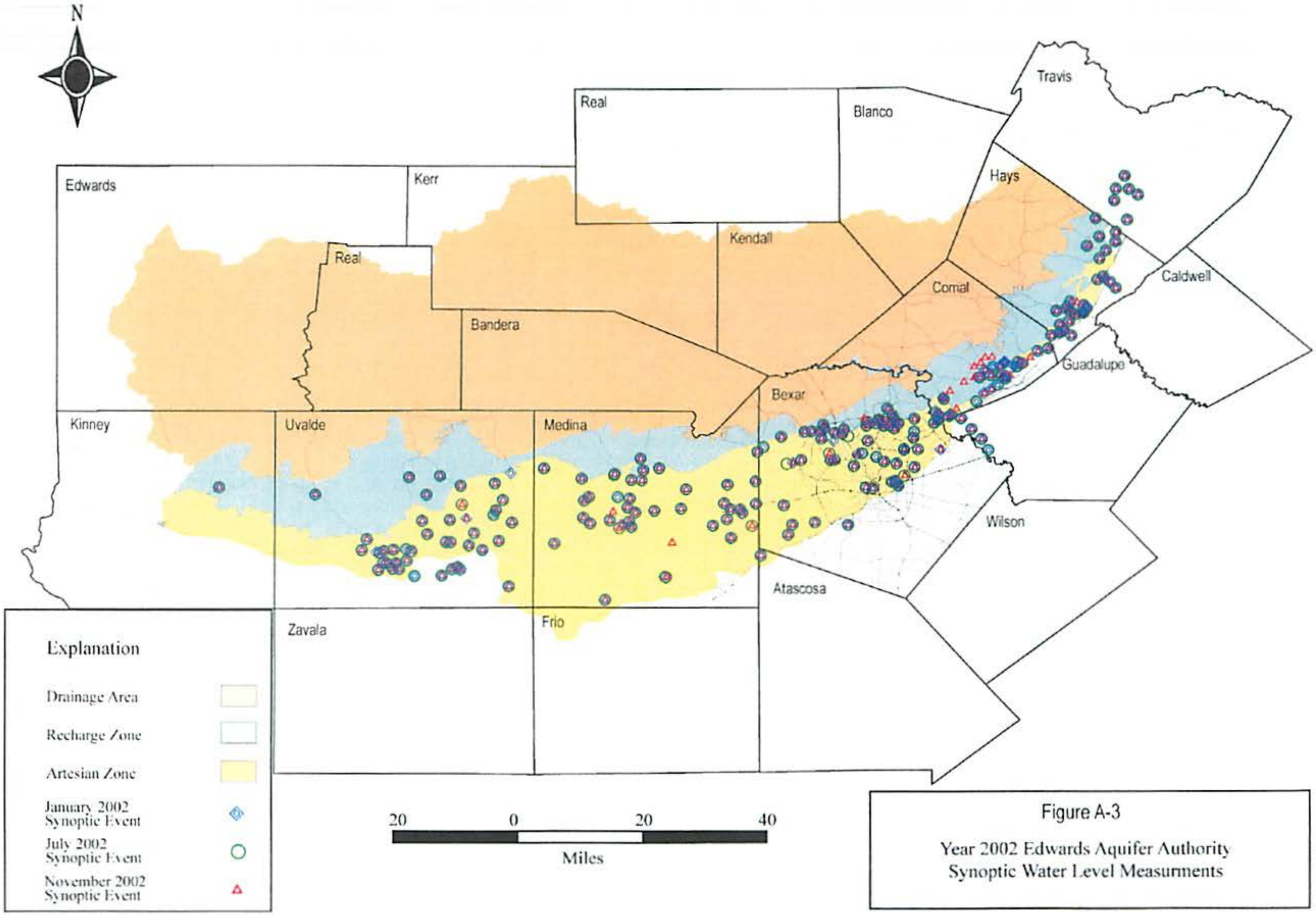

Figure A-3

Year 2002 Edwards Aquifer Authority Synoptic Water Level Measurments

APPENDIX B

Groundwater Level Monitoring Well Summary for:
Continuous Recorder and Monthly Tape Down Wells

Continuous Recorder Wells

Station / Well Name	State Well Number	Latitude	Longitude
Kyle North	LR-67-01-303	29.98972222	-97.87527778
	LR-67-01-809	29.91194444	-97.92833333
HWY 306	DX-68-16-701	29.75694444	-98.10444444
Landa Park	DX-68-23-302	29.70000000	-98.13333333
Comal Plant #3	DX-68-23-304	29.71083333	-98.13722222
Loop 337	DX-68-23-316	29.72111111	-98.14777778
Randolph	AY-68-30-807	29.52472222	-98.29555556
Bracken	DX-68-30-208	29.61000000	-98.31916667
City of Hondo	TD-69-47-306	29.34638889	-99.13888889
Interchange Parkway	AY-68-29-925	29.51527778	-98.39777778
Encino Rio	AY-68-21-806	29.62944444	-98.44833333
Hill Country	AY-68-29-103	29.58916667	-98.48777778
J17 (Dodd Field)	AY-68-37-203	29.47805556	-98.49000000
Bexar-Met. W.D.	AY-68-28-313	29.60972222	-98.50555556
SARA @ Blanco Driving Range	AY-68-28-314	29.59305556	-98.51138889
Fawn Bluff	AY-68-28-315	29.60278000	-98.52194400
Blanco Rd.(Cow Creek)	AY-68-20-602	29.68138889	-98.52138889
Blanco Rd.(Glen Rose)	AY-68-20-602	29.68138889	-98.52138889
Huebner @ Salado Crk	AY-68-28-609	29.58305556	-98.53666667
Shavano Park & Cliffside	AY-68-28-518	29.57777778	-98.54500000
Shavano Water Supply #2	AY-68-28-202	29.58750000	-98.54777778
Shavano Park & Fawn Dr.	AY-68-28-211	29.58805556	-98.54861111
Huebner @ Olmos Crk.	AY-68-28-519	29.56888889	-98.55361111
Lockhill-Selma P.O.	AY-68-28-515	29.56250000	-98.56027778
Shavano Woods	AY-68-28-517	29.57666667	-98.57527778
Lockhill-Selma @1604	AY-68-28-210	29.59194444	-98.57611111
Vance Jackson @ Beckwith	AY-68-28-407	29.57361111	-98.58555556
UTSA @ Regency	AY-68 28-113	29.58777778	-98.60777778
Boerne Stage Rd	AY-68-19-618	29.67277778	-98.65388889
La Escondida	AY-68-19-806	29.63194444	-98.68583333
City of Castroville	TD-68-41-301	29.35277778	-98.88333333
Quihi	TD-69-40-102	29.46111111	-99.11722222
City of Sabinal	YP-69-45-401	29.31666667	-99.46666667
Trio	YP-69-36-402	29.42194444	-99.61000000
Knippa	YP-69-43-607	29.32638889	-99.63833333
N. Uvalde	YP-69-43-409	29.32388889	-99.71333333
	YP-69-51-406	29.17361111	-99.74083333
City of Uvalde	YP-69-50-302	29.21027778	-99.78666667
Seven Mile Hill	YP-69-42-709	29.27305556	-99.86222222
Tularosa Rd	RP-70-38-902	29.41305556	-100.28333330

Monthly Tape Down Wells

Station / Well Name	State Well Number	Lattitude	Longitude
	LR-58-57-902	30.00861111	-97.96166667
City of Kyle	LR-67-01-304	29.98583333	-97.87583333
SWT Farms	LR-67-09-110	29.84305556	-97.98194444
	DX-68-16-801	29.78888889	-98.05305556
	DX-68-23-701	29.65000000	-98.21666667
West Ave	AY-68-28-920	29.54111111	-98.51083333
SA Airport Well	AY-68-29-701	29.53722222	-98.46305556
Cibolo Creek	AY-68-30-211	29.60472222	-98.32777778
Judson Rd Well	AY-68-29-305	29.60222222	-98.38833333
	TD-68-33-604	29.42194444	-98.88888889
Tarpley Rd	TD-69-39-504	29.46750000	-99.20055556
	TD-69-48-102	29.35277778	-99.09583333
	YP-69-35-401	29.59194444	-99.74666667
Frio River	YP-69-35-602	29.44611111	-99.66444444
HWY 187	YP-69-37-402	29.45305556	-99.47277778
Seco Creek	TD-69-38-601	29.43722222	-99.28166667
Nueces River	YP-70-40-901	29.39555556	-100.07500000