GROUND-WATER RESOURCES OF THE EDWARDS AQUIFER IN THE DEL RIO AREA, TEXAS

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INTRODUCTION

Water has played a major role in the location of settlements throughout the history of man. Evidence that man has inhabited the area around Del Rio for many thousands of years exists in the form of pictographs or paintings found on cave walls and cliffs in the area. The tribes of Indians that inhabited the region lived in close proximity to the streams and springs. San Felipe Springs located in the town of Del Rio was the site of the first Spanish settlement founded on St. Phillip=s Day in 1635. The Spaniards named the area San Felipe del Rio (St. Phillip of the River). Even today, the springs and the river have continued to be a focal point for civilization, providing water for domestic, industrial and irrigation purposes.

The population of the City of Del Rio and Laughlin Air Force Base for the year 2000 is estimated to be 38,946, which is currently completely reliant on San Felipe Springs for its water supply. The City previously supplemented its supply with two wells located north of town, but these wells were abandoned because of disrepair and have not been used in the last 10 years. The population and the associated municipal water demand of the City of Del Rio are expected to grow by 46 percent and 30 percent, respectively, over the next 50 years (Plateau RWPG, 2001). Additional water supplies other than the springs are needed to meet future demands of the area. Because Del Rio has no permitted water rights for the Rio Grande, future water supplies will likely be developed from local ground-water resources.

Purpose and Scope of This Investigation

This study, funded by the City of Del Rio and the Texas Water Development Board, evaluates the ground-water resources in the vicinity of Del Rio, focusing on the possibility of completing additional Edwards aquifer wells to help meet increased demands by the City for water in the future. The following tasks were performed as part of the work for this study for the City of Del Rio: (1) Evaluate existing data for geology, ground-water levels and water chemistry; (2) measure water levels in the Edwards in the vicinity of Del Rio to understand how water flows in the aquifer; (3) sample water issuing from the springs to understand the chemical, bacterial and microparticulate constituents of that water source; (4) conduct sampling and

pumping tests of existing wells (Figure 1) previously used by the City and of a test well located to the north of the City (referred to as the "Y" Well) to compare to the quality of water issuing from the springs and to estimate the quantity available from those wells; and (5) deepen the "Y" Well to evaluate the potential of the deeper Edwards to be an additional ground-water source for the City.

Previous Investigations

Many of the first investigations into ground water in Val Verde County occurred in the 1940's with studies by Frazier (1940), Bennett (1942) and Bennett and Livingston (1942). The International Boundary and Water Commission (IBWC) has published a number of reports and basic data on the geology and hydrology of the area starting about 1950. Three consulting reports were prepared by William F. Guyton & Associates (predecessor to LBG-Guyton Associates) for the Del Rio Utilities Commission: (1) a report on ground-water conditions (Guyton, 1964a); (2) well specifications (Guyton, 1964b) and (3) a completion report on the City's Well 1 (Guyton, 1965). Two reports written by authors from the U. S. Geological Survey (USGS) and published by State water agencies included reports by Follett (1956) and Reeves and Small (1973). Some regional reports that included the Val Verde County area were prepared by State agencies (Walker, 1979; Rees and Buckner, 1980). The springs in Val Verde County were discussed in Brune=s survey of springs (1981) for the State. Geologic work has been performed by many, but most of the geologic names and descriptions of the units as they are accepted today were made by Lozo and Smith (1964) and Rose (1972). Geologic maps of the area were compiled by the University of Texas Bureau of Economic Geology (UT-BEG) and published as the Del Rio sheet (UT-BEG, 1972) of their Geologic Atlas series.

GEOLOGY

About 100 million years ago during the Cretaceous age, a large depositional basin in the shape of an ellipsoid existed in the Del Rio area called the Maverick Basin (Rose, 1972). To the south, the Maverick Basin was bordered by the Stuart City Reef, to the north and east the basin was bordered by the Devils River Trend and further to the north was the Comanche Shelf (Figure 2). Within this basin, a thicker sequence of limestones was deposited. From top to bottom, three formations, the Salmon Peak, McKnight and West Nueces, were formed, which make up the Edwards Group (Lozo and Smith, 1964; Rose, 1972). Within the bordering trend to the north and east, the limestone deposits were somewhat thinner and indistinct, forming one massive unit called the Devils River Limestone (Lozo and Smith, 1964; Rose, 1972).

Overlying the Edwards Group, the Del Rio Clay is about 200 feet of blue fossiliferous clay and shaley limestone that weathers to yellow when exposed. Where it has not been eroded and removed, the Del Rio Clay forms a confining layer above the Edwards aquifer. The Salmon Peak Formation is 400 to 500 feet thick and can be divided into an upper and lower unit (Lozo and Smith, 1964), with the upper unit being mostly grainstones mixed with mudstones. Near the top of the lower unit is a reworked and burrowed limestone and the bottom is mostly a dense lime mudstone. The McKnight Formation can be 200 to 300 feet thick and is mostly composed of thin-bedded limey mudstones, shales and some anhydrite deposits. The West Nueces Formation is generally a massive limestone with fossil fragments and grainstones. Near the bottom of the West Nueces Formation is a dense nodular mudstone. Below the Edwards Group is the Glen Rose Limestone, the upper member of which is composed of thin alternating sequences of limestones and shales. A summary of the lithology and water-bearing properties of the geologic units is given in Table 1. Geologic cross sections are shown in Figure 3 for the area near Del Rio. One cross section includes a geophysical log run on the recently deepened test hole north of Del Rio known as the "Y" Well.

Some previous reports on ground water in the area have called the aquifer the Georgetown aquifer. This is because the Salmon Peak Formation (uppermost unit in the Edwards Group) had been previously called the Georgetown Formation by some investigators.

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The aquifer in the Del Rio area has been lumped together and named by the Texas Water Development Board (TWDB) as the Edwards-Trinity (Plateau) aquifer. This aquifer extends throughout all or parts of 38 counties from the Hill Country of Central Texas to the Trans-Pecos region of West Texas. This regional aquifer consists of saturated sediments of lower Cretaceous age Trinity Group formations and overlying limestones and dolomites of the Edwards Group. However, the Edwards Limestone in the Maverick Basin is very thick, up to 1,000 feet, and the underlying Trinity is deep and probably contains saline water. Most wells are only completed in the upper portion of the Edwards (Salmon Peak). As a result of these circumstances, it is more appropriate to refer to the local aquifer as the Edwards aquifer, similar to that in the San Antonio region (Edwards Balcones Fault Zone aquifer).

HYDROLOGY

All fresh water that is found in an aquifer originates as rainfall. Most water that falls as rain either runs off into streams and lakes or is evaporated or transpired by plants before the water can make its way into aquifers. Only a very small percentage of total rainfall ever enters an aquifer as recharge. Smaller percentages of that rainfall become recharge to aquifers in more arid environments. The combination of high temperatures, high potential evapotranspiration and intermediate rainfall totals in the Del Rio area combine to produce a semiarid climate with drought conditions during all or parts of some years (Bomar, 1995). The rainfall in Val Verde County decreases from east to west, from about 22 inches per year in the northeastern end of the county to about 12 inches per year in the western part of the county near Del Rio. Most of the rainfall occurs as thunderstorms during the months of April through October, with the highest amounts falling in September and May (Figure 4). The average annual rainfall over the period of record at the Del Rio International Airport is 17.6 inches and has ranged from 4.3 inches in 1956 to 33.2 inches in 1969 (Figure 4). Generally, the drought during the mid-1950's is considered the most severe drought of record. Net lake evaporation, which is about 60 inches in western Val Verde County, is the difference between total evaporation from a lake's surface and total precipitation.

Several very large springs issue from the Edwards aquifer in Val Verde County. Brune (1981) identifies 48 springs in Val Verde County. The springs range from seeps to mostly medium to very large springs (2.8 to 2,800 cubic feet per second (cfs)). The third and fourth largest springs in Texas are Goodenough and San Felipe, respectively (Brune, 1981). The recharge area for these springs is not directly known but is surmised to be a large area extending into northern Val Verde, Kinney and Edwards Counties (Reeves and Small, 1973). After the filling of Lake Amistad in the 1960=s, Goodenough Springs, the largest spring in the county, was submerged below about 100 feet of lake water. However, Goodenough Springs still discharges significant volumes of water under the lake surface.

San Felipe Springs, the fourth largest spring in Texas is actually a combination of about 10 springs located along San Felipe Creek. Two of these 10 springs, referred to as the East

Spring and West Spring, supply all the water currently used by the City of Del Rio by means of pumps installed in the springs. Cumulatively, San Felipe Springs has never ceased flowing throughout recorded history. Discharge records from USGS Gage 084528.00, maintained by the IBWC at San Felipe Springs, for the period of record from February 1961 to present are shown in Figure 5. This reported springflow includes gaged flow downstream plus the City's pumpage and the amount withdrawn for an irrigation canal (Breiten, 2000). The minimum monthly amount of flow occurred during 1963 at about 2,000 acre-feet (ac-ft) per month (Figure 5). An acre-foot of water equals 325,851 gallons. The yearly total flow for 1963 was 36,580 ac-ft. Since the filling of Lake Amistad, the lowest flow occurred in 1996 at a little less than 4,000 ac-ft per month (Figure 5). Miscellaneous measurements by the USGS during the drought of the 1950's indicate an instantaneous low flow of about 25 to 30 cfs for San Felipe Springs (Reeves and Small, 1973).

Long periods of below-normal rainfall may have severe impacts on ground-water recharge, springflow, and streamflow. The lack of rainfall leads to reduced recharge of aquifers and to lower water levels. As water levels fall in aquifers, the volume of water discharging from San Felipe Springs may decrease to levels that are insufficient to supply the City of Del Rio. The direct linkage between precipitation and springflow from San Felipe Springs is indicated by spring discharge records showing an increase in discharge rate as a response to rainfall (Figure 5).

Water Levels

Hydrographs illustrating water levels measured in wells by the TWDB over a period of time are shown in Figure 6. A dramatic change or rise in water levels in the wells located to the north and east of Lake Amistad is seen after the lake was filled in 1968. Water levels in wells located south of the lake have been affected less as a result of the lake's filling. This indicates two potential scenarios B that the effects are not seen to the south of the lake or that water levels in those areas are controlled by the springs located near these wells, namely San Felipe and Cienegas Springs.

Ground-water flow is driven by gravity. The direction of flow is from areas of higher elevations (high hydraulic head) to areas of lower elevations (lower hydraulic head). When

water-level maps are constructed, inferences can be made that ground-water flow is perpendicular to the contoured water levels.

Water level measurements were compiled from early work performed in Val Verde County and used to construct an early water-level map (1937-1940) (Figure 7) representing aquifer conditions prior to the construction of Lake Amistad. This contoured water-level map indicates that the flow in the aquifer through Val Verde County was from north to south or southwest. This also indicates that the recharge for San Felipe Springs comes from the northern parts of Val Verde County and the northwestern parts of Kinney County reaching into Edwards County.

An additional water-level map was constructed from data gathered by the IBWC and TWDB in 1993 and 1994 (Figure 8). Figure 9 shows water-level changes from the 1930's to the 1990's. The contours indicate that water levels rose in the vicinity of the lake. However, the ground-water flow is still from the northern portion of the county to the south or southwest towards the springs. The increased head measured in wells near the lake (Figure 9) does not indicate that water flows from the lake into the aquifer. Goodenough Springs, for example, is submerged beneath about 100 feet of water. The induced hydraulic pressure caused by the column of water above the orifice of the springs reduces the flow. However, Goodenough Springs still discharges significant volumes of water. The rise in the aquifer levels near the lake (Figure 9) is a result of decreased losses from the springs submerged below the lake and the dam-like effect resulting from the hydraulic head or pressure on the springs. The reduction in flow causes increased back pressure in the aquifer and higher water levels.

A recent water-level map (Figure 10) was constructed from a combination of water levels measured by LBG-Guyton Associates in March 2000 along with some additional water levels from monitor wells measured by the IBWC. Contour lines are superimposed on a digital elevation model (three-dimension image) of the surface topography. This allows comparison of land- surface features and the water table. As expected in an unconfined aquifer, the configuration of the water table mimics the overlying topography.

CITY OF DEL RIO WELLS

The drought of the mid-1950's and another in the early 1960's caused concern about the dependability and quantity of the spring water. William F. Guyton & Associates (1964a) conducted a ground-water study for the Del Rio Utilities Commission. One of the recommendations of the study was to construct water wells to supply water to the City. Subsequently, contract specifications were developed (Guyton, 1964b), and a report on the completion of City of Del Rio Well 1 (Guyton, 1965) was provided. Well 1 (State ID# 70-33-904) (Figure 1), now referred to as the Agarita Well (named for the nearby road), was drilled in late 1964 by York and Coates. The well was originally drilled to 499 feet but was later plugged back to 445 feet. A 28-inch diameter hole was initially drilled to 100 feet with 20-inch diameter surface casing cemented in place. An 18-inch diameter hole was drilled to total depth below the surface casing. Water samples were collected every 50 feet during drilling to the total depth of 499 feet. The last sample retrieved at 499 feet had a conductivity of 2,422 micromhos, compared to a range of 436 to 502 micromhos for the seven bailed samples from the other 50-foot intervals above. The bottom sample was from the McKnight Formation of the Edwards Group (formerly referred to as Kiamichi Limestone). Because of the poorer water quality encountered, the well was plugged back to 445 feet. The hole was then acidized with 10,000 gallons of 15 percent hydrochloric acid followed by 10,000 gallons of water injected through tubing set to a depth of 430 feet. A 16-inch liner was then installed to protect the pump bowls to a depth of 300 feet, with slots from 100 to 300 feet.

Pumping tests on the Agarita Well were performed before and after the acid treatment. Obvious enhancements in flow were observed. Before the well was treated with acid, the maximum rate tested was 900 gallons per minute (gpm), with about 155 feet of drawdown in 1.5 hours. This calculates to a specific capacity of 5.8 gallons per minute per foot (gpm/ft). Specific capacity is the volume of water discharged per foot of drawdown in a well. On December 7, 1964, a sustained test was performed for 20 hours at about 700 gpm. The drawdown based on this test was about 95 feet. The specific capacity was 7.4 gpm/ft. After the acid treatment, the maximum rate tested was 2,010 gpm for 4 hours on December 18, 1964 with a drawdown of 115

feet, or a specific capacity of 17.5 gpm/ft. An extended test was performed for 23.5 hours on December 19, 1964 at a rate of 1,751 gpm. The test produced about 90 feet of drawdown and a specific-capacity estimate of 19.5 gpm/ft. The permanent pump was designed to be installed at a depth of 200 feet, with the flexibility of being lowered to 300 feet, if necessary, and to produce about 700 gpm (Guyton, 1965).

A second well (TWDB ID# 70-33-608) (Figure 1), which is now referred to as the Hackberry Well (named for a nearby road), was constructed by Layne-Western Company, Inc. in August 1981. The completion records and driller=s reports on file with the TWDB for the Agarita (TWDB ID# 70-33-904) and Hackberry (TWDB ID# 70-33-608) Wells were actually reversed for the two wells. These records, now properly arranged, are given in Appendix 1, along with chemistry reports for the Agarita Well. The water well report submitted by Layne-Western for Del Rio Well No. 2 indicates that the Hackberry Well was drilled at a diameter of 26 inches to 256 feet with a 22-inch diameter steel casing cemented in place. The well was then drilled at a 20-inch diameter to a depth of 431 feet. The pump bowls were set at 380 feet. Pumping tests indicated 302 feet of drawdown after 24 hours of pumping at 460 gpm. This calculates to a specific capacity of 1.5 gpm/ft. Production from this well might be increased if the well were deepened to near the contact with the McKnight Formation, and then treated with acid. According to available records, the well does not appear to have been acidized.

The "Y" Well is a test well that was drilled in August 1990 for the City of Del Rio by Hutto Drilling, Inc. of Del Rio, Texas on county property north of the intersection of IH 90 and Highway 377 (Figure 1). The 9-1/2-inch diameter hole was drilled to a depth of 100 feet, and 90 feet of 8-5/8-inch diameter steel casing was cemented in place. The hole was then drilled at a 7-7/8-inch diameter to a depth of 500 feet. The driller=s report is included in Appendix 2.

DETERMINING AQUIFER CHARACTERISTICS FROM PUMPING TESTS

When a well is pumped and water is withdrawn from an aquifer, water levels in the vicinity of the well are drawn down to form an inverted cone with its apex located at the pumping well. This is referred to as a cone of depression. Ground water flows from higher water levels to lower water levels and, therefore, in the case of a pumping well, toward the well or the center of the cone of depression. A diagram of this cone of depression in the water-level surface is shown in the upper illustration on Figure 11. The shape and size of the cone is directly related to the aquifer parameters. When more than one well is pumped, the cones of depression of neighboring wells intersect one another. When the cone of one well overlaps the cone of another, the lowering of water levels becomes additive because both wells are competing for the same water in the aquifer. The bottom illustration in Figure 11 shows the increased decline in water levels created by the interference between pumping wells. The amount of additional water-level decline depends on the rate of pumping from each well, the spacing between wells and the hydraulic characteristics of the aquifer.

Various hydrologic parameters are required for making a quantitative evaluation of an aquifer. The primary aquifer characteristics of concern are (1) transmissivity, an index of the aquifer's ability to transmit water measured in gallons per day per foot (gpd/ft); and (2) the storage coefficient (unitless), an index of the amount of water released from or taken into storage as water levels change. Hydraulic conductivity can be calculated by dividing the calculated transmissivity by the saturated thickness of the aquifer; the unit of measurement is reported as gallons per day per foot squared (gpd/ft^2). Important measurements made during a pumping test are discharge and water-level decline versus time.

One of the basic assumptions in determining these parameters from pumping-test data is that flow takes place through a homogeneous medium B that is, one for which properties are the same in all directions. In properly applying the results, however, one must consider that the physical characteristics of an aquifer are probably not uniform in all directions. This is particularly true for fractured-rock karst systems, such as the Edwards aquifer.

Pumping Tests on City of Del Rio Wells

LBG-Guyton Associates performed pumping tests on the Agarita, Hackberry, and "Y" Wells. Transducers and a Hermit 3000 data logger manufactured by In-Situ, Inc. were used by LBG-Guyton during the tests. Readings recorded by the data logger were compared with measurements made with a calibrated electrical tape. Data were collected prior to, during and after pumping. Hydrographs and semilog plots created with calculations based on these data are shown on Figures 12 through 14. Each test was conducted for a period of approximately 24 hours.

The turbine pump originally installed in the Agarita Well had locked up because of corrosion. The well had not been used for about 10 years. The old pump was removed and a temporary 50-horsepower (hp) submersible pump was installed for testing purposes. The pumping test of the Agarita Well started March 14, 1999 and lasted for 27.5 hours. The pumping rate fluctuated during the test from a high of about 780 gpm to about 700 gpm but averaged about 716 gpm. The total drawdown near the end of the test was 14.5 feet. The specific capacity for this test is calculated to be 49 gpm/ft, and transmissivity is calculated as187,700 gpd/ft.

For comparison, the testing in 1964 at a rate of 900 gpm prior to the acid treatment caused about 155 feet of drawdown in 1.5 hours, or a specific capacity of 5.8 gpm/ft. The sustained test at a rate of about 700 gpm prior to acid treatment created a drawdown of about 95 feet, or a specific capacity of 7.4 gpm/ft. After the acid treatment, the Agarita Well was pumped at a rate of 2,010 gpm for 4 hours with a drawdown of 115 feet, or a specific capacity of 17.5 gpm/ft. The extended test after acid treatment was performed at a rate of 1,751 gpm for 23.5 hours. This caused about 90 feet of drawdown. The specific capacity was 19.5 gpm/ft.

The Hackberry Well was initially pumped using the existing pump on March 10, 1999. The electrical breaker and control system had been burned out by a lightning strike several years before, and the well had not been used for about 10 years. A portable generator was used to supply power. The well was disconnected from the existing plumbing and was pumped open discharge. A gate valve was used to regulate the discharge rate, and a flow meter from the Agarita Well was used to measure discharge. The initial pumping rate of 680 gpm quickly declined to about 550 gpm. However, the water level in the well fell to levels close to the pump

in about 1 hour. Water levels were allowed to recover and pumping was restarted later that day at a decreased rate of about 310 gpm for a duration of 24 hours. The average discharge rate over the 24 hours was 286 gpm. The accompanying drawdown near the end of the test was about 230 feet below the static water level. The specific capacity and the transmissivity for this test are calculated to be 1.3 gpm/ft and 1,936 gpd/ft, respectively. This specific capacity compares to 1.5 gpm/ft calculated from information submitted by Layne-Western Company, Inc in 1981.

The "Y" well was completed with 8-5/8- inch diameter casing. The diameter of the casing allowed only a 15-hp submersible pump to be installed for testing purposes. If the well's diameter were larger, a larger pump could have been used. The installed pump initially pumped at about 260 gpm. The well was pumped for about 23.5 hours at an average rate of 246 gpm, and the drawdown was 1.5 feet. The specific capacity calculated from these data is 166 gpm/ft. The trend in the data was neither consistent nor typical (Figure 14). A slight trend in the data is the basis for a calculated transmissivity of 405,900 gpd/ft. Because of the data and lack of a consistent trend, the results are not presumed to be accurate. A larger pump might stress the aquifer enough to get a more definitive data trend.

The Hackberry Well is apparently completed in a tighter section of the Salmon Peak Formation than is characteristic of the formation in the vicinity of the Agarita and "Y" Wells. The pumping tests indicate that the Agarita and "Y" Wells are the most productive of the three wells.

GROUND-WATER CHEMISTRY

All ground water contains minerals that are dissolved and transported in solution. The types and concentrations of the minerals depend upon the history of the water, its source, movement and environment. Specifically, the concentration of dissolved solids depends upon the solubility of the minerals present in the rocks with which the water is in contact, the length of time the water is in contact with the rocks, and the chemical activity of the water. In general, the concentration of dissolved minerals in ground water increases with depth. This is especially the case where circulation in the deeper sediments is restricted by low permeability. Restricted circulation retards the flushing action of water moving through the aquifer and causes the water to become more stagnant and highly mineralized.

In general, for water to be considered acceptable for public supply or domestic consumption, the concentrations of certain constituents should not exceed Texas Natural Resource Conservation Commission (TNRCC) recommendations. The recommendations for maximum concentrations of the common inorganic constituents for which samples were analyzed in this study are as follows:

Primary Standards

Constituent	Mg/l
Fluoride	4
Nitrate (as N)	10

Secondary Standards

Constituent	Mg/l
Chloride	300
Fluoride	2
Iron	0.3
Manganese	0.05
Sulfate	300
Dissolved Solids	1,000

Fluoride is included in both the Primary and Secondary Standards. Primary Standards establish limits for dissolved constituents that are known to have adverse effects on human health. Secondary Standards establish limits for dissolved constituents that affect the aesthetic qualities of drinking water (e.g., taste and odor).

Samples from the Wells and Springs

LBG-Guyton Associates collected water samples from the three City wells, the Agarita, Hackberry and "Y" Wells (Figure 1), and from the East and West Springs of San Felipe Springs. All water samples taken for chemical analyses were collected after extensive purging. Stabilization parameters, i.e. temperature, specific conductivity and pH, were measured before and after the samples were retrieved to document adequate purging of the wells before samples were collected. Samples taken for metal analyses were filtered in the field with 0.45-micron certified filters and preserved with nitric acid. After collection, the samples were appropriately preserved and placed in ice-filled coolers for transport to the laboratory. The following table lists the field parameters measured near the time of sampling.

Well/Spring	Sample Date	Temperature (1C)	Specific Conductivity (µmhos)	pH
Wells				
Agarita Well	3/15/99	23.5	745	7.2
Hackberry Well	3/11/99	25.0	725	7.2
"Y" Well	4/13/99	24.0	730	7.1
"Y" Well (Deep)	7/19/00	24.5	430	7.3
Tierra del Lago	4/22/99	25.5	523	7.2
Springs				
San Felipe East Spring (Pump #2)	3/11/99	24.0	450	7.2
San Felipe West Spring (Pump #5)	3/15/99	24.0	535	7.1

The samples were submitted to the Lower Colorado River Authority=s Environmental Laboratory Services (Austin, Texas) for chemical analyses. The laboratory report is attached as Appendix 3. The chemical analyses indicate that water from the three wells meets the primary and secondary drinking-water standards established by the U. S. Environmental Protection Agency and the TNRCC for those constituents analyzed. Total dissolved solids (TDS) range from 376 milligrams per liter (mg/l) at the Hackberry Well to 455 mg/l at the Agarita Well. These TDS concentrations compare very favorably with the TDS of water discharging at the East and West San Felipe Springs of 235 mg/l and 277 mg/l, respectively. The TDS for the initial sample from the "Y" Well was 413 mg/l. A sample collected after the well was deepened and a packer was set to isolate the bottom of hole had a TDS concentration of 224 mg/l. The deepening of the "Y" Well is discussed in a later section of this report.

Stiff diagrams and Piper diagrams can be used to compare water chemistries. The Stiff diagram (Figure 15) uses four parallel horizontal axes extending on each side of the vertical zero line. The concentrations in milliequivalents per liter (meq/l) of the four major cations (positively charged ions) are plotted to the left and the major anions (negatively charged ions) are plotted to the right, producing a geometric shape which defines the geochemical fingerprint of the sample. The concentration of an ion in meq/l is derived by dividing its concentration in milligrams per liter by the gram formula weight of the ion and then multiplying by the charge of the ion. The Piper diagram (Figure 16) is a trilinear plot of the major dissolved ions. The composition of waters can be approximated in terms of three sets of cations (Ca, Mg, Na plus K) and three sets of anions (bicarbonate plus carbonate, SO_4 and Cl) expressed as a percentage of total milliequivalents. The proportions are plotted as points in separate triangles of cation and anion constituents. These points are then projected into a central diamond-shaped field to identify general compositions in terms of water-chemistry types. Figures 15 and 16 show the similarities between the spring water, and the well water. Both diagrams indicate that the waters are mostly calcium-bicarbonate type water. The water sampled from the wells shows slightly elevated levels of sodium, chloride and sulfate.

Microparticulate Analyses

In 1989, the EPA initiated the Surface Water Treatment Rule to protect public systems from surface-water pathogens. The rule also applied to ground water under the direct influence of surface water. The TNRCC is responsible for the enforcement of these rules. Microparticulate analysis (MPA) is a method used by TNRCC to ascertain whether ground water is under the direct influence of surface water. MPA identifies surface-water bioindicators such as plant debris, algae, diatoms, insects, rotifers and other identifiable particulates found only in surface-water bodies. The TNRCC has performed these analyses on water from the springs collected directly from the spring lakes. The analyses are presented in Appendix 4. The samples were collected when turbidity levels ranged from less than 1 NTU to 77 NTU. Despite the wide range of the values, the MPAs showed little variation.

LBG-Guyton collected samples for MPA from April to June 1999 from the San Felipe East Spring (Pump #2) and the San Felipe West Spring (Pump #5), as well as from the Agarita, Hackberry and "Y" Wells. An independent system that the City recently acquired (Tierra del Lago), which is located near Lake Amistad, was also sampled. The West Spring was sampled a second time on June 22, 1999 when the water from that spring became turbid after a rainstorm. Because of high turbidity, water from the West Spring could not be pumped into the City's distribution system. The East Spring's water, which was not turbid, was used to supply the City. Because the West Spring's pump had been shut down, a peristaltic pump was used for sampling. The procedure involved lowering a small tube next to Pump #5 into the cave that feeds the West Spring. The discharge was then run through the filter apparatus.

All other samples were filtered by attaching the filter to the faucets near the wells or to the pump heads above the chlorine injector. A pressure gage and a flow meter were used to adjust the flow valve attached to the filter so the flow rate could be set at about 1 gpm at a pressure of 10 pounds per square inch (psi). The filter was positioned in line, and the well was pumped at capacity during the sampling. The filter was allowed to collect particulate matter for almost one day, or until about 1,000 gallons of water had passed through the filter. The filter was then removed, sealed, chilled and sent to the laboratory for analysis.

Analytical Services Incorporated (ASI) of Williston, Vermont, conducted the MPAs. The accompanying lab reports are presented in Appendix 5. ASI also conducted tests for two waterborne pathogens, *Cryptosporidium parvum* and *Giardia lamblia*. MPA test results are rated as either "low," "moderate" or "high," based on the presence or absence of indicators such as vegetative debris, algae, diatoms, rotifers, nematodes and protozoa. The MPA results for the three City wells are all classified as "low" by ASI. Ratings for samples of water collected from the springs, however, ranged from "low" at West San Felipe Spring to "moderate" at East San Felipe Spring. The samples from West San Felipe Spring during higher turbidity and from Tierra del Lago were rated as "moderate." Neither *Cryptosporidium* nor *Giardia* was detected in samples from the wells and the springs.

Mineralogic Analysis of Spring Turbidity

After the MPAs of the West Spring water were concluded, the sediment that was captured in the MPA filter during the turbid event at the West Spring was sent to Core Laboratories for mineralogic analysis (Appendix 6). The analysis indicates the particulate material suspended in water discharging from West San Felipe Spring is composed (by weight percentage) of quartz (11%), calcite (66%), dolomite (4%) and clay (19%) grains.

A recent study of the Edwards aquifer (Barton Springs segment) near Austin, Texas (Mahler, 1997), concluded that allochthonous and autochthonous sediments are transported through karst aquifers. Allochthonous sediments are derived from outside an aquifer and are transported into the aquifer by recharge water from streams. These sediments, which are composed of varying proportions of calcite, quartz and clay, have high organic carbon content. Suspended sediments with these compositions are observed in sinkholes, streams and springs. Autochthonous sediments are derived from aquifer rock. These sediments, which are composed of dolomite grains, are characterized by low organic carbon content and are most obvious in unconfined wells. Sediments that occur in caves and confined wells are typically characterized by a mixture of allochthonous and autochthonous material and low organic carbon.

The composition of the sediment from San Felipe Springs was compared with the compositions of suspended material found in water from wells, caves, sinkholes, springs and streams, as well as the Del Rio Clay and Edwards Limestone Formations in Central Texas (Mahler, 1997). This comparison indicates that there are similarities between the compositions of particulate material in San Felipe Springs water and the average compositions of particulate material collected from springs and streams in Central Texas. However, the composition of clay minerals present in these Central Texas waters differs from San Felipe Springs sediments. In Central Texas, suspended clays are primarily illite and smectite. Illite is the dominant clay in the Del Rio area. This difference could be related to a higher degree of chemical weathering of rocks in the more humid environment of Central Texas than in the drier Del Rio area.

One possible explanation for the composition of the suspended sediment at San Felipe Springs is that the suspended sediment is derived from the Edwards Formation and the overlying Del Rio Clay. A mixture of these sediments would be characterized by varying proportions of clay, quartz, calcite and dolomite similar to that found at San Felipe Springs. The other possibility is a combination of autochthonous sediments and suspended material derived from surficial sources and transported into the aquifer from streams such as San Felipe Creek.

DEEPENING THE "Y" WELL FOR TESTING

All known water wells in the vicinity of Del Rio produce water from the Salmon Peak Formation near the top of the aquifer. The McKnight Formation is generally tighter and often has poorer water quality in this area. However, geophysical logs from wells drilled for the exploration of oil indicate that fresh water may occur in the West Nueces Formation in this area. LBG-Guyton recommends investigating the lower portion of the Edwards aquifer by deepening the existing "Y" test well located north of town (Figure 1). This well has been named for the "Y"-shaped branch of IH 90 and Highway 377 south of the well.

The "Y" Well was originally drilled to a depth of about 500 feet. Steel casing with a diameter of 8-5/8 inches was cemented to a depth of 90 feet. On June 6, 2000, Hutto Drilling Co., Inc. of Del Rio, Texas began drilling the well deeper using a conventional air-rotary method. This method pushes air out of small holes in the drill bit. The air forces the formation cuttings and fluid out of drill hole to the surface on the outside of the drill pipe. Because of the sizable porosity of the formation, no water or cuttings returned to the surface. The cuttings either settled to the bottom of the hole or were forced into large openings in the formation. Because of compressor problems and the depth of the drill hole, the drilling method was changed to mud circulation using fresh water from a City fire hydrant piped to a circulation pit at the site. This method also did not generate any surface returns.

After drilling, downhole geophysical and video log surveys were performed. Geophysical logs run in the well included gamma, self potential (SP), and short-normal and long-normal resistivity. These logs can be used to infer water quantity and quality and to precisely determine depths to geologic contacts. Based on the logs, the geologic contacts below the "Y" Well, in feet below land surface, are:

Salmon Peak/McKnight contact at 495 feet
McKnight/West Nueces contact at 701 feet
West Nueces/Glen Rose contact at 874 feet

The downhole video survey showed water coming into the borehole at velocities high enough to move small cuttings around, mostly along fractures or horizontal bedding joints. The depth intervals with visible high-current water entering the borehole were at 154 to 155, 508 and 536 feet below land surface. Below the 550-foot level, the visibility in the borehole went to zero. This indicates that water was not entering the borehole at a high enough rate to flush the turbidity from the hole.

Based on the geophysical logs of the "Y" Well, some fresh water appears to be present near the top of the West Nueces Formation. An inflatable packer, which resembles a large doughnut that fits on the pump tubing, was installed at about 703 feet below land surface and inflated with about 400 psi of air pressure. The packer acts to isolate the section below the packer from the top part of the borehole. Initially, the packer was not inflated completely because of the high pressure needed to inflate below 600 feet of water. Additional pressure was needed prior to final pumping but whether the seal in the borehole was complete is not absolutely known. Because of the relatively thin section of fresh water interpreted from the geophysical log, the pump was installed at about 725 feet below land surface. The pump installed was a 7.5-horsepower submersible pump capable of producing about 50 gpm.

Resistivity decreases toward the bottom portion of the log, which represents the deeper zone of the test hole. Resistivity is the inverse of conductivity. Both are related to the TDS of the fluid. The resistivity curve indicates that the bottom of the formation becomes increasingly higher in TDS. This was another reason for installing the pump adjacent to the fresh water indicated by the resistivity profile of the geophysical log.

A transducer and a Hermit 3000 data logger were used during the tests. The transducer was rated for 250 psi (2.31 feet/psi x 250 psi = 578 feet) and was installed in the well just below the packer. The static water level of the open hole was about 107 feet below land surface. (This gives the differential between the static level and the point at which the transducer was installed, 600 feet.) This is above the rating of the transducer but below the safety factor for the instrument (1,155 feet). The reading may have been slightly inaccurate, but during the pumping test, the change in water level is the point of interest.

The pumping test, conducted on July 20, 2000, was initiated at a rate of about 40 gpm but discharge dropped off in about 15 minutes. The pump was turned off and the water level allowed to recover. The lower portion was pumped three times for about 10 to 15 minutes each. During the third pumping period, a sample was retrieved. The discharged water was turbid, and as a result, all samples were filtered with a 0.45-micron filter prior to adding an acid preservative. The low TDS for the sample retrieved was not expected, especially since it was lower than the sample retrieved from the "Y" Well before the well was deepened. One explanation for the lower TDS may be that the three short-duration tests prior to sampling did not purge a sufficient volume of water from that section of the well. Water from a fire hydrant was injected into the well during the drilling process. The sample taken from the East Spring shows similarly low TDS and conductivity. It is possible that this water was not removed prior to the time the sample was taken.

Although not enough data were collected from the pumping portion of the test to analyze, the recovery data were sufficient to support a transmissivity calculation of 3,080 gpd/ft. This is approximately two orders of magnitude less than the transmissivities calculated for the upper section of the "Y" Well and for the Agarita Well. Graphs and calculations of the transducer data are shown on Figure 17. As mentioned before, the seal by the packer, between the upper section and lower section, may not have been complete isolation that would result in this calculated transmissivity being high.

The testing of the deeper section in the "Y" Well indicated that fresh water might occur near the top of the deeper West Nueces Limestone, but in relatively small quantities.

GROUND-WATER AVAILABILITY

Previous studies have stated that the Edwards aquifer is underutilized and have estimated the amount of ground water available near the City of Del Rio. These estimates were based on the amount of flow issuing from San Felipe Springs and along the Devils River north and northeast of the city. It was considered that the amount of ground water available for development was equal to the springflow issuing from the Edwards aquifer. Guyton (1964) concluded that about one-half of the springflow from the Devils River originated in this area north of the city. He added to the historical flows of San Felipe Springs (prior to the filling of Amistad) for an estimate of 200,000 acre-feet per year (ac-ft/yr) or about 180 million gallons per day of ground-water availability from the Edwards near Del Rio. Reeves and Small (1973) used the total flow from Goodenough Springs plus San Felipe Springs to estimate ground-water availability from the Edwards at about 500,000 ac-ft/yr.

The availability amounts estimated in Section 3.2.2.2 of the Senate Bill 1 Plateau Regional Water Plan (Plateau RWPG, 2001) are retrievable volumes from the total storage in the aquifer based on Geographic Information System (GIS) coverages and calculated aquifer volumes. The bottoms of the aquifers were taken from structure maps of contacts between geologic units derived from interpretations of geophysical logs. The tops of the aquifers were estimated from historic water-level maps of the area. The aquifer thickness was then reduced by 50 feet to simulate drought conditions. A conservative estimate of aquifer volume was made based on this saturated thickness of the Salmon Peak of the Maverick Basin Edwards Limestone. A conservative storage coefficient of 0.02 was then applied to the saturated aquifer volume for calculating water in storage.

Much of the water in storage within an aquifer cannot be removed because the water is bound by capillary forces within the pore spaces of the rocks. The amount that is assumed to be recoverable is determined by the "specific yield" of an aquifer. This term refers to the volume of water that will drain, under the force of gravity, from the pore spaces of an aquifer. Specific yield is related to the permeability of an aquifer. Because all of the water in storage in an aquifer cannot be drained from the pores of that aquifer, a conservative 30-percent specific yield was

applied to the calculated aquifer volumes. Applying this percentage to the total area of an aquifer makes the assumption that wells are spread evenly over the entire extent of the aquifer. This assumption, however, is not realistic, as there are physical and economic limitations to the number of wells that can be developed in close proximity in an aquifer. Using this method of estimating the specific yield, the potential retrievable amount of ground water from the Edwards aquifer in Val Verde County was estimated at 3,199,700 ac-ft, with no consideration for environmental factors such as maintaining springflow.

With the limitation being minimum flow from San Felipe Springs, the aquifer availability in the Del Rio area could be estimated from the difference between minimum required flow and the instantaneous flow. The average discharge of San Felipe Springs is about 110 cfs or about 80,000 ac-ft/yr. During recent droughts the spring discharge fell below 50 cfs. Extrapolated over 1 year, this would be about 36,000 ac-ft. Recent droughts as compared to the 1950=s drought would be appropriate to use because the filling of Amistad Lake has generally increased the springflow after 1968. A minimum flow has not been determined for the endangered species living downstream from the springs, and a study is needed to determine the actual amount that would have to be subtracted from the total springflow for availability. Also, studies are needed to evaluate the effects of pumping from the aquifer at some distance to the flow issuing from the springs. This is especially critical with respect to wells in the recharge area for San Felipe Springs.

Most availability studies evaluate amounts of water on an annual basis. When the critical component of the water supply is often the daily peak demand during a year, the City must also evaluate the amount of water necessary on a peak or maximum daily usage basis to properly plan for future supply needs.

Del Rio Water System

The City of Del Rio relies on San Felipe Springs for all of its water supply. The water is collected through a number of pumps set in two of the spring orifices (referred to as East Spring and West Spring) where water is issuing from the Edwards aquifer. The water is then treated with chlorine and distributed to the city and to Laughlin Air Force Base. The pumps in the West

Spring are installed in boreholes drilled just upstream of the spring outlet. The pumps in the East Spring are set near the surface of the manmade lake at those springs.

Occasionally after rainstorms, the water discharging from the springs becomes turbid. The turbidity has caused some concern at TNRCC about the potential for microbial contamination and the reliability of the current chlorine treatment of the spring water. As a result, a microfiltration plant has been proposed to treat all spring water that will be supplied to the city.

The City of Del Rio has a water right authorizing it to divert 11,416 ace-ft/yr from the surface-water portion of the springs for municipal use. San Felipe Manufacturing and Irrigation Company has a water right authorizing it to divert 4,962 ac-ft/yr for irrigation use and 50 ac-ft/yr for industrial use from San Felipe Creek. The total authorized amount is 16,428 ac-ft/yr.

Increasing water demand as a result of population growth is expected to exceed the capability of the present system to meet all needs for water. To address these expected shortfalls, the City has started a long-term program to develop ground water as a supplemental source of municipal water. The City also plans to replace leaking storage tanks and distribution lines to reduce the water loss in the system. The City is also adding a 16-million-gallon-per-day filtration plant to comply with a directive from the TNRCC to ensure that water from San Felipe Springs meets the primary drinking water standards for microorganisms. The directive was issued by TNRCC because of concerns raised by elevated levels of turbidity in water discharging from San Felipe Springs, especially after rainstorm events in the vicinity of Del Rio.

Two Edwards aquifer public-supply wells located north of the city were previously used by the City but were abandoned because of disrepair. The wells have not been used for about the last 10 years. The City plans to repair the wells and bring them back into service. A steel cable brush was fabricated and used to scrub the slotted interval of the Agarita Well during November 1999. This well was then jetted to remove debris for rehabilitation purposes. Video surveys before and after the well rehabilitation show a great amount of corrosion and excess growth being removed from the slotted interval in the liner installed in the well.

Because of the aquifer characteristics determined during the pumping test, it was decided that only the burned-out electrical system would be replaced on the Hackberry Well. At some future date, the Hackberry Well may be considered for deepening near the McKnight Formation and having acid injection performed to enhance the yield of the well. Also, a third well will be developed on municipal property north of the City near the "Y" test well. Other wells may be developed as needed.

A new pump will soon be installed in the Agarita Well that will yield about 1,800 gpm. The Hackberry Well appears to be currently capable of producing up to 300 gpm. A third public-supply well to be constructed near the "Y" Well site is expected to yield from 1,000 to 2,000 gpm. This adds up to a potential capacity of about 4 million gallons per day if the wells are run about 70 percent of the time during a daily pumping cycle.

SUMMARY AND CONCLUSIONS

The City of Del Rio relies entirely on San Felipe Springs that issue from the Salmon Peak Formation of the Edwards Group for its water supply. Occasionally after rainstorms, the water discharging from the springs becomes turbid. The turbidity has caused concern with regulating agencies about the potential for microbial contamination and the reliability of the current chlorine treatment of the spring water. As a result, a microfiltration plant has been proposed to treat all spring water that will be supplied to the city.

The size of the treatment plant may be reduced if additional water from wells can be used. It is believed that water can be produced from wells properly completed with cemented surface casing that would not be under the direct influence of surface water and which would not become turbid or contaminated by runoff. As a result, the produced ground water would not require the treatment prescribed for spring water and could be used as a supply that supplements the treated spring water. However, continued sampling of wells is recommended on a regular basis (and at times immediately after unusually heavy rainstorms) for analysis of microparticulate and microbiological indicators of surface water. Also, wellhead protection around public water-supply wells is recommended. All nearby residences and commercial buildings should be taken off private septic systems and placed on the City=s sanitary sewer system. Underground storage tanks should be located and closely monitored to follow all State guidelines. For protection and enforcement, one possibility might be to use TNRCC=s Edwards Rules on the areas around the public-supply wells.

The Agarita Well has been scrubbed to remove corrosion, and a new pump will soon be installed in the well that will yield about 1,800 gpm. The Hackberry Well appears to be currently capable of producing up to 300 gpm. The depth and development of the Hackberry Well may be modified in the future to enhance its production. Information from the testing of the existing "Y" Well supports the conclusion that constructing a third public-supply well near this site would yield from1,000 to 2,000 gpm. This adds up to a potential capacity of about 4 million gallons per day if the wells are run about 70 percent of the time during a daily pumping cycle. However, it

will be important to conduct a number of long-term pumping tests before specifying the optimal discharge rate and yield for each well, especially for the yet to be constructed "Y" Well.

A sufficient volume of ground water of acceptable quality can be developed within the Edwards aquifer to supplement supplies withdrawn from East and West San Felipe Springs and to meet future increases in demand. Initially, this supplemental production can be supplied by the three proposed City wells. Additional growth and increase in demand can be met by additional water wells. This may become increasingly important during periods of drought, and during times of peak water demand during the summer months.

REFERENCES

Bennett, R. R., and Sayre, A. N., 1962, Geology and ground-water resources of Kinney County, Texas: Texas Water Commission Bulletin 6216.

Breiten, Ken (IBWC), 2000, Oral communication with Bill Stein of LBG-Guyton Associates in April 2000.

Brune, Gunnar, 1975, Springs of Texas, v. 1: Fort Worth, Texas, Branch-Smith Inc.

Follett, C. R., 1956, Records of water-level measurements in Kinney, Uvalde and Val Verde Counties, Texas, 1929 to March 1956: Texas Board of Engineers Bulletin 5611.

Guyton, William F., & Associates, 1964a, Ground-water conditions in the Del Rio area, Texas: consulting report prepared for Del Rio Utilities Commission.

Guyton, William F., & Associates, 1964b, Specifications and other contract documents for construction and testing of water well: prepared for the City of Del Rio Utilities Commission.

Guyton, William F., & Associates, 1965, Report on completion and testing of City of Del Rio Well 1: Del Rio Utilities Commission.

Lozo, F. E., and Smith, C. I., 1964, Revision of Comanche Cretaceous stratigraphic nomenclature, southern Edwards Plateau, southwest Texas, *in* Transactions, Gulf Coast Association of Geol. Socs. 14th Annual Convention, v. 14, p. 285-306.

Maclay, R. W., and Small, T. A., 1984, Carbonate geology and hydrology of the Edwards aquifer in the San Antonio area, Texas: U. S. Geological Survey Open-File Report 83-537.

Mahler, B. J., 1997, Mobile sediments in a karst aquifer: Univ. of Texas at Austin, Ph.D. dissertation, 171 pp.

Plateau Regional Water Planning Group, 2001, Plateau Regional Water Plan: planning report prepared for Texas Water Development Board.

Rees, R., and Buckner, A.W., 1980, Occurrence and quality of ground water in the Edwards-Trinity (Plateau) aquifer in the Trans-Pecos region of Texas: Texas Department of Water Resources Report 255.

Reeves, R. D., and Small, T. A., 1973, Ground-water resources of Val Verde County, Texas: Texas Water Development Board Report 172.

Rose, Peter R., 1972, Edwards Group, surface and subsurface, central Texas: The University of Texas at Austin, Bureau of Economic Geology Report of Investigations No. 74.

University of Texas at Austin, Bureau of Economic Geology, 1977, Geologic atlas of Texas, Del Rio sheet, scale 1:250,000.

University of Texas at San Antonio Student Geological Society, 1990, Cretaceous geology north and northwest of Del Rio, Texas: S.A.S.G.S. Fall Field Trip Field Guide and Related Papers, October 13-14, 1990, San Antonio, Texas.

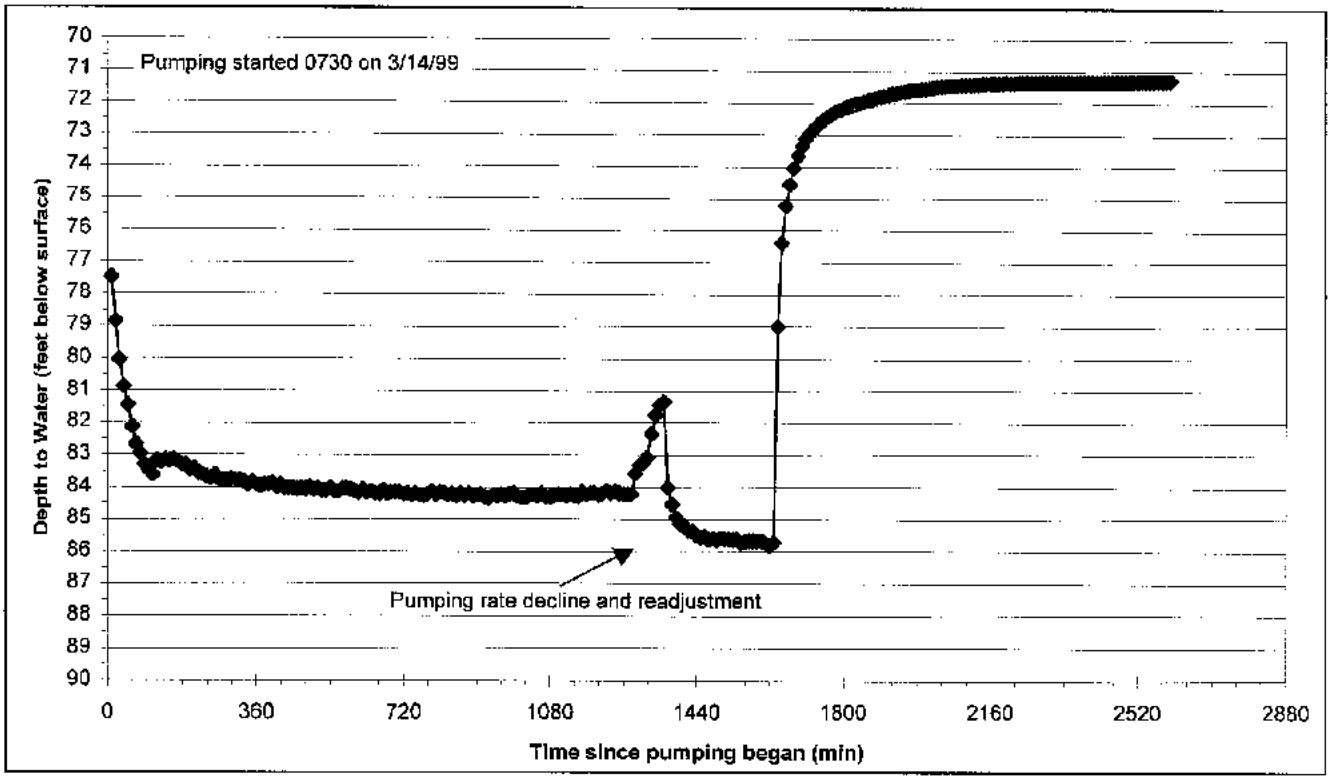
Walker, L. E., 1979, Occurrence, availability, and chemical quality of ground water in the Edwards Plateau region of Texas: Texas Department of Water Resources Report 235.

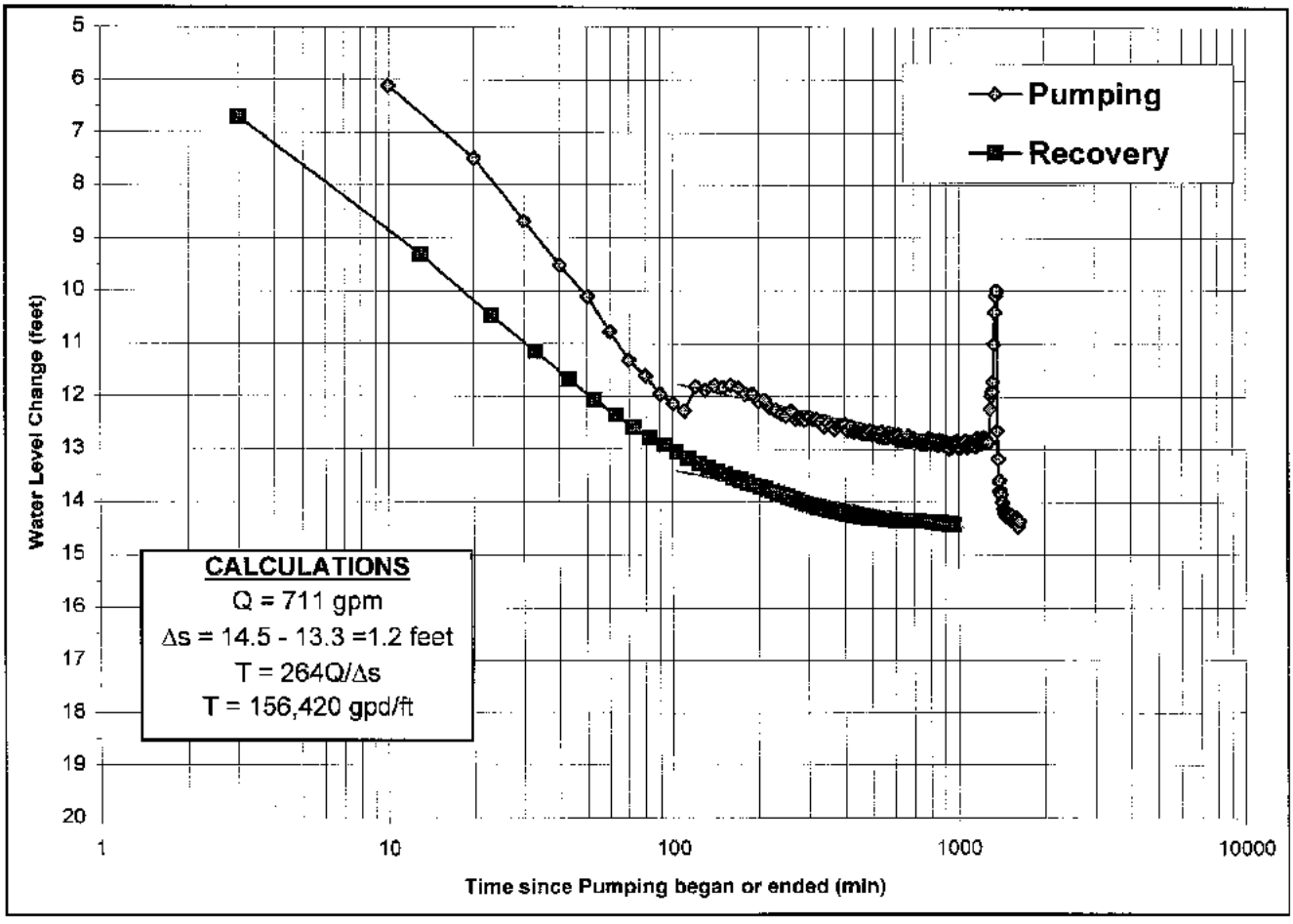
West Texas Geological Society, 1959, Geology of the Val Verde Basin, and field trip guidebook West Texas Geological Society Guidebook 1959.

TABLE 1. LITHOLOGY AND WATER-BEARING CHARACTERISTICS OF THE MAVERICK BASIN

SYSTEM	SERIES	STAGE/GROUP	FORMATION	FUNCTION	MEMBER OR INFORMAL UNIT	APPROXIMATE THICKNESS (feet)	LITHOLOGY	HYDROSTRATIGRAPHY
Quaternary and Tertiary			Alluvial fan and fluviatile terrace deposits	Aquifer where saturated		6 - 80	Gravel, sand, silt and clay. Coarser nearer the base and toward the Balcones Fault Escarpment.	Alluvial fans extending from the Balcones Fault Escarpment. Associated fluviatile deposits.
Cretaceous	Gulfian		Anacacho Limestone	Confining Bed		500	Limestone and marl; contains bentonite; chalky, and massive bedded.	Little permeability.
		Austin	Undivided	Confining Bed		600	Chalk and marl; chalk mostly microgranular calcite; bentonite seams, glauconitic.	Little to moderate permeability.
			Igneous rocks				Basalt.	Intrusive sills, laccoliths, and volcanic necks. Negligible permeability.
		Eagle Ford	Undivided	Confining Bed		250	Shale, siltstone, and limestone; flaggy limestone beds are interbedded with carbonaceous shale.	Little permeability.
	Comanchean	Washita	Buda Limestone	Confining Bed		100	Limestone; fine-grained, bioclastic, glauconitic, hard, massive, nodular, argillaceous toward top.	Little permeability.
			Del Rio Clay	Confining Bed		120	Clay and shale; calcareous and gypsiferous; some thin beds of siltstone.	Negligible permeability.
		Edwards	Salmon Peak Formation	Aquifer		380	Limestone; upper 80 feet contains reef talus grainstones and caprinid boundstones, crossbedding of grainstones; the lower 300 feet is a uniform dense carbonate mudstone.	Deep water deposits except toward the top. Upper part is moderately to very permeable. Lower part is almost impermeable except where fractured.
			McKnight	Confining Bed		150	Limestone and shale; upper 55 feet is a mudstone containing thin zones of collapse breccias; middle 24 feet is shaly, lime mudstone; lower part is limestone containing collapse breccias in upper part.	Deep basinal, euxinic deposits. Little permeability.
			West Nueces	Confining Bed		140	Limestone; upper 80 feet is largely a massive unit of miliolid and mollusck-bearing grainstone; lower 60 feet is a nodular, dense mudstone.	Upper part is moderately permeable. Lower part is almost impermeable.
		Trinity	Glen Rose	Confining Bed	Upper member	1,000 - 1,500	Limestone, dolomite, and marl; limestone is fine-grained, hard to soft, marly; dolomite is porous and finely crystallized.	Little permeability.
					Lower member		Limestone and some marl. Massive bedded.	More permeable toward base of unit.
			Pearsall	Confining Bed		400	Sandstone, limestone, and shale.	Little permeability.
	Coahulian		Sligo	Confining Bed		200	Limestone and some shale.	Little to moderate permeability.
			Hosston			900	Sandstone and shale.	Moderate to little permeability.
Pre-Cretaceous rocks							Sandstone and limestone.	Little permeability.

(Modified from Maclay and Small, 1984)

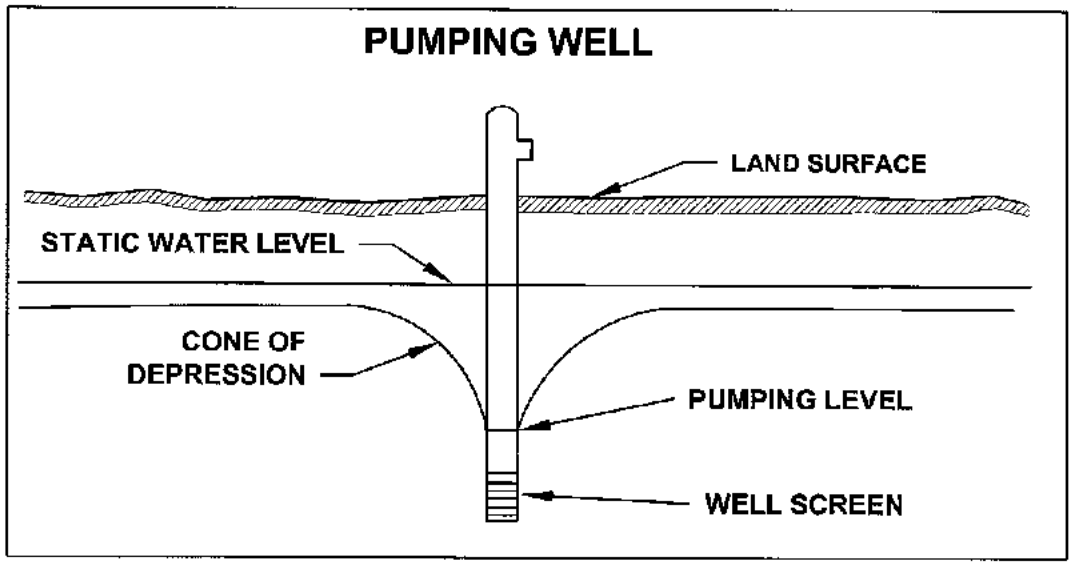


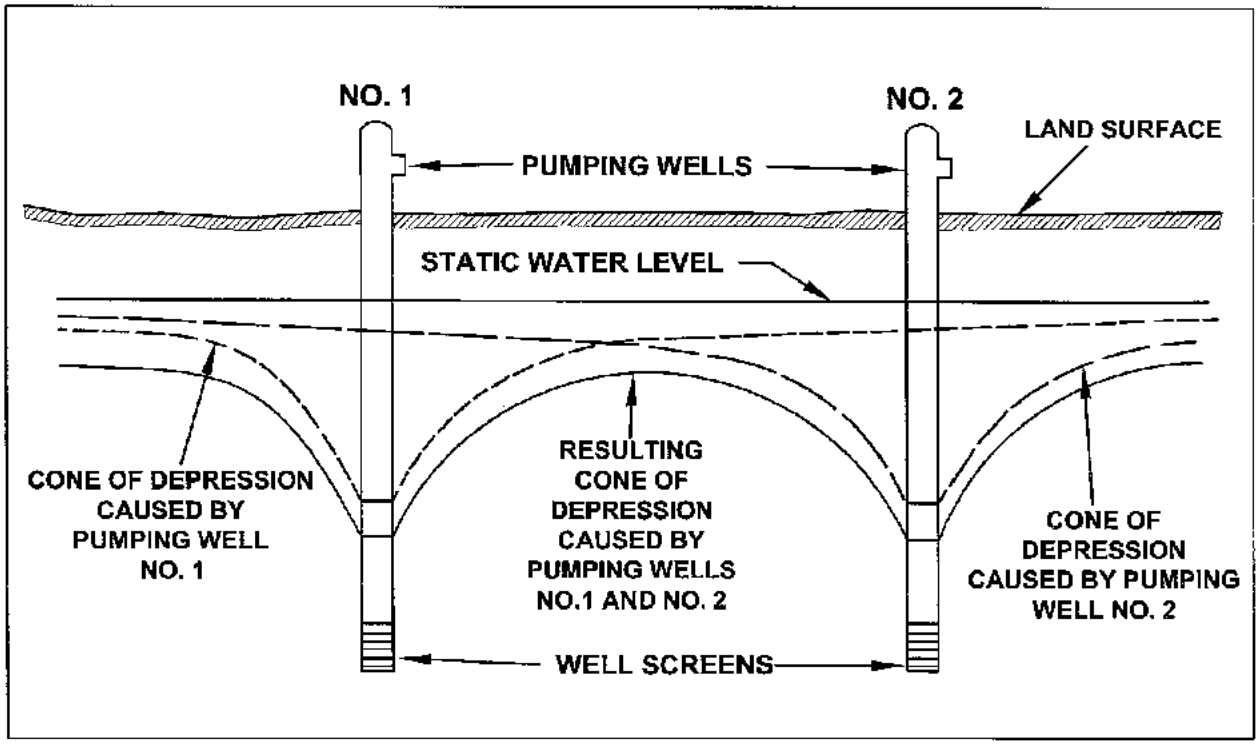


HYDROGRAPH, SEMILOG PLOT AND CALCULATIONS OF PUMPING-TEST DATA FROM THE AGARITA WELL (70-33-904)

FIGURE 12

LBG-GUYTON ASSOCIATES

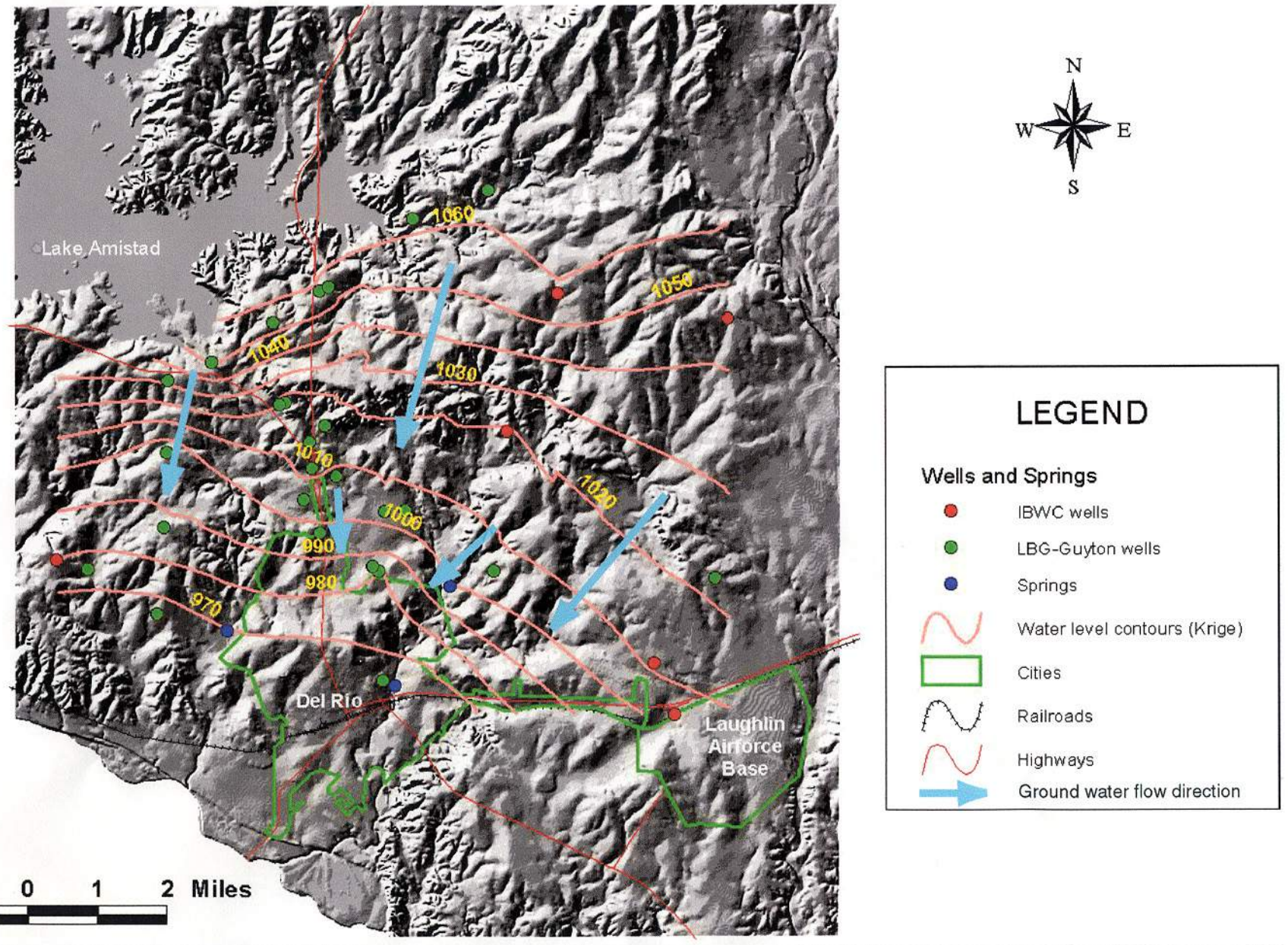




INTERFERENCE EFFECTS CAUSED BY PUMPING

FIGURE 11

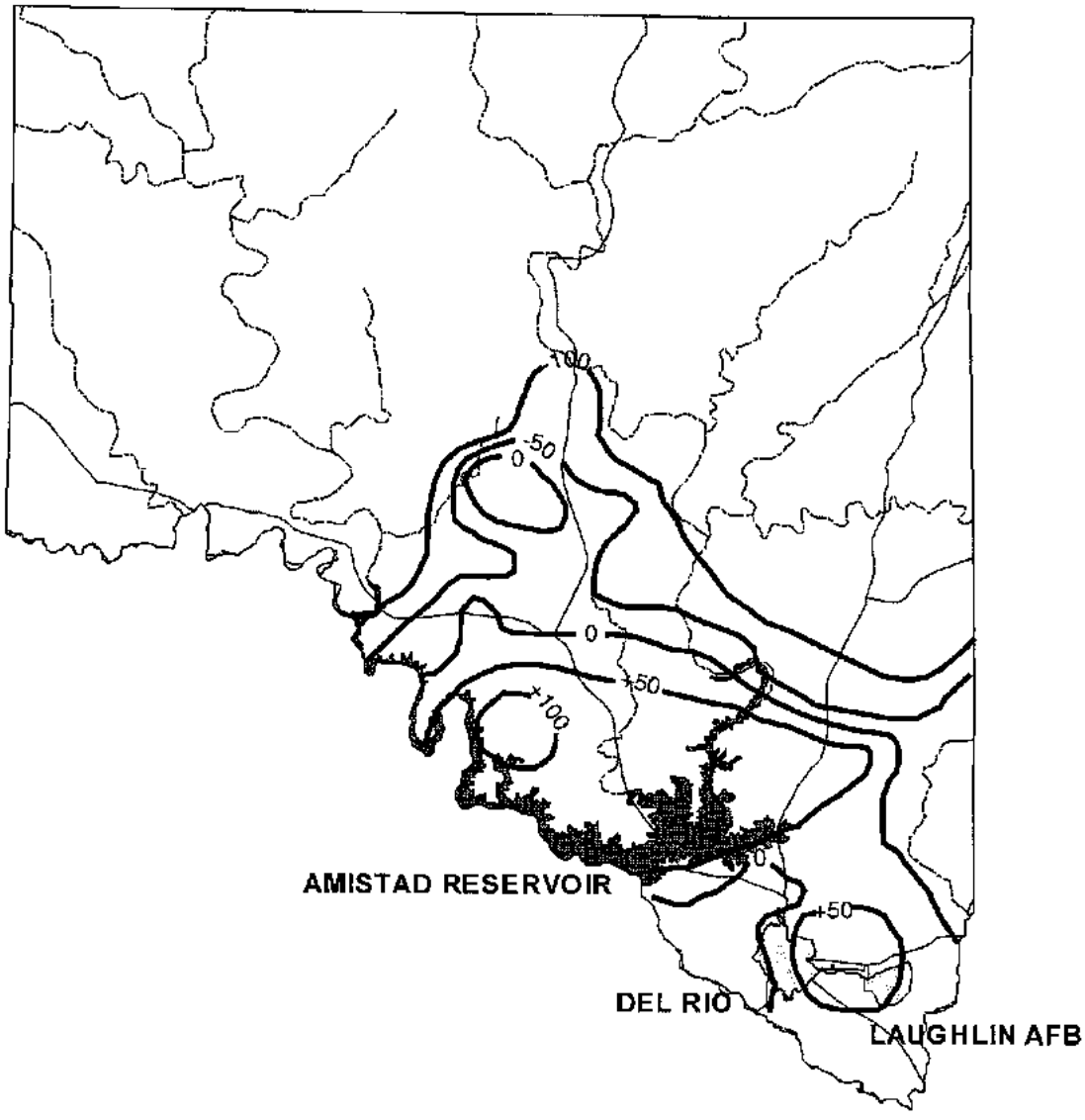
LBG-GUYTON ASSOCIATES



YEAR 2000 WATER-LEVEL CONTOURS SUPERIMPOSED ON DIGITAL ELEVATION MODEL, DEL RIO AREA, TEXAS

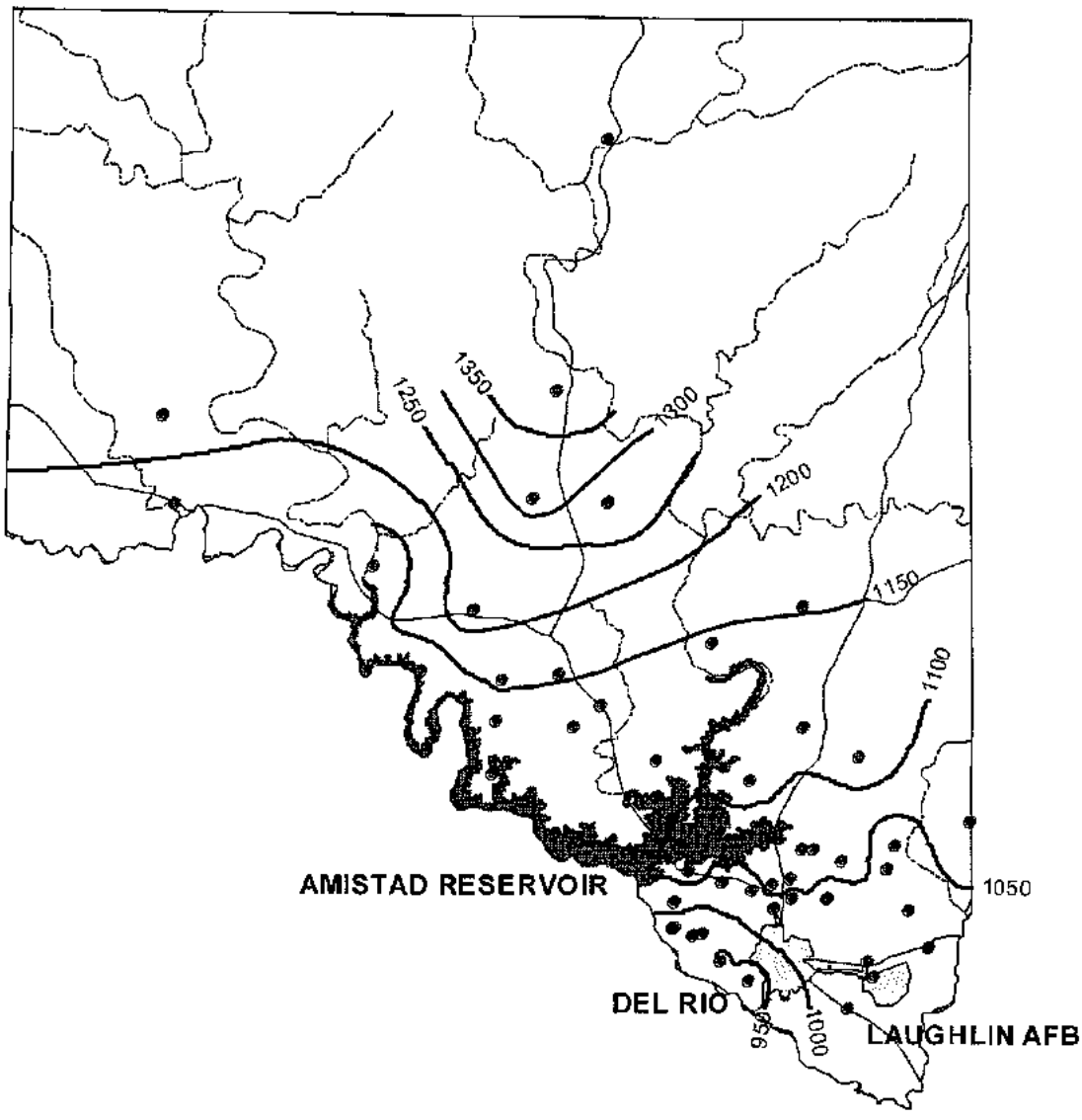
FIGURE 10

LBG-GUYTON ASSOCIATES



EDWARDS AQUIFER WATER-LEVEL CHANGES (1930s TO 1990s) **FIGURE 9**

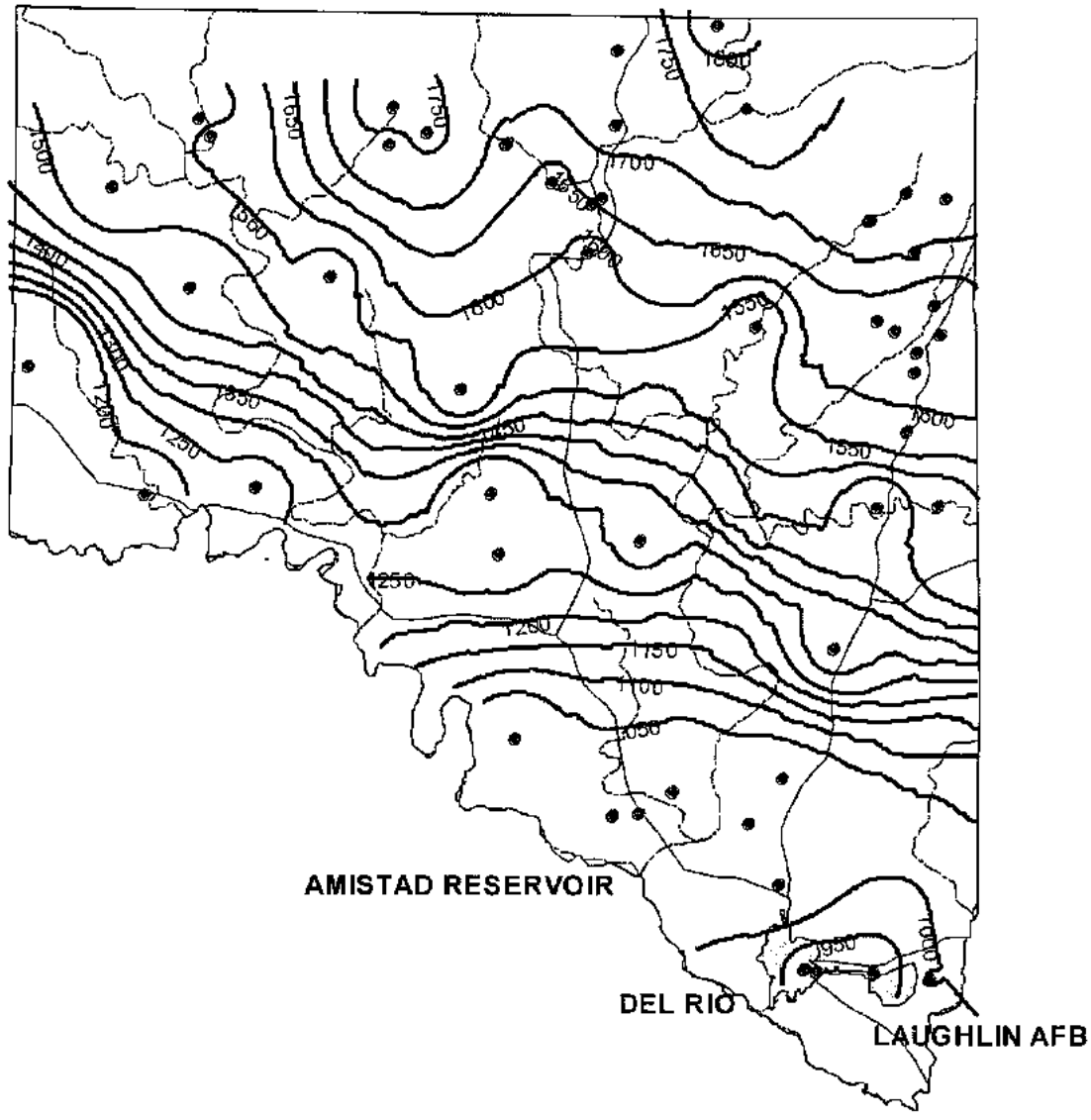
LBG-GUYTON ASSOCIATES



EDWARDS AQUIFER WATER LEVELS, 1993-94

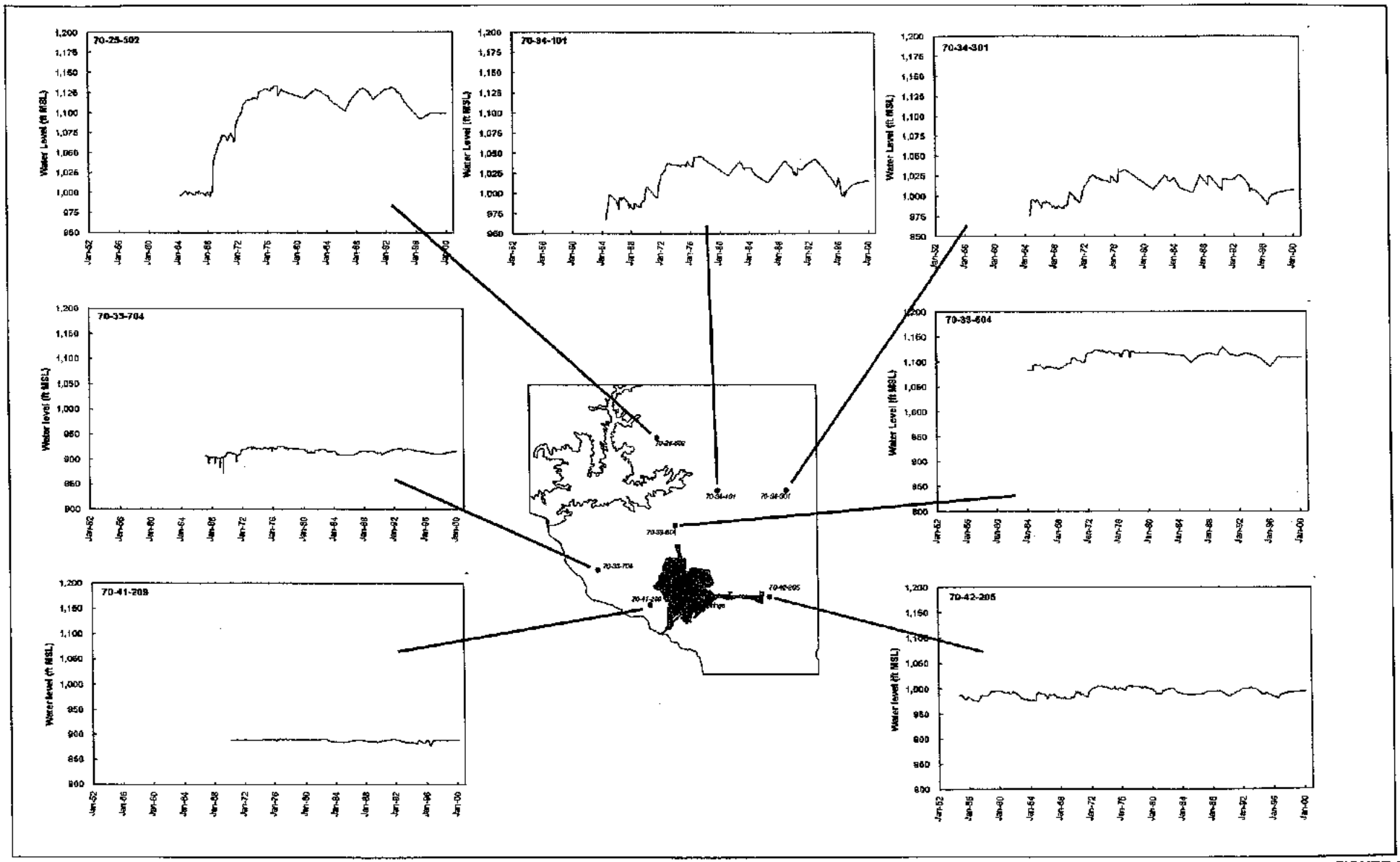
FIGURE 8

LBG-GUYTON ASSOCIATES



EDWARDS AQUIFER WATER LEVELS, 1937-40 FIGURE 7

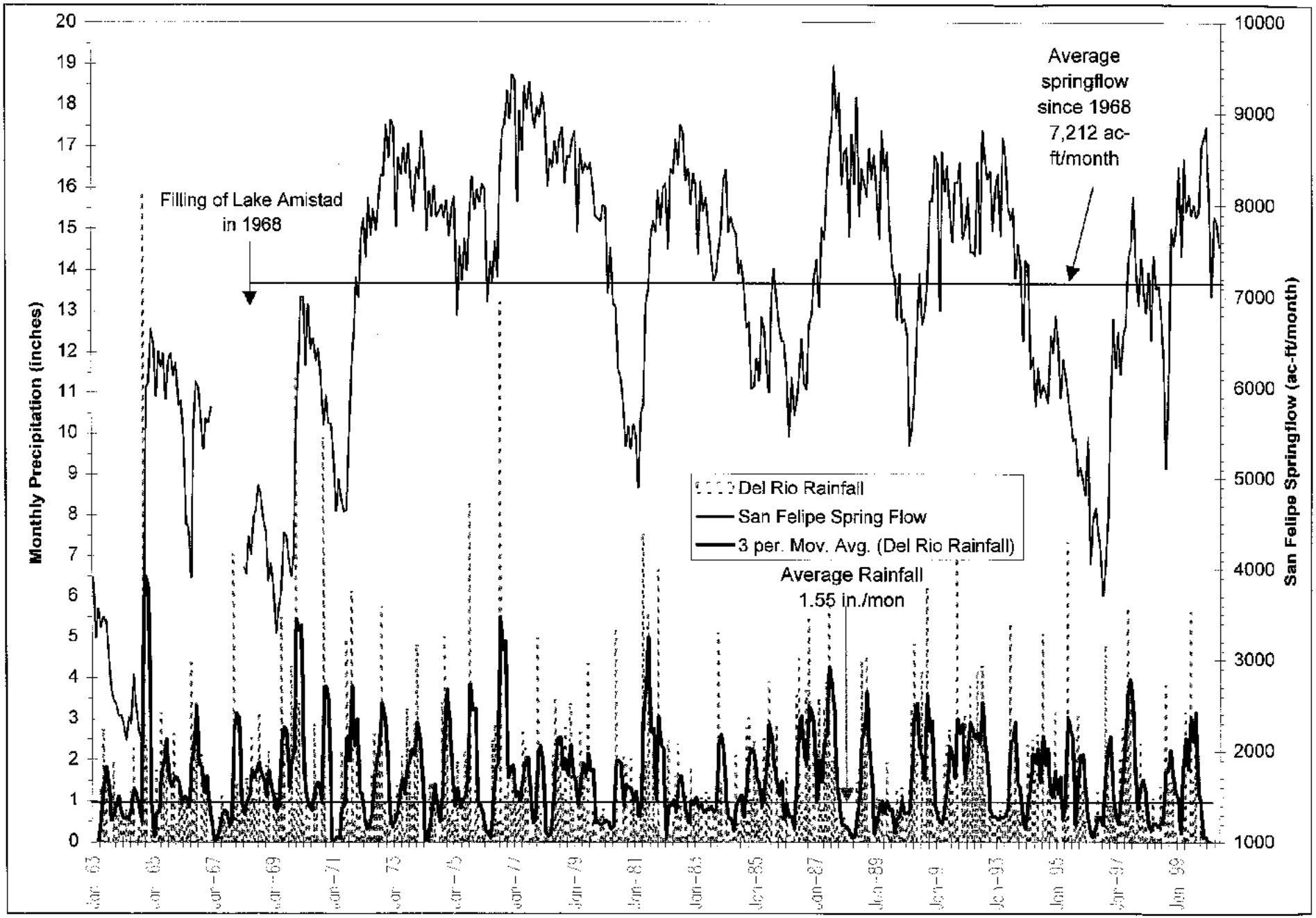
LBG-GUYTON ASSOCIATES



HYDROGRAPHS

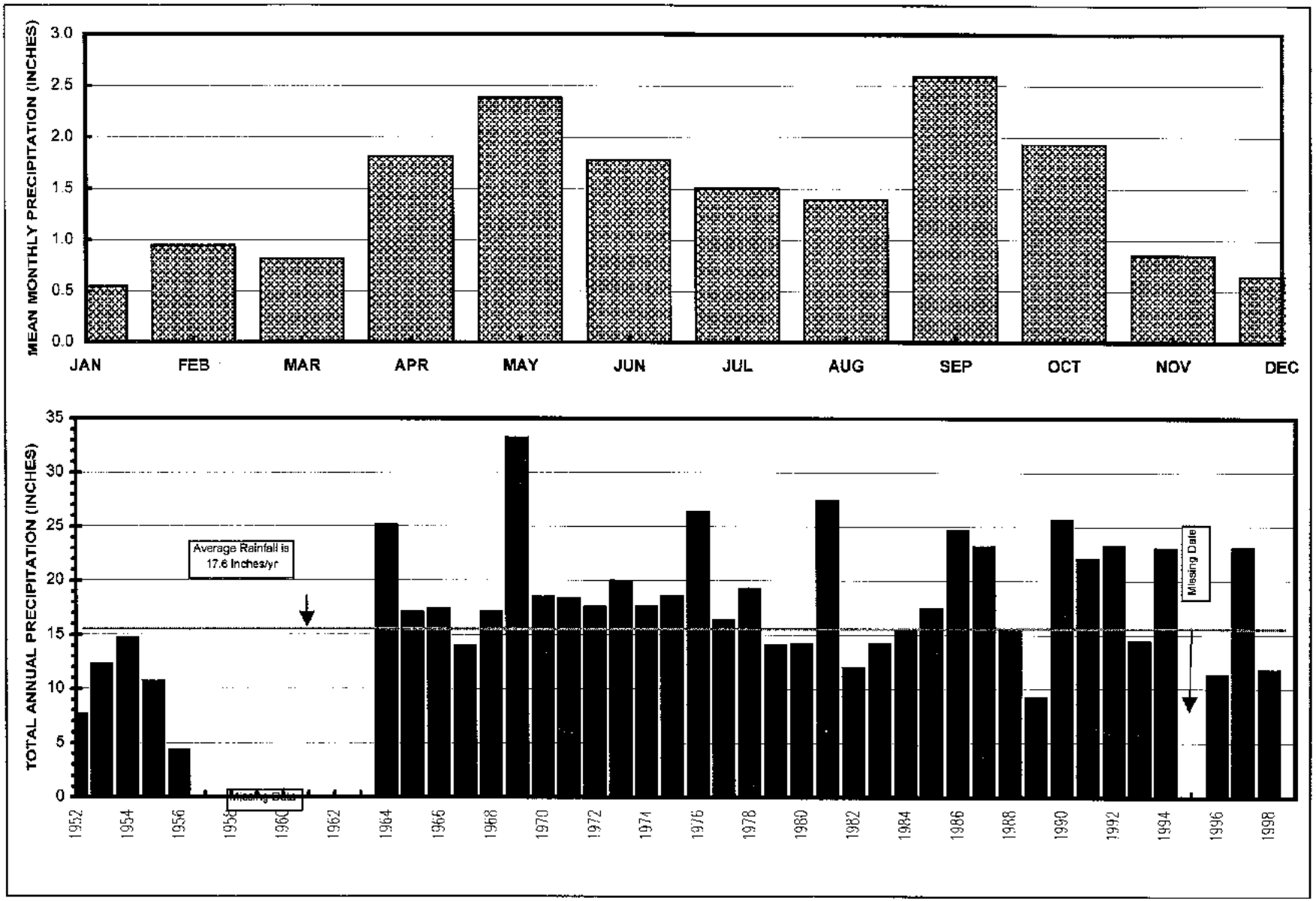
FIGURE 6

LBG-GUYTON ASSOCIATES



MONTHLY RAINFALL AT DEL RIO AND SAN FELIPE SPRINGFLOW

LBG-GUYTON ASSOCIATES
FIGURE 5

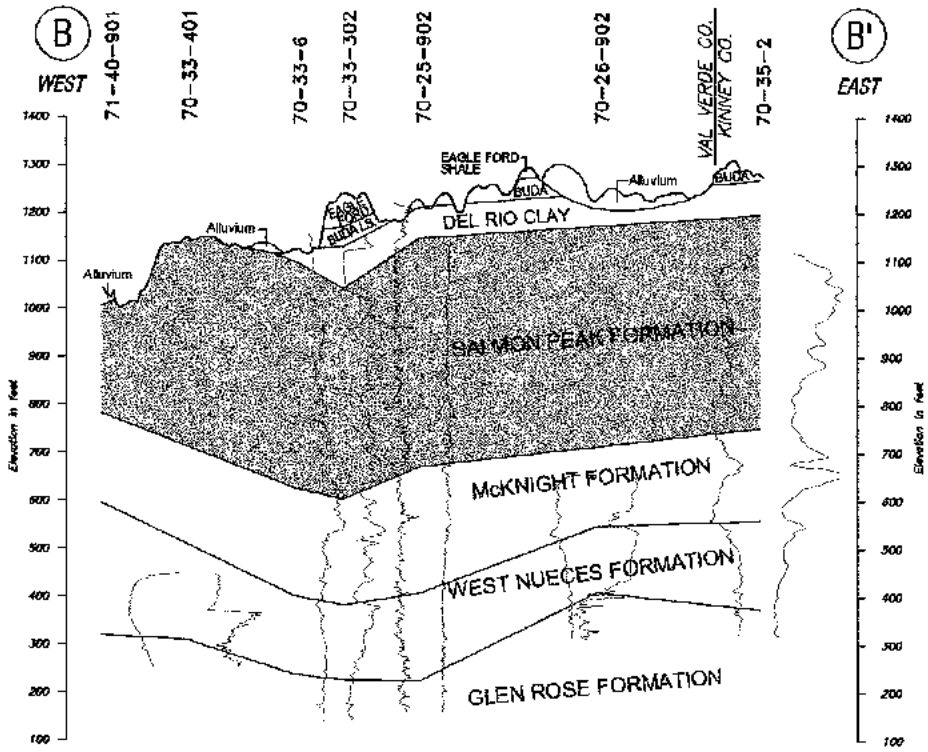


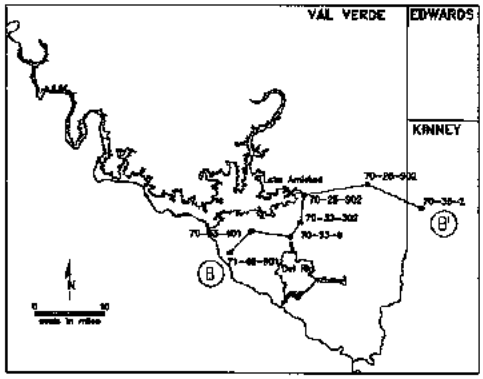
MEAN MONTHLY AND HISTORIC TOTAL ANNUAL PRECIPITATION AT DEL RIO INTERNATIONAL AIRPORT, VAL VERDE COUNTY, TEXAS

1951 - 1998

LBG-GUYTON ASSOCIATES

FIGURE 4





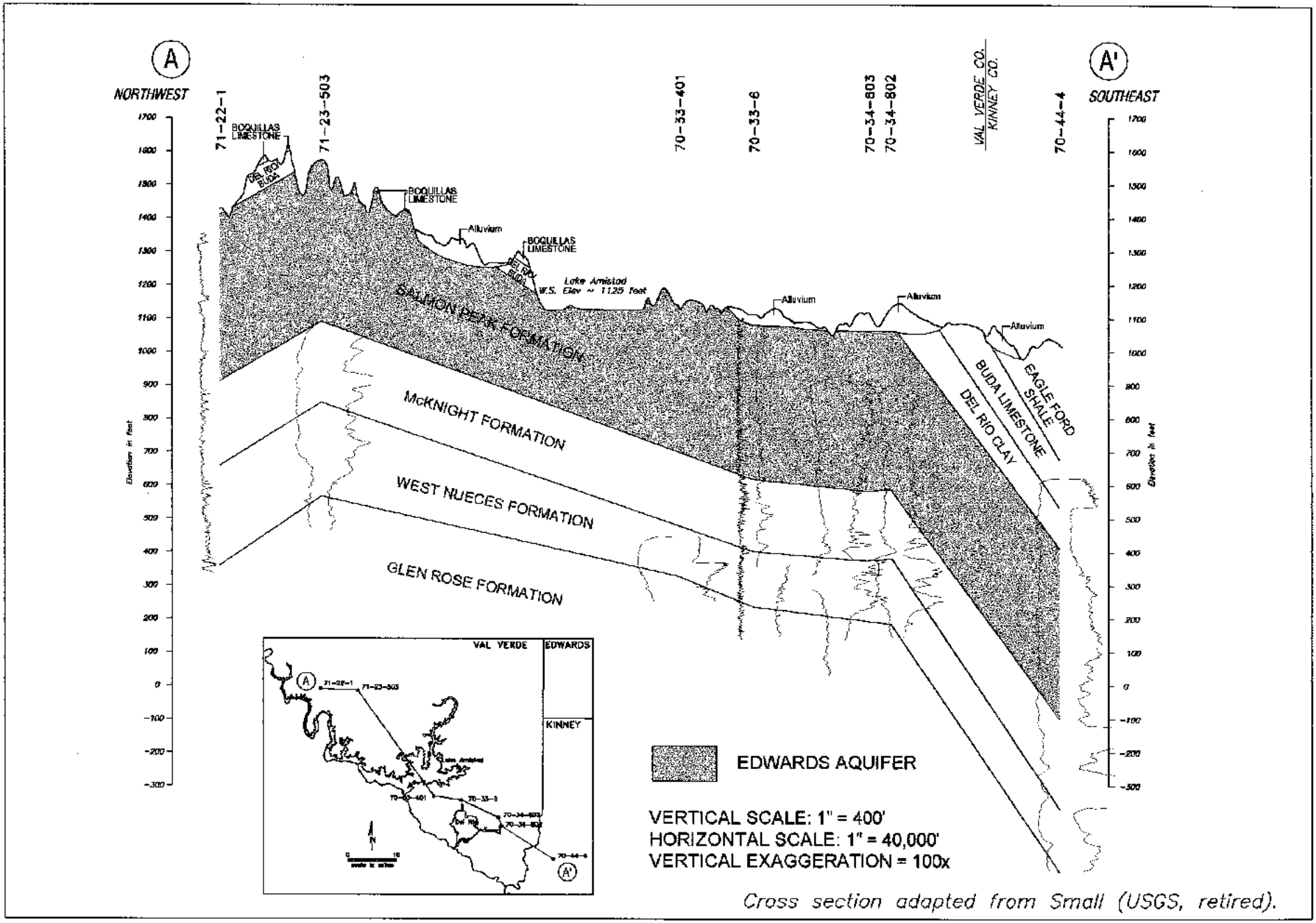
EDWARDS AQUIFER

VERTICAL SCALE: 1" = 300'
HORIZONTAL SCALE: 1" = 30,000'
VERTICAL EXAGGERATION = 100x

Cross section adapted from Small (USGS, retired).

EDWARDS AQUIFER
CROSS SECTION B - B'

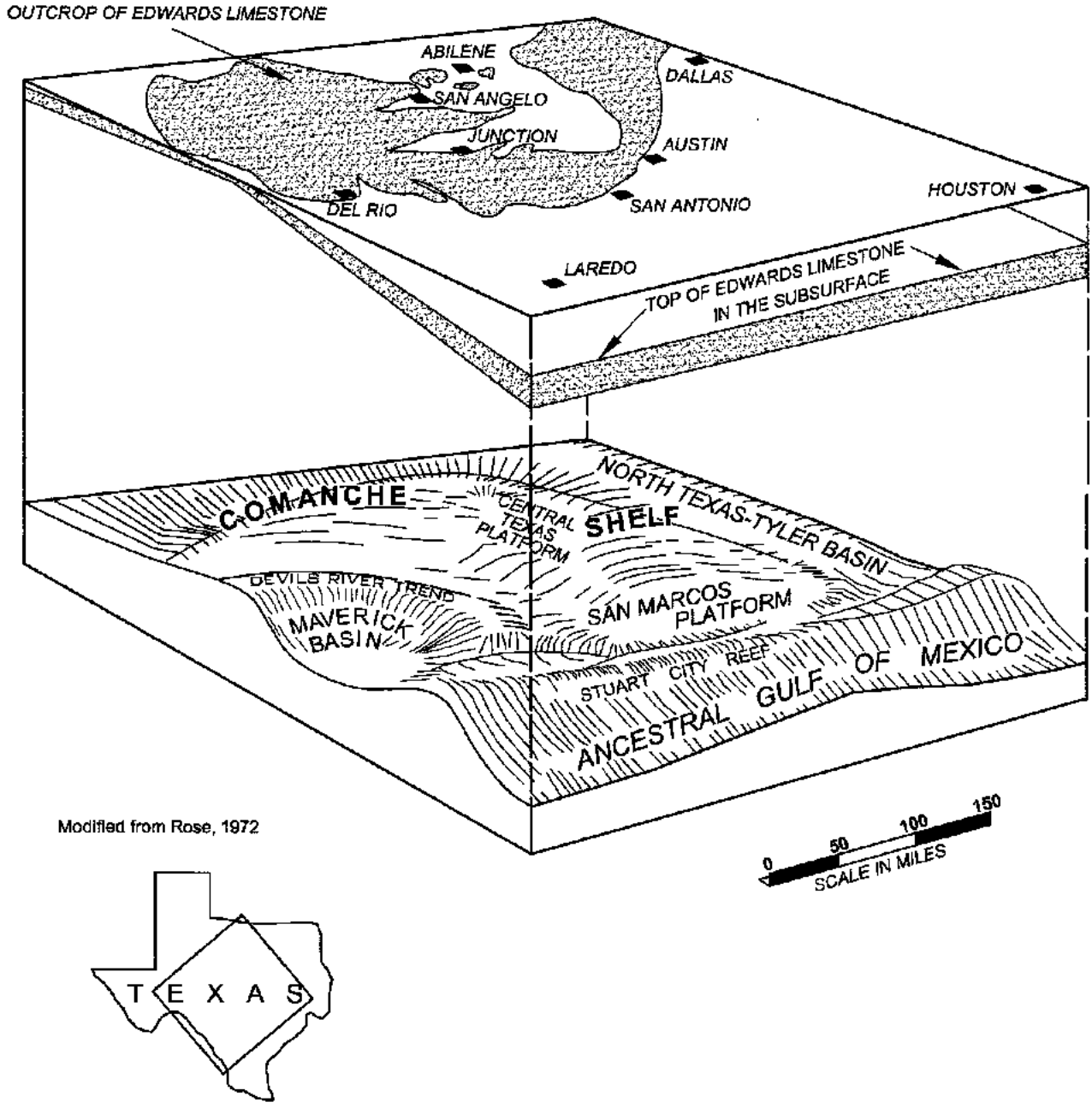
FIGURE 3B
LBG-GUYTON ASSOCIATES



Cross section adapted from Small (USGS, retired).

EDWARDS AQUIFER
CROSS SECTION A - A'

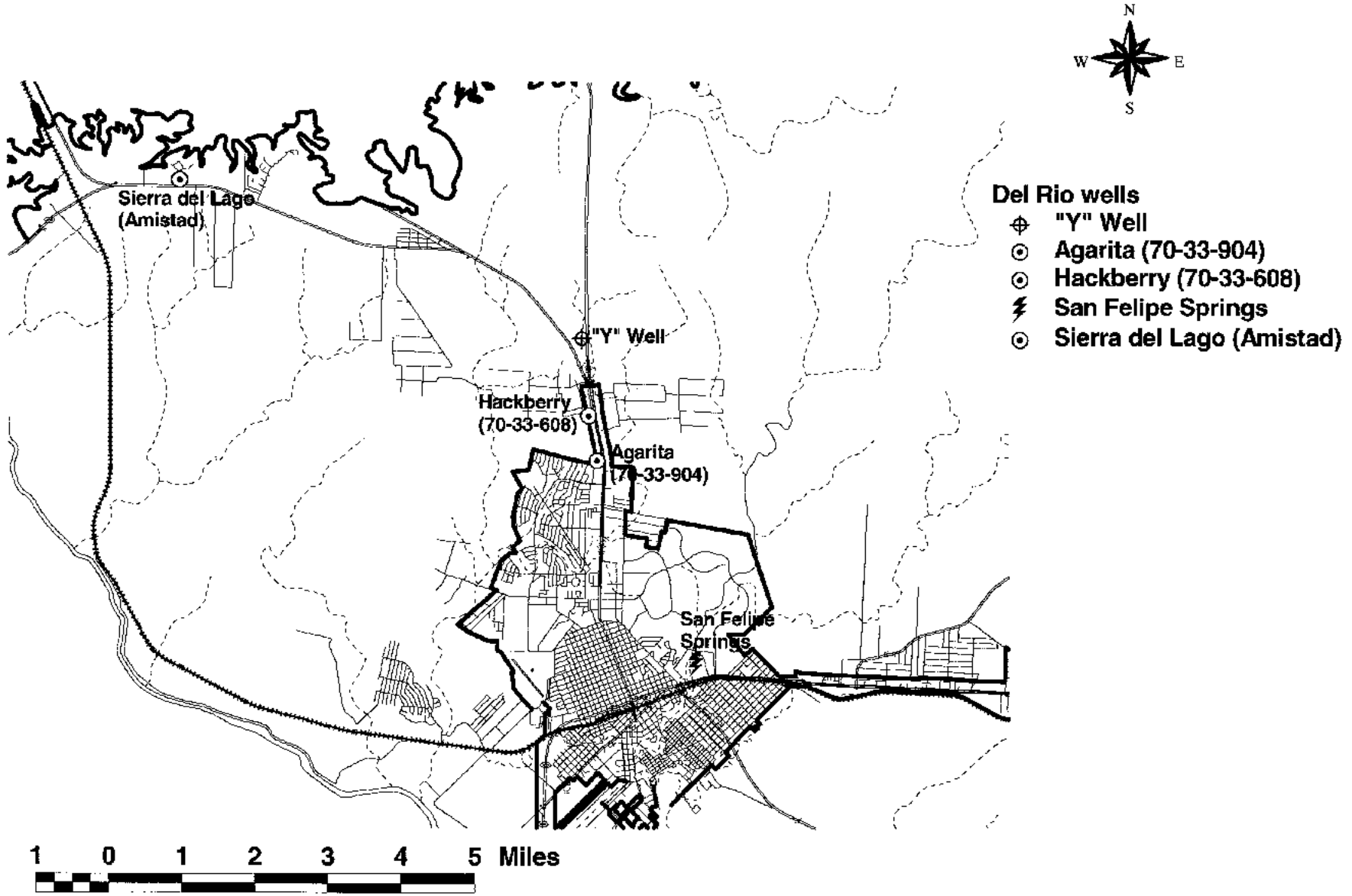
FIGURE 3A
LBG-GUYTON ASSOCIATES



EDWARDS OUTCROP AND DEPOSITIONAL ENVIRONMENT FOR CENTRAL TEXAS

FIGURE 2

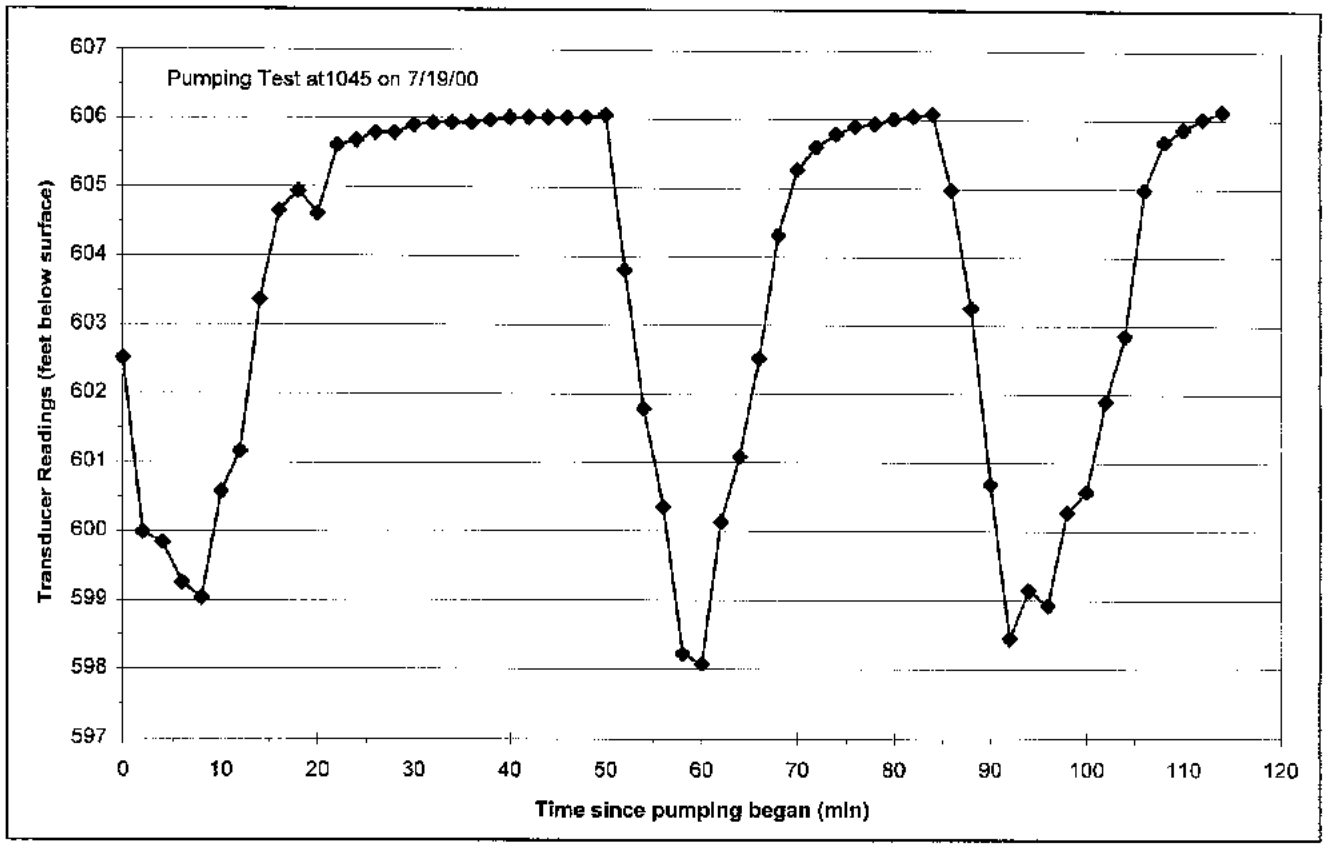
LBG-GUYTON ASSOCIATES

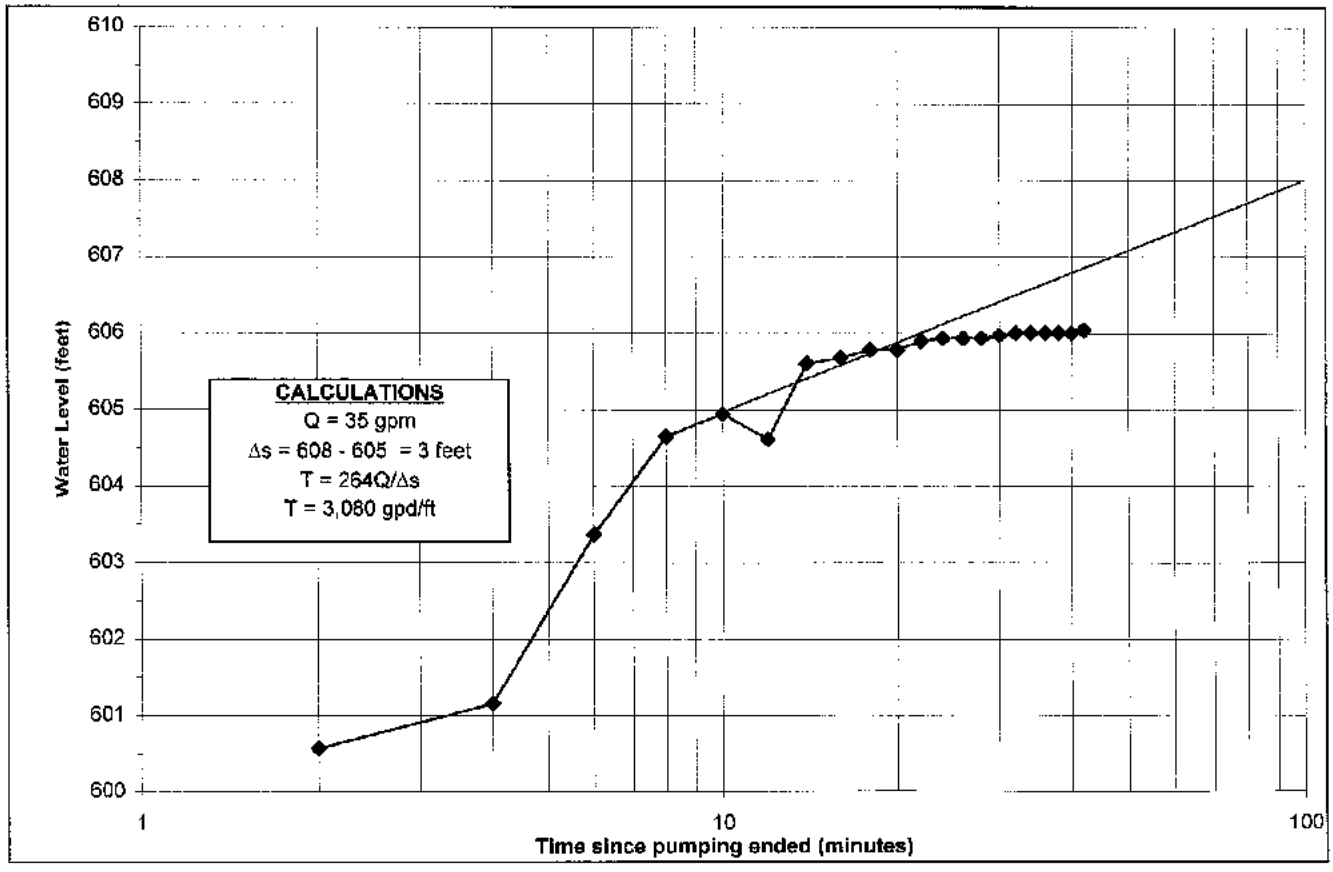


LOCATION MAP

FIGURE 1

LBG-GUYTON ASSOCIATES

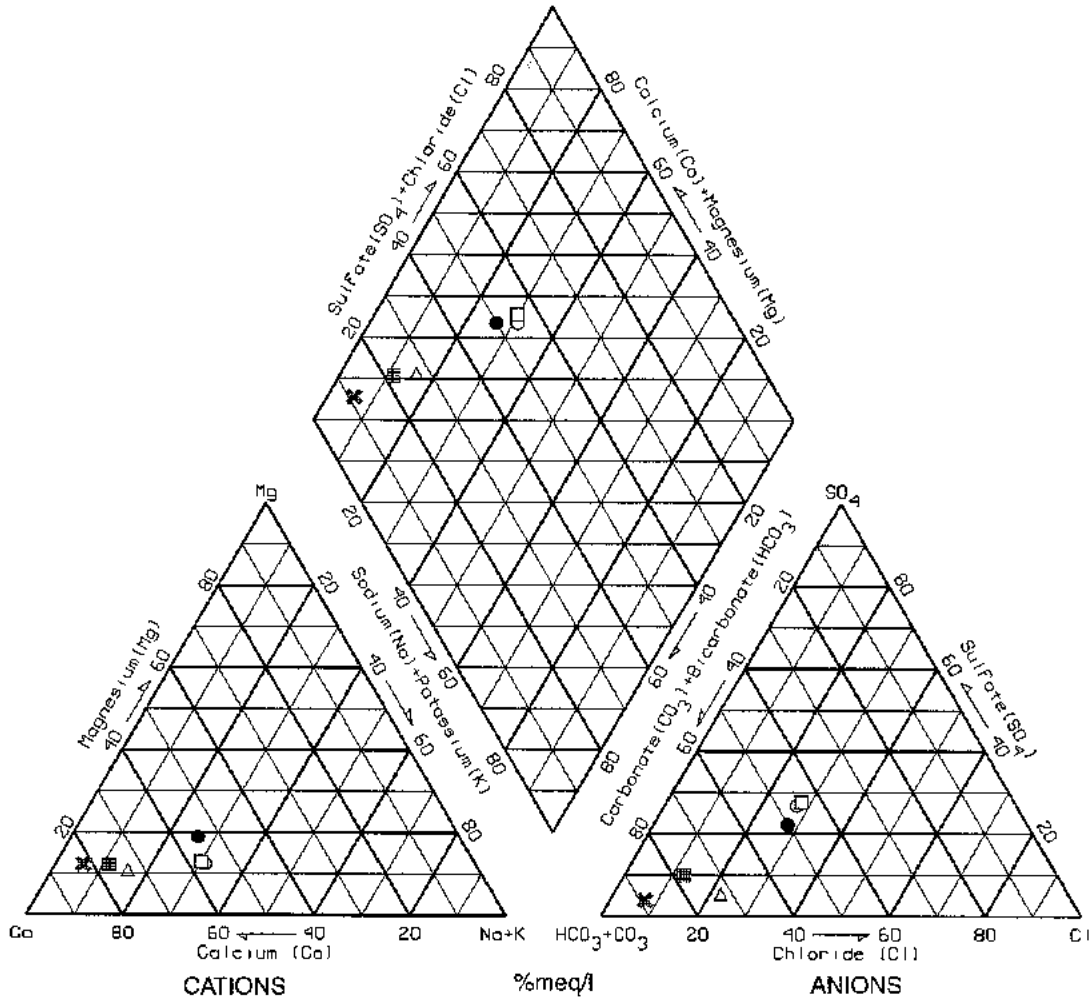




HYDROGRAPH, SEMILOG PLOT AND CALCULATIONS OF PACKER-TEST DATA FROM THE DEEPENED "Y" TEST WELL

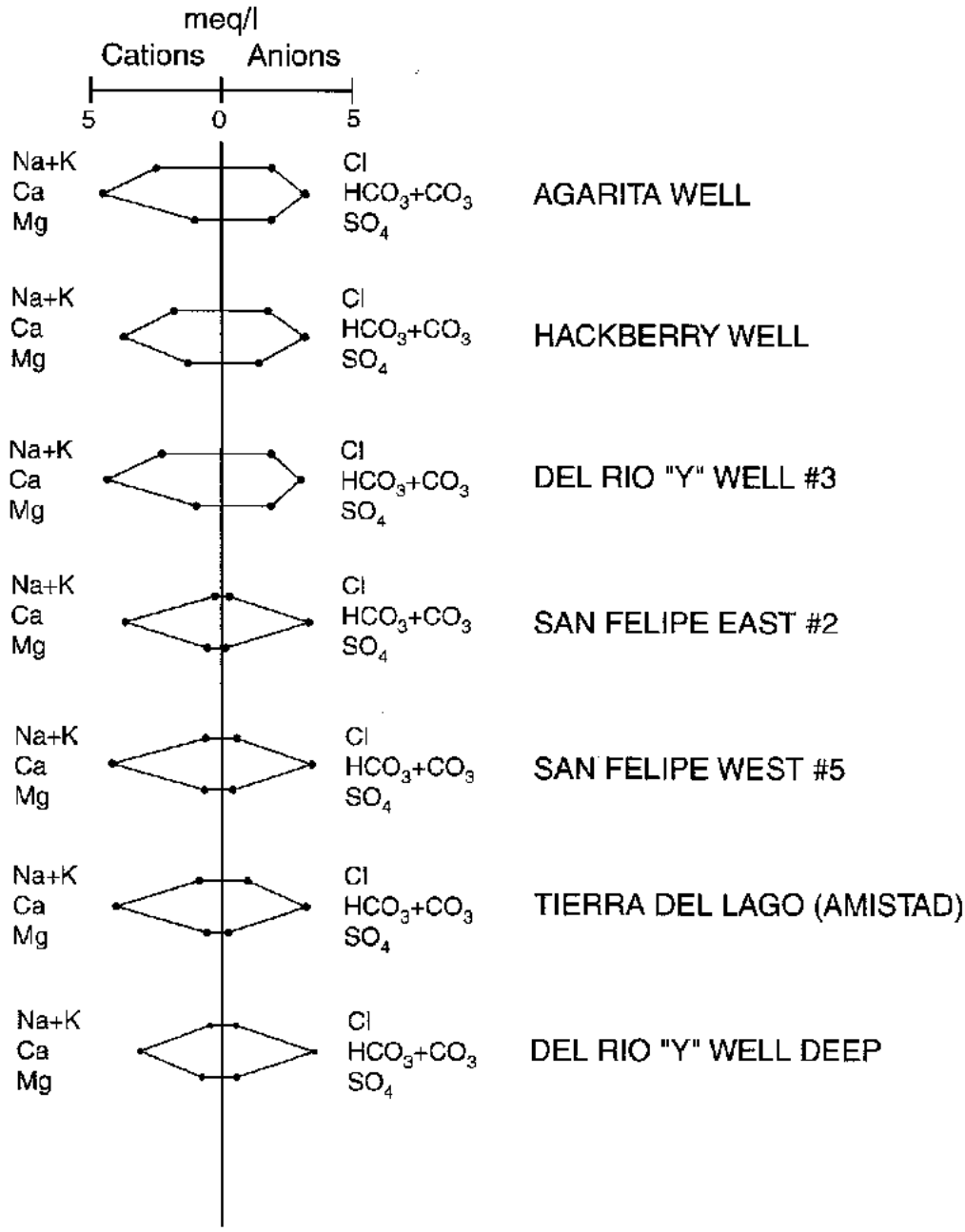
FIGURE 17

LBG-GUYTON ASSOCIATES

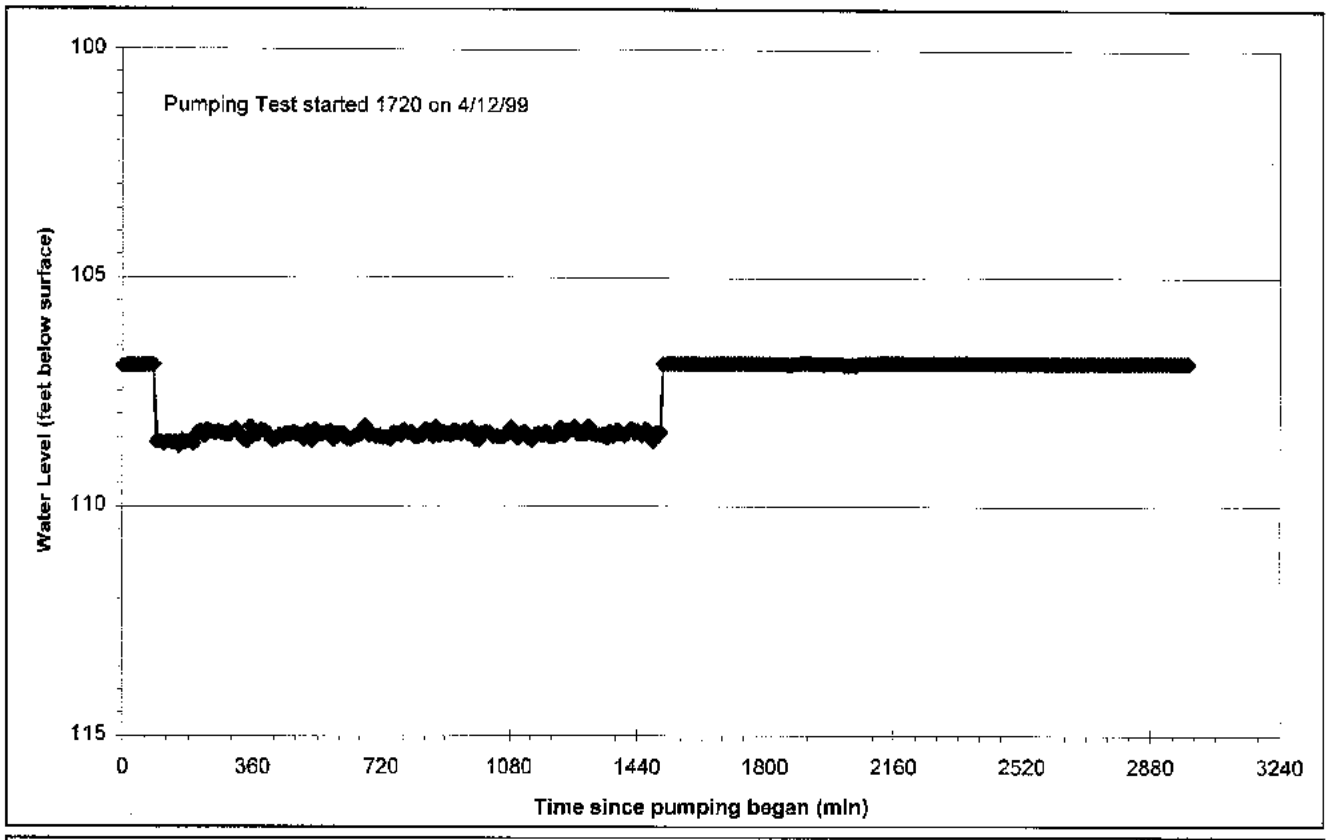


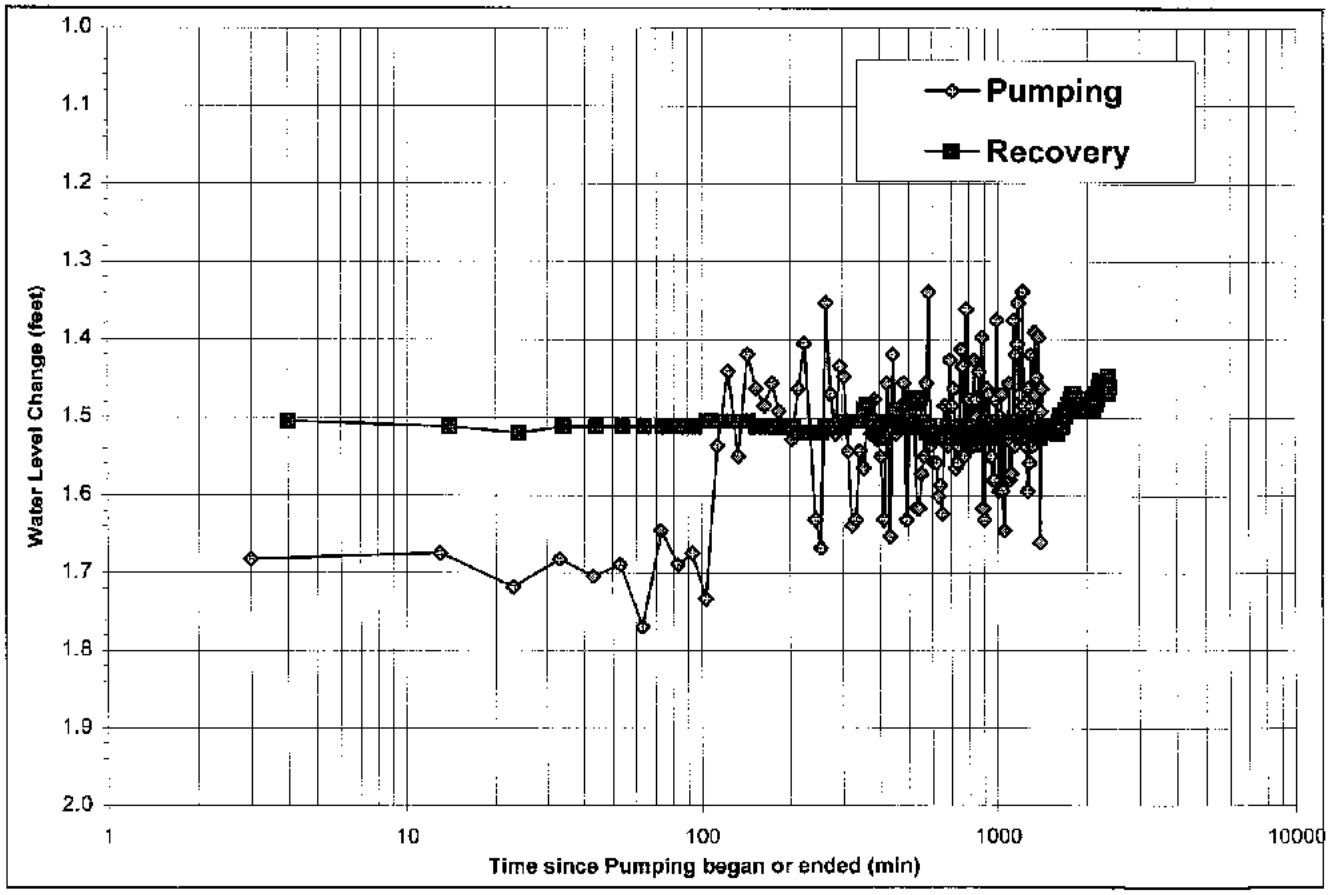
- ○ AGARITA WELL
- ● HACKBERRY WELL
- □ DEL RIO "Y" WELL #3
- ✖ SAN FELIPE EAST #2
- ▦ SAN FELIPE WEST #5
- △ TIERRA DEL LAGO (AMISTAD)

PIPER DIAGRAM **FIGURE 16**



STIFF DIAGRAM **FIGURE 15**

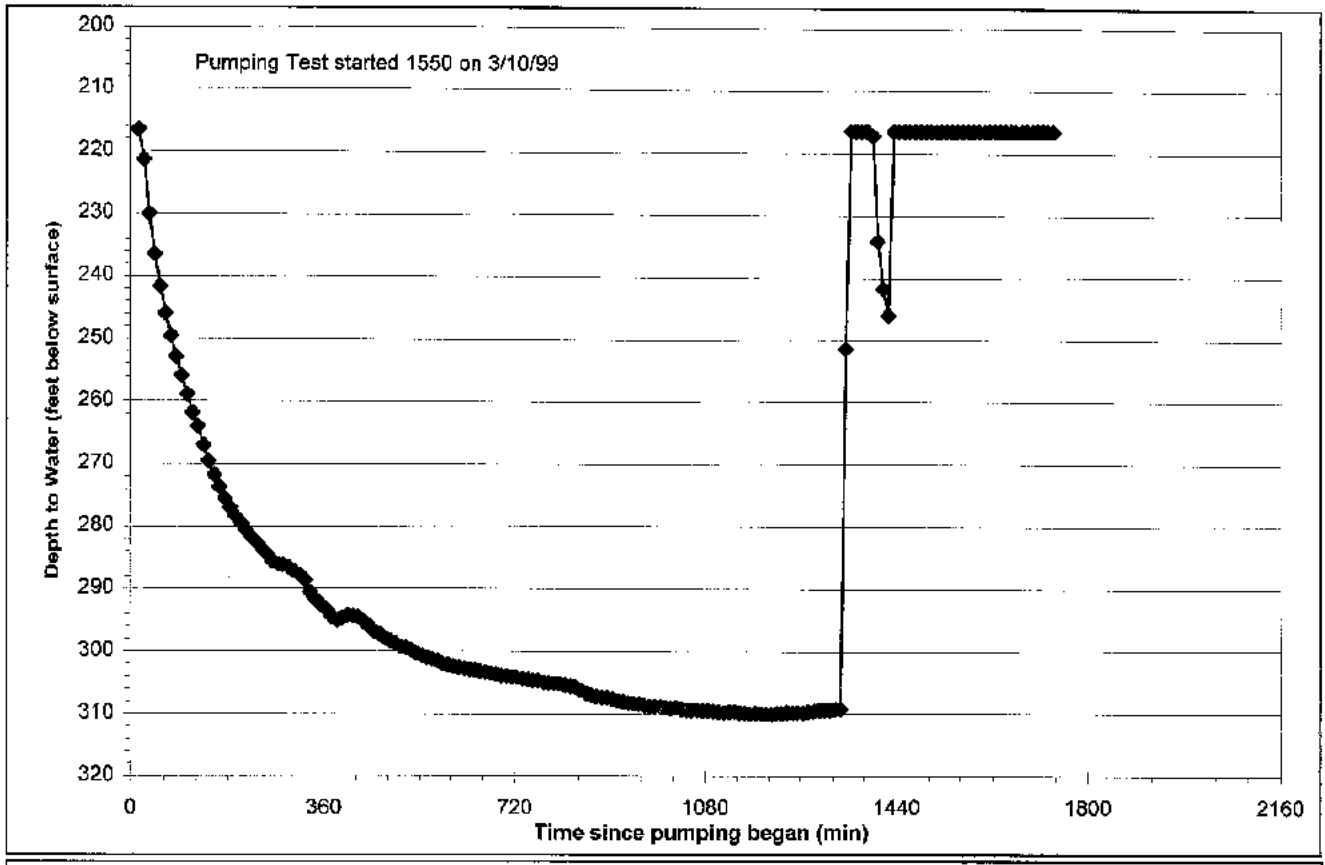


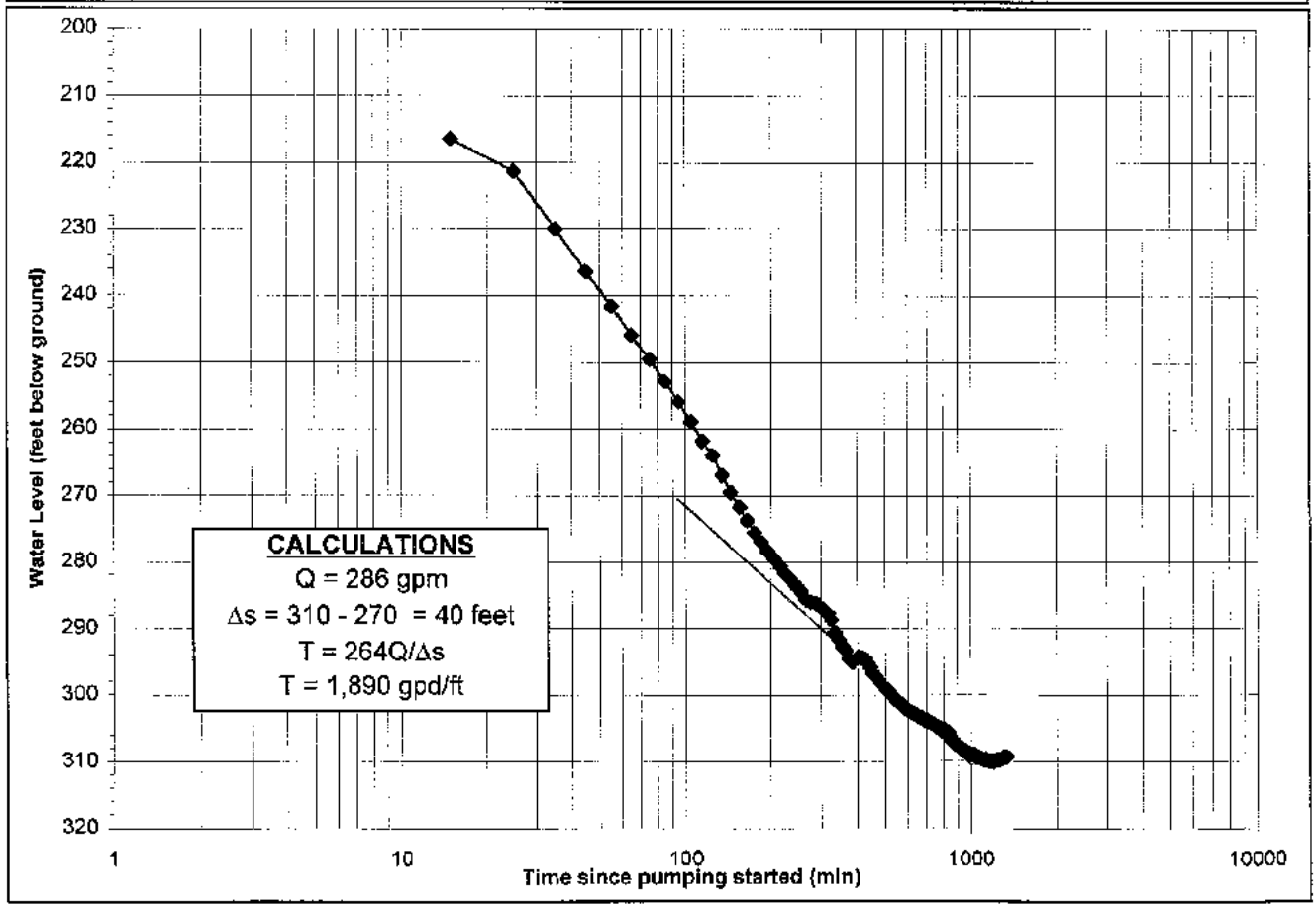


HYDROGRAPH, SEMILOG PLOT
OF PUMPING-TEST DATA FROM THE "Y" TEST WELL

FIGURE 14

LBG-GUYTON ASSOCIATES





HYDROGRAPH, SEMILOG PLOT AND CALCULATIONS OF PUMPING-TEST DATA FROM THE HACKBERRY WELL (70-33-608)

FIGURE 13

LBG-GUYTON ASSOCIATES

APPENDIX 3

LABORATORY REPORTS OF ANALYSES BY LCRA

Environmental Laboratory Services
The Solution Lab

FINAL ANALYSIS REPORT

LAB ID: 9905602 SAMPLE DESCRIPTION: Groundwater
COMPANY: LBG-Guyton Associate SAMPLE DATE: 03/11/9
ACCT NO: SAMPLE TIME: 1655
REQUISITION No.: R10369 DATE RECEIVED: 03/12/9
LOCATION ID: San Felipe East #2 REPORT DATE: 03/26/9

PARAMETER	RESULTS	UNITS	METHOD #	PQL in WATER	DATE ANALYZED
Chloride	9.8	mg/L	EPA300.0	1.5	03/12/99
Fluoride	0.10	mg/L	EPA300.0	0.01	03/23/99
Nitrogen, Nitrate	1.930	mg/L	EPA300.0	0.010	03/12/99
Nitrogen, Nitrite	<0.010	mg/L	EPA300.0	0.010	03/12/99
Potassium, Dissolved	0.87	mg/L	EPA200.7	0.20	03/17/99
Sulfate	6.86	mg/L	EPA300.0	1.50	03/12/99
Aluminum, Dis. ICPMS	<4.0	ug/L	EPA200.8	4.0	03/18/99
Arsenic, Diss. ICPMS	<2.0	ug/L	EPA200.8	2.0	03/18/99
Barium, Diss. ICPMS	<1.0	ug/L	EPA200.8	1.0	03/18/99
Calcium, Dissolved	74.20	mg/L	EPA200.7	0.20	03/17/99
Chromium, Diss ICPMS	12.5	ug/L	EPA200.8	1.0	03/18/99
Copper, Diss. ICPMS	2.5	ug/L	EPA200.8	2.0	03/18/99
Iron, Dissolved	<0.07	mg/L	EPA200.7	0.01	03/17/99
Lead, Diss. ICPMS	1.9	ug/L	EPA200.8	1.0	03/18/99
Magnesium, Dissolved	6.77	mg/L	EPA200.7	0.20	03/17/99
Manganese, Dis ICPMS	4.0	ug/L	EPA200.8	1.0	03/18/99
Selenium, Dis. ICPMS	<4.0	ug/L	EPA200.8	4.0	03/18/99
Silver, Diss. ICPMS	<1.0	ug/L	EPA200.8	1.0	03/18/99
Sodium, Dissolved	5.36	mg/L	EPA200.7	0.20	03/17/99
Beryllium, Dis ICPMS	63.4	ug/L	EPA200.8	1.0	03/18/99
Zinc, Diss. ICPMS	10.7	ug/L	EPA200.8	2.0	03/18/99
Alkalinity, Total	203	mg/L	EPA310.1	1	03/16/99
Alkalinity, bicarb.	203	mg/L	SM2320B	0	03/16/99
Residue, Filt. - TDS	235	mg/L	EPA160.1	5	03/12/99

Field pH = 7.2
Field Cond. = 450
Field Temp = 24.0 °C

Sampled by W.G.Stein
Note: metals filted 0.45M

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Environmental Laboratory Services
The Solution Lab

FINAL ANALYSIS REPORT

LAB ID: 9905637 SAMPLE DESCRIPTION: Groundwater
COMPANY: LBG-Guyton Associate
ACCT NO:
REQUISITION No.: R10387
LOCATION ID: San Felipe West #5

SAMPLE DATE: 03/15/9
SAMPLE TIME: 1610
DATE RECEIVED: 03/16/9
REPORT DATE: 03/26/9

PARAMETER	RESULTS	UNITS	METHOD #	PQL in WATER	DATE ANALYZED
Aluminum, DW	<4.0	ug/L	EPA200.8	4.0	03/18/99
Arsenic, DW	<2.0	ug/L	EPA200.8	2.0	03/18/99
Barium, DW	66.6	ug/L	EPA200.8	1.0	03/18/99
Beryllium, DW	<1.0	ug/L	EPA200.8	1.0	03/18/99
Calcium, DW	84.3	mg/L	EPA200.7	0.2	03/22/99
Chloride	19.7	mg/L	EPA300.0	1.5	03/17/99
Chromium, DW	19.6	ug/L	EPA200.8	1.0	03/18/99
Copper, DW	<2.0	ug/L	EPA200.8	2.0	03/18/99
Fluoride	0.15	mg/L	EPA300.0	0.01	03/23/99
Iron, DW	<0.05	mg/L	EPA200.7	0.05	03/22/99
Lead, DW	<1.0	ug/L	EPA200.8	1.0	03/18/99
Magnesium, DW	8.0	mg/L	EPA200.7	0.2	03/22/99
Manganese, DW	<1.0	ug/L	EPA200.8	1.0	03/18/99
Nitrogen, Nitrate	1.970	mg/L	EPA300.0	0.010	03/17/99
Nitrogen, Nitrite	<0.010	mg/L	EPA300.0	0.010	03/17/99
Potassium, DW	1.1	mg/L	EPA200.7	0.2	03/22/99
Selenium, DW	<4.0	ug/L	EPA200.8	4.0	03/18/99
Silver, DW	<1.0	ug/L	EPA200.8	1.0	03/18/99
Sodium, DW	13.7	mg/L	EPA200.7	0.2	03/22/99
Sulfate	20.00	mg/L	EPA300.0	1.50	03/17/99
Tot. Coli. Pres/Abs.	Present	/100 ml	Pres/Abs	-----	03/16/99
Zinc, DW	<4.000	ug/L	EPA200.8	4.000	03/18/99
Alkalinity, Total	210	mg/L	EPA310.1	1	03/18/99
Alkalinity, bicarb.	210	mg/L	SM2320B	0	03/18/99
Residue, Filt. - TDS	277	mg/L	EPA160.1	5	03/17/99

Total Coliform Comments: Found Total Coliform

Field pH = 7.1
Field Cond. = 535 µmhos
Field Temp. = 24.0 °C

Sampled by W.G.Stein
Note: metals filtered 0.45µ

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POLLUTION CONTROL SERVICES

REPORT OF SAMPLE ANALYSIS

To: W.G. Stein
LBG-Guyton Associates
1101 S. Capital of Texas Highway
Austin, Tx 78746-6437

SAMPLE INFORMATION		*LABORATORY INFORMATION*	
Project Name:		PCS Sample #:	**78149**
Sample ID:	San Felipe Springs West #5b	Date Received:	04/14/1999
Date Taken:	04/13/1999	Time Received:	09:00
Time Taken:	1730	Report Date:	04/15/1999

TEST DESCRIPTION	SAMPLE RESULT	UNITS	ANALYZED DATE	ANALYZED TIME	ANALYST'S INITIALS	METHOD USED
Coliform, Total (Present/Absent)	Absent	N/A	04/14/1999	10:00	CS	SM 9221 D

Water passed / failed criteria for bacteriological test.
Water of satisfactory bacteriological quality should be free from Coliform organisms.

Coliform Organisms _X_ Not Found
___ Found
___ Total
___ Fecal
___ Repeat Samples Recommended
___ Unsuitable - See Below

__ Sample too old. Sample not received within 30 hours of collection.
__ Date discrepancy or form incomplete.
__ Heavy (silt/bacteria growth) present, possibly compromising test results.

APPROVED BY: _____
CHUCK WALLGREN

1-800-880-4616
435 Isom Road, Suite 228
San Antonio, TX 78216-5144
(210) 340-0343

Environmental Laboratory Services
The Solution Lab

FINAL ANALYSIS REPORT

LAB ID: 9905638 SAMPLE DESCRIPTION: Groundwater
COMPANY: LBG-Guyton Associate
ACCT NO:
REQUISITION No.: R10387
LOCATION ID: Agarita Well
70-33-904

SAMPLE DATE: 03/15/99
SAMPLE TIME: 1715
DATE RECEIVED: 03/16/99
REPORT DATE: 03/26/99

PARAMETER	RESULTS	UNITS	METHOD #	PQL in WATER	DATE ANALYZED
Aluminum, DW	5.1	ug/L	EPA200.8	4.0	03/18/99
Arsenic, DW	<2.0	ug/L	EPA200.8	2.0	03/18/99
Barium, DW	101.0	ug/L	EPA200.8	1.0	03/18/99
Beryllium, DW	<1.0	ug/L	EPA200.8	1.0	03/18/99
Calcium, DW	90.9	mg/L	EPA200.7	0.2	03/22/99
Chloride	68.1	mg/L	EPA300.0	1.5	03/17/99
Chromium, DW	15.4	ug/L	EPA200.8	1.0	03/18/99
Copper, DW	<2.0	ug/L	EPA200.8	2.0	03/18/99
Fluoride	0.33	mg/L	EPA300.0	0.01	03/23/99
Iron, DW	<0.05	mg/L	EPA200.7	0.05	03/22/99
Lead, DW	<1.0	ug/L	EPA200.8	1.0	03/18/99
Magnesium, DW	12.3	mg/L	EPA200.7	0.2	03/22/99
Manganese, DW	<1.0	ug/L	EPA200.8	1.0	03/18/99
Nitrogen, Nitrate	1.560	mg/L	EPA300.0	0.010	03/17/99
Nitrogen, Nitrite	<0.010	mg/L	EPA300.0	0.010	03/17/99
Potassium, DW	2.5	mg/L	EPA200.7	0.2	03/22/99
Selenium, DW	<4.0	ug/L	EPA200.8	4.0	03/18/99
Silver, DW	<1.0	ug/L	EPA200.8	1.0	03/18/99
Sodium, DW	55.9	mg/L	EPA200.7	0.2	03/22/99
Sulfate	91.00	mg/L	EPA300.0	1.50	03/25/99
Tot. Coli. Pres/Abs.	Present	/100 ml	Pres/Abs	-----	03/16/99
Zinc, DW	<4.000	ug/L	EPA200.8	4.000	03/18/99
Alkalinity, Total	196	mg/L	EPA310.1	1	03/18/99
Alkalinity, bicarb.	196	mg/L	SM2320B	0	03/18/99
Residue, Filt. - TDS	455	mg/L	EPA160.1	5	03/17/99

Total Coliform Comments: Found Total Coliform

Field pH = 7.2
Field Conductivity = 745 µmhos
Field Temp = 23.5 °C

Pump started 1930 on 3/14/99 at rate of 780 gpm

Sampled by W.G. Stein
Note: metals filtered 0.45µ

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POLLUTION CONTROL SERVICES

REPORT OF SAMPLE ANALYSIS

To: W.G. Stein
LBG-Guyton Associates
1101 S. Capital of Texas Highway
Austin, Tx 78746-6437

SAMPLE INFORMATION		*LABORATORY INFORMATION*	
Project Name:	Del Rio	PCS Sample #:	77533
Sample ID:	Well Water Agarita	Date Received:	03/12/1999
Date Taken:	03/11/1999	Time Received:	09:55
Time Taken:	1545	Report Date:	03/15/1999

TEST DESCRIPTION	SAMPLE RESULT	UNITS	ANALYZED DATE	ANALYZED TIME	ANALYST'S INITIALS	METHOD USED
Coliform,Presence-Absence	Absent	N/A	03/12/1999	10:20	CS	SM 9221E

QUALITY ASSURANCE DATA

TEST DESCRIPTION	M.D.L.	PRECISION	LIMIT	LCL	RECOVERY	UCL
Coliform,Presence-Absence	N/A	N/A	N/A	N/A	N/A	N/A

APPROVED BY: Chuck Wallgren
CHUCK WALLGREN

1-800-880-4616
435 Isom Road, Suite 228
San Antonio, TX 78216-5144
(210) 340-0343

Environmental Laboratory Services
The Solution Lab

FINAL ANALYSIS REPORT

LAB ID: 9905601 SAMPLE DESCRIPTION: Groundwater
COMPANY: LBG-Guyton Associate SAMPLE DATE: 03/11/9
ACCT NO: SAMPLE TIME: 1545
REQUISITION No.: R10369 DATE RECEIVED: 03/12/9
LOCATION ID: Hackberry Well REPORT DATE: 03/26/9
70-33-608

PARAMETER	RESULTS	UNITS	METHOD #	PQL in WATER	DATE ANALYZED
Chloride	63.2	mg/L	EPA300.0	1.5	03/12/99
Fluoride	1.34	mg/L	EPA300.0	0.01	03/23/99
Nitrogen, Nitrate	0.075	mg/L	EPA300.0	0.010	03/12/99
Nitrogen, Nitrite	<0.010	mg/L	EPA300.0	0.010	03/12/99
Potassium, Dissolved	1.91	mg/L	EPA200.7	0.20	03/17/99
Sulfate	67.60	mg/L	EPA300.0	1.50	03/12/99
Aluminum, Dis. ICPMS	<4.0	ug/L	EPA200.8	4.0	03/18/99
Arsenic, Diss. ICPMS	<2.0	ug/L	EPA200.8	2.0	03/18/99
Barium, Diss. ICPMS	101.0	ug/L	EPA200.8	1.0	03/18/99
Calcium, Dissolved	75.10	mg/L	EPA200.7	0.20	03/17/99
Chromium, Diss ICPMS	14.9	ug/L	EPA200.8	1.0	03/18/99
Copper, Diss. ICPMS	2.3	ug/L	EPA200.8	2.0	03/18/99
Iron, Dissolved	0.16	mg/L	EPA200.7	0.01	03/17/99
Lead, Diss. ICPMS	8.1	ug/L	EPA200.8	1.0	03/18/99
Magnesium, Dissolved	15.70	mg/L	EPA200.7	0.20	03/17/99
Manganese, Dis ICPMS	12.7	ug/L	EPA200.8	1.0	03/18/99
Selenium, Dis. ICPMS	<4.0	ug/L	EPA200.8	4.0	03/18/99
Silver, Diss. ICPMS	<1.0	ug/L	EPA200.8	1.0	03/18/99
Sodium, Dissolved	40.50	mg/L	EPA200.7	0.20	03/17/99
Beryllium, Dis ICPMS	<1.0	ug/L	EPA200.8	1.0	03/18/99
Zinc, Diss. ICPMS	10.3	ug/L	EPA200.8	2.0	03/18/99
Alkalinity, Total	195	mg/L	EPA310.1	1	03/16/99
Alkalinity, bicarb.	195	mg/L	SM2320B	0	03/16/99
Residue, Filt. - TDS	376	mg/L	EPA160.1	5	03/12/99

Field pH 7.2
Field Cond. 725 µmho
Field Temp 25.0°C

Pump started 1415 on 3/10/99 at a rate of 460 gpm then down to 320 gpm near sample time

Sampled by W.G. Stein
Note: Metals filtered 0.45µ

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Environmental Laboratory Services
The Solurian Lab

FINAL ANALYSIS REPORT

LAB ID: 9906445 SAMPLE DESCRIPTION: Groundwater
COMPANY: LBG-Guyton Associate
ACCT NO:
REQUISITION No.: R10612
LOCATION ID: Del Rio "Y" Well #3

SAMPLE DATE: 04/13/99
SAMPLE TIME: 1002
DATE RECEIVED: 04/14/99
REPORT DATE: 04/21/99

PARAMETER	RESULTS	UNITS	METHOD #	PQL in WATER	DATE ANALYZED
Carbon, Tot. Organic	0.5	mg/L	EPA415.1	0.5	04/14/99
Chloride	66.6	mg/L	EPA300.0	1.5	04/14/99
Fluoride	0.43	mg/L	EPA300.0	0.01	04/14/99
Nitrogen, Nitrate	1.340	mg/L	EPA300.0	0.010	04/14/99
Nitrogen, Nitrite	<0.010	mg/L	EPA300.0	0.010	04/14/99
Potassium, Dissolved	2.44	mg/L	EPA200.7	0.20	04/16/99
Sulfate	89.50	mg/L	EPA300.0	1.50	04/14/99
Tot. Coli. Pres/Abs.	Absent	/100 ml	Pres/Abs	-----	04/14/99
Aluminum, Dis. ICPMS	<4.0	ug/L	EPA200.8	4.0	04/15/99
Arsenic, Diss. ICPMS	<2.0	ug/L	EPA200.8	2.0	04/15/99
Barium, Diss. ICPMS	141.0	ug/L	EPA200.8	1.0	04/15/99
Calcium, Dissolved	87.90	mg/L	EPA200.7	0.20	04/16/99
Chromium, Diss ICPMS	9.2	ug/L	EPA200.8	1.0	04/15/99
Copper, Diss. ICPMS	2.8	ug/L	EPA200.8	2.0	04/15/99
Iron, Dissolved	0.09	mg/L	EPA200.7	0.01	04/16/99
Lead, Diss. ICPMS	<1.0	ug/L	EPA200.8	1.0	04/15/99
Magnesium, Dissolved	12.00	mg/L	EPA200.7	0.20	04/16/99
Manganese, Dis ICPMS	<1.0	ug/L	EPA200.8	1.0	04/15/99
Selenium, Dis. ICPMS	<4.0	ug/L	EPA200.8	4.0	04/15/99
Silver, Diss. ICPMS	<1.0	ug/L	EPA200.8	1.0	04/15/99
Sodium, Dissolved	51.20	mg/L	EPA200.7	0.20	04/16/99
Beryllium, Dis ICPMS	<1.0	ug/L	EPA200.8	1.0	04/15/99
Zinc, Diss. ICPMS	8.1	ug/L	EPA200.8	2.0	04/15/99
Alkalinity, Total	184	mg/L	EPA310.1	1	04/15/99
Alkalinity, bicarb.	184	mg/L	SM2320B	0	04/15/99
Residue, Filt. - TDS	413	mg/L	EPA160.1	5	04/15/99

Total Coliform Comments: Not Found

Field pH 7.1
Field Conductivity 730 µmho
Field Temp 24.0°C

Pump started 1721 on 4/12/99 at 240 – 260 gpm

Sampled by WG Stein
Note: Metals Filtered w/ 0.45µ

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Environmental Laboratory Services
The Solution Lab

FINAL ANALYSIS REPORT

LAB ID: 9906737 SAMPLE DESCRIPTION: Groundwater
COMPANY: LBG-Guyton Associate SAMPLE DATE: 04/22/99
ACCT NO: SAMPLE TIME: 0955
REQUISITION No.: R10684 DATE RECEIVED: 04/22/99
LOCATION ID: Tierra del Lago (Amistad) REPORT DATE: 05/05/99

PARAMETER	RESULTS	UNITS	METHOD #	PQL in WATER	DATE ANALYZED
Aluminum, DW	<4.0	ug/L	EPA200.8	4.0	04/27/99
Arsenic, DW	<2.0	ug/L	EPA200.8	2.0	04/27/99
Barium, DW	146.0	ug/L	EPA200.8	1.0	04/27/99
Beryllium, DW	<1.0	ug/L	EPA200.8	1.0	04/27/99
Calcium, DW	81.2	mg/L	EPA200.7	0.2	04/27/99
Carbon, Tot. Organic	<0.5	mg/L	EPA415.1	0.5	05/03/99
Chloride	34.3	mg/L	EPA300.0	1.5	04/23/99
Chromium, DW	7.8	ug/L	EPA200.8	1.0	04/27/99
Copper, DW	2.1	ug/L	EPA200.8	2.0	04/27/99
Fluoride	0.27	mg/L	EPA300.0	0.01	04/23/99
Iron, DW	<0.05	mg/L	EPA200.7	0.05	04/27/99
Lead, DW	<1.0	ug/L	EPA200.8	1.0	04/27/99
Magnesium, DW	6.9	mg/L	EPA200.7	0.2	04/27/99
Manganese, DW	<1.0	ug/L	EPA200.8	1.0	04/27/99
Nitrogen, Nitrate	1.210	mg/L	EPA300.0	0.010	04/23/99
Nitrogen, Nitrite	<0.010	mg/L	EPA300.0	0.010	04/23/99
Potassium, DW	1.3	mg/L	EPA200.7	0.2	04/27/99
Selenium, DW	<4.0	ug/L	EPA200.8	4.0	04/27/99
Silver, DW	<1.0	ug/L	EPA200.8	1.0	04/27/99
Sodium, DW	19.3	mg/L	EPA200.7	0.2	04/27/99
Sulfate	10.70	mg/L	EPA300.0	1.50	04/23/99
Tot. Coli. Pres/Abs.	Absent	/100 ml	Pres/Abs	-----	04/22/99
Zinc, DW	6.890	ug/L	EPA200.8	4.000	04/27/99
Alkalinity, Total	196	mg/L	EPA310.1	1	04/23/99
Alkalinity, bicarb.	196	mg/L	SM2320B	0	04/23/99
Residue, Filt. - TDS	280	mg/L	EPA160.1	5	04/22/99

Total Coliform Comments: Not Found

Field pH = 7.2
Field Cond = 523
Field Temp (water) = 25.5°C

Sampled by W.G. Stein
Note: filtered w/0.45 µ Metals

Lower Colorado River Authority • P. O. Box 220 • Austin, Texas 78767
3505 Montopolis Drive • Austin, Texas 78744 • (512) 356-6022 • (800) 776-5272 • (512) 356-6021 FAX

********** CONFIDENTIAL LABORATORY REPORTS **********
TEXAS DEPARTMENT OF HEALTH
1100 W. 49th Street AUSTIN, TX 787563194

Date: 4/26/1999

Submitter copy to:

STEIN,BILL-80279676
1101 S. CAPITOL OF TX HWY # B-220
ATTN: BILL STEIN
AUSTIN, TX 78746

Spec #: E99BW004846
Subm #:
Lab: ENVIRONMENTAL
Tel #: (512)458-7578

Source
DEL RIO,CITY OF

Date Rcvd: 4/23/1999
Time Rcvd: 0730
Time Coll: 0950
Spec Type: WELL
Coll By: WGS
COUNTY VAL VERDE

Chlorine: Not given
Collected at: WELL NO 1 @ TEIRRA DEL LAGO AMISTAD
System type: Public
Well Depth(ft) 0
Test Reas: ROUTINE

Final Results

Specimen Numbers: E99BW004846
Date Collected: 4/22/1999

WATER TEST RESULT: NO COLIFORM FOUND (by MMO-MUG test)

Water of satisfactory bacteriological quality must be free from coliform organisms.
For questions about standards or treatment, call Water Utilities at (512)239-6020.

David L. Maserang, Ph.D.
Chief, Bureau of Laboratories
CLIA License Number 45D0660644

LCRA Environmental Laboratory Services

Date: *02-Aug-00*

CLIENT: LBG-Guyton Associates
Client Sample ID: Del Rio Y Deep
Lab Order: 0007140 **COC ID:** 13967
Project: SDWA - Analysis
Collection Date: 07/19/2000 12:15:00 PM
Lab ID: 0007140-01
Matrix: GROUNDWATER

Analyses	Result	PQL	Qual	Units	DF	QC Batch	Date Analyzed
ICP METALS IN DRINKING WATER		**E200.7**					Analyst: **BL**
Calcium	63.3	0.200		mg/L	1	R5202	07/31/2000
Iron	ND	0.0500		mg/L	1	R5202	07/31/2000
Magnesium	9.56	0.200		mg/L	1	R5202	07/31/2000
Potassium	2.04	0.200		mg/L	1	R5202	07/31/2000
Sodium	9.46	0.700		mg/L	1	R5202	07/31/2000
ICPMS METALS IN DRINKING WATER		**E200.8**					Analyst: **PJM**
Lead	ND	1.00		µg/L	1	R5168	07/28/2000
ANIONS BY ION CHROMATOGRAPHY		**E300**					Analyst: **AMJ**
Bromide	0.0900	0.0200		mg/L	1	R5215	07/21/2000
Chloride	17.6	1.00		mg/L	1	R5215	07/21/2000
Fluoride	0.430	0.0100		mg/L	1	R5215	07/21/2000
Nitrogen, Nitrate (As N)	0.340	0.0100		mg/L	1	R5215	07/21/2000
Sulfate	25.8	1.00		mg/L	1	R5215	07/21/2000
ALKALINITY		**M2320 B**					Analyst: **WR**
Alkalinity, Bicarbonate (As CaCO3)	176	2.00		mg/L CaCO3	1	R5132	07/26/2000
Alkalinity, Total (As CaCO3)	176	2.00		mg/L CaCO3	1	R5132	07/26/2000
SILICA		**E370.1**					Analyst: **CL**
Silica, Dissolved (as SIO2)	15.0	0.500		mg/L	1	R5135E	07/26/2000
TOTAL DISSOLVED SOLIDS		**E160.1**					Analyst: **JJM**
Total Dissolved Solids (Residue, Filterable)	224	5.00		mg/L	1	R5114A	07/21/2000

Field pH = 7.3
Field Conductivity = 430
Field Temp = 24.5 °C

Sampled by W.G. Stein

Note: All samples filtered due to turbidity (0.45µ)

Qualifiers:

ND - Not Detected at the Reporting Limit
J - Analyte detected below quantitation limits
B - Analyte detected in the associated Method Blank
* - Value exceeds Maximum Contaminant Level
S - Spike Recovery outside accepted recovery limits
R - RPD outside accepted recovery limits
E - Value above quantitation range

APPENDIX 2

DRILLER'S REPORT FOR THE "Y" WELL

Send original copy by certified mail to: **Texas Water Commission, P.O. Box 13087, Austin, Texas 78711**

Please use black ink.

ATTENTION OWNER: *Confidentiality Privilege Notice on Reverse Side*

State of Texas WELL REPORT

Texas Water Well Drillers Board
P.O. Box 13087
Austin, Texas 78711

1) **OWNER** City of Del Rio (Name) **ADDRESS** 109 W. Broadway (Street or RFD) Del Rio (City) TX (State) 78840 (Zip)

2) **LOCATION OF WELL:** County Val Verde, 1 miles in N (NE, SW, etc.) direction from Del Rio (Town)

Driller must complete the legal description below with distance and direction from two intersecting section or survey lines, or he must locate and identify the well on an official Quarter- or Half-Scale Texas County General Highway Map and attach the map to this form.

☐ **LEGAL DESCRIPTION:**

Section No. _____ Block No. _____ Township _____ Abstract No. _____ Survey Name _____

Distance and direction from two intersecting section or survey lines _____

☑ **SEE ATTACHED MAP**

3) **TYPE OF WORK (Check):**
☑ New Well ☐ Deepening ☐ Reconditioning ☐ Plugging

4) **PROPOSED USE (Check):**
☐ Domestic ☐ Industrial ☐ Monitor ☐ Public Supply ☐ Irrigation ☑ Test Well ☐ Injection ☐ De-Watering

5) **DRILLING METHOD (Check):**
☐ Driven ☐ Mud Rotary ☐ Air Hammer ☐ Jetted ☐ Bored ☑ Air Rotary ☐ Cable Tool ☐ Other _____

6) **WELL LOG:**

Date Drilling: Started 8-1 1990 Completed 8-3 1990

DIAMETER OF HOLE		
Dia. (in.)	From (ft.)	To (ft.)
9 7/2	Surface	100'
7 7/8	100'	500'

7) **BOREHOLE COMPLETION:**
☑ Open Hole ☐ Straight Wall ☐ Underreamed ☐ Gravel Packed ☐ Other _____
If Gravel Packed give interval . . . from _____ ft. to _____ ft.

From (ft.)	To (ft.)	Description and color of formation material
0	2	fill & gravel
40	100	white limestone
100	150	white limestone
150	162	" " rough drilling little water
162	308	yellow limestone
308	370	gray " more water
370	450	white limestone - rough & fast drilling
450	496	white limestone - more water
496	500	gray shell

(Use reverse side if necessary)

8) **CASING, BLANK PIPE, AND WELL SCREEN DATA:**

Dia. (in.)	New or Used	Steel, Plastic, etc. Perf., Slotted, etc. Screen Mfg., if commercial	Setting (ft.) From	Setting (ft.) To	Gage Casting Screen
8 5/8	U	steel	0'	90'	

9) **CEMENTING DATA** [Rule 287.44(1)]
Cemented from 0 ft. to 90 ft. No. of Sacks Used _____
_____ ft. to _____ ft. No. of Sacks Used _____
Method used _____
Cemented by Hutto Drilling

10) **SURFACE COMPLETION**
☐ Specified Surface Slab Installed [Rule 287.44(2)(A)]
☑ Pitless Adapter Used [Rule 287.44(3)(B)]
☐ Approved Alternative Procedure Used [Rule 287.71]

13) **TYPE PUMP:**
☐ Turbine ☐ Jet ☐ Submersible ☐ Cylinder ☐ Other _____
Depth to pump bowls, cylinder, jet, etc., _____ ft.

14) **WELL TESTS:**
Type Test: ☐ Pump ☐ Bailer ☑ Jetted ☐ Estimated
Yield: _____ gpm with _____ ft. drawdown after _____ hrs.

RECEIVED
SEP 16 1991
TEXAS WATER WELL DRILLERS BOARD

11) **WATER LEVEL:**
Static level 104 ft. below land surface Date 8-4-90
Artesian flow _____ gpm. Date _____

15) **WATER QUALITY:**
Did the drilling penetrate any strata which contained undesirable constituents?
☐ Yes ☑ No If yes, submit "REPORT OF UNDESIRABLE WATER"
Type of water? _____ Depth of strata _____
Was a chemical analysis made? ☐ Yes ☐ No

12) **PACKERS:** Type _____ Depth _____

I hereby certify that this well was drilled by me (or under my supervision) and that each and all of the statements herein are true to the best of my knowledge and belief. I understand that failure to complete items 1 thru 15 will result in the log(s) being returned for completion and resubmittal.

COMPANY NAME Hutto Drilling Inc. (Type or print) **WELL DRILLER'S LICENSE NO.** 2472 W

ADDRESS 905 N. Main (Street or RFD) Del Rio (City) TX (State) 78840 (Zip)

(Signed) _____ (Licensed Well Driller) (Signed) _____ (Registered Driller Trainee)

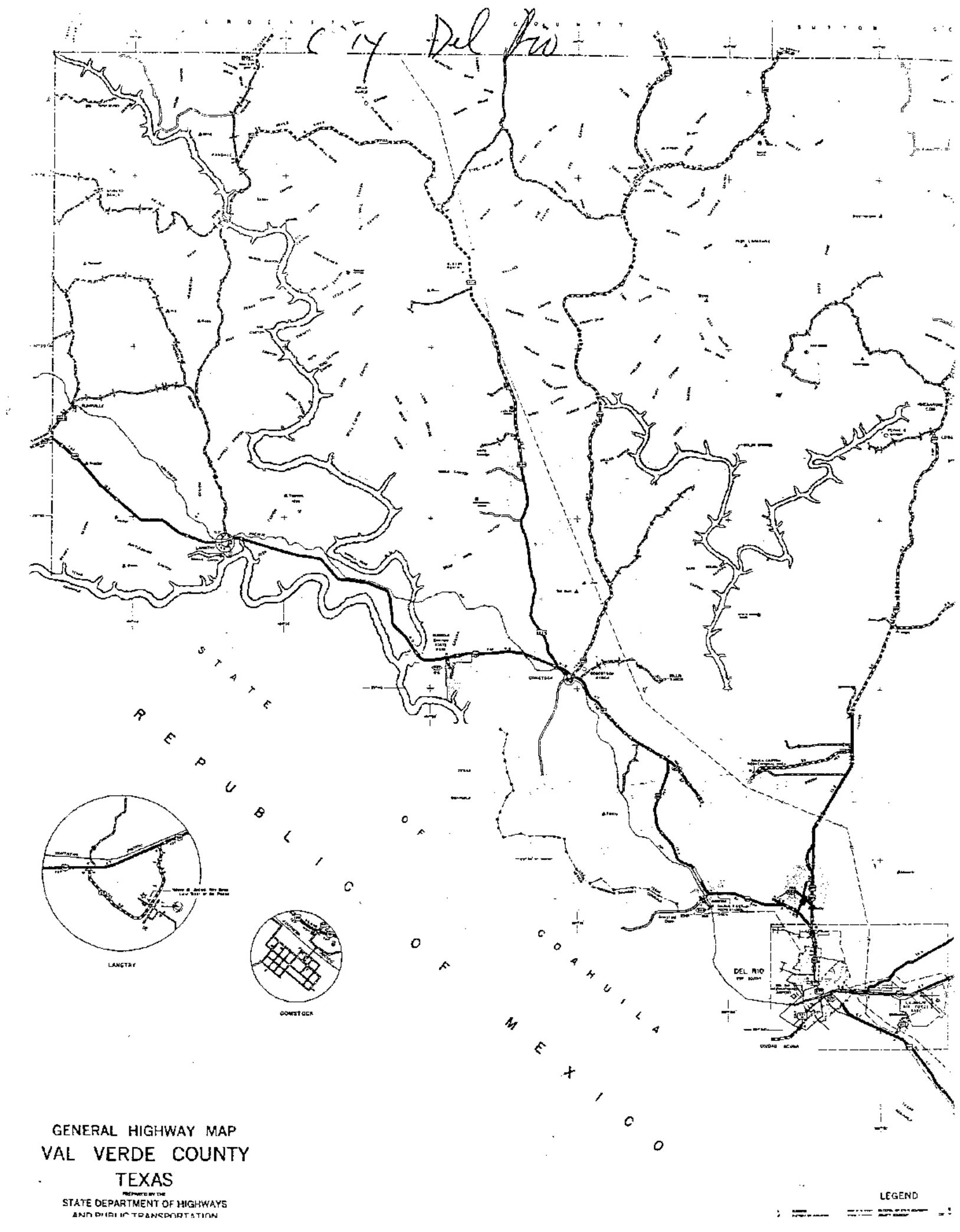
Please attach electric log, chemical analysis, and other pertinent information, if available.

For TWC use only: Well No. _____ Located on map _____

WWD-012 (Rev. 09/21/88)

TEXAS WATER COMMISSION COPY

City Del Rio



GENERAL HIGHWAY MAP

VAL VERDE COUNTY

TEXAS

PREPARED BY THE
STATE DEPARTMENT OF HIGHWAYS
AND PUBLIC TRANSPORTATION

LEGEND

APPENDIX 1

TEXAS WATER DEVELOPMENT BOARD RECORDS FOR CITY OF DEL RIO WELLS

HACKBERRY

Texas Water Development Board
Well Schedule

State Well No. 70 33 608 Previous Well No. County Val Verde 465

River Basin Rio Grande 23 Zone 3 Lat. 29 25 19 Long. 100 54 28 Source of Coord. 1

Owner's Well No. _____ Location ____ 1/4, ____ 1/4, Section ____, Block ____, Survey ____

Owner City of Del Rio Driller

Address 114 W. Martin Del Rio, Tx. 78840 Tenant/Oper. Mitchell Lomax

Date Drilled ____ Depth ____ Source of Depth Datum A Altitude 1085 Source of Alt. Datum NS

Aquifer Edwards 210EDRD Well Type W User 22120

TNRCC 2330001

Well Construction — Const. Method ____ Casing Material Steel S

Completion ____ Screen Material ____

Lift Data — Pump Mfr. ____ Type Turbine T No. Stages ____

Bowls Diam. ____ in. Setting ____ ft. Column Diam. ____ in.

Motor Mfr. ____ Fuel or Power ____ Horsepower ____

Yield — Flow ____ GPM Pump ____ GPM Meas.,Repr.,Est. ____ Date ____

Performance Test — Date ____ Length of Test ____ Production ____ GPM

Static Level ____ ft. Pumping Level ____ ft. Drawdown ____ ft. Sp.Cap. ____ GPM/ft.

Quality (Remarks ____

Water Use — Primary Unused U Secondary ____ Tertiary ____

Other Data Available — Water Level N Water Quality N Logs ____ Other Data ____

Water Levels	Date	Meas.	
	Date	Meas.	
	Date	Meas.	

Could not find D. Log

Casing or Blank Pipe (C)
Well Screen or Slotted Zone (S)
Open Hole (O)
Cemented from ___ to ___

	Diam. (in.)	Setting (feet) From	To
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			

(20 max)

Recorded By D.R. James Date Record Collected or Updated 05 24 1994 Reporting Agency 01

Remarks

Aquifer Edwards

Well No. 70-33-608

93-0384
2/9/93

WLS - Appears not to have been used since 1989 - Called w/notes in file here

DUP

Send original copy by certified mail to the Texas Department of Water Resources P. O. Box 13087 Austin, Texas 78711

State of Texas
WATER WELL REPORT

ATTENTION OWNER: *Confidentiality Privilege Notice on Reverse Side*

For TDWR use only
Well No. 70-33-608
Located on map
Received: 8-8

1) OWNER City of Del Rio (Name) Address 109 W. Broadway (Street or RFD) Del Rio (City) Tx. (State) 78840 (Zip)

2) LOCATION OF WELL County Val Verde 3.5 miles in N (N.E., S.W., etc.) direction from City Hall (Town)

Driller must complete the legal description to the right with distance and direction from two intersecting section or survey lines, or he must locate and identify the well on an official Quarter- or Half-Scale Texas County General Highway Map and attach the map to this form.

☒ Legal description:
Section No. 13 Block No. ____ Township ____
Abstract No. 1050 Survey Name T & GN R.R.
Distance and direction from two intersecting section or survey lines ____
☒ See attached map.

3) TYPE OF WORK (Check): ☒ New Well ☐ Deepening ☐ Reconditioning ☐ Plugging

4) PROPOSED USE (Check): ☐ Domestic ☐ Industrial ☒ Public Supply ☐ Irrigation ☐ Test Well ☐ Other ____

5) DRILLING METHOD (Check): ☒ Mud Rotary ☐ Air Hammer ☐ Driven ☐ Bored ☐ Air Rotary ☐ Cable Tool ☐ Jetted ☐ Other ____

6) WELL LOG:

Dia. (in.)	From (ft.)	To (ft.)
20	Surface	431
26	0	256

Date drilled 8-81

From (ft.)	To (ft.)	Description and color of formation material
		See Attached

(Use reverse side if necessary)

7) BOREHOLE COMPLETION: ☒ Open Hole ☐ Straight Wall ☐ Underreamed ☐ Gravel Packed ☒ Other Open Hole 256-431
If Gravel Packed give interval . . . from ____ ft. to ____ ft.

8) CASING, BLANK PIPE, AND WELL SCREEN DATA:

Dia. (in.)	New or Used	Steel, Plastic, etc. Perf., Slotted, etc. Screen Mfr., if commercial	Setting (ft.) From	Setting (ft.) To	Gage Casing Screen
22	N	Steel	6	256	.500

CEMENTING DATA
Cemented from 0 ft. to 256 ft.
Method used Pump thru D.P. or 1" Line
Cemented by Halliburton (Company or Individual)

9) WATER LEVEL:
Static level 92 ft. below land surface Date 8-81
Artesian flow -0- gpm. Date ____

10) PACKERS: Type ____ Depth ____
None

11) TYPE PUMP:
☒ Turbine ☐ Jet ☐ Submersible ☐ Cylinder
☐ Other ____
Depth to pump bowls, cylinder, jet, etc., 380 ft.

12) WELL TESTS:
☐ Type Test: ☒ Pump ☐ Bailer ☐ Jetted ☐ Estimated
Yield: 460 gpm with 302 ft. drawdown after 24 hrs.

13) WATER QUALITY:
Did you knowingly penetrate any strata which contained undesirable water? ☐ Yes ☒ No
If yes, submit "REPORT OF UNDESIRABLE WATER"
Type of water? ____ Depth of strata ____
Was a chemical analysis made? ☒ Yes ☐ No

I hereby certify that this well was drilled by me (or under my supervision) and that each and all of the statements herein are true to the best of my knowledge and belief.

NAME James O'Connor (Type or Print) Water Well Drillers Registration No. 999

ADDRESS 5931 Brittmoore Road (Street or RFD) Houston (City) Texas (State) 77041 (Zip)

(Signed) James O'Connor (Water Well Driller) Layne-Western Company, Inc. (Company Name)

Please attach electric log, chemical analysis, and other pertinent information, if available.

~~70-33-604~~ → 70-33-608

TDWR-0382 (Rev. 1-12-79)

DEPARTMENT OF WATER RESOURCES COPY

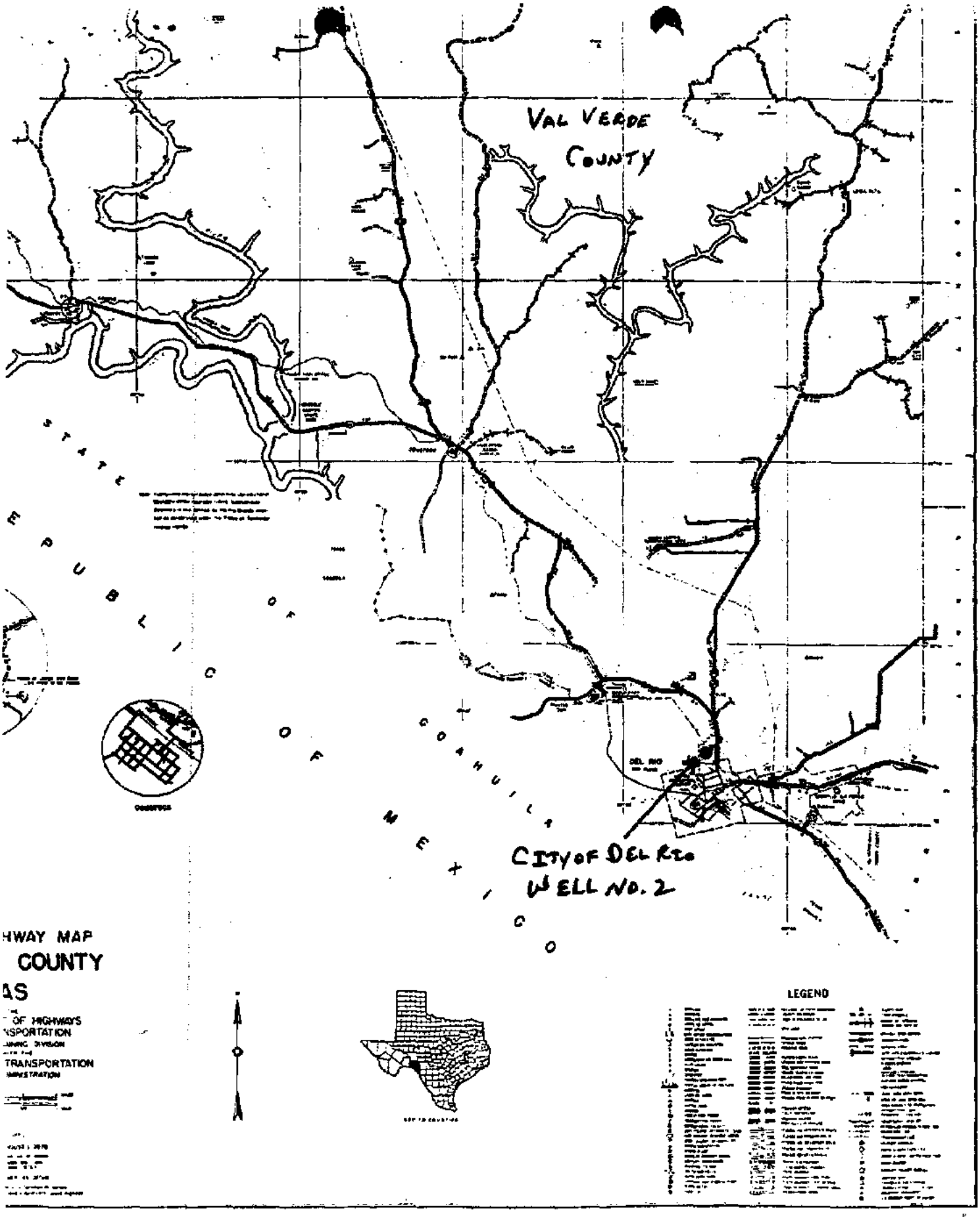
Layne-Western Company, Inc. A Marley Company

P.O. Box 79009 · Houston, Texas 77079 · 713/466-5001

CITY OF DEL RIO
WATER WELL NO. 2
Job No. M-1202
Original - July 22, 1981
Revised - August 12, 1981

Depth	Drillers Log
0 - 2'	Top Soil
2'- 42'	Rock and Clay
42'	Lost Circulation
42' to 375'	Rock, Limestone with short breaks
375'-381'	Rock, sticky, difficult to clean hole
381'-406'	Rock, limestone
406'-431'	Lime, chalky

70-33-204



HWAY MAP
COUNTY
AS
OF HIGHWAYS
NSPORTATION
TRANSPORTATION

TD-33-984

Agarita Well

Texas Water Development Board
Well Schedule

State Well No. 7033904   Previous Well No. ________   County Val Verde 465

River Basin Rio Grande 23   Zone 2   Lat. 292447   Long. 1005421   Source of Coord. 1

Owner's Well No. ______ Location ____ 1/4, ____ 1/4, Section ____, Block ____, Survey ____

Owner: CITY OF DEL RIO   Driller: Layne Western Co. James O'Connor

Address 114 W. Martin, Del Rio, TX 78840   Tenant/Oper. Mitchell Lomas

Date Drilled 08 12 1981   Depth 431   Source of Depth Datum D   Altitude 1070 (1085)   Source of Alt. Datum M

Aquifer Edwards Limestone 218EDRD   Well Type W   User 221300 (THREC 2330001)

Well Construction Const. Method Mud Rotary H   Casing Material Steel S

Completion Open Hole X   Screen Material ______

Lift Data   Pump Mfr. ______ Type Turbine T   No. Stages ______

Bowls Diam. ______ in.   Setting 380 ft.   Column Diam. ______ in.

Motor Mfr. ______   Fuel or Power electric E   Horsepower ______

Yield   Flow ____ GPM   Pump ____ GPM   Meas. (Rept.) Est. ______ Date ______

Performance Test   Date 8/81   Length of Test 24 Hr.   Production 460 GPM

Static Level 92 ft.   Pumping Level 394 ft.   Drawdown 302 ft.   Sp.Cap. 1.52 GPM/ft.

Quality (Remarks ______

Water Use   Primary Public supply P   Secondary ______   Tertiary ______

Other Data Available   Water Level N   Water Quality Y   Logs D   Other Data ______

Water Levels:

	Date	Meas.	
6/6/94	08 12 1981	92.00	Driller

Casing or Blank Pipe (C), Well Screen or Slotted Zone (S), Open Hole (O), Cemented from __ to __

		Diam. (in.)	Setting (feet) From	To
1	C	22	0	256
2	O	20	256	431
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				

(20 max)

Recorded By Cindy Lee   Date Record Collected or Updated 05 24 1994   Reporting Agency 01

Remarks:
1 Measured yield 460 GPM with 302
2 feet drawdown after pumping 24
3 hours in 1981. Specific capacity
4 1.52 GPM/ft. Pumping level 394
5 feet.
6

Aquifer 218EDRD
Well No. 70-33-904

200 saff

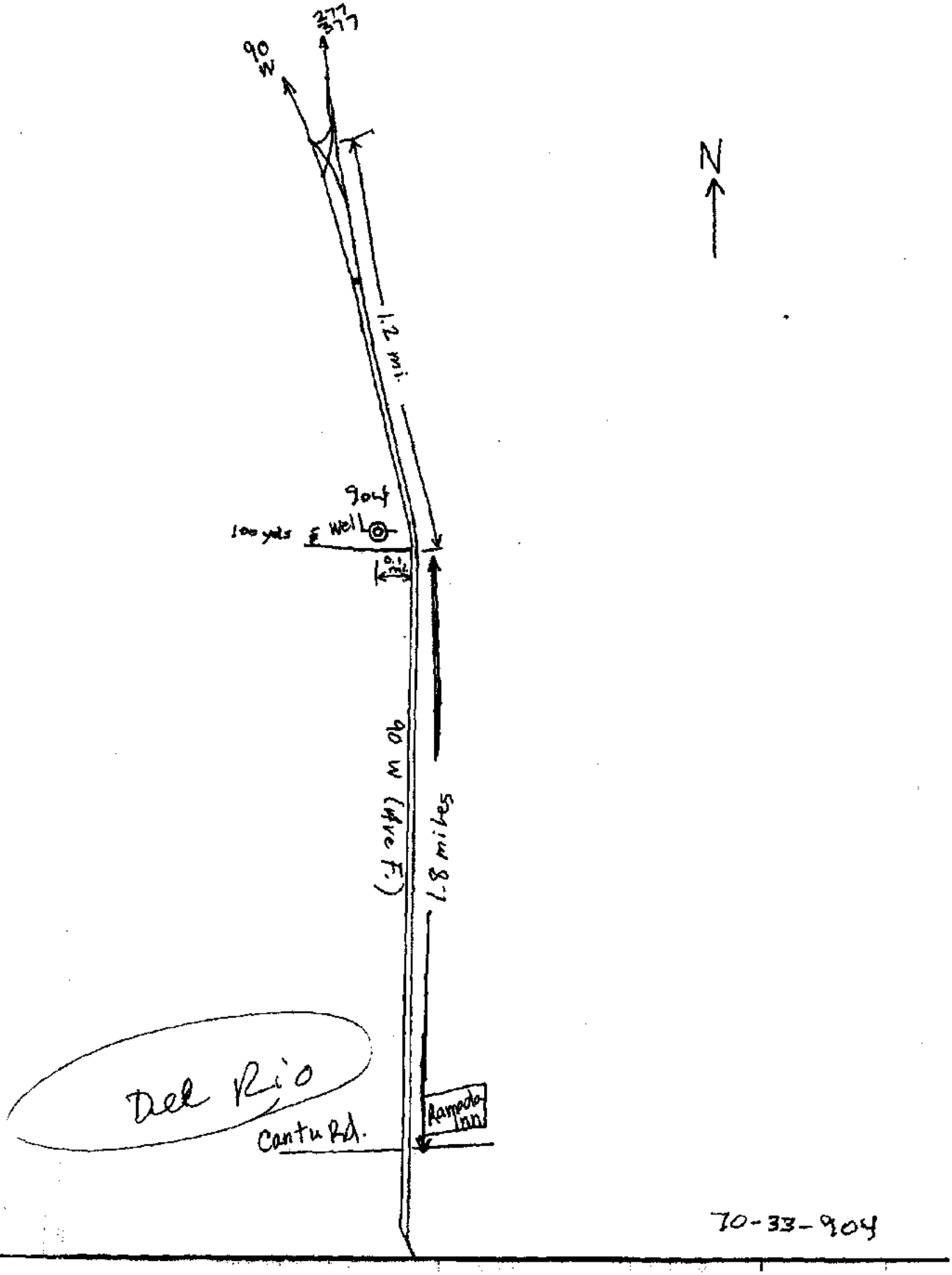
Note: This is for 33-608 WGS

70-33-608 not -904

HACKBERRY WELL → NOT AGARITA

92-0023 4/91

70-33-904



70-33-904

904

Water Quality Sampling Run

SWN: 70-33-904
County: Val Verde
Aquifer(s): 218EDRD

Attn: Mitchell Lomas
Name: City of Del Rio
Address: 114 W. Martin
Del Rio, TX 78840

Sample No. CL-1994-886
Date: 5-24-94
By: C. Lee
D. Jones

Bottle 1	Bottle 2	Bottle 3	Bottle 4	Bottle 5	Bottle 6	Bottle 7	Total SUB-Samples
1 liter Anions	1 liter Cations	1 liter Radioactivity	500 ml Nitrate	1 Qt (glass) ~~(TOC) Organics~~ GC/MS			5
Preserve with:	2 ml HNO_3 (Nitric)	2 ml HNO_3 (Nitric)	1 ml H_2SO_4 (Sulfuric)				All filtered unless otherwise stipulated. All on ice.

Water Level _____ LSD Remark _____
Temperature (00010) 24.4 c
Specific Conductance (00094) 954 umhos/cm
pH (00400) 7.02
Eh (00090) -9.5 mv.
Phenol ALK (82244) 0 mg/l
Total ALK (39086) 204 mg/l
Carbonate (00452) 0 meq/l 0 mg/l
Bicarbonate (00453) 4.05 meq/l 248.95 mg/l
Total Cations(+) _____
Total Anions (-) _____
Total Hardness (46570) 330
Dissolved Solids(70301) 615

Time in: PUMP on 10:50
Time out: 12:00
Weather sunny, breezy, hot
Outside Temp: _____
Sampling point:

Starting pH 7.17
10.2 ml. of 0.02N to
50 ml. of Sample
Ending pH 4.46

Time:	11:00	11:05	11:10	11:15	11:18	
pH:	7.25	7.05	7.03	7.02		
Temp:	24.3	24.3	24.3	24.4	24.4	
Eh:					-9.5	
Cond.	948	956	955	954	956	

other notes:

ml.	pH	ml.	pH	ml.	pH
1	7.13	10.2	4.46		
2	6.87				
3	6.69				
4	6.47				
5	6.33				
6	6.22				
7	6.01				
8	5.77				
9	5.31				
10	4.69				

Texas Water Development Board

Chemical Water Analysis Report

HM- CL 1994. 806
HM = Heavy Trace and Alkaline-Earth Metals

TWDB Use Only
Work No. 3120-11220
IAC No. _____

Send Reply To:
Ground Water Unit
Texas Water Development Board
P.O. Box 13231
Austin, Texas 78711

Attention: Phil Nordstrom
County: Val Verde
Owner: City of Del Rio
Address: 114 W. Martin, Del Rio, Tx 78840
Date Drilled: _____ Depth: _____
Collection Point: FAW pH 7.02
By: Cindy Lee

State Well Number: 70-33-904
Date & Time: 5-24-94 11:35
☒ Send Copy To Owner
Sampled After Pumping: 0.75 Hours
Yield: 800 GPM ☐ Measured ☒ Estimated
Use: Public supply Temperature: 24.4 °C
Specific Conductance: 954

Requested Chemical Analysis

Laborato[redacted] Date Received: MAY 27 1994 Date Reported: JUL 25 1994

		mg/l			mg/l
Calcium	(00915)	107	Sodium	(00930)	97
Magnesium	(00925)	15	Potassium	(00935)	3.4
		µg/l			**µg/l**
Aluminum	(01106)	28	Manganese	(01056)	6.9
Arsenic	(01000)	<2.0	Mercury	(71890)	0.14
Barium	(01005)	116	Molybdenum	(01062)	<20
Cadmium	(01025)	<0.5	Selenium	(01145)	<4.0
Chromium	(01030)	<10	Silver	(01075)	<10
Copper	(01040)	<4.0	Strontium	(01080)	1170
Iron	(01046)	10.3	Vanadium	(01085)	<20
Lead	(01049)	<5.0	Zinc	(01090)	<10

Note: Crossout those elements not to be analyzed.

Texas Water Development Board

Chemical Water Analysis Report

GWR- CL.1994.806
(Anions)

TWDB Use Only
Work No. 3120-11220
IAC No. _____

Send Reply To:
Ground Water Unit
Texas Water Development Board
P.O. Box 13231
Austin, Texas 78711

Attention: Phil Nordstrom
State Well Number: 70-33-904
County: Val Verde
Date & Time: 5-24-94 11:35
Owner: City of Del Rio
☒ Send Copy To Owner
Address: 114 W. Martin, Del Rio
Sampled After Pumping: 0.75 Hours
Date Drilled: _____ Depth: _____
Yield: _____ GPM ☐ Measured ☐ Estimated
Collection Point: _____ pH _____
Use: _____ Temperature: _____ °C
By: Cindy Lee
Specific Conductance: _____

Requested Che[redacted]
Laboratory No.: [redacted] Date Received: MAY 27 1994 Date Reported: JUN 15 1994

THD-Sample No. EB4 997 Date Received 05/27/94 Date Reported 06/09/94

		MEQ/L	MG/L
Silica	(00955)		16
Sulfate	(00946)	3.52	169
Chloride	(00941)	2.68	95
Fluoride	(00950)	0.03	0.62
P.Alkalinity	(00415)	0.00	0
T.Alkalinity	(00410)	3.64	182

* *Convert mg/l Boron to µg/l for data entry.*

Texas Water Development Board

Chemical Water Analysis Report

MISC. CL 1994.806

TWDB Use Only
Work No. 3120-11220
IAC No.

Send Reply To:
Ground Water Unit
Texas Water Development Board
P.O. Box 13231
Austin, Texas 78711

Attention: Phil Nordstrom
State Well Number: 70-33-904
County: Val Verde
Date & Time: 5-24-94 11:35
Owner: City of Del Rio
☑ Send Copy To Owner
Address: 114 W. Martin, Del Rio
Sampled After Pumping: 0.75 Hours
Date Drilled: ____ Depth: ____
Yield: ____ GPM ☐ Measured ☐ Estimated
Collection Point: ____ pH ____
Use: ____ Temperature: ____ °C
By: Cindy Lee
Specific Conductance: ____

Requested Chemical Analysis

JUN 24 1994

Laboratory N[redacted] Date Received: ____ Date Reported: ____

#305710 WT/LQD WSTS/SED - Acid & Bn Ext (GC-MS)

890091-A

TEXAS DEPARTMENT OF HEALTH
GC/MS ANALYTICAL RESULTS - SEMIVOLATILE ORGANICS

Analyst: *M. Terry* Date: *6-22-94* TDH sample number: *E94-1098*
TWC sample number: *Well # 70-53-9*
(✓) micrograms/liter ( ) milligrams/kilogram sample type: *liquid* sample condition: *intact*

Compound	amount	Compound	amount
		Fluoranthene	*<6*
Phenol	*<12*	Pyrene	
2-Chlorophenol		bis(2-ethylhexyl)adipate	
2-Nitrophenol		Butylbenzyl phthalate	
2,4-Dimethylphenol		Benz(a)anthracene	
2,4-Dichlorophenol		Chrysene	
3-Methyl-4-chlorophenol		bis(2-ethylhexyl)phthalate	
2,4,6-Trichlorophenol		Di-n-octyl phthalate	
2,4,5-Trichlorophenol		Benzo(b)fluoranthene	
2,4-Dinitrophenol	*<24*	Benzo(k)fluoranthene	
4-Nitrophenol		Benzo(a)pyrene	
4,6-Dinitro-2-cresol		Indeno(1,2,3-cd)pyrene	
Pentachlorophenol		Dibenz(a,h)anthracene	
n-Nitroso-n-dimethylamine	*<6*	Benzo(g,h,i)perylene	
Pyridine		alpha-BHC	*<12*
n-Nitrosodiethylamine		beta-BHC	
n-Nitrosodibutylamine		Lindane	
Aniline		delta-BHC	
bis(2-Chloroethyl)ether		Heptachlor	
1,3-Dichlorobenzene		Aldrin	
Benzyl alcohol		Heptachlor epoxide	
1,4-Dichlorobenzene		Benzidine	
1,2-Dichlorobenzene		3,3'-Dichlorobenzidine	
o-Cresol		alpha-Endosulfan	
bis(2-Chloroisopropyl)ether		p,p'-DDE	
m&p-Cresol (coelute)		Dieldrin	
Hexachloroethane		Endrin	
n-Nitroso-di-n-propylamine		beta-Endosulfan	*<24*
Nitrobenzene		p,p'-DDD	
Benzoic acid		Endrin aldehyde	
Isophorone		p,p'-DDT	
bis(2-chloroethoxy)methane		Endosulfan sulfate	
1,2,4-Trichlorobenzene			
Naphthalene			
4-Chloroaniline			
Hexachlorobutadiene			
2-Methyl naphthalene			
1,2,4,5-Tetrachlorobenzene			
Hexachlorocyclopentadiene			
2-Chloronaphthalene			
total Nitroanilines			
Acenaphthylene			
Dimethyl phthalate			
2,6-Dinitrotoluene			
Acenaphthene			
Dibenzofuran			
2,4-Dinitrotoluene			
Fluorene			
4-Chlorodiphenyl ether			
Diethyl phthalate			
n-Nitrosodiphenylamine			
Diphenyl hydrazine			
4-Bromodiphenyl ether			
Hexachlorobenzene			
Phenanthrene			
Anthracene			
Di-n-butyl phthalate			

Tentative identification of the largest non-priority pollutant peaks by comparison with EPA/NIH mass spectral library. Quantitaion as internal standard is provided and the values should be regarded as approximate.

Tentative Compound Identification	approximate concentrations
(✓) micrograms/liter ( ) milligrams/kilogram	
None	

* common lab contaminants
** reported at less than quantitation limits
comments:

approval: *[signature]*

Texas Water Development Board

Chemical Water Analysis Report

RAD - CL 1994. 806
RAD = Radioactivity Sample

TWDB Use Only
Work No. 3120-11220
IAC No. _____

Send Reply To:
Ground Water Monitoring Unit
Texas Water Development Board
P.O. Box 13231
Austin, Texas 78711

Attention: Phil Nordstrom
State Well Number: 70-33-904
County: Val Verde
Date & Time: 5-24-94 11:35
Owner: City of Del Rio
X Send Copy To Owner
Address: 114 E. Martin, Del Rio
Sampled After Pumping: 0.75 Hours
Date Drilled: _____ Depth: _____
Yield: _____ GPM ☐ Measured ☐ Estimated
Collection Point: _____ pH _____
Use: _____ Temperature: _____ °C
By: Cindy Lee
Specific Conductance: _____

Requested Chemical: [redacted]
Laboratory No.: [redacted] Date Received: MAY 27 1994 Date Reported: JUL 29 1994

Alpha	(01503)	< 3.6	pCi/l
Beta	(03503)	< 5.3	pCi/l
~~Radium 226~~	~~(09505)~~		~~pCi/L~~
~~Radium 228~~	~~(81366)~~		~~pCi/l~~
~~Total Radium~~	~~(11500)~~		~~pCi/l~~

94-0147-RJJ

Texas Water Development Board

Chemical Water Analysis Report

GWN. CL.1994.806
(Nitrogen Cycle)

TWDB Use Only
Work No. 3120-11220
IAC No. _____

Send Reply To:
Ground Water Unit
Texas Water Development Board
P.O. Box 13231
Austin, Texas 78711

Attention: Phil Nordstrom
State Well Number: 70-33-904
County: Val Verde
Date & Time: 5-24-94 11:35
Owner: City of Del Rio
X Send Copy To Owner
Address: 114 W. Martin, Del Rio, TX
Sampled After Pumping: 0.75 Hours
Date Drilled: _____ Depth: _____ Yield: _____ GPM ☐ Measured ☐ Estimated
Collection Point: _____ pH _____ Use: _____ Temperature: _____ °C
By: Cindy Lee
Specific Conductance: _____

Requested Chemical Analysis

MAY 27 1994

Laboratory No.: [redacted] Date Received: _____ Date Reported: JUN 17 1994

THD-Sample No. EB4 973 Date Received 05/27/94 Date Reported 06/16/94

00623-	0.2	TKN as N mg/L
00608-	0.03	Ammonia as N mg/L
00613-	< 0.01	Nitrite as N mg/L
00618-	0.51	Nitrate as N mg/L

*Note: To convert NO_3-N to NO_3, multiply by 4.427.

APPENDIX 6

MINERALOGIC ANALYSIS BY CORE LABORATORIES OF TURBIDITY SEDIMENT FROM WEST SAN FELIPE SPRING

CORE LABORATORIES

LBG Guyton and Associates
Del Rio 411L

Table 1
Mineral Analysis by X-ray Diffraction

File: 199156

Whole Rock Composition (weight %)									Relative Clay Abundance (Normalized to 100%)				
Sample	Quartz	K feldspar	Plagioclase	Calcite	Dolomite	Siderite	Pyrite	*Total Clays*	Illite/ Mica	Kaolinite	Chlorite	Smectite	Illite/ Smectite
Del Rio 411L	11	0	0	66	4	0	0	*19*	54	15	4	0	27

APPENDIX 5

MICROPARTICULATE ANALYSES BY ANALYTICAL SERVICES INCORPORATED

Analytical Services, Inc.

Client: LBG-Guyton & Associates
1101 South Capitol of Texas Highway
Austin, TX 78746
Project: 4DLRIO/DELRIO

Sampling Date: March 11, 1999
Date Received: March 12, 1999

Section IV.

MPA Risk Rating Table

The risk rating for surface water influence as calculated according to the EPA Consensus Method for Microscopic Particulate Analysis is as follows:

Lab ID	Sample ID	Table 1	Table 2	Total	Risk Rating
99071-010	Hackberry Well	None	NA	0	Low*
99071-011	San Felipe East #2	Algae = 1.3×10^4 = EH	EH = 14	14	Moderate*

EH = Extremely Heavy NA = Not Applicable

The tables of relative risk factors used to calculate surface water influence in the EPA Consensus Method for Microscopic Particulate Analysis are based on a limited set of data. These data are not representative of all aquifer types or well designs. Therefore, the relative risk values calculated from these tables are of limited value in determining health risks associated with surface water indicators.

* This EPA Risk Rating table classifies each sample according to the number of surface water indicating organisms per 100 gallons. However, due to the high amount of sediment recovered from these samples, only 3.3 and 1.5 gallons, respectively, could be analyzed for MPA. Due to the small volumes analyzed, this risk rating result should be interpreted with caution.

Mari-Beth DeLucia
Staff Microbiologist

Analytical Services, Inc.

Client: LBG-Guyton & Associates
1101 South Capitol of Texas Highway
Austin, TX 78746
Project: 4DLRIO/DELRIO

Sampling Date: March 11, 1999
Date Received: March 12, 1999
Analyst: mbd

Section II.

Analytical Results

Sample No.: 99071-010

I. SAMPLE DATA		
Sample ID:	**Hackberry Well**	
Sample Site:	**Del Rio, Texas**	
Water Type:	raw/well	
Turbidity, NTU's:	S: --	E: 1.6
pH:	S: –	E: 7.2 – 7.3
Treatment:	none	
Distance From Surface Water:	"miles"	
Volume Filtered:	1000 gallons	
Filter:	Commercial Honeycomb 1 µm	
Filter Color:	dark brown	
Sediment Volume:	3.0 mL	
Volume Floated:	0.5 mL	
Pellet Volume After Float:	80 µL	
Levitant –		
type:	Percoll sucrose	
specific gravity:	1.15	

S = Start of Sampling; E = End of Sampling

II. MPA			
Numbers reported are per 100 gallons			
Detection Limit = 30			
Amorphous Debris:	Confluent	**Rotifers:**	BDL
Vegetative Debris -		**Rotifer Eggs:**	BDL
with chlorophyll:	BDL	**Crustaceans:**	BDL
without chlorophyll:	BDL	**Crustacean Parts:**	BDL
Diatoms -		**Crustacean Eggs:**	BDL
with chlorophyll:	BDL	**Invertebrate Eggs:**	BDL
without chlorophyll:	BDL	**Water Mites:**	BDL
Other Algae*:	BDL	**Gastrotrichs:**	BDL
Fungal Hyphae:	BDL	**Tardigrades:**	BDL
Spores:	3.4×10^4	**Nematodes:**	BDL
Pollen:	1.2×10^2	**Nematode Eggs:**	BDL
Iron Bacteria:**	BDL	**Annelids:**	BDL
Protozoa:	BDL	**Insects/Larvae:**	BDL
Amoebae:	BDL		

BDL = Below Detection Limit

***Algae Identifications:**	NA
****Iron Bacteria:**	NA
Comments:	

NA = Not Applicable

Analytical Services, Inc.

Client: LBG-Guyton & Associates
1101 South Capitol of Texas Highway
Austin, TX 78746
Project: 4DLRIO/DELRIO

Sampling Date: March 11, 1999
Date Received: March 12, 1999
Sample No.: 99071-010
Sample I.D.: Hackberry Well

Section III.

GIARDIA AND *CRYPTOSPORIDIUM*

Analytical Result	Analyte	Numbers/ 13 L	Number/ 100 L
Giardia	Empty *Giardia* cysts detected	ND	<7.7
	Giardia Cysts with Amorphous Structure detected	ND	<7.7
	Giardia Cysts with one Internal Structure detected	ND	<7.7
	Giardia Cysts with more than one Internal Structure detected	ND	<7.7
	Total IFA *Giardia* Count	**ND**	**<7.7**
Cryptosporidium	Empty *Cryptosporidium* Oocysts detected	ND	<7.7
	Cryptosporidium Oocysts with Amorphous Structure detected	ND	<7.7
	Cryptosporidium Oocysts with Internal Structure detected	ND	<7.7
	Total IFA *Cryptosporidium* Count	**ND**	**<7.7**

ND = None Detected

Sample(s) were processed, stained and examined using a modified version of the Information Collection Rule (ICR) Protozoan Method (EPA/814-B-95-003). This method employs an immunofluorescent dual monoclonal antibody, which is specific for *Giardia* and *Cryptosporidium*. Positive and negative controls were stained and examined concurrently. Numbers are reported using significant figures.

Analyst: Christopher Ciardelli

Analytical Services, Inc.

Client: LBG-Guyton & Associates
1101 South Capitol of Texas Highway
Austin, TX 78746
Project: 4DLRIO/DELRIO

Sampling Date: March 11, 1999
Date Received: March 12, 1999
Analyst: mbd,sh

Section II.

Analytical Results

Sample No.: 99071-011

I. SAMPLE DATA		
Sample ID:	**San Felipe East #2**	
Sample Site:	**Del Rio, Texas**	
Water Type:	raw/spring	
Turbidity, NTU's:	S: 0.45	E: 0.58
pH:	S: --	E: 7.2
Treatment:	none	
Distance From Surface Water:	approx. 20 feet	
Volume Filtered:	1000 gallons	
Filter:	Commercial Honeycomb 1 μm	
Filter Color:	tan	
Sediment Volume:	1.5 mL	
Volume Floated:	0.5 mL	
Pellet Volume After Float:	0.1 mL	
Levitant --		
type:	Percoll sucrose	
specific gravity:	1.15	

S = Start of Sampling E = End of Sampling

II. MPA			
Numbers reported are per 100 gallons			
Detection Limit = 69			
Amorphous Debris:	Fine Confluent	**Rotifers:**	BDL
Vegetative Debris -		**Rotifer Eggs:**	BDL
with chlorophyll:	BDL	**Crustaceans:**	BDL
without chlorophyll:	BDL	**Crustacean Parts:**	BDL
Diatoms -		**Crustacean Eggs:**	BDL
with chlorophyll:	BDL	**Invertebrate Eggs:**	BDL
without chlorophyll:	BDL	**Water Mites:**	BDL
Other Algae*:	1.3×10^4	**Gastrotrichs:**	BDL
Fungal Hyphae:	BDL	**Tardigrades:**	BDL
Spores:	BDL	**Nematodes:**	BDL
Pollen:	BDL	**Nematode Eggs:**	BDL
Iron Bacteria:**	BDL	**Annelids:**	BDL
Protozoa:	BDL	**Insects/Larvae:**	BDL
Amoebae:	BDL		

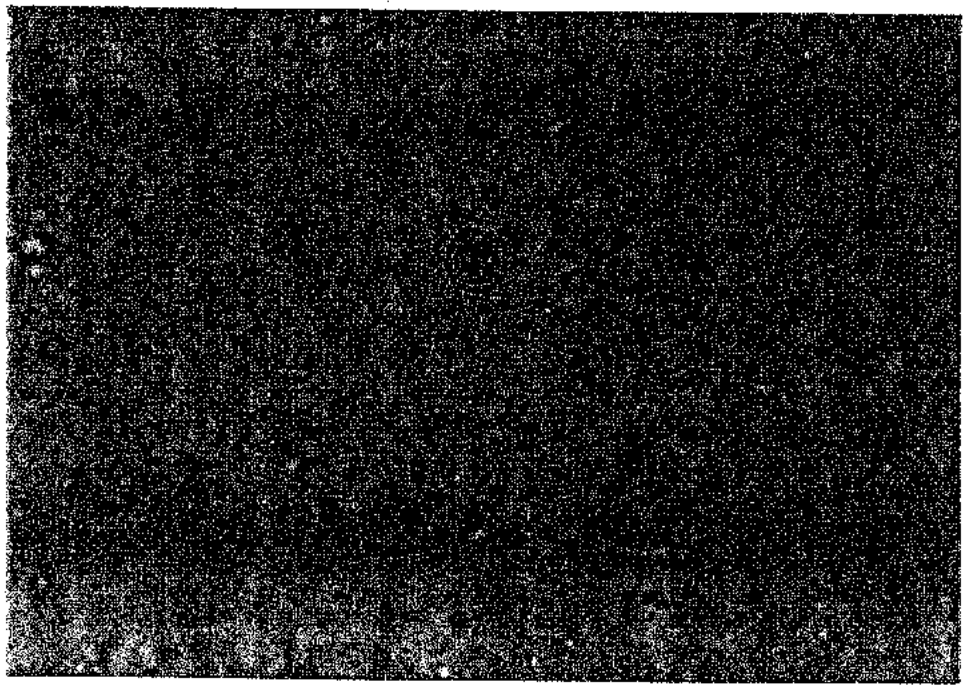
BDL = Below Detection Limit

***Algae Identifications:**	unicellular Chlorophyta and filamentous Chlorophyta
****Iron Bacteria:**	NA
Comments:	

NA = Not Applicable

Project No.: 99071-017

Analytical Services, Inc.



Sample No. 99071-011, LBG-Guyton Associates
Del Rio/San Felipe #2
unicellular Chlorophyta taken at 1000X magnification

Analytical Services, Inc.

Client: LBG-Guyton & Associates
1101 South Capitol of Texas Highway
Austin, TX 78746
Project: 4DLRIO/DELRIO

Sampling Date: March 11, 1999
Date Received: March 12, 1999
Sample No.: 99071-011
Sample I.D.: San Felipe East #2

Section III.

GIARDIA AND *CRYPTOSPORIDIUM*

Analytical Result	Analyte	Numbers/ 23 L	Number/ 100 L
Giardia	Empty *Giardia* cysts detected	ND	<4.3
	Giardia Cysts with Amorphous Structure detected	ND	<4.3
	Giardia Cysts with one Internal Structure detected	ND	<4.3
	Giardia Cysts with more than one Internal Structure detected	ND	<4.3
	Total IFA *Giardia* Count	ND	<4.3
Cryptosporidium	Empty *Cryptosporidium* Oocysts detected	ND	<4.3
	Cryptosporidium Oocysts with Amorphous Structure detected	ND	<4.3
	Cryptosporidium Oocysts with Internal Structure detected	ND	<4.3
	Total IFA *Cryptosporidium* Count	ND	<4.3

ND = None Detected

Sample(s) were processed, stained and examined using a modified version of the Information Collection Rule (ICR) Protozoan Method (EPA/814-B-95-003). This method employs an immunofluorescent dual monoclonal antibody, which is specific for *Giardia* and *Cryptosporidium*. Positive and negative controls were stained and examined concurrently. Numbers are reported using significant figures.

Analyst: Christopher Ciardelli

Analytical Services, Inc.

Client: LBG-Guyton & Associates
1101 South Capitol of Texas Highway
Austin, TX 78746
Project: 4DLRIO/DELRIO

Sampling Date: March 15, 1999
Date Received: March 16, 1999

Section IV.

MPA Risk Rating Table

The risk rating for surface water influence as calculated according to the EPA Consensus Method for Microscopic Particulate Analysis is as follows:

Lab ID	Sample ID	Table 1	Table 2	Total	Risk Rating
99075-011	San Felipe West #5	None	NA	0	Low*
99075-012	Agarita Well	None	NA	0	Low*

NA = Not Applicable

The tables of relative risk factors used to calculate surface water influence in the EPA Consensus Method for Microscopic Particulate Analysis are based on a limited set of data. These data are not representative of all aquifer types or well designs. Therefore, the relative risk values calculated from these tables are of limited value in determining health risks associated with surface water indicators.

* This EPA Risk Rating table classifies each sample according to the number of surface water indicating organisms per 100 gallons. However, due to a high amount of sediment recovered from this sample, only 1.2 and 5.8 x 10^{-2} gallons, respectively, could be analyzed for MPA. Due to this small volume of sample analyzed, this risk rating result should be interpreted with caution.

Mari-Beth DeLucia
Staff Microbiologist

Analytical Services, Inc.

Client: LBG-Guyton & Associates
1101 South Capitol of Texas Highway
Austin, TX 78746
Project: 4DLRIO/DELRIO

Sampling Date: March 15, 1999
Date Received: March 16, 1999
Analyst: mbd

Section II.

Analytical Results

Sample No.: 99075-011

I. SAMPLE DATA		
Sample ID:	San Felipe West #5	
Sample Site:	Del Rio, TX	
Water Type:	raw/spring	
Turbidity, NTU's:	S: 0.56	E: 0.76
pH:	S: 7.1	E: 7.2
Treatment:	none	
Distance From Surface Water:	unknown	
Volume Filtered:	1064 gallons	
Filter:	Commercial Honeycomb 1 µm	
Filter Color:	light brown	
Sediment Volume:	3.0 mL	
Volume Floated:	0.5 mL	
Pellet Volume After Float:	50 µL	
Levitant –		
type:	Percoll sucrose	
specific gravity:	1.15	

S = Start of Sampling; E = End of Sampling

II. MPA			
Numbers reported are per 100 gallons			
Detection Limit = 84			
Amorphous Debris:	Fine Confluent	Rotifers:	BDL
Vegetative Debris -		Rotifer Eggs:	BDL
with chlorophyll:	BDL	Crustaceans:	BDL
without chlorophyll:	BDL	Crustacean Parts:	BDL
Diatoms -		Crustacean Eggs:	BDL
with chlorophyll:	BDL	Invertebrate Eggs:	BDL
without chlorophyll:	BDL	Water Mites:	BDL
Other Algae*:	BDL	Gastrotrichs:	BDL
Fungal Hyphae:	BDL	Tardigrades:	BDL
Spores:	BDL	Nematodes:	BDL
Pollen:	BDL	Nematode Eggs:	BDL
Iron Bacteria**:	BDL	Annelids:	BDL
Protozoa:	BDL	Insects/Larvae:	BDL
Amoebae:	BDL		

BDL = Below Detection Limit

*Algae Identifications:	NA
**Iron Bacteria:	NA
Comments:	

NA = Not Applicable

Analytical Services, Inc.

Client: LBG-Guyton & Associates
1101 South Capitol of Texas Highway
Austin, TX 78746
Project: 4DLRIO/DELRIO

Sampling Date: March 15, 1999
Date Received: March 16, 1999
Sample No.: 99075-011
Sample I.D.: San Felipe West #5

Section III.

GIARDIA AND *CRYPTOSPORIDIUM*

Analytical Result	Analyte	Numbers/ 18 L	Number/ 100 L
Giardia	Empty *Giardia* cysts detected	ND	<5.6
	Giardia Cysts with Amorphous Structure detected	ND	<5.6
	Giardia Cysts with one Internal Structure detected	ND	<5.6
	Giardia Cysts with more than one Internal Structure detected	ND	<5.6
	Total IFA *Giardia* Count	**ND**	**<5.6**
Cryptosporidium	Empty *Cryptosporidium* Oocysts detected	ND	<5.6
	Cryptosporidium Oocysts with Amorphous Structure detected	ND	<5.6
	Cryptosporidium Oocysts with Internal Structure detected	ND	<5.6
	Total IFA *Cryptosporidium* Count	**ND**	**<5.6**

ND = None Detected

Sample(s) were processed, stained and examined using a modified version of the Information Collection Rule (ICR) Protozoan Method (EPA/814-B-95-003). This method employs an immunofluorescent dual monoclonal antibody, which is specific for *Giardia* and *Cryptosporidium*. Positive and negative controls were stained and examined concurrently. Numbers are reported using significant figures.

Analyst: Christopher Ciardelli

Analytical Services, Inc.

Client: LBG-Guyton & Associates
1101 South Capitol of Texas Highway
Austin, TX 78746
Project: 4DLRIO/DELRIO

Sampling Date: March 15, 1999
Date Received: March 16, 1999
Analyst: mbd

Section II.

Analytical Results

Sample No.: 99075-012

I. SAMPLE DATA		
Sample ID:	Agarita Well	
Sample Site:	Del Rio, TX	
Water Type:	raw/well	
Turbidity, NTU's:	unknown	
pH:	S: 7.2	E: 7.3
Treatment:	none	
Distance From Surface Water:	unknown	
Volume Filtered:	988 gallons	
Filter:	Commercial Honeycomb 1 µm	
Filter Color:	brown	
Sediment Volume:	23.0 mL	
Volume Floated:	0.5 mL	
Pellet Volume After Float:	0.1 mL	
Levitant –		
type:	Percoll sucrose	
specific gravity:	1.15	

S = Start of Sampling E = End of Sampling

II. MPA			
Numbers reported are per 100 gallons			
Detection Limit = 1.7×10^3			
Amorphous Debris:	Fine Confluent	Rotifers:	BDL
Vegetative Debris -		Rotifer Eggs:	BDL
with chlorophyll:	BDL	Crustaceans:	BDL
without chlorophyll:	BDL	Crustacean Parts:	BDL
Diatoms -		Crustacean Eggs:	BDL
with chlorophyll:	BDL	Invertebrate Eggs:	BDL
without chlorophyll:	BDL	Water Mites:	BDL
Other Algae*:	BDL	Gastrotrichs:	BDL
Fungal Hyphae:	BDL	Tardigrades:	BDL
Spores:	BDL	Nematodes:	BDL
Pollen:	BDL	Nematode Eggs:	BDL
Iron Bacteria**:	BDL	Annelids:	BDL
Protozoa:	BDL	Insects/Larvae:	BDL
Amoebae:	BDL		

BDL = Below Detection Limit

*Algae Identifications:	NA
**Iron Bacteria:	NA
Comments:	

NA = Not Applicable

Analytical Services, Inc.

Client: LBG-Guyton & Associates
1101 South Capitol of Texas Highway
Austin, TX 78746
Project: 4DLRIO/DELRIO

Sampling Date: March 15, 1999
Date Received: March 16, 1999
Sample No.: 99075-012
Sample I.D.: Agarita Well

Section III.

GIARDIA AND *CRYPTOSPORIDIUM*

Analytical Result	Analyte	Numbers/ 1.8 L	Number/ 100 L
Giardia	Empty *Giardia* cysts detected	ND	<56
	Giardia Cysts with Amorphous Structure detected	ND	<56
	Giardia Cysts with one Internal Structure detected	ND	<56
	Giardia Cysts with more than one Internal Structure detected	ND	<56
	Total IFA *Giardia* Count	**ND**	**<56**
Cryptosporidium	Empty *Cryptosporidium* Oocysts detected	ND	<56
	Cryptosporidium Oocysts with Amorphous Structure detected	ND	<56
	Cryptosporidium Oocysts with Internal Structure detected	ND	<56
	Total IFA *Cryptosporidium* Count	**ND**	**<56**

ND = None Detected

Sample(s) were processed, stained and examined using a modified version of the Information Collection Rule (ICR) Protozoan Method (EPA/814-B-95-003). This method employs an immunofluorescent dual monoclonal antibody, which is specific for *Giardia* and *Cryptosporidium*. Positive and negative controls were stained and examined concurrently. Numbers are reported using significant figures.

Analyst: Christopher Ciardelli

Analytical Services, Inc.

Client: LBG-Guyton & Associates
1101 South Capitol of Texas Highway
Austin, TX 78746

Sampling Date: June 22, 1999
Date Received: June 23, 1999

Section IV.

MPA Risk Rating Table

The risk rating for surface water influence as calculated according to the EPA Consensus Method for Microscopic Particulate Analysis is as follows:

Lab ID	Sample ID	Table 1	Table 2	Total	Risk Rating
99174-022	San Felipe West of the Side of Pump #5 Cave, Del Rio, TX	Algae = 2.0×10^4 = EH	EH = 14	14	Moderate*

EH = Extremely Heavy

The tables of relative risk factors used to calculate surface water influence in the EPA Consensus Method for Microscopic Particulate Analysis are based on a limited set of data. These data are not representative of all aquifer types or well designs. Therefore, the relative risk values calculated from these tables are of limited value in determining health risks associated with surface water indicators.

* This EPA Risk Rating table classifies each sample according to the number of surface water indicating organisms per 100 gallons. However, due to a high amount of sediment recovered from this sample, only 2.3 gallons could be analyzed for MPA. Due to this small volume of sample analyzed, this risk rating result should be interpreted with caution.

Christopher Ciardelli
Staff Microbiologist

Analytical Services, Inc.

Client: LBG-Guyton & Associates
1101 South Capitol of Texas Highway
Austin, TX 78746

Sampling Date: June 22, 1999
Date Received: June 23, 1999
Analysts: cc,mbd

Section II.

Analytical Results

Sample No.: 99174-022

I. SAMPLE DATA		
Sample ID:	**San Felipe West of the Side of Pump #5 Cave**	
Sample Site:	**Del Rio, TX**	
Water Type:	raw/spring	
Turbidity, NTU's:	S: 19.8	E: 1.1
pH:	S: 7.1	E: --
Treatment:	none	
Distance From Surface Water:	10 feet	
Volume Filtered:	1087 gallons	
Filter:	Commercial Honeycomb 1 µm	
Filter Color:	brown	
Sediment Volume:	5.0 mL	
Volume Floated:	0.5 mL	
Pellet Volume After Float:	80 µL	
Levitant –		
type:	Percoll sucrose	
specific gravity:	1.15	

S = Start of Sampling; E = End of Sampling

II. MPA			
Numbers reported are per 100 gallons			
Detection Limit = 43			
Amorphous Debris:	Confluent	**Rotifers:**	BDL
Vegetative Debris -		**Rotifer Eggs:**	BDL
with chlorophyll:	BDL	**Crustaceans:**	BDL
without chlorophyll:	BDL	**Crustacean Parts:**	BDL
Diatoms -		**Crustacean Eggs:**	BDL
with chlorophyll:	BDL	**Invertebrate Eggs:**	BDL
without chlorophyll:	BDL	**Water Mites:**	BDL
Other Algae*:	2.0×10^4	**Gastrotrichs:**	BDL
Fungal Hyphae:	BDL	**Tardigrades:**	BDL
Spores:	2.6×10^2	**Nematodes:**	BDL
Pollen:	BDL	**Nematode Eggs:**	BDL
Iron Bacteria:**	BDL	**Annelids:**	BDL
Protozoa:	6.7×10^3	**Insects/Larvae:**	BDL
Amoebae:	BDL		

BDL = Below Detection Limit

***Algae Identifications:**	*Phacus* sp.; filamentous Chlorophyta, unicellular Chlorophyta, colonial Chlorophyta; filamentous Cyanophyta
****Iron Bacteria:**	NA
Comments:	

NA = Not Applicable

Project No.: 99174-022

Analytical Services, Inc.

Client: LBG-Guyton & Associates
1101 South Capitol of Texas Highway
Austin, TX 78746

Sampling Date: June 22, 1999
Date Received: June 23, 1999
Sample I.D.: San Felipe West of the Side of Pump #5 Cave, Del Rio, TX

Section III.

GIARDIA AND *CRYPTOSPORIDIUM*

Sample No.: 99174-022

Analytical Result	Analyte	Numbers/ 11 L	Number/ 100 L
Giardia	Empty *Giardia* cysts detected	ND	<9.1
	Giardia Cysts with Amorphous Structure detected	ND	<9.1
	Giardia Cysts with one Internal Structure detected	ND	<9.1
	Giardia Cysts with more than one Internal Structure detected	ND	<9.1
	Total IFA *Giardia* Count	**ND**	**<9.1**
Cryptosporidium	Empty *Cryptosporidium* Oocysts detected	ND	<9.1
	Cryptosporidium Oocysts with Amorphous Structure detected	ND	<9.1
	Cryptosporidium Oocysts with Internal Structure detected	ND	<9.1
	Total IFA *Cryptosporidium* Count	**ND**	**<9.1**

ND = None Detected

Sample(s) were processed, stained and examined using a modified version of the Information Collection Rule (ICR) Protozoan Method (EPA/814-B-95-003). This method employs an immunofluorescent dual monoclonal antibody, which is specific for *Giardia* and *Cryptosporidium*. Positive and negative controls were stained and examined concurrently. Numbers are reported using significant figures.

Analyst: Jennifer Teague

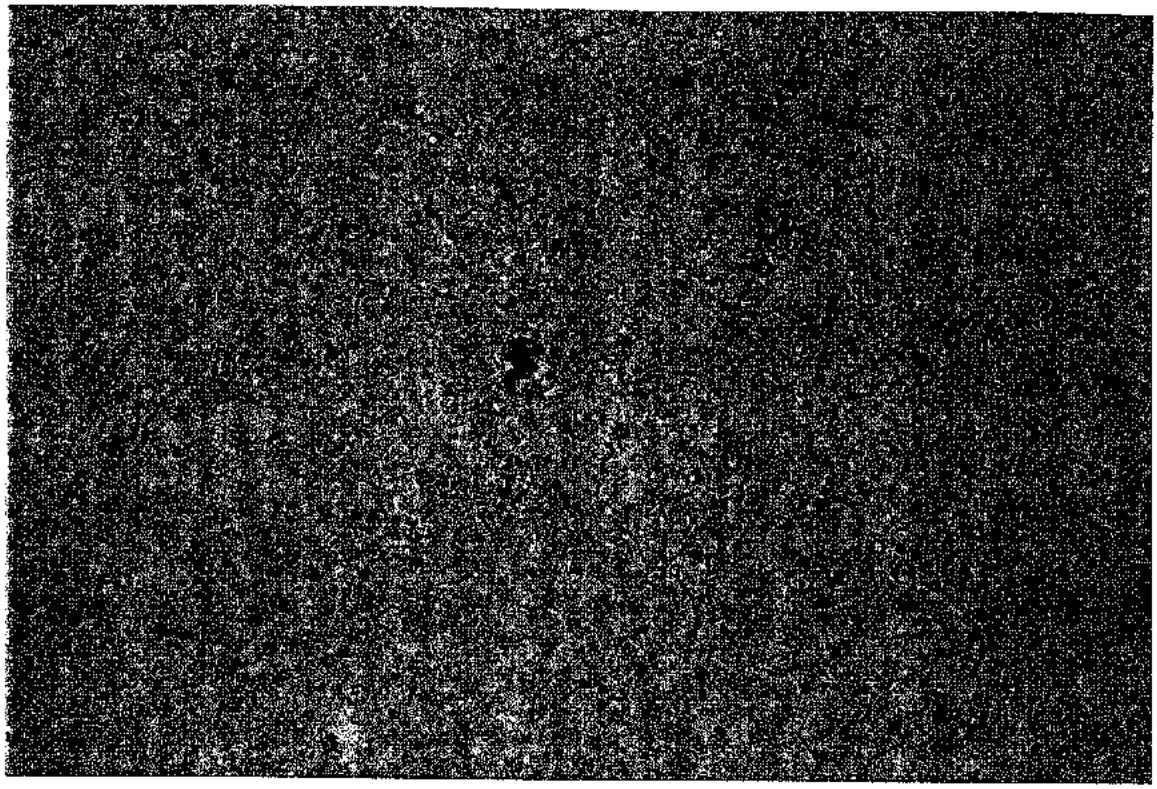


Figure 1. Photomicrograph, taken at 400X magnification, of a representative section of sample 99174-022 (San Felipe West of the Side of Pump #5 Cave), showing *Phacus* sp. algae. This sample was received in our laboratory on June 23, 1999.

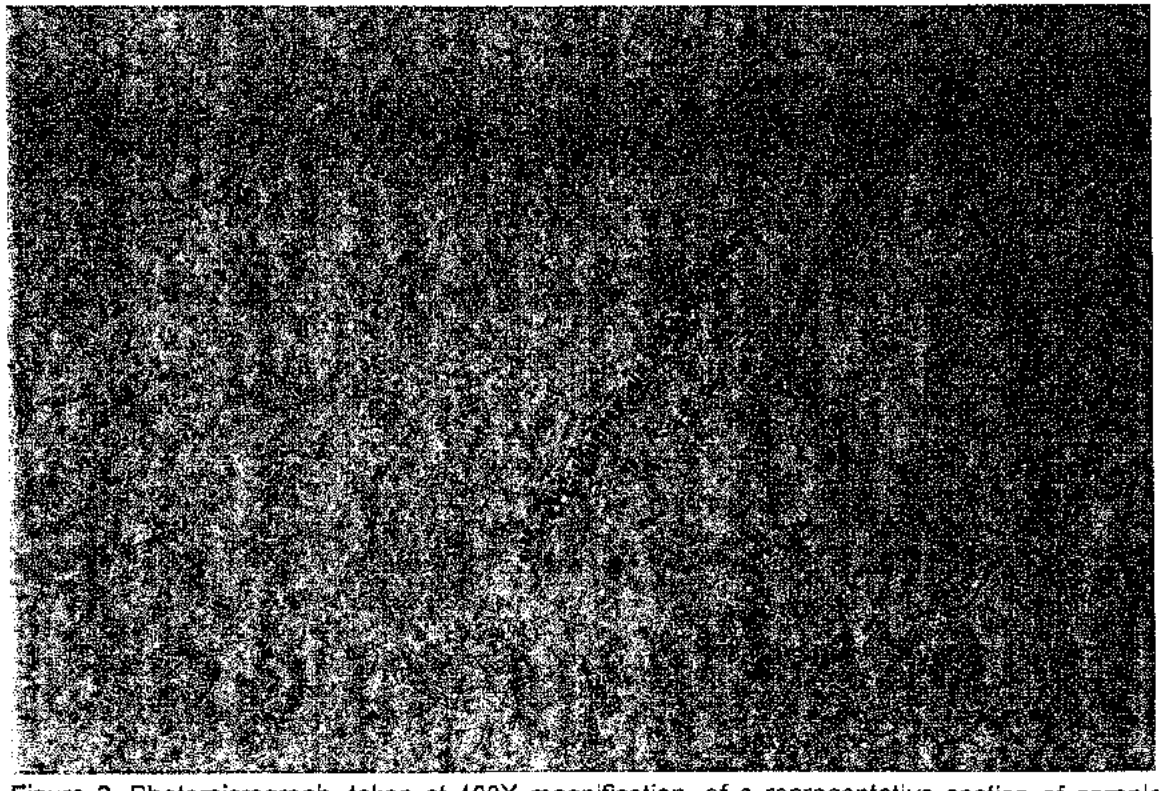


Figure 2. Photomicrograph, taken at 400X magnification, of a representative section of sample 99174-022 (see Fig.1), which was received in our laboratory on June 23, 1999. Filamentous Chlorophyta were detected in this sample.

Analytical Services, Inc.

Client: LBG-Guyton & Associates
1101 South Capitol of Texas Highway
Austin, TX 78746

Sampling Date: April 13, 1999
Date Received: April 14, 1999

Project: Del Rio, TX

Section IV.

MPA Risk Rating Table

The risk rating for surface water influence as calculated according to the EPA Consensus Method for Microscopic Particulate Analysis is as follows:

Lab ID	Sample ID	Table 1	Table 2	Total	Risk Rating
99104-003	Del Rio "Y" Well #3 Del Rio, TX	None	NA	0	Low

NA = Not Applicable

The tables of relative risk factors used to calculate surface water influence in the EPA Consensus Method for Microscopic Particulate Analysis are based on a limited set of data. These data are not representative of all aquifer types or well designs. Therefore, the relative risk values calculated from these tables are of limited value in determining health risks associated with surface water indicators.

Christopher Ciardelli
Staff Microbiologist

Analytical Services, Inc.

Client: LBG-Guyton & Associates
1101 South Capitol of Texas Highway
Austin, TX 78746

Project: Del Rio, TX

Sampling Date: April 13, 1999
Date Received: April 14, 1999
Analyst: cc

Section II.

Analytical Results

Sample No.: 99104-003

I. SAMPLE DATA		
Sample ID:	Del Rio "Y" Well #3	
Sample Site:	Del Rio, TX	
Water Type:	raw/well	
Turbidity, NTU's:	S: 0.12	E: 0.31
pH:	S: --	E: 7.06
Treatment:	none	
Distance From Surface Water:	>1 mile	
Volume Filtered:	1000 gallons	
Filter:	Commercial Honeycomb 1 μm	
Filter Color:	tan	
Sediment Volume:	50 μL	

S = Start of Sampling; E = End of Sampling

II. MPA			
Numbers reported are per 100 gallons			
Detection Limit = 4			
Amorphous Debris:	Confluent	Rotifers:	BDL
Vegetative Debris -		Rotifer Eggs:	BDL
with chlorophyll:	BDL	Crustaceans:	BDL
without chlorophyll:	BDL	Crustacean Parts:	BDL
Diatoms -		Crustacean Eggs:	BDL
with chlorophyll:	BDL	Invertebrate Eggs:	BDL
without chlorophyll:	BDL	Water Mites:	BDL
Other Algae*:	BDL	Gastrotrichs:	BDL
Fungal Hyphae:	4	Tardigrades:	BDL
Spores:	4	Nematodes:	BDL
Pollen:	16	Nematode Eggs:	BDL
Iron Bacteria**:	BDL	Annelids:	BDL
Protozoa:	16	Insects/Larvae:	BDL
Amoebae:	BDL		

BDL = Below Detection Limit

*Algae Identifications:	NA
**Iron Bacteria:	NA
Comments:	

NA = Not Applicable

Analytical Services, Inc.

Client: LBG-Guyton & Associates
1101 South Capitol of Texas Highway
Austin, TX 78746

Project: Del Rio, TX

Sampling Date: April 13, 1999
Date Received: April 14, 1999
Sample No.: 99104-003
Sample I.D.: Del Rio "Y" Well #3
Del Rio, Texas

Section III.

GIARDIA AND *CRYPTOSPORIDIUM*

Analytical Result	Analyte	Numbers/ 1.3 x 10^2 L	Number/ 100 L
Giardia	Empty *Giardia* cysts detected	ND	<0.77
	Giardia Cysts with Amorphous Structure detected	ND	<0.77
	Giardia Cysts with one Internal Structure detected	ND	<0.77
	Giardia Cysts with more than one Internal Structure detected	ND	<0.77
	Total IFA *Giardia* Count	**ND**	**<0.77**
Cryptosporidium	Empty *Cryptosporidium* Oocysts detected	ND	<0.77
	Cryptosporidium Oocysts with Amorphous Structure detected	ND	<0.77
	Cryptosporidium Oocysts with Internal Structure detected	ND	<0.77
	Total IFA *Cryptosporidium* Count	**ND**	**<0.77**

ND = None Detected

Sample(s) were processed, stained and examined using a modified version of the Information Collection Rule (ICR) Protozoan Method (EPA/814-B-95-003). This method employs an immunofluorescent dual monoclonal antibody, which is specific for *Giardia* and *Cryptosporidium*. Positive and negative controls were stained and examined concurrently. Numbers are reported using significant figures.

Analyst: Jennifer Teague

Analytical Services, Inc.

Client: LBG-Guyton & Associates
1101 South Capitol of Texas Highway
Austin, TX 78746

Sampling Date: April 22, 1999
Date Received: April 23, 1999

Section IV.

MPA Risk Rating Table

The risk rating for surface water influence as calculated according to the EPA Consensus Method for Microscopic Particulate Analysis is as follows:

Lab ID	Sample ID	Table 1	Table 2	Total	Risk Rating
99113-001	Tierra del Lago (Amistad) Well #1 Del Rio, TX	Algae = 7.9×10^2 = EH Rotifers = 6 = R	EH = 14 R = 1	15	Moderate

EH = Extremely Heavy R = Rare

The tables of relative risk factors used to calculate surface water influence in the EPA Consensus Method for Microscopic Particulate Analysis are based on a limited set of data. These data are not representative of all aquifer types or well designs. Therefore, the relative risk values calculated from these tables are of limited value in determining health risks associated with surface water indicators.

Some rotifers, insects and larvae are found in both surface and ground waters. These organisms live and burrow in soils, and therefore are not necessarily indicative of surface water influence.

Christopher Ciardelli
Staff Microbiologist

Analytical Services, Inc.

Client: LBG-Guyton & Associates
1101 South Capitol of Texas Highway
Austin, TX 78746

Sampling Date: April 22, 1999
Date Received: April 23, 1999
Analysts: cc,sh

Section II.

Analytical Results

Sample No.: 99113-001

I. SAMPLE DATA		
Sample ID:	Tierra del Lago (Amistad) Well #1	
Sample Site:	Del Rio, TX	
Water Type:	raw/well	
Turbidity, NTU's:	S: 0.23	E: 0.54
pH:	S: 7.14	E: 7.19
Treatment:	none	
Distance From Surface Water:	~ 0.5 mile	
Volume Filtered:	1023 gallons	
Filter:	Commercial Honeycomb 1 µm	
Filter Color:	off-white	
Sediment Volume:	50 µL	

S = Start of Sampling; E = End of Sampling

II. MPA			
Numbers reported are per 100 gallons			
Detection Limit = 6			
Amorphous Debris:	Confluent	Rotifers:	6
Vegetative Debris -		Rotifer Eggs:	BDL
with chlorophyll:	BDL	Crustaceans:	BDL
without chlorophyll:	BDL	Crustacean Parts:	BDL
Diatoms -		Crustacean Eggs:	BDL
with chlorophyll:	BDL	Invertebrate Eggs:	BDL
without chlorophyll:	BDL	Water Mites:	BDL
Other Algae*:	7.9×10^2	Gastrotrichs:	BDL
Fungal Hyphae:	BDL	Tardigrades:	BDL
Spores:	32	Nematodes:	6
Pollen:	38	Nematode Eggs:	BDL
Iron Bacteria**:	BDL	Annelids:	BDL
Protozoa:	2.6×10^3	Insects/Larvae:	BDL
Amoebae:	BDL		

BDL = Below Detection Limit

*Algae Identifications:	filamentous Cyanophyta, unicellular Chlorophyta
**Iron Bacteria:	NA
Comments:	

NA = Not Applicable

Analytical Services, Inc.

Client: LBG-Guyton & Associates
1101 South Capitol of Texas Highway
Austin, TX 78746

Sampling Date: April 22, 1999
Date Received: April 23, 1999
Sample No.: 99113-001
Sample I.D.: Tierra del Lago (Amistad) Well #1 Del Rio, TX

Section III.

GIARDIA AND *CRYPTOSPORIDIUM*

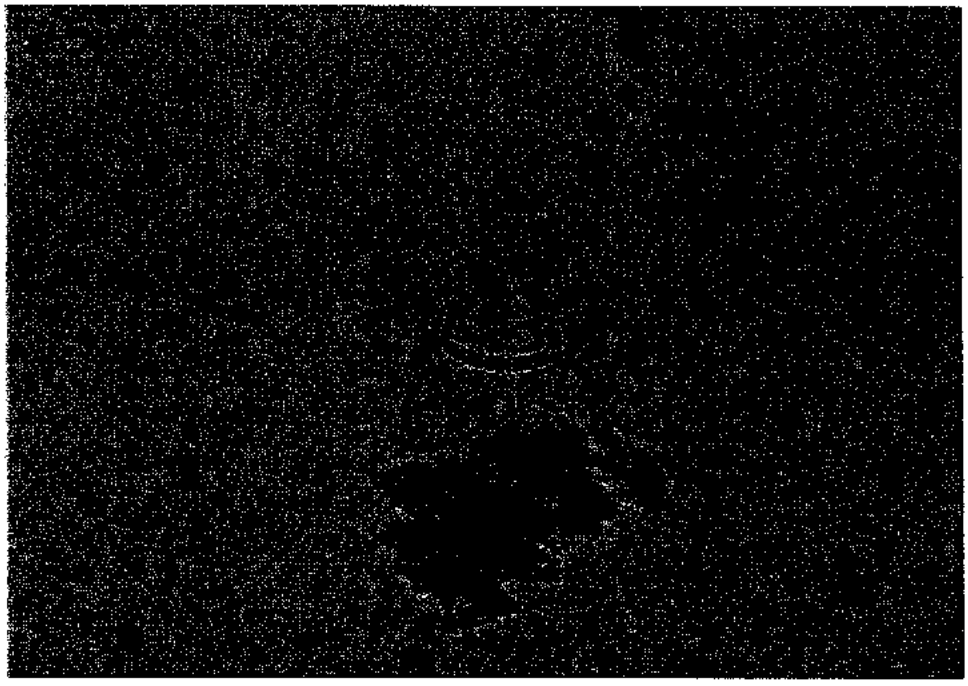
Analytical Result	Analyte	Numbers/ 77 L	Number/ 100 L
Giardia	Empty *Giardia* cysts detected	ND	<1.3
	Giardia Cysts with Amorphous Structure detected	ND	<1.3
	Giardia Cysts with one Internal Structure detected	ND	<1.3
	Giardia Cysts with more than one Internal Structure detected	ND	<1.3
	Total IFA *Giardia* Count	**ND**	**<1.3**
Cryptosporidium	Empty *Cryptosporidium* Oocysts detected	ND	<1.3
	Cryptosporidium Oocysts with Amorphous Structure detected	ND	<1.3
	Cryptosporidium Oocysts with Internal Structure detected	ND	<1.3
	Total IFA *Cryptosporidium* Count	**ND**	**<1.3**

ND = None Detected

Sample(s) were processed, stained and examined using a modified version of the Information Collection Rule (ICR) Protozoan Method (EPA/814-B-95-003). This method employs an immunofluorescent dual monoclonal antibody, which is specific for *Giardia* and *Cryptosporidium*. Positive and negative controls were stained and examined concurrently. Numbers are reported using significant figures.

Analyst: Jennifer Teague

Analytical Services, Inc.



99113-001: LBG-Guyton & Associates for the City of Del Rio –
Tierra del Lago (Amistad) Well #1
Filamentous Chlorophyta taken at 400X magnification

APPENDIX 4

MICROPARTICULATE ANALYSES (MPAs) FROM TEXAS NATURAL RESOURCE CONSERVATION COMMISSION

Texas Department of Health

Robert Bernstein, M.D., F.A.C.P.
Commissioner

1100 West 49th Street
Austin, Texas 78756
(512) 458-7111

Robert A. MacLean, M.D.
Deputy Commissioner
Professional Services

Hermas L. Miller
Deputy Commissioner
Management and Administration

January 17, 1990

Honorable Alfredo Gutierrez, Mayor
City of Del Rio
P. O. Box 4239
Del Rio, Texas 78840

Subject: Public Drinking Water Supply
Del Rio Utilities Commission
I.D. #2330001
Val Verde County, Texas

Dear Mayor Gutierrez:

This Department has recently completed a filtrate analysis of the City of Del Rio's raw water supply. The results of this analysis indicates the presence of a number of aquatic organisms consistent with those found in surface water. A review of water borne disease outbreaks in the United States implicate improperly treated surface water, springs and shallow groundwater as the main contributors to these outbreaks. While we have no direct evidence that a water borne disease event has occurred in your community, it is certainly a possible occurrence given the existing conditions.

It is imperative therefore that further treatment be performed on this source of supply if it is to be utilized in the future. Because of the serious nature of this condition we ask that you reply in writing within 45 days as to what corrective measures you intend to pursue.

If you have need of further information or we can provide you with the nature and results of the tests performed, please call us at 512/458-7497.

Sincerely,

Steven E. Walden

Steven E. Walden, R.S., Chief
Surveillance and Technical
Assistance Branch
Division of Water Hygiene

ML/SEW/pw

ccs: Public Health Region 6
Del Rio-Val Verde County Health Department
Texas Water Development Board
Attn: Ms. Cheryl Conger

EXAMINATION FOR PARASITES
Form No. G-31

Texas Department of Health
Bureau of Laboratories

Lab. No. | Date Rec'd. NOV 16 | Date Reported NOV 20

Do Not Mark Above This Line—Please Print Below with BALLPOINT PEN OR TYPEWRITER:

Patient's Name City of Del Rio
Last First Middle | Age | Sex | Race

Address _____ County _____

Patient's Ident. No. _____

Send Report to:
PHYSICIAN Tony Bennett
STREET Water Hygiene
CITY Austin TEXAS
(Zip Code)

Disease suspected or test desired _____

Date of onset _____ Date Collected 11-15-89

Type of specimen:
☐ Feces ☐ Pinworm swab
☐ Blood ☒ Other Water Filter - Scag 65°F Air 72°F Water

Condition of specimen:
☐ Unpreserved ☐ PVA pH 7.2
☐ Formalin ☐ Other Cl 0.0 Turbidity < 0.5 NTU

Remarks _____

LABORATORY REPORT (DO NOT WRITE BELOW)

FECES EXAMINATION
☐ No parasites Found

☐ Entamoeba histolytica

☐ Entamoeba hartmanni
☐ Entamoeba coli
☐ Endolimax nana
☐ Iodamoeba butschlii
☐ Chilomastix mesnili
☐ Dientamoeba fragilis

☐ Giardia lamblia

☐ Hookworm
☐ Ascaris lumbricoides
☐ Strongyloides stercoralis
☐ Trichuris trichiura
☐ Hymenolepis nana
☐ Other _____

Please submit another specimen.

Results of bacteriological studies will be reported separately.

PINWORM SWAB EXAMINATION
☐ No Pinworm Eggs Found
☐ Pinworm (Enterobius vermicularis) Found

BLOOD EXAMINATION
☐ No Parasites found
☐ Parasites found _____

TISSUE EXAMINATION
☐ No Parasites found
☐ Parasites found _____

OTHER EXAMINATION WATER:
No GIARDIA/Cryptosporidium Seen
(Many free-living protozoa/aquatic flora + fauna)
☐ SPECIMEN UNSATISFACTORY: _____

EXAMINATION FOR PARASITES
Form No. G-31

Texas Department of Health
Bureau of Laboratories

Lab. No. | Date Rec'd. [illegible] | Date Reported 12/00

Do Not Mark Above This Line—Please Print Below with BALLPOINT PEN OR TYPEWRITER:

Patient's Name Del Rio (Val Verde Co. 232 CCC) ____ ____ ____
Last First Middle Age Sex Race

Address _____ County _____

Patient's Ident. No. _____

Send report to:
PHYSICIAN Tony Bennett
STREET Water Hygiene - TDH
CITY Austin TEXAS _____ (Zip Code)

Disease suspected or test desired Protozoa

Date of onset _____ Date Collected _____

Type of specimen: ☐ Feces ☐ Blood ☐ Pinworm swab ☒ Other Water Filter

Condition of specimen: ☐ Unpreserved ☐ Formalin ☐ PVA ☐ Other _____

Remarks: Air Temp: 71°F, Water 71°F, pH 7.2, Turbidity 3.4 NTU; Signal.

LABORATORY REPORT (DO NOT WRITE BELOW)

FECES EXAMINATION
☐ No parasites Found
☐ Entamoeba histolytica
☐ Entamoeba hartmanni
☐ Entamoeba coli
☐ Endolimax nana
☐ Iodamoeba butschlii
☐ Chilomastix mesnili
☐ Dientamoeba fragilis
☐ Giardia lamblia
☐ Hookworm
☐ Ascaris lumbricoides
☐ Strongyloides stercoralis
☐ Trichuris trichiura
☐ Hymenolepis nana
☐ Other _____

☐ Please submit another specimen.

PINWORM SWAB EXAMINATION
☐ No Pinworm Eggs Found
☐ Pinworm (Enterobius vermicularis) Found

BLOOD EXAMINATION
☐ No Parasites found
☐ Parasites found _____

TISSUE EXAMINATION
☐ No Parasites found
☐ Parasites found _____

(+) OTHER EXAMINATION water: no G lamblia or Cryptosporidium sp. found

☐ SPECIMEN UNSATISFACTORY: pellet size - 1.75 ml # smears read 23

☐ Results of bacteriological studies will be reported separately.

Nematodes 1+; Algae 1+; Diatoms 1+ free-living protozoa 2+; bacteria 4+; debris 4+.

********** CONFIDENTIAL LABORATORY REPORTS **********
TEXAS DEPARTMENT OF HEALTH
1100 W. 49th Street AUSTIN, TX 787563194

Date: 6/6/95

Submitter copy to:

TWC/WATER UTILITIES - FAX-00000010
P O BOX 13087
AUSTIN, TX 00001

Spec #: E95WF000029
Subm #:
Lab: ENVIRONMENTAL
Tel #: (512)458-7578

Source
DEL RIO,CITY OF

Date Rcvd: 5/26/95
Time Rcvd: 1600
Time Coll: 1230
Spec Type: WATER FILTER
Amt filtered: 500 GAL
Collected at: SAN FELIPE SPRINGS-WEST SPRING

System ID #: 2330001
Turbidity(NTU): 12.0 NTU - 77.0 NTU
Water temp: 23.6 CELCIUS
pH: 7.04

Final Results

Specimen Numbers:	E95WF000029
Date Collected:	5/25/95
FILTER EXAM	
Protozoa	NONE SEEN
Nematodes	NONE SEEN
Diatoms	1+ nonmotile
Algae	1+ nonmotile
Bacteria	4+ motile
Debris	4+
Pellet size (ml):	3.0
Smears examined (#):	4

David L. Maserang, Ph.D.
Chief, Bureau of Laboratories
CLIA License Number 45D0660644

********** CONFIDENTIAL LABORATORY REPORTS **********
TEXAS DEPARTMENT OF HEALTH
1100 W. 49th Street AUSTIN, TX 787563194

Date: 6/7/95

Submitter copy to:

TWC/WATER UTILITIES - FAX-00000010
P O BOX 13087
AUSTIN, TX 00001

Spec #: E95WF000030
Subm #:
Lab: ENVIRONMENTAL
Tel #: (512)458-7578

Source
DEL RIO,CITY OF

Date Rcvd: 5/26/95
Time Rcvd: 1600
Time Coll: 1600
Spec Type: WATER FILTER
* Not given
Amt filtered: 500 GAL
Collected at: SAN FELIPE SPRINGS-WEST SPRINGS

System ID #: 2330001
Turbidity(NTU): 32.0 NTU -3.1 NTU
Water temp: 24.9 C
pH: 7.04

Final Results

Specimen Numbers:	E95WF000030
Date Collected:	5/25/95
FILTER EXAM	
Protozoa	NONE SEEN
Nematodes	NONE SEEN
Diatoms	1+ nonmotile
Algae	1+ nonmotile
Bacteria	4+ motile
Debris	4+
Pellet size (ml):	4.0
Smears examined (#):	4

David L. Maserang, Ph.D.
Chief, Bureau of Laboratories
CLIA License Number 4500660644

********** CONFIDENTIAL LABORATORY REPORTS **********
TEXAS DEPARTMENT OF HEALTH
1100 W. 49th Street AUSTIN, TX 787563194

Date: 6/7/95

Submitter copy to:

TWC/WATER UTILITIES - FAX-00000010
P O BOX 13087
AUSTIN, TX 00001

Spec #: E95WF000031
Subm #:
Lab: ENVIRONMENTAL
Tel #: (512)458-7578

Source
DEL RIO,CITY OF

Date Rcvd: 5/26/95
Time Rcvd: 1600
Time Coll: 2030
Spec Type: WATER FILTER
* Not given
Amt Filtered: 500 GAL
Collected at: SAN FELIPE SPRINGS-EAST SPRINGS

System ID #: 2330001
Turbidity(NTU): 60.0 NTU - 10.5 NTU
Water temp: 23.8
pH: 6.99

Final Results

Specimen Numbers:	E95WF000031
Date Collected:	5/25/95

FILTER EXAM

Protozoa	NONE SEEN
Nematodes	1+ motile
Diatoms	1+ nonmotile
Algae	1+ nonmotile
Bacteria	4+ motile
Debris	4+
Pellet size (ml):	4.0
Smears examined (#):	4

David L. Maserang, Ph.D.
Chief, Bureau of Laboratories
CLIA License Number 45D0660644

********** CONFIDENTIAL LABORATORY REPORTS **********
TEXAS DEPARTMENT OF HEALTH
1100 W. 49th Street AUSTIN, TX 787563194

Submitter copy to: Date: 5/20/94

TWC/WATER UTILITIES - FAX-00000010
P O BOX 13087
AUSTIN, TX 00001

Spec #: E94WF000012
Subm #:
Lab: ENVIRONMENTAL
Tel #: (512)458-7578

Source
CITY OF DEL RIO/WEST SPRING

Date Rcvd:	5/9/94	Chlorine:	0.0
Time Rcvd:	1000	Collected at:	WEST SPRING
Time Coll:	0445	Turbidity(NTU):	0.57 NTU
Spec Type:	WATER FILTER	Water temp:	74.3 F
*	Raw	pH:	7.02
Air temp:	72 F	Test Reas:	ROUTINE

Final Results

Specimen Numbers:	E94WF000012
Date Collected:	5/9/94
FILTER EXAM	Protozoa 1+ nonmotile
	Nematodes NONE SEEN
	Diatoms 1+ nonmotile
	Algae 1+ nonmotile
	Bacteria 4+ motile
	Debris 4+
	Pellet size (ml): 3.0
	Smears examined (#): 8

No Cryptosporidium or Giardia seen.

David L. Maserang, Ph.D.
Chief, Bureau of Laboratories
CLIA License Number 45D0660644

********** CONFIDENTIAL LABORATORY REPORTS **********
TEXAS DEPARTMENT OF HEALTH
1100 W. 49th Street AUSTIN, TX 787563194

Date: 9/21/94

Submitter copy to:

TWC/WATER UTILITIES - FAX-00000010
P O BOX 13087
AUSTIN, TX 00001

Spec #: E94WF000029
Subm #:
Lab: ENVIRONMENTAL
Tel #: (512)458-7578

Source
DEL RIO,CITY OF

Date Rcvd:	9/19/94	Collected at:	east spring
Time Rcvd:	1345	Contact time:	1610
Spec Type:	WATER FILTER	Turbidity(NTU):	9.6-5.3
Coll By:	ML	Water temp:	23.2 C
Amt filtered:	500 gal	pH:	6.96
Chlorine:	raw water		

Final Results

Specimen Numbers: E94WF000029
Date Collected: 9/16/94

FILTER EXAM

Protozoa NONE SEEN
Nematodes NONE SEEN
Diatoms 1+ nonmotile
Algae 1+ nonmotile
Bacteria 2+ motile
Debris 4+
Pellet size (ml): 3.75
Smears examined (#): 4

David L. Maserang, Ph.D.
Chief, Bureau of Laboratories
CLIA License Number 4500660644

********** CONFIDENTIAL LABORATORY REPORTS **********
TEXAS DEPARTMENT OF HEALTH
1100 W. 49th Street AUSTIN, TX 787563194

Date: 9/21/94

Submitter copy to:

TWC/WATER UTILITIES - FAX-00000010
P O BOX 13087
AUSTIN, TX 00001

Spec #: E94WF000030
Subm #:
Lab: ENVIRONMENTAL
Tel #: (512)458-7578

Source
DEL RIO,CITY OF

Date Rcvd:	9/19/94	Collected at:	west spring
Time Rcvd:	1345	Contact time:	1000
Spec Type:	WATER FILTER	Turbidity(NTU):	2.3-1.6
Coll By:	ML	Water temp:	23.8 C
Amt filtered:	500 gal	pH:	6.89
Chlorine:	raw water		

Final Results

Specimen Numbers: E94WF000030
Date Collected: 9/17/94

FILTER EXAM

Protozoa NONE SEEN
Nematodes NONE SEEN
Diatoms 1+ nonmotile
Algae 1+ nonmotile
Bacteria 1+ motile
Debris 4+
Pellet size (ml): 3
Smears examined (#): 4

David L. Maserang, Ph.D.
Chief, Bureau of Laboratories
CLIA License Number 45D0660644

Texas Department of Health

1100 WEST 49TH STREET
AUSTIN, TEXAS 78756-3194
(512) 458-7318

BUREAU OF LABORATORIES
CLIA #45D0660644
CONFIDENTIAL LABORATORY REPORT

Date: 1/2/95

Submitter copy to:

WATER UTILITIES,DIVISION OF-822270722
TWC-PO BOX 13087
AUSTIN, TX 78711

Spec #: E94WF000045
Subm #:
Lab: ENVIRONMENTAL
Tel #: (512)458-7578

Source
DEL RIO,CITY OF

Date Rcvd:	12/29/94	Collected at:	WEST WELL-SPRING
Time Rcvd:	1350	Turbidity(NTU):	.42 NTU- .28 NTU
Time Coll:	1145	pH:	6.90
Spec Type:	WATER FILTER	Test Reas:	ROUTINE
Amt filtered:	500 GAL		

Final Results

Specimen Numbers:	E94WF000045
Date Collected:	12/28/94

FILTER EXAM

Protozoa	1+ nonmotile
Nematodes	1+ nonmotile
Diatoms	2+ nonmotile
Algae	2+ nonmotile
Bacteria	2+ motile
Debris	3+
Pellet size (ml):	3
Smears examined (#):	4

Organisms containing chlorophyll were found.

Specimen Comments:
REPLY TO JIM PALMER WATER/WASTEWATER DIV

David L. Haserang, Ph.D.
Chief, Bureau of Laboratories
CLIA License Number 45D0660644

********** CONFIDENTIAL LABORATORY REPORTS **********
TEXAS DEPARTMENT OF HEALTH
1100 W. 49th Street AUSTIN, TX 787563194

Submitter copy to:

Date: 6/24/93

TEXAS WATER COMM/WATER UTILITIES-00000010
P O BOX 13087
AUSTIN, TX 00001

Spec #: E93WF000019
Subm #:
Lab: ENVIRONMENTAL
Tel #: (512)458-7578

Source
CITY OF DEL RIO

Date Rcvd:	6/18/93	Chlorine:	.7
Time Rcvd:	1030	System ID #:	233001
Spec Type:	WATER FILTER	Turbidity(NTU):	.44
Air temp:	25.6	pH:	7.26

Final Results

Specimen Numbers:	E93WF000019
Date Collected:	6/17/93

FILTER EXAM

Protozoa 1+ motile
Nematodes 1+ motile
Diatoms 2+ nonmotile
Algae 1+ nonmotile
Bacteria 2+ motile
Debris 4+
Pellet size (ml): 4.85
Smears examined (#): 5

No Giardia/Cryptosporidium seen.
Organisms containing chlorophyll were found.
Rotifers were found.

Charles E. Sweet, Dr. P.H.
Chief, Bureau of Laboratories

********** CONFIDENTIAL LABORATORY REPORTS **********
TEXAS DEPARTMENT OF HEALTH
1100 W. 49th Street AUSTIN, TX 787563194

Submitter copy to: Date: 7/21/95

TWC/WATER UTILITIES - FAX-00000010
P O BOX 13087
AUSTIN, TX 00001

Spec #: E95WF000036
Subm #:
Lab: ENVIRONMENTAL
Tel #: (512)458-7578

Source
CITY OF DEL RIO

Date Rcvd:	7/12/95	Air temp:	24.1 C
Time Rcvd:	0915	Collected at:	AGARITA WELL
Time Coll:	2310	Turbidity(NTU):	5.80 NTU
Spec Type:	WATER FILTER	pH:	5.17

Final Results

Specimen Numbers: E95WF000036
Date Collected: 7/11/95

FILTER EXAM

Protozoa NONE SEEN
Nematodes NONE SEEN
Diatoms NONE SEEN
Algae NONE SEEN
Bacteria 4+ motile
Debris 2+
Pellet size (ml): 12.5
Smears examined (#): 4

David L. Maserang, Ph.D.
Chief, Bureau of Laboratories
CLIA License Number 45D0660644

********** CONFIDENTIAL LABORATORY REPORTS **********
TEXAS DEPARTMENT OF HEALTH
1100 W. 49th Street AUSTIN, TX 787563194

Date: 7/21/95

Submitter copy to:

TWC/WATER UTILITIES - FAX-00000010
P O BOX 13087
AUSTIN, TX 00001

Spec #: E95WF000037
Subm #:
Lab: ENVIRONMENTAL
Tel #: (512)458-7578

Source
CITY OF DEL RIO

Date Rcvd:	7/12/95	Air temp:	24.8 C
Time Rcvd:	0915	Collected at:	EAST SPRINGS
Time Coll:	1936	Turbidity(NTU):	0.24 NTU
Spec Type:	WATER FILTER	pH:	5.16

Final Results

Specimen Numbers:	E95WF000037
Date Collected:	7/11/95

FILTER EXAM

Protozoa	NONE SEEN
Nematodes	NONE SEEN
Diatoms	3+ nonmotile
Algae	2+ nonmotile
Bacteria	4+ motile
Debris	3+
Pellet size (ml):	2
Smears examined (#):	3

Organisms containing chlorophyll were found.

David L. Maserang, Ph.D.
Chief, Bureau of Laboratories
CLIA License Number 4500660644

********** CONFIDENTIAL LABORATORY REPORTS **********
TEXAS DEPARTMENT OF HEALTH
1100 W. 49th Street AUSTIN, TX 787563194

Submitter copy to:

Date: 9/15/98

TWC/WATER UTILITIES - FAX-00000010
P O BOX 13087
AUSTIN, TX 00001

Spec #: E98WF000034
Subm #:
Lab: ENVIRONMENTAL
Tel #: (512)458-7578

Source
DEL RIO UTILITIES

Date Rcvd: 9/10/98
Time Rcvd: 0900
Time Coll: 1155
Spec Type: WATER FILTER
Coll By: JAY DON JOBSON
Amt filtered: 425
Chlorine: 0

Collected at: WEST SPRING EP #002
Last rain: 2 WEEKS
Sample Is Raw
System ID #: 2330001
Turbidity(NTU): 2.5
Test Reas: ROUTINE

Final Results

Specimen Numbers: E98WF000034
Date Collected: 9/9/98

FILTER EXAM

Protozoa Not Tested
Nematodes Not Tested
Diatoms Not Tested
Algae Not Tested
Bacteria Not Tested
Debris Not Tested
Pellet size (ml): 5.0
Smears examined (#): 2

No Cryptosporidium or Giardia seen.

David L. Maserang, Ph.D.
Chief, Bureau of Laboratories
CLIA License Number 4500660644

Texas Department of Health

1100 WEST 49TH STREET
AUSTIN, TEXAS 78756-3194
(512) 458-7318

BUREAU OF LABORATORIES
CLIA #45D0660644

CONFIDENTIAL LABORATORY REPORT

Submitter copy to:

Date: 9/14/98

TWC/WATER UTILITIES - FAX-00000010
P O BOX 13087
AUSTIN, TX 00001

Spec #: E98WF000033
Subm #:
Lab: ENVIRONMENTAL
Tel #: (512)458-7578

Source

CITY OF DEL RIO

Date Rcvd: 9/9/98
Time Rcvd: 1430
Spec Type: WATER FILTER
Coll By: DON WHITE
Air temp: 85 F
Amt filtered: 500
Chlorine: 0.0MG/L

Collected at: EAST SPRINGS EP001
Last rain: 14-15 DAYS
Sample Is Raw
System ID #: 2330001
Turbidity(NTU): 3.20
Water temp: 23 C
Test Reas: ROUTINE

Final Results

Specimen Numbers: E98WF000033
Date Collected: 9/8/98

FILTER EXAM

Protozoa NONE SEEN
Nematodes NONE SEEN
Diatoms NONE SEEN
Algae 2+ nonmotile
Bacteria 3+ nonmotile
Debris 3+
Pellet size (ml): 6.0
Smears examined (#): 5

No Cryptosporidium or Giardia seen.

David L. Maserang, Ph.D.
Chief, Bureau of Laboratories
CLIA License Number 45D0660644

Texas Department of Health
AUSTIN, TEXAS 78756-3194
(512) 458-7318
BUREAU OF LABORATORIES
CLIA #45D0660644

CONFIDENTIAL LABORATORY REPORT

Submitter copy to: ** DUPLICATE REPORT ** Date: 9/14/98

TWC/WATER UTILITIES - FAX-00000010
P O BOX 13087
AUSTIN, TX 00001

Spec #: E98WF000033
Subm #:
Lab: ENVIRONMENTAL
Tel #: (512)458-7578

Source

CITY OF DEL RIO

Date Rcvd:	9/9/98	Collected at:	EAST SPRINGS EP001
Time Rcvd:	1430	Last rain:	14-15 DAYS
Spec Type:	WATER FILTER	Sample Is	Raw
Coll By:	DON WHITE	System ID #:	2330001
Air temp:	85 F	Turbidity(NTU):	3.20
Amt filtered:	500	Water temp:	23 C
Chlorine:	0.0MG/L	Test Reas:	ROUTINE

Final Results

Specimen Numbers:	E98WF000033
Date Collected:	9/8/98

FILTER EXAM

Protozoa	NONE SEEN
Nematodes	NONE SEEN
Diatoms	NONE SEEN
Algae	2+ nonmotile
Bacteria	3+ nonmotile
Debris	3+
Pellet size (ml):	6.0
Smears examined (#):	5

No Cryptosporidium or Giardia seen.

David L. Maserang, Ph.D.
Chief, Bureau of Laboratories
CLIA License Number 45D0660644

1100 West 49th Street
AUSTIN, TEXAS 78756-3194
(512) 458-7318

Texas Department of Health

BUREAU OF LABORATORIES
CLIA #45D0660644
CONFIDENTIAL LABORATORY REPORT

Submitter copy to: ** DUPLICATE REPORT ** Date: 9/9/98

TWC/WATER UTILITIES - FAX-00000010
P O BOX 13087
AUSTIN, TX 00001

Spec #: E98WF000030
Subm #: 2330001
Lab: ENVIRONMENTAL
Tel #: (512)458-7578

Source
CITY OF DEL RIO

Date Rcvd:	9/6/98	Last rain:	13 DAYS
Time Coll:	1000	Sample Is	Raw
Spec Type:	WATER FILTER	System ID #:	2330001
Coll By:	DON WHITE	Turbidity(NTU):	2.91
Air temp:	85 F	Water temp:	24 C
Amt filtered:	500 GALS	pH:	7.3
Chlorine:	0.0 mg/l	Test Reas:	ROUTINE
Collected at:	WEST SPRINGS EP002		

Final Results

Specimen Numbers:	E98WF000030
Date Collected:	9/5/98

FILTER EXAM

Protozoa NotTested
Nematodes Not Tested
Diatoms Not Tested
Algae Not Tested
Bacteria Not Tested
Debris Not Tested
Pellet size (ml): 6.0
Smears examined (#): 2

No Cryptosporidium or Giardia present.

David L. Maserang, Ph.D.
Chief, Bureau of Laboratories
CLIA License Number 45D0660644

Texas Department of Health

AUSTIN, TEXAS 78756-3194
(512) 458-7318

BUREAU OF LABORATORIES
CLIA #45D0660644
CONFIDENTIAL LABORATORY REPORT

Submitter copy to: ** DUPLICATE REPORT ** Date: 9/10/98

TWC/WATER UTILITIES - FAX-00000010
P O BOX 13087
AUSTIN, TX 00001

Spec #: E98WF000032
Subm #: 2330001
Lab: ENVIRONMENTAL
Tel #: (512)458-7578

Source

CITY OF DEL RIO

Date Rcvd:	9/8/98	Collected at:	WEST SPRINGS E P 002
Time Rcvd:	1300	Last rain:	14
Time Coll:	1000	Sample Is	Raw
Spec Type:	WATER FILTER	System ID #:	2330001
Coll By:	DON WHITE	Turbidity(NTU):	2.60 NTU
Air temp:	88F	Water temp:	23C
Amt filtered:	500	Test Reas:	ROUTINE
Chlorine:	0.0 MG/L		

Final Results

Specimen Numbers: E98WF000032
Date Collected: 9/7/98

FILTER EXAM

Protozoa 1+ nonmotile
Nematodes NONE SEEN
Diatoms NONE SEEN
Algae 2+ nonmotile
Bacteria 3+ motile
Debris 3+
Pellet size (ml): 5.0
Smears examined (#): 5

No Giardia or Cryptosporidium seen.

David L. Maserang, Ph.D.
Chief, Bureau of Laboratories
CLIA License Number 45D0660644

Texas Department of Health

AUSTIN, TEXAS 78756-3194
(512) 458-7318

BUREAU OF LABORATORIES
CLIA #45D0660644

CONFIDENTIAL LABORATORY REPORT

Submitter copy to: ** DUPLICATE REPORT ** Date: 9/15/98

TWC/WATER UTILITIES - FAX-00000010
P O BOX 13087
AUSTIN, TX 00001

Spec #: E98WF000034
Subm #:
Lab: ENVIRONMENTAL
Tel #: (512)458-7578

Source

DEL RIO UTILITIES

Date Rcvd: 9/10/98
Time Rcvd: 0900
Time Coll: 1155
Spec Type: WATER FILTER
Coll By: JAY DON JOBSON
Amt filtered: 425
Chlorine: 0

Collected at: WEST SPRING EP #002
Last rain: 2 WEEKS
Sample Is Raw
System ID #: 2330001
Turbidity(NTU): 2.5
Test Reas: ROUTINE

Final Results

Specimen Numbers:	E98WF000034
Date Collected:	9/9/98
FILTER EXAM	Protozoa Not Tested Nematodes Not Tested Diatoms Not Tested Algae Not Tested Bacteria Not Tested Debris Not Tested Pellet size (ml): 5.0 Smears examined (#): 2

No Cryptosporidium or Giardia seen.

David L. Maserang, Ph.D.
Chief, Bureau of Laboratories
CLIA License Number 45D0660644

Texas Department of Health
AUSTIN, TEXAS 78756-3194
(512) 458-7318

BUREAU OF LABORATORIES
CLIA #45D0660644
CONFIDENTIAL LABORATORY REPORT

Submitter copy to: ** DUPLICATE REPORT ** Date: 9/19/98

WC/WATER UTILITIES - FAX-00000010
P O BOX 13087
AUSTIN, TX 00001

Spec #: E98WF000035
Subm #:
Lab: ENVIRONMENTAL
Tel #: (512)458-7578

Source
DEL RIO UTILITIES

Date Rcvd: 9/11/98
Time Rcvd: 0700
Time Coll: 1150
Spec Type: WATER FILTER
Coll By: JAY DON JOBSON
Amt filtered: 460
Chlorine: 0

Collected at: EAST SPRING EP#001
Last rain: 2 WEEKS
Sample Is Raw
System ID #: 2330001
Turbidity(NTU): 2.6
Test Reas: ROUTINE

Final Results

Specimen Numbers:	E98WF000035
Date Collected:	9/10/98
FILTER EXAM	Pellet size (ml): 5.0
	Smears examined (#): 2

No Cryptosporidium or Giardia seen.
Microscopic Particulate Analysis (MPA) not performed.

David L. Maserang, Ph.D.
Chief, Bureau of Laboratories
CLIA License Number 45D0660644

Texas Department of Health

AUSTIN, TEXAS 78756-3194
(512) 458-7318

BUREAU OF LABORATORIES
CLIA #45D0660644
CONFIDENTIAL LABORATORY REPORT

Submitter copy to: ** DUPLICATE REPORT ** Date: 9/9/98

TWC/WATER UTILITIES - FAX-00000010
P O BOX 13087
AUSTIN, TX 00001

Spec #: E98WF000031
Subm #: 233001
Lab: ENVIRONMENTAL
Tel #: (512)458-7578

Source
~~CITY OF UVALDE~~ Del Rio

Date Rcvd:	9/7/98	Collected at:	EAST SPRINGS EP 001
Time Coll:	1045	Last rain:	13 DAYS
Spec Type:	WATER FILTER	Sample Is	Raw
Coll By:	DON WHITE	System ID #:	233001
Air temp:	85 F	Turbidity(NTU):	2.44 NTU
Amt filtered:	500 GAL	Water temp:	23 C
Chlorine:	0.0 MG/L	Test Reas:	ROUTINE

Final Results

Specimen Numbers:	E98WF000031
Date Collected:	9/6/98
FILTER EXAM	Protozoa Not Tested
	Nematodes NotTested
	Diatoms NotTested
	Algae Not Tested
	Bacteria Not Tested
	Debris Not Tested
	Pellet size (ml): 6.0
	Smears examined (#): 2

No Cryptosporidium or Giardia seen.

David L. Maserang, Ph.D.
Chief, Bureau of Laboratories
CLIA License Number 45D0660644

TDH
TEXAS DEPARTMENT OF HEALTH

Texas Department of Health

William R. Archer III, M.D.
Commissioner of Health

http://www.tdh.state.tx.us

1100 West 49th Street
Austin, Texas 78756-3199
512/ 458-7111

Patti J. Patterson, M.D., M.P.H.
Executive Deputy Commissioner

FAX COVERSHEET

DATE: 5/27/99

TO: Larry Mitchel

Phone 239-6020

FAX NO: 239-6050

FROM: Katherine von Alt 458-7560

Number of pages (including coversheet) 5

OUR FAX NO (512) 458-7294

If any page is missing or illegible, please telephone (512) 458-7318 immediately and we will retransmit.

MESSAGE: Hope this Helps -
If you need anything else - let me know

Texas Department of Health
Specimen Inquiry

May 27, 1999
<ENVIRONMENTAL>

Spec Status: Closed Rcvd: 6/18/1993 1030 Spec #: E93WF000019
Source: CITY OF DEL RIO
Agency: 00000010-TWC/WATER UTILITIES - FAX City: AUSTIN

Requisition Entry Information

Source: CITY OF DEL RIO

Agency: TWC/WATER UTILITIES - FAX-00000010
P O BOX 13087
AUSTIN, TX 00001

Panel	Test Selected	Priority	NR?	Account
	FILTERS	Normal	NO	

Collected: 6/17/1993
Specimen Type: WATER FILTER
System ID #: 233001
Chlorine: .7
Turbidity(NTU): .44
Air temp: 25.6
pH: 7.26

Report History

Printed on	Type	Recipient	Tests	Other Spec
6/24/1993 1130	Sub	TEXAS WATER COMM/WATER UTILITIES	FILTERS	

Test Information

None

Preliminary Results

None

Batch Summary

None

Communication Log

Type of Contact	Date	Time	Lab Contact	Other Contact
Incoming call	5/27/1999	1047	VON ALT, KATHERINE	LARRY MITCHEL

Notes:
Requested a fax copy of reprot.

Org.	(-)	1+	2+	3+	4+	comments
GI	✓					
Crypto	✓					
Prot.		✓				
Dem.		✓				
Diatoms			✓			
Algae ✓		✓				
Bact.			✓			
Debris					✓	
Motil.						

Pellet size 4.75 # slides exam. 1

Received
6-23-23 BK

June 17 1993 – 500 gall filtration test

Time		Reading
1450	Before 30 gallon flush	13520
1458	After 30 gallon flush	13550
1504	Before 500 gallon test	13550
1722	After 500 gallon test	14050
1445	Cl_2 Residual	0.7
1520	Temperature	25.6 C°
1520	PH	7.26

TURBIDITY

1502	Before filtration	1.4
1620	During filtration	0.165
1735	After filtration	0.44

City of Del Rio System #2350001
109 W Broadway
Del Rio, Tx (78840)

TURBIDITY West Springs

1032	2.5	RD JD	@ 1400 [illegible] Tony Bessel
1113	2.1	RD - JD	from TDH and Reported present
1152	1.2	RD - JD	turbidity [illegible] [illegible] Mr
1230	1.2	RD	Bessel [illegible] Heaton Test
1300	1.2	RD	and hand deliver Samples in
1340	2.5	RD	the morning of 6-18-95 to
1421	2.4	RD	Austin Lab. for testing
1510	1.4	RD JD	
1620	0.65	RD JD	
1732	0.4[illegible]	RD JD	