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

January 2001
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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
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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.
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
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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.
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
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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/ft²). 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 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 as 187,700 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:

<table>
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<tr>
<td>Fluoride</td>
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<td>Nitrate (as N)</td>
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<th>Secondary Standards</th>
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<td><strong>Constituent</strong></td>
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<tr>
<td>Chloride</td>
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<td>Fluoride</td>
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<tr>
<td>Iron</td>
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<td>Sulfate</td>
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<td>Dissolved Solids</td>
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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.

<table>
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<th>Sample Date</th>
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<td><strong>Wells</strong></td>
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<td>7/19/00</td>
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<tr>
<td>Tierra del Lago</td>
<td>4/22/99</td>
<td>25.5</td>
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<td><strong>Springs</strong></td>
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<td>450</td>
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<tr>
<td>San Felipe West Spring (Pump #5)</td>
<td>3/15/99</td>
<td>24.0</td>
<td>535</td>
<td>7.1</td>
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</table>
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 1950s 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
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in the Del Rio Area, Texas

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


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in the Del Rio Area, Texas


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


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<th>SYSTEM</th>
<th>SERIES</th>
<th>STAGE/GROUP</th>
<th>FORMATION</th>
<th>FUNCTION</th>
<th>MEMBER OR INFORMAL UNIT</th>
<th>APPROXIMATE THICKNESS (feet)</th>
<th>LITHOLOGY</th>
<th>HYDROSTRATIGRAPHY</th>
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<td>Alluvial fan and fluviatile terrace deposits</td>
<td>Aquifer where saturated</td>
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<td>6 - 80</td>
<td>Gravel, sand, silt and clay. Coarser nearer the base and toward the Balcones Fault Escarpment.</td>
<td>Alluvial fans extending from the Balcones Fault Escarpment. Associated fluviatile deposits.</td>
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<td>Anacacho Limestone</td>
<td>Confining Bed</td>
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<td>500</td>
<td>Limestone and marl; contains bentonite; chalky, and massive bedded.</td>
<td>Little permeability.</td>
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<td>Undivided</td>
<td>Confining Bed</td>
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<td>Chalk and marl; chalk mostly microgranular calcite; bentonite seams, glauconitic.</td>
<td>Little to moderate permeability.</td>
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<td>Igneous rocks</td>
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<td>Basalt.</td>
<td>Intrusive sills, laccoliths, and volcanic necks. Negligible permeability.</td>
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<td>Shale, siltstone, and limestones; flaky limestone beds are interbedded with carbonaceous shale</td>
<td>Little permeability.</td>
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<td>Buda Limestone</td>
<td>Confining Bed</td>
<td></td>
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<td>100</td>
<td>Limestone; fine-grained, bioclastic, glauconitic, hard, massive, nodular, argillaceous toward top.</td>
<td>Little permeability.</td>
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<td></td>
<td>Del Rio Clay</td>
<td>Confining Bed</td>
<td></td>
<td></td>
<td>120</td>
<td>Clay and shale; calcarceous and gysiferous; some thin beds of siltstone.</td>
<td>Negligible permeability.</td>
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<td>Salmon Peak Formation</td>
<td>Aquifer</td>
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<td>380</td>
<td>Limestone; upper 85 feet contains reef talus gravestones and caprinid boundstones, crossbedding of gravestones; the lower 300 feet is a uniform dense carbonate mudstone.</td>
<td>Deep water deposits except toward the top. Upper part is moderately to very permeable. Lower part is almost impermeable except where fractured.</td>
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<td>McKnight</td>
<td>Confining Bed</td>
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<td>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</td>
<td>Deep basinal, euxinic deposits. Little permeability.</td>
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<td>West Nueces</td>
<td>Confining Bed</td>
<td></td>
<td></td>
<td>140</td>
<td>Limestone; upper 80 feet is largely a massive unit of milliod and mouluske-bearing gravestone; lower 60 feet is a nodular, dense mudstone.</td>
<td>Upper part is moderately permeable. Lower part is almost impermeable.</td>
</tr>
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<td>Trinity</td>
<td>Glen Rose</td>
<td>Confining Bed</td>
<td>Upper member</td>
<td>1,000 - 1,500</td>
<td>Limestone, dolomite, and marl; limestone is fine-grained, hard to soft, marly; dolomite is porous and finely crystallized.</td>
<td>Little permeability.</td>
</tr>
<tr>
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<td>Lower member</td>
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<td>Limestone and some marl. Massive bedded.</td>
<td>More permeable toward base of unit.</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>Sandstone and limestone.</td>
<td>Little permeability.</td>
</tr>
</tbody>
</table>

(Modified from Macay and Small, 1984)

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

FIGURE 12
LBG-GUYTON ASSOCIATES

CALCULATIONS

\[ Q = 711 \text{ gpm} \]
\[ \Delta s = 14.5 - 13.3 = 1.2 \text{ feet} \]
\[ T = 264Q/\Delta s \]
\[ T = 156,420 \text{ gpd/ft} \]
INTERFERENCE EFFECTS CAUSED BY PUMPING

FIGURE 11

LBG-GUYTON ASSOCIATES
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
CROSS SECTION B - B'

FIGURE 3B

LBG-GUYTON ASSOCIATES
EDWARDS AQUIFER
CROSS SECTION A - A'

VERTICAL SCALE: 1" = 400'
HORIZONTAL SCALE: 1" = 40,000'
VERTICAL EXAGGERATION = 100x

Cross section adapted from Small (USGS, retired).

FIGURE 3A

LBG-GUYTON ASSOCIATES
EDWARDS OUTCROP AND DEPOSITIONAL ENVIRONMENT
FOR CENTRAL TEXAS

FIGURE 2

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

FIGURE 17
LBG-GUYTON ASSOCIATES
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

Pumping Test started 1550 on 3/10/99

CALCULATIONS
Q = 286 gpm
Δs = 310 - 270 = 40 feet
T = 264Q/Δs
T = 1,890 gpd/ft
APPENDIX 3

LABORATORY REPORTS OF ANALYSES BY LCRA
### FINAL ANALYSIS REPORT

**LAB ID:** 9905602  
**SAMPLE DESCRIPTION:** Groundwater  
**COMPANY:** LBG-Guyton Associate  
**ACCT NO:**  
**REQUISITION No.:** R10369  
**LOCATION ID:** San Felipe East #2  
**SAMPLE DATE:** 03/11/99  
**SAMPLE TIME:** 16:55  
**DATE RECEIVED:** 03/12/99  
**REPORT DATE:** 03/26/99

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>RESULTS</th>
<th>UNITS</th>
<th>METHOD #</th>
<th>PQL in WATER</th>
<th>DATE ANALYZED</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chloride</td>
<td>9.8</td>
<td>mg/L</td>
<td>EPA300.0</td>
<td>1.5</td>
<td>03/12/99</td>
</tr>
<tr>
<td>Fluoride</td>
<td>0.10</td>
<td>mg/L</td>
<td>EPA300.0</td>
<td>0.01</td>
<td>03/23/99</td>
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<td>Nitrogen, Nitrate</td>
<td>1.930</td>
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<td>EPA300.0</td>
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<tr>
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<td>mg/L</td>
<td>EPA300.0</td>
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<td>mg/L</td>
<td>EPA300.0</td>
<td>1.50</td>
<td>03/12/99</td>
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<td>ug/L</td>
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<td>03/18/99</td>
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<td>1.0</td>
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<td>Selenium, Dis. ICPMS</td>
<td>&lt;4.0</td>
<td>ug/L</td>
<td>EPA200.8</td>
<td>4.0</td>
<td>03/18/99</td>
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<tr>
<td>Silver, Diss. ICPMS</td>
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<td>EPA200.8</td>
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<td>Sodium, Dissolved</td>
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<td>Beryllium, Dis ICPMS</td>
<td>63.4</td>
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<td>EPA200.8</td>
<td>1.0</td>
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<td>Zinc, Diss. ICPMS</td>
<td>10.7</td>
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<td>EPA200.8</td>
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<td>03/18/99</td>
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<tr>
<td>Alkalinity, Total</td>
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<td>mg/L</td>
<td>EPA310.1</td>
<td>1</td>
<td>03/16/99</td>
</tr>
<tr>
<td>Alkalinity, bicarb.</td>
<td>203</td>
<td>mg/L</td>
<td>SM2320B</td>
<td>0</td>
<td>03/15/99</td>
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<tr>
<td>Residue, Filt. - TDS</td>
<td>235</td>
<td>mg/L</td>
<td>EPA160.1</td>
<td>5</td>
<td>03/12/99</td>
</tr>
</tbody>
</table>

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

Sampled by W. G. Stein  
**Note:** Metals filtered 0.45 μ
# 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:** 03/15/99  
**SAMPLE TIME:** 1610  
**DATE RECEIVED:** 03/16/99  
**REPORT DATE:** 03/25/99

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<tr>
<th>PARAMETER</th>
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<th>UNITS</th>
<th>METHOD #</th>
<th>PQL in WATER</th>
<th>DATE ANALYZED</th>
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</thead>
<tbody>
<tr>
<td>Aluminum, DW</td>
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<td>EPA200.9</td>
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<td>ug/L</td>
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<td>03/18/99</td>
</tr>
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<td>mg/L</td>
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<td>03/18/99</td>
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<tr>
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<td>EPA200.8</td>
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<td>03/18/99</td>
</tr>
<tr>
<td>Copper, DW</td>
<td>&lt;2.0</td>
<td>mg/L</td>
<td>EPA200.8</td>
<td>2.0</td>
<td>03/18/99</td>
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<td>Fluoride</td>
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<td>EPA300.0</td>
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<td>EPA200.7</td>
<td>0.05</td>
<td>03/22/99</td>
</tr>
<tr>
<td>Lead, DW</td>
<td>&lt;1.0</td>
<td>mg/L</td>
<td>EPA200.8</td>
<td>1.0</td>
<td>03/18/99</td>
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<tr>
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<tr>
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<td>mg/L</td>
<td>EPA200.8</td>
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<td>Nitrogen, Nitrate</td>
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<td>EPA300.0</td>
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<tr>
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<td>mg/L</td>
<td>EPA300.0</td>
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<td>03/22/99</td>
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<td>Selenium, DW</td>
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<td>mg/L</td>
<td>EPA200.8</td>
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<td>03/18/99</td>
</tr>
<tr>
<td>Silver, DW</td>
<td>&lt;1.0</td>
<td>mg/L</td>
<td>EPA200.8</td>
<td>1.0</td>
<td>03/18/99</td>
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<tr>
<td>Sodium, DW</td>
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<td>mg/L</td>
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<td>03/22/99</td>
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<tr>
<td>Sulfate</td>
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<td>EPA300.0</td>
<td>1.50</td>
<td>03/17/99</td>
</tr>
<tr>
<td>Tot. Coli. Pres/Abs.</td>
<td>Present</td>
<td>/100 ml</td>
<td>Pres/Abs</td>
<td>-----</td>
<td>03/16/99</td>
</tr>
<tr>
<td>Zinc, DW</td>
<td>&lt;4.000</td>
<td>mg/L</td>
<td>EPA200.8</td>
<td>4.000</td>
<td>03/18/99</td>
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<tr>
<td>Alkalinity, Total</td>
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<td>mg/L</td>
<td>SM2320B</td>
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<td>03/18/99</td>
</tr>
<tr>
<td>Residue, Filt. - TDS</td>
<td>277</td>
<td>mg/L</td>
<td>EPA160.1</td>
<td>5</td>
<td>03/17/99</td>
</tr>
</tbody>
</table>

Total Coliform Comments: Found Total Coliform

**Field pH = 7.1**  
**Field Cond. = 535 mhos**  
**Field Temp. = 24.0°C**

**Sampled by W.G. Stein**  
**Note: Metals filtered 0.45μM**
REPORT OF SAMPLE ANALYSIS

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

SAMPLE INFORMATION

<table>
<thead>
<tr>
<th>Project Name</th>
<th>LABORATORY INFORMATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample ID:</td>
<td>PCS Sample #:</td>
</tr>
<tr>
<td>San Felipe Springs West #5b</td>
<td>78149</td>
</tr>
<tr>
<td>Date Taken:</td>
<td>Date Received:</td>
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<tr>
<td>04/13/1999</td>
<td>04/14/1999</td>
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<tr>
<td>Time Taken:</td>
<td>Time Received:</td>
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<tr>
<td>1730</td>
<td>09:00</td>
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<td>Report Date:</td>
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<th>TEST DESCRIPTION</th>
<th>RESULT</th>
<th>UNITS</th>
<th>ANALYZED DATE</th>
<th>ANALYST'S INITIALS</th>
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<tr>
<td>Coliform, Total (Present/Absent)</td>
<td>Absent</td>
<td>N/A</td>
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</table>

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: [Signature]

CHUCK WALLGREN

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

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>RESULTS</th>
<th>UNITS</th>
<th>METHOD #</th>
<th>PQL in WATER</th>
<th>DATE ANALYZED</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aluminum, DW</td>
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<td>4.0</td>
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<td>ug/L</td>
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<td>03/18/99</td>
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<td>03/17/99</td>
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<tr>
<td>Nitrogen, Nitrite</td>
<td>&lt;0.010</td>
<td>mg/L</td>
<td>EPA300.0</td>
<td>0.010</td>
<td>03/17/99</td>
</tr>
<tr>
<td>Potassium, DW</td>
<td>2.5</td>
<td>mg/L</td>
<td>EPA200.7</td>
<td>0.2</td>
<td>03/22/99</td>
</tr>
<tr>
<td>Selenium, DW</td>
<td>&lt;4.0</td>
<td>ug/L</td>
<td>EPA200.8</td>
<td>4.0</td>
<td>03/18/99</td>
</tr>
<tr>
<td>Silver, DW</td>
<td>&lt;1.0</td>
<td>ug/L</td>
<td>EPA200.8</td>
<td>1.0</td>
<td>03/18/99</td>
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<td>mg/L</td>
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<td>03/25/99</td>
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<td>Tot. Coli. Pres/Abs.</td>
<td>Present</td>
<td>/100 ml</td>
<td>Pres/Abs</td>
<td>-----</td>
<td>03/16/99</td>
</tr>
<tr>
<td>Zinc, DW</td>
<td>&lt;4.000</td>
<td>ug/L</td>
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<td>03/18/99</td>
</tr>
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<td>Alkalinity, Total</td>
<td>196</td>
<td>mg/L</td>
<td>EPA310.1</td>
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<tr>
<td>Alkalinity, bicarb.</td>
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<td>mg/L</td>
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<td>0</td>
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<td>Residue, Filt. - TDS</td>
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<td>mg/L</td>
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**Total Coliform Comments:** Found Total Coliform

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

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

---

Pump started 1930 on 3/14/99 at rate of 780 gpm
To: W.G. Stein  
LBG-Guyton Associates  
1101 S. Capital of Texas Highway  
Austin, TX 78746-6437

---

**SAMPLE INFORMATION**

<table>
<thead>
<tr>
<th>Project Name:</th>
<th>Del Rio</th>
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<tr>
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<td>Date Taken:</td>
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<td>Time Taken:</td>
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**LABORATORY INFORMATION**

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<td>Time Received:</td>
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<td>Report Date:</td>
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**SAMPLE TESTED**

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<tr>
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<th>SAMPLE RESULT</th>
<th>UNITS</th>
<th>ANALYZED DATE</th>
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<th>METHOD</th>
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**QUALITY ASSURANCE DATA**

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<th>M.D.L.</th>
<th>PRECISION</th>
<th>LIMIT</th>
<th>LCL</th>
<th>RECOVERY</th>
<th>UCL</th>
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<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
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</table>

---

APPROVED BY: [Signature]

Chuck Wallgren

1-800-880-4616  
435 Isom Road, Suite 228  
San Antonio, TX 78216-5144  
(210) 340-0343
<table>
<thead>
<tr>
<th>PARAMETER</th>
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<th>UNITS</th>
<th>METHOD #</th>
<th>PQL in WATER</th>
<th>DATE ANALYZED</th>
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Field pH 7.2
Field Cond. 725 µmho
Field Temp 25°C

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

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

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<tr>
<th>Parameter</th>
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<th>Date Analyzed</th>
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<tbody>
<tr>
<td>Carbon, Tot. Organic</td>
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<td>mg/L</td>
<td>EPA415.1</td>
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<td>Pres/Abs</td>
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</tr>
<tr>
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Total Coliform Comments: Not Found

Field pH 7.1  
Field Conductivity 730 uS/cm  
Field Temp 24.0°C

Pump started 11/21 on 4/12/99 at 240 - 260 gpm

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

Page 2

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
**FINAL ANALYSIS REPORT**

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

<table>
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<tr>
<th>PARAMETER</th>
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<th>METHOD #</th>
<th>PQL in WATER</th>
<th>DATE ANALYZED</th>
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<tbody>
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<td>/100 ml</td>
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</tr>
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</table>

Total Coliform Comments: Not Found

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

Sampled by W.G. Stein
Note: Filtered w/0.45 M Metals

---

Lower Colorado River Authority • P. O. Box 220 • Austin, Texas 78767
3305 Montopolis Drive • Austin, Texas 78744 • (512) 356-6022 • (800) 776-3872 • (512) 356-6021 FAX
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)458-7570

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. Masang, Ph.D.
Chief, Bureau of Laboratories
CLIA License Number 45D0660644
<table>
<thead>
<tr>
<th>Analyses</th>
<th>Result</th>
<th>PQL</th>
<th>Qual</th>
<th>Units</th>
<th>DF</th>
<th>QC Batch</th>
<th>Date Analyzed</th>
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<tbody>
<tr>
<td>ICP METALS IN DRINKING WATER</td>
<td>E200.7</td>
<td></td>
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<tr>
<td>Calcium</td>
<td>63.3</td>
<td>0.200</td>
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<td>1</td>
<td>R5202</td>
<td>07/31/2000</td>
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<td>Iron</td>
<td>ND</td>
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<td>mg/L</td>
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<td>1</td>
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<td>Magnesium</td>
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<td>Potassium</td>
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<td>mg/L</td>
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<td>Sodium</td>
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<td>0.700</td>
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<td>ICPMS METALS IN DRINKING WATER</td>
<td>E200.8</td>
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<td>Lead</td>
<td>ND</td>
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<td>R5198</td>
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<td>ANIONS BY ION CHROMATOGRAPHY</td>
<td>E300</td>
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<tr>
<td>Bromide</td>
<td>0.0900</td>
<td>0.0200</td>
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<td>Chloride</td>
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<td>mg/L</td>
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<tr>
<td>Fluoride</td>
<td>0.430</td>
<td>0.0100</td>
<td>mg/L</td>
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<td>07/21/2000</td>
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<tr>
<td>Nitrogen, Nitrate (As N)</td>
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<td>0.0100</td>
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<tr>
<td>Sulfate</td>
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<tr>
<td>ALKALINITY</td>
<td>M2320</td>
<td></td>
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<tr>
<td>Alkalinity, Bicarbonate (As CaCO₃)</td>
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<tr>
<td>Alkalinity, Total (As CaCO₃)</td>
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<td>mg/L CaCO₃</td>
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<td>SILICA</td>
<td>E370.1</td>
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<td>Silica, Dissolved (as SiO₂)</td>
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<tr>
<td>TOTAL DISSOLVED SOLIDS</td>
<td>E160.1</td>
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<tr>
<td>Total Dissolved Solids (Residue, Filterable)</td>
<td>224</td>
<td>5.000</td>
<td>mg/L</td>
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<td>1</td>
<td>R5114A</td>
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</table>

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

Sampled by W.G. Stein

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

Qualifiers:
- ND - Not Detected above the Reporting Limit
- J - Analyte detected below quantification 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
### WELL REPORT

**1) OWNER**: City of Del Rio  
**ADDRESS**: 109 W. Broadway  
**TX**: 78840

**2) LOCATION OF WELL**:  
County: Val Verde  
Miles in direction from Del Rio: 1

**3) TYPE OF WORK (Check):**  
- [ ] New Well  
- [ ] Deepening  
- [x] Reconditioning  
- [ ] Plugging

**4) PROPOSED USE (Check):**  
- [ ] Domestic  
- [ ] Industrial  
- [x] Monitor  
- [ ] Public Supply  
- [ ] Firefighting  
- [ ] Test Well  
- [ ] Injection  
- [ ] De-Watering

**5) DRILLING METHOD (Check):**  
- [x] Air Rotary  
- [ ] Cable Tool  
- [ ] Other

**6) WELL LOG:**  
- **Date Drilling:**  
  - Started: 8-1  
  - Completed: 8-3  
- **Diameter of Hole (in ft.):**  
  - [ ] 9'2" from surface  
  - [ ] 100' from 9'2"  
  - [ ] 600' from 100'
- **Description of formation material:**  
  - [ ] Fill: gravel  
  - [ ] 40-100 white limestone  
  - [ ] 100-150 white limestone  
  - [ ] 150-162 “rough drilling”  
  - [ ] 162-308 yellow limestone  
  - [ ] 308-370 gray “more water”  
  - [ ] 370-450 white limestone “rough  
    - fast drilling  
  - [ ] 450-496 white limestone “more water”  
  - [ ] 496-500 (Use reverse side if necessary: gray shell

**7) BOREHOLE COMPLETION:**  
- [ ] Open Hole  
- [ ] Straight Wall  
- [ ] Underreamed  
- [ ] Gravel Pack  
- [ ] Other

**8) CASING, BLANK PIPE, AND WELL SCREEN DATA:**  
- **Steel, Plastic, etc.**  
  - [ ] 9'6" steel  
- **Setting (ft.):**  
  - From: 0'  
  - To: 90'

**9) CEMENTING DATA (Rule 287.44(1)):**  
- **Cemented from:**  
  - From: 0'  
  - To: 90'  
- **No. of Sacks Used:**  
  - From: 0  
  - To: 0

**10) SURFACE COMPLETION:**  
- [ ] Specified Surface Slab Installed  
- [ ] Flexi-Adaptor Used  
- [ ] Approved Alternative Procedure Used

**11) WATER LEVEL:**  
- **Static level:** 104 ft. below land surface  
- **Date:** 8-4-90  
- **Gage:**  
- **Casting Screen:**

**12) PACKERS:**

**13) TYPE PUMP:**  
- [ ] Turbine  
- [ ] Jet  
- [ ] Submersible  
- [ ] Cylinder  
- [ ] Other

**Depth to pump bowls, cylinder, jet, etc., ft.**

**14) WELL TESTS:**  
- **Type Test:**  
  - [ ] Pump  
  - [ ] Bailer  
  - [ ] None  
- **Yield:**

**15) WATER QUALITY:**  
- **Did the drilling penetrate any strata which contained undesirable constituents?**  
  - Yes  
  - No  
- **Type of water:**
- **Depth of strata:**
- **Was a chemical analysis made?**  
  - Yes  
  - No

**COMPANY NAME:** Hallon Drilling Inc.  
**WELL DRILLER’S LICENSE NO.:** 2473 W

**ADDRESS:** 905 N. Main  
**Del Rio**  
**TX:** 78840

**(Signed):**

**(Registered Driller Trainee):**

---

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.

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

**Texas Water Commission Copy**
APPENDIX 1

TEXAS WATER DEVELOPMENT BOARD RECORDS
FOR CITY OF DEL RIO WELLS
Texas Water Development Board
Well Schedule

State Well No. 70 33 608
Previous Well No. County Val Verde
River Basin Rio Grande Zone 1
Lat. 29° 35' 15" Long. 100° 54' 38"
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/Op. Mitchell Lemus

Date Drilled Depth
Well Type user 201 250 00
Aquifer Edwards

Well Construction
Constr. Method
Casing Material Steel

Completion 
Screen Material 

Lift Data
Pump Mfr. Type Turbine No. Stages

Bowls Diam. Setting ft. Column Diam. in.
Motor Mfr. Fuel or Power Horsepower

Yield Flow GPM Pump GPM Meas. Rept. Est. Date
Performance Test Date Length of Test Production GPM

Quality (Remarks)
Water Use Primary Mixed Secondary Tertiary

Other Data Available
Water Level Water Quality Logs Other Data

Date 

Water Level Date 

Water Level Date 

Could not find D. Log

Recorded By D.R. James Date Record Collected or Updated 05 24 1984 (20 max) Reporting Agency 01

Aquifer Edwards
Well No. 70 33 608

99-3284 2/999
**WATER WELL REPORT**

**State of Texas**

**City of Del Rio**

**Address:** 109 W. Broadway

**City:** Del Rio, **State:** Tx, **Zip:** 78840

**Well No.:** 904-33-38

**ATTENTION OWNER:** Confidentiality Privilege Notice on Reverse Side

**1. OWNER:** City of Del Rio

**2. LOCATION:**

**Well No.:** 3.3

**Street or RFO:** N

**City:** Del Rio

**Street:** Broadway

**Town:** City Hall

**3. TYPE OF WORK (Check):**

- New Well
- Deepening
- Domestic
- Industrial
- Public Supply
- Recommissioning
- Drilling
- Other

**4. PROPOSED USE (Check):**

- Domestic
- Industrial
- Public Supply
- Other

**5. DRILLING METHOD (Check):**

- Mud Rotary
- Air Hammer
- Driven
- Trench
- Air Rotary
- Cable Tool
- Jetted
- Other

**6. WELL LOG:**

<table>
<thead>
<tr>
<th>Diameter of Hole</th>
<th>From (ft.)</th>
<th>To (ft.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>431</td>
<td></td>
</tr>
<tr>
<td>26</td>
<td>0</td>
<td>256</td>
</tr>
</tbody>
</table>

**7. BOREHOLE COMPLETION:**

- Open Hole
- Straight Wall
- Underslabbed
- Gravel Packed
- Other Open Hole 256-431

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

<table>
<thead>
<tr>
<th>Depth (ft.)</th>
<th>Steel, Plastic, etc.</th>
<th>Per. Slotted, etc.</th>
<th>Screen Wrap, if commercial</th>
</tr>
</thead>
<tbody>
<tr>
<td>22</td>
<td>N Steel</td>
<td>6</td>
<td>256</td>
</tr>
</tbody>
</table>

**9. CEMENTING DATA:**

- Cemented from 0 ft. to 256 ft.
- Method used: Pump thru B.P. or 1" Line
- Cemented by Halliburton

**10. WATER LEVEL:**

- Static level: 92 ft. below land surface
- Date: 6/81
- Annual flow: -0- gpm
- Date:

**11. PACKERS:**

- Type: None

**12. TYPE PUMP:**

- Turbine
- Jet
- Submersible
- Cylinder
- Other

- Depth to start: 300 ft.

**13. WELL TESTS:**

- Type: Yield
- Pressure: 460 gpm
- Drawdown: 302 ft. at 24 hrs.

- Depth: 256 ft.

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

**Water Well Driller:**

**Registration No.:** 999

**ADDRESS:** 5531 Brittmoore Road

**City:** Houston, **State:** Texas

**77041**

**(Signature):**

Layne-Western Company, Inc.

**Company Name:**

**RECEIVED:**

DEPARTMENT OF WATER RESOURCES COPY

70-33-608
CITY OF DEL RIO  
WATER WELL NO. 2  
Job No. M-1202  
Original - July 22, 1981  
Revised - August 12, 1981

<table>
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<tr>
<th>Depth</th>
<th>Drillers Log</th>
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<tr>
<td>0 - 2'</td>
<td>Top Soil</td>
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<tr>
<td>2'- 42'</td>
<td>Rock and Clay</td>
</tr>
<tr>
<td>42'</td>
<td>Lost Circulation</td>
</tr>
<tr>
<td>42' to 375'</td>
<td>Rock, Limestone with short breaks</td>
</tr>
<tr>
<td>375'</td>
<td>Rock, sticky, difficult to clean hole</td>
</tr>
<tr>
<td>375'-381'</td>
<td>Rock, limestone</td>
</tr>
<tr>
<td>381'-406'</td>
<td>Lime, chalky</td>
</tr>
<tr>
<td>406'-431'</td>
<td></td>
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</tbody>
</table>
Texas Water Development Board
Well Schedule

State Well No. 70 33 904  Previous Well No.  County Val Verde
River Basin Rio Grande  Zone 2  Lat. 29° 24' 17"  Long. 100° 54' 27"
Owner's Well No.  Location 1/4, 1.4, Section, Block, Survey

Owner CITY OF DEL RIO  Driller LAINE WESTERN CO.
Address 114 W. Martin, Del Rio, TX 78840  Tenant/Oper. MITCHELL ROMAS
Date Drilled 03/13/1981  Depth 1431  Source of Depth Datum
Aquifer Edwards Limestone
Well Const. Method Mud Rotary  Casing Material Steel
Completion Open Hole  Screen Material
Lift Data Pump Mfr.  Type  No. Stages
Bowls Diam. 380 in.  Setting Column Diam. in.
Motor Mfr. Electric  Horsepower
Yield Flow GPM Pump GPM Mean Res. Est. Date
Performance Test Date 4/81  Length of Test 24 Hour Production 440 GPM
Quality (Remarks)
Water Use Primary  Supply  Secondary  Tertiary
Other Data Available Water Level Log Water Quality Log Other Data
6/19/74 Date 6/12 1971 Meas. 42 63  Driller
Levels Date Meas.

Measured yield 460 GPM with 303 feet drawdown after pumping 24 hours in 1981. Specific capacity 1.52 GPM/ft. Pumping level 394 feet.

No, this is HACKERRY WELLY NOT AGARRITA

Recorded By CINDY LEE  Data Record Collected or Updated 05/24/1984
(20 max) Reporting Agency 01

Aquifer ZIELED  Well No. 70 33 904
Water Quality Sampling Run

Att:  Mitchell Comas
Name: City of Del Rio
Address: 114 W. Martin
Del Rio, TX 78840

Sample No. CL-1994-806
Date: 5-21-94
By: C. Jones

TOTAL SUB-SAMPLS 5

Preserve with: 2 ml 2 ml 1 ml
Anions Cations Radioactivity Nitrate (FOG) Organics
HNO₃ (Nitric) HNO₃ (Nitric) H₂SO₄ (Sulfuric)

All filtered unless otherwise stipulated.
All on ice.

Time In: PUMP ON 10:50
Time Out: 12:00
Starting pH 7.17

Weather sunny, breezy, hot

Outside Temp: __________

Sampling point:

pH: 7.25 7.05 7.00 7.02
Temp: 70.3 70.3 70.3 70.4
Eh: 495
Cond: 948 956 955 957

ml  pH  ml  pH  ml  pH
1  7.13  102  4.46
2  6.87
3  6.69
4  6.47
5  6.33
6  6.22
7  6.0
8  5.71
9  5.31
10 4.69

Other notes:

---

Water Level LSD 24.4 c 954 umhos/cm
Temperature (00010) 7.02
Specific Conductance (00094) 954 umhos/cm
pH (00400) 24.4 c
Eh (00090) -9.5 mv.

Phenol ALK (82244) 8 mg/l
Total ALK (39086) 204 mg/l
Carbonate (00452) 0 meq/l
Bicarbonate (00453) 4.08 meq/l
Total Cations (+) ______
Total Anions (-) ______
Total Hardness (46570) 330
Dissolved Solids (70301) 615
Texas Water Development Board
Chemical Water Analysis Report

HM: CL 1994. 8060
HM = Heavy Trace and Alkaline-Earth Metals

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

Date Drilled: Depth:
Collection Point: FAW
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 µS/cm

Requested Chemical Analysis

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<th>Element</th>
<th>Code</th>
<th>Date Received</th>
<th>Date Reported</th>
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<td>10.7</td>
<td>mg/l</td>
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<td>Magnesium</td>
<td>(00925)</td>
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<td>Aluminum</td>
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<td>Arsenic</td>
<td>(01000)</td>
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<td>Barium</td>
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<td>Cadmium</td>
<td>(01025)</td>
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<td>Lead</td>
<td>(01049)</td>
<td>&lt;5.0</td>
<td>µg/l</td>
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Note: Crossout those elements not to be analyzed.
# Chemical Water Analysis Report

**GWR:** CL-1994-806  
(Anions)

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

**Attention:** Phil Nordstrom  
**County:** Val Verde  
**Owner:** City of Del Rio  
**Address:** 1140 W. Martin, Del Rio

- **State Well Number:** 70-33-904
- **Date & Time:** 5-24-94 11:35
- **Sampled After Pumping:** 0.75 Hours
- **Yield:** GPM
  - Measured
  - Estimated
- **Use:**
- **Temperature:** °C
- **Specific Conductance:**

**By:** Cindy Lee

**Requested Check:**
- **Laboratory No.:**
- **Date Received:** MAY 27 1994
- **Date Reported:** JUN 15 1994

**THD-Sample No. EB4 997**

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<th>Silica (00955)</th>
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<th>MG/L</th>
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<th>Chloride (00941)</th>
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<td>95</td>
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<th>Fluoride (00960)</th>
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<th>MG/L</th>
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<tbody>
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<td>0.03</td>
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<td>0.62</td>
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<th>P. Alkalinity (00415)</th>
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<th>MG/L</th>
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<td>0.00</td>
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<table>
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<th>T. Alkalinity (00410)</th>
<th>MEQ/L</th>
<th>MG/L</th>
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</table>

*Convert mg/l Boron to μg/l for data entry.*
Texas Water Development Board
Chemical Water Analysis Report

MISC. CL1994-800

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: 174 E. Martin, Del Rio
Date Drilled:
Depth:
Collection Point: pH
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: GPM ☐ Measured ☐ Estimated
Use: Temperature: °C
Specific Conductance: 

Requested Chemical Analysis

Laboratory No. [redacted] Date Received: Date Reported:

# 305710 WT/LQD WSTS/SED
Acid & Bn Ext (GC-ms)
<table>
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<tr>
<th>Compound</th>
<th>micrograms/liter</th>
<th>milligrams/kilogram</th>
<th>amount</th>
<th>Compound</th>
<th>micrograms/liter</th>
<th>milligrams/kilogram</th>
<th>amount</th>
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<td>4,8-Dinitro-2-cresol</td>
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<td>Indeno(1,2,3-cd)pyrene</td>
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<td>n-Nitroso-n-dimethylamine</td>
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<td>N-Nitrosodimethylamine</td>
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<td>alpha-BHC</td>
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<tr>
<td>N-Nitrosodimethylamine</td>
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<td></td>
<td></td>
<td>beta-BHC</td>
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<tr>
<td>Aniline</td>
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<td></td>
<td></td>
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<td>Heptachlor</td>
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</tr>
</tbody>
</table>

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

**Tentative Compound**

<table>
<thead>
<tr>
<th>Compound</th>
<th>approximate identification</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Compound</th>
<th>concentrations</th>
</tr>
</thead>
</table>

*Common lab contaminants
**reported at less than quantitation limits

Comments: None

Approval: [Signature]
Texas Water Development Board
Chemical Water Analysis Report

RAD: CL 1994 800
RAD = Radioactivity Sample

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

Attention: Phil Nordstrom
County: Val Verde
Owner: City of Del Rio
Address: 114 E Martin, Del Rio

State Well Number: 70-33-904
Date & Time: 5-24-94 11:35
Send Copy To Owner
Sampled After Pumping: 0.75 Hours

Date Drilled: 
Depth: 
Yield: GPM
Measurement: Measured

Collection Point: 
pH: 
Use: 
Temperature: °C

By: Cindy Lee
Specific Conductance:

Requested Chemicals: 

Laboratory No: 
Date Received: 
Date Reported: MAY 27 1994

Alpha
(01503) 3.6 pCi/l

Beta
(03503) 5.3 pCi/l

Radon-226
(09503) pCi/l

Radon-228
(81366) pCi/l

Total Radon
(44500) pCi/l

94-01-17-432
Texas Water Development Board
Chemical Water Analysis Report

GWN- CL-1994 -800
(Nitrogen Cycle)

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 N 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

Laboratory No.: Date Received: Date Reported:

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 NO₂⁻N to NO₃⁻, multiply by 4.427.
APPENDIX 6

MINERALOGIC ANALYSIS BY CORE LABORATORIES
OF TURBIDITY SEDIMENT FROM WEST SAN FELIPE SPRING
<table>
<thead>
<tr>
<th>Sample</th>
<th>Quartz</th>
<th>K feldspar</th>
<th>Plagioclase</th>
<th>Calcite</th>
<th>Dolomite</th>
<th>Siderite</th>
<th>Pyrite</th>
<th>Total Clays</th>
<th>Illite/Ilmenite</th>
<th>Kaolinite</th>
<th>Chlorite</th>
<th>Smectite</th>
<th>Illite/Smectite</th>
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</thead>
<tbody>
<tr>
<td>Del Rio 411L</td>
<td>11</td>
<td>0</td>
<td>0</td>
<td>66</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>19</td>
<td>54</td>
<td>15</td>
<td>4</td>
<td>0</td>
<td>27</td>
</tr>
</tbody>
</table>
APPENDIX 5

MICROPARTICULATE ANALYSES BY
ANALYTICAL SERVICES INCORPORATED


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:

<table>
<thead>
<tr>
<th>Lab ID</th>
<th>Sample ID</th>
<th>Table 1</th>
<th>Table 2</th>
<th>Total</th>
<th>Risk Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>99071-010</td>
<td>Hackberry Well</td>
<td>None</td>
<td>NA</td>
<td>0</td>
<td>Low*</td>
</tr>
<tr>
<td>99071-011</td>
<td>San Felipe East #2</td>
<td>Algae = 1.3 x 10^4 = EH</td>
<td>EH = 14</td>
<td>14</td>
<td>Moderate*</td>
</tr>
</tbody>
</table>

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.

[Signature]

Mari-Beth DeLucia
Staff Microbiologist
### Analytical Results

**Sample No.: 99071-010**

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

#### Section II.

**I. SAMPLE DATA**

<table>
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<tr>
<th>Sample ID:</th>
<th>Hackberry Well</th>
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<td>Water Type:</td>
<td>raw well</td>
</tr>
<tr>
<td>Turbidity, NTU's:</td>
<td>S: --, E: 1.6</td>
</tr>
<tr>
<td>pH:</td>
<td>S: --, E: 7.2 - 7.3</td>
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<tr>
<td>Treatment:</td>
<td>none</td>
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<tr>
<td>Distance From Surface Water:</td>
<td>&quot;miles&quot;</td>
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<tr>
<td>Volume Filtered:</td>
<td>1000 gallons</td>
</tr>
<tr>
<td>Filter:</td>
<td>Commercial Honeycomb 1 µm</td>
</tr>
<tr>
<td>Filter Color:</td>
<td>dark brown</td>
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<tr>
<td>Sediment Volume:</td>
<td>3.0 mL</td>
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<tr>
<td>Volume Floated:</td>
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<tr>
<td>Pellet Volume After Float:</td>
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<td>Levitant - type:</td>
<td>Percoll sucrose</td>
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<tr>
<td>specific gravity:</td>
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</table>

---

**II. MPA**

Numbers reported are per 100 gallons  
Detection Limit = 30

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<th>Amorphous Debris:</th>
<th>Confluent</th>
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<tr>
<td>Rotifers:</td>
<td>BDL</td>
</tr>
<tr>
<td>Vegetative Debris - with chlorophyll:</td>
<td>BDL</td>
</tr>
<tr>
<td>Rotifer Eggs:</td>
<td>BDL</td>
</tr>
<tr>
<td>without chlorophyll:</td>
<td>BDL</td>
</tr>
<tr>
<td>Crustaceans:</td>
<td>BDL</td>
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<tr>
<td>Diatoms - with chlorophyll:</td>
<td>BDL</td>
</tr>
<tr>
<td>Crustacean Parts:</td>
<td>BDL</td>
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<tr>
<td>without chlorophyll:</td>
<td>BDL</td>
</tr>
<tr>
<td>Crustacean Eggs:</td>
<td>BDL</td>
</tr>
<tr>
<td>with chlorophyll:</td>
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<td>Other Algae*:</td>
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<td>Spores:</td>
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<td>1.2 x 10^2</td>
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<td>Iron Bacteria**:</td>
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<td>Protozoa:</td>
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<td>Insects/Larvae:</td>
<td>BDL</td>
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<td>Amoebae:</td>
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</table>

BDL = Below Detection Limit

*Algae Identifications: NA  
**Iron Bacteria: NA  
Comments: NA = Not Applicable
Section III.

**GIARDIA AND CRYPTOSPORIDIUM**

<table>
<thead>
<tr>
<th>Analytical Result</th>
<th>Analyte</th>
<th>Numbers/ 13 L</th>
<th>Number/ 100 L</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Giardia</strong></td>
<td>Empty <em>Giardia</em> cysts detected</td>
<td>ND</td>
<td>&lt;7.7</td>
</tr>
<tr>
<td></td>
<td><em>Giardia</em> Cysts with Amorphous Structure detected</td>
<td>ND</td>
<td>&lt;7.7</td>
</tr>
<tr>
<td></td>
<td><em>Giardia</em> Cysts with one Internal Structure detected</td>
<td>ND</td>
<td>&lt;7.7</td>
</tr>
<tr>
<td></td>
<td><em>Giardia</em> Cysts with more than one Internal Structure detected</td>
<td>ND</td>
<td>&lt;7.7</td>
</tr>
<tr>
<td></td>
<td>Total IFA <em>Giardia</em> Count</td>
<td>ND</td>
<td>&lt;7.7</td>
</tr>
<tr>
<td><strong>Cryptosporidium</strong></td>
<td>Empty <em>Cryptosporidium</em> Oocysts detected</td>
<td>ND</td>
<td>&lt;7.7</td>
</tr>
<tr>
<td></td>
<td><em>Cryptosporidium</em> Oocysts with Amorphous Structure detected</td>
<td>ND</td>
<td>&lt;7.7</td>
</tr>
<tr>
<td></td>
<td><em>Cryptosporidium</em> Oocysts with Internal Structure detected</td>
<td>ND</td>
<td>&lt;7.7</td>
</tr>
<tr>
<td></td>
<td>Total IFA <em>Cryptosporidium</em> Count</td>
<td>ND</td>
<td>&lt;7.7</td>
</tr>
</tbody>
</table>

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
Section II.

Sample No.: 99071-011

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

**Analytical Results**

### 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

### II. MPA

Numbers reported are per 100 gallons
Detection Limit = 69

<table>
<thead>
<tr>
<th>Amorphous Debris</th>
<th>Fine Confluent</th>
<th>Rotifers: BDL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vegetative Debris -</td>
<td></td>
<td>Rotifer Eggs: BDL</td>
</tr>
<tr>
<td>with chlorophyll:</td>
<td>BDL</td>
<td>Crustaceans: BDL</td>
</tr>
<tr>
<td>without chlorophyll:</td>
<td>BDL</td>
<td>Crustacean Parts: BDL</td>
</tr>
<tr>
<td>Diatoms -</td>
<td></td>
<td>Crustacean Eggs: BDL</td>
</tr>
<tr>
<td>with chlorophyll:</td>
<td>BDL</td>
<td>Invertebrate Eggs: BDL</td>
</tr>
<tr>
<td>without chlorophyll:</td>
<td>BDL</td>
<td>Water Mites: BDL</td>
</tr>
<tr>
<td>Other Algae*</td>
<td>1.3 x 10^4</td>
<td>Gastrotriches: BDL</td>
</tr>
<tr>
<td>Fungal Hyphae:</td>
<td>BDL</td>
<td>Tardigrades: BDL</td>
</tr>
<tr>
<td>Spores:</td>
<td>BDL</td>
<td>Nematodes: BDL</td>
</tr>
<tr>
<td>Pollen:</td>
<td>BDL</td>
<td>Nematode Eggs: BDL</td>
</tr>
<tr>
<td>Iron Bacteria**</td>
<td>BDL</td>
<td>Annelids: BDL</td>
</tr>
<tr>
<td>Protozoa:</td>
<td>BDL</td>
<td>Insects/Larvae: BDL</td>
</tr>
<tr>
<td>Amoebae:</td>
<td>BDL</td>
<td></td>
</tr>
</tbody>
</table>

BDL = Below Detection Limit

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

NA = Not Applicable
Sample No. 99071-011, LBG-Guyton Associates
Del Rio/San Felipe #2
unicellular Chlorophyta taken at 1000X magnification
Section III.

**GIARDIA AND CRYPTOSPORIDIIUM**

<table>
<thead>
<tr>
<th>Analytical Result</th>
<th>Analyte</th>
<th>Numbers/ 23 L</th>
<th>Number/ 100 L</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Giardia</strong></td>
<td>Empty <em>Giardia</em> cysts detected</td>
<td>ND</td>
<td>&lt;4.3</td>
</tr>
<tr>
<td></td>
<td><em>Giardia</em> Cysts with Amorphous Structure detected</td>
<td>ND</td>
<td>&lt;4.3</td>
</tr>
<tr>
<td></td>
<td><em>Giardia</em> Cysts with one Internal Structure detected</td>
<td>ND</td>
<td>&lt;4.3</td>
</tr>
<tr>
<td></td>
<td><em>Giardia</em> Cysts with more than one Internal Structure detected</td>
<td>ND</td>
<td>&lt;4.3</td>
</tr>
<tr>
<td></td>
<td>Total IFA <em>Giardia</em> Count</td>
<td>ND</td>
<td>&lt;4.3</td>
</tr>
<tr>
<td><strong>Cryptosporidium</strong></td>
<td>Empty <em>Cryptosporidium</em> Oocysts detected</td>
<td>ND</td>
<td>&lt;4.3</td>
</tr>
<tr>
<td></td>
<td><em>Cryptosporidium</em> Oocysts with Amorphous Structure detected</td>
<td>ND</td>
<td>&lt;4.3</td>
</tr>
<tr>
<td></td>
<td><em>Cryptosporidium</em> Oocysts with Internal Structure detected</td>
<td>ND</td>
<td>&lt;4.3</td>
</tr>
<tr>
<td></td>
<td>Total IFA <em>Cryptosporidium</em> Count</td>
<td>ND</td>
<td>&lt;4.3</td>
</tr>
</tbody>
</table>

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
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:

<table>
<thead>
<tr>
<th>Lab ID</th>
<th>Sample ID</th>
<th>Table 1</th>
<th>Table 2</th>
<th>Total</th>
<th>Risk Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>99075-011</td>
<td>San Felipe West #5</td>
<td>None</td>
<td>NA</td>
<td>0</td>
<td>Low*</td>
</tr>
<tr>
<td>99075-012</td>
<td>Agarita Well</td>
<td>None</td>
<td>NA</td>
<td>0</td>
<td>Low*</td>
</tr>
</tbody>
</table>

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.

Marl-Beth DeLucia  
Staff Microbiologist
### Section II.

#### Sample No.: 99075-011

<table>
<thead>
<tr>
<th>J. SAMPLE DATA</th>
<th>II. MPA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample ID: San Felipe West #5</td>
<td>Amorphous Debris: Fine Confluent</td>
</tr>
<tr>
<td>Sample Site: Del Rio, TX</td>
<td>Rotifers: BDL</td>
</tr>
<tr>
<td>Water Type: raw/spring</td>
<td>Vegetative Debris -</td>
</tr>
<tr>
<td>Turbidity, NTU's:</td>
<td>with chlorophyll: BDL</td>
</tr>
<tr>
<td>S: 0.56 E: 0.76</td>
<td>Rotifer Eggs: BDL</td>
</tr>
<tr>
<td>pH: S: 7.1 E: 7.2</td>
<td>without chlorophyll: BDL</td>
</tr>
<tr>
<td>Treatment: none</td>
<td>Crustaceans: BDL</td>
</tr>
<tr>
<td>Distance From Surface Water: unknown</td>
<td>Diatoms -</td>
</tr>
<tr>
<td>Volume Filtered: 1064 gallons</td>
<td>with chlorophyll: BDL</td>
</tr>
<tr>
<td>Filter: Commercial Honeycomb 1 μm</td>
<td>Invertebrate Eggs: BDL</td>
</tr>
<tr>
<td>Filter Color: light brown</td>
<td>without chlorophyll: BDL</td>
</tr>
<tr>
<td>Sediment Volume: 3.0 mL</td>
<td>Water Mites: BDL</td>
</tr>
<tr>
<td>Volume Floated: 0.5 mL</td>
<td>Other Algae*: BDL</td>
</tr>
<tr>
<td>Pellet Volume After Float: 50 μL</td>
<td>Fungal Hyphae: BDL</td>
</tr>
<tr>
<td>Levitants -</td>
<td>Tardigrades: BDL</td>
</tr>
<tr>
<td>type: Percoll sucrose</td>
<td>Spores: BDL</td>
</tr>
<tr>
<td>specific gravity: 1.15</td>
<td>Nematodes: BDL</td>
</tr>
<tr>
<td>S = Start of Sampling; E = End of Sampling</td>
<td>Pollen: BDL</td>
</tr>
<tr>
<td></td>
<td>Nematode Eggs: BDL</td>
</tr>
<tr>
<td></td>
<td>Iron Bacteria**: BDL</td>
</tr>
<tr>
<td></td>
<td>Annelids: BDL</td>
</tr>
<tr>
<td></td>
<td>Protozoa: BDL</td>
</tr>
<tr>
<td></td>
<td>Insects/Larvae: BDL</td>
</tr>
<tr>
<td></td>
<td>Amoebae: BDL</td>
</tr>
</tbody>
</table>

BDL = Below Detection Limit

*Algae Identifications: NA
**Iron Bacteria: NA

NA = Not Applicable
Sample(s) were processed, stained and examined using a modified version of the Information Collection Rule (ICR) Protozoan Method (EPA/614-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
**Section II.**

**Sample No.: 99075-012**

### I. SAMPLE DATA

<table>
<thead>
<tr>
<th>Sample ID:</th>
<th>Agarita Well</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample Site:</td>
<td>Del Rio, TX</td>
</tr>
<tr>
<td>Water Type:</td>
<td>raw/well</td>
</tr>
<tr>
<td>Turbidity, NTU’s:</td>
<td>unknown</td>
</tr>
<tr>
<td><strong>pH:</strong></td>
<td>S: 7.2 E: 7.3</td>
</tr>
<tr>
<td>Treatment:</td>
<td>none</td>
</tr>
<tr>
<td>Distance From</td>
<td>unknown</td>
</tr>
<tr>
<td>Surface Water:</td>
<td></td>
</tr>
<tr>
<td>Volume Filtered:</td>
<td>988 gallons</td>
</tr>
<tr>
<td><strong>Filter:</strong></td>
<td>Commercial Honeycomb 1 μm</td>
</tr>
<tr>
<td><strong>Filter Color:</strong></td>
<td>brown</td>
</tr>
<tr>
<td>Sediment Volume:</td>
<td>23.0 mL</td>
</tr>
<tr>
<td>Volume Floated:</td>
<td>0.5 mL</td>
</tr>
<tr>
<td>Pellet Volume</td>
<td></td>
</tr>
<tr>
<td>After Float:</td>
<td>0.1 mL</td>
</tr>
<tr>
<td>Levitent –</td>
<td>type: Percoll sucrose</td>
</tr>
<tr>
<td><strong>specific gravity:</strong></td>
<td>1.15</td>
</tr>
</tbody>
</table>

*S = Start of Sampling  E = End of Sampling*

---

### II. MPA

Numbers reported are per 100 gallons

Detection Limit = $1.7 \times 10^3$

- **Amorphous Debris**: Fine Confluent
- **Rotifers**: BDL
- **Vegetative Debris -**
  - with chlorophyll: BDL
  - \textit{without chlorophyll}: BDL
- **Diatoms -**
  - with chlorophyll: BDL
  - \textit{without chlorophyll}: BDL
- **Other Algae**: BDL
- **Fungal Hyphae**: BDL
- **Sponges**: BDL
- **Pollen**: BDL
- **Iron Bacteria**: BDL
- **Protozoa**: BDL
- **Amoebae**: BDL
- **Rotifer Eggs**: BDL
- **Crustaceans**: BDL
- **Crustacean Parts**: BDL
- **Crustacean Eggs**: BDL
- **Invertebrate Eggs**: BDL
- **Water Mites**: BDL
- **Gastrotichs**: BDL
- **Tardigrades**: BDL
- **Nematodes**: BDL
- **Nematode Eggs**: BDL
- **Annelids**: BDL
- **Insects/Larvae**: BDL

BDL = Below Detection Limit

*Algae Identifications: NA
**Iron Bacteria: NA
Comments: NA = Not Applicable*
### Section III.

**GIARDIA AND CRYPTOSPORIDIUM**

<table>
<thead>
<tr>
<th>Analytical Result</th>
<th>Analyte</th>
<th>Numbers/1.8 L</th>
<th>Number/100 L</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Giardia</strong></td>
<td>Empty <em>Giardia</em> cysts detected</td>
<td>ND</td>
<td>&lt;56</td>
</tr>
<tr>
<td></td>
<td><em>Giardia</em> Cysts with Amorphous Structure</td>
<td>ND</td>
<td>&lt;56</td>
</tr>
<tr>
<td></td>
<td>detected</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><em>Giardia</em> Cysts with one Internal Structure</td>
<td>ND</td>
<td>&lt;56</td>
</tr>
<tr>
<td></td>
<td>detected</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><em>Giardia</em> Cysts with more than one</td>
<td>ND</td>
<td>&lt;56</td>
</tr>
<tr>
<td></td>
<td>Internal Structure detected</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Total IFA Giardia Count</strong></td>
<td>ND</td>
<td>&lt;56</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Cryptosporidium</strong></td>
<td>Empty <em>Cryptosporidium</em> Oocysts detected</td>
<td>ND</td>
<td>&lt;56</td>
</tr>
<tr>
<td></td>
<td><em>Cryptosporidium</em> Oocysts with Amorphous</td>
<td>ND</td>
<td>&lt;56</td>
</tr>
<tr>
<td></td>
<td>Structure detected</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><em>Cryptosporidium</em> Oocysts with Internal</td>
<td>ND</td>
<td>&lt;56</td>
</tr>
<tr>
<td></td>
<td>Structure detected</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Total IFA Cryptosporidium Count</strong></td>
<td>ND</td>
<td>&lt;56</td>
</tr>
</tbody>
</table>

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
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:

<table>
<thead>
<tr>
<th>Lab ID</th>
<th>Sample ID</th>
<th>Table 1</th>
<th>Table 2</th>
<th>Total</th>
<th>Risk Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>99174-022</td>
<td>San Felipe West of the Side of Pump #5 Cave, Del Rio, TX</td>
<td>Algae = 2.0 x 10^4 = EH</td>
<td>EH = 14</td>
<td>14</td>
<td>Moderate*</td>
</tr>
</tbody>
</table>

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
**Section II.**

**Sample No.: 99174-022**

### Analytical Results

#### I. SAMPLE DATA

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

*S = Start of Sampling; E = End of Sampling*

#### II. MPA

Numbers reported are per 100 gallons

Detection Limit = 43

<table>
<thead>
<tr>
<th>Amorphous Debris:</th>
<th>Confluent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rotifer Eggs:</td>
<td>BDL</td>
</tr>
<tr>
<td>Vegetative Debris -</td>
<td></td>
</tr>
<tr>
<td>with chlorophyll:</td>
<td>BDL</td>
</tr>
<tr>
<td>without chlorophyll:</td>
<td>BDL</td>
</tr>
<tr>
<td>Crustaceans:</td>
<td>BDL</td>
</tr>
<tr>
<td>Crustacean Parts:</td>
<td>BDL</td>
</tr>
<tr>
<td>Diatoms -</td>
<td></td>
</tr>
<tr>
<td>with chlorophyll:</td>
<td>BDL</td>
</tr>
<tr>
<td>without chlorophyll:</td>
<td>BDL</td>
</tr>
<tr>
<td>Crustacean Eggs:</td>
<td>BDL</td>
</tr>
<tr>
<td>Invertebrate Eggs:</td>
<td>BDL</td>
</tr>
<tr>
<td>Other Algae*:</td>
<td>2.0 \times 10^4</td>
</tr>
<tr>
<td>Fungal Hyphae:</td>
<td>BDL</td>
</tr>
<tr>
<td>Tardigrades:</td>
<td>BDL</td>
</tr>
<tr>
<td>Spores:</td>
<td>2.6 \times 10^2</td>
</tr>
<tr>
<td>Water Mites:</td>
<td>BDL</td>
</tr>
<tr>
<td>Pollen:</td>
<td>BDL</td>
</tr>
<tr>
<td>Nematode Eggs:</td>
<td>BDL</td>
</tr>
<tr>
<td>Iron Bacteria**:</td>
<td>BDL</td>
</tr>
<tr>
<td>Annelids:</td>
<td>BDL</td>
</tr>
<tr>
<td>Protozoa:</td>
<td>6.7 \times 10^3</td>
</tr>
<tr>
<td>Insects/Larvae:</td>
<td>BDL</td>
</tr>
<tr>
<td>Amoebae:</td>
<td>BDL</td>
</tr>
</tbody>
</table>

BDL = Below Detection Limit

*Algae Identifications: Phacus sp.; filamentous Chlorophyta, unicellular Chlorophyta, colonial Chlorophyta; filamentous Cyanophyta

**Iron Bacteria: NA

Comments: NA = Not Applicable
**GIARDIA AND CRYPTOSPORIDIUM**

**Sample No.: 99174-022**

<table>
<thead>
<tr>
<th>Analytical Result</th>
<th>Analyte</th>
<th>Numbers/ 11 L</th>
<th>Number/ 100 L</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Giardia</strong></td>
<td>Empty <em>Giardia</em> cysts detected</td>
<td>ND</td>
<td>&lt;9.1</td>
</tr>
<tr>
<td></td>
<td><em>Giardia</em> Cysts with Amorphous Structure detected</td>
<td>ND</td>
<td>&lt;9.1</td>
</tr>
<tr>
<td></td>
<td><em>Giardia</em> Cysts with one Internal Structure detected</td>
<td>ND</td>
<td>&lt;9.1</td>
</tr>
<tr>
<td></td>
<td><em>Giardia</em> Cysts with more than one Internal Structure detected</td>
<td>ND</td>
<td>&lt;9.1</td>
</tr>
<tr>
<td></td>
<td>Total IFA <em>Giardia</em> Count</td>
<td>ND</td>
<td>&lt;9.1</td>
</tr>
<tr>
<td><strong>Cryptosporidium</strong></td>
<td>Empty <em>Cryptosporidium</em> Oocysts detected</td>
<td>ND</td>
<td>&lt;9.1</td>
</tr>
<tr>
<td></td>
<td><em>Cryptosporidium</em> Oocysts with Amorphous Structure detected</td>
<td>ND</td>
<td>&lt;9.1</td>
</tr>
<tr>
<td></td>
<td><em>Cryptosporidium</em> Oocysts with Internal Structure detected</td>
<td>ND</td>
<td>&lt;9.1</td>
</tr>
<tr>
<td></td>
<td>Total IFA <em>Cryptosporidium</em> Count</td>
<td>ND</td>
<td>&lt;9.1</td>
</tr>
</tbody>
</table>

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

**Project No.: 99174-022**
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.
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:

<table>
<thead>
<tr>
<th>Lab ID</th>
<th>Sample ID</th>
<th>Table 1</th>
<th>Table 2</th>
<th>Total</th>
<th>Risk Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>99104-003</td>
<td>Del Rio &quot;Y&quot; Well #3</td>
<td>None</td>
<td>NA</td>
<td>0</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td>Del Rio, TX</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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

Project No.: 99104-003
**Section II.**

**Sample No.: 99104-003**

<table>
<thead>
<tr>
<th>I. SAMPLE DATA</th>
<th>II. MPA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample ID: Del Rio “Y” Well #3</td>
<td>Numbers reported are per 100 gallons</td>
</tr>
<tr>
<td>Sample Site: Del Rio, TX</td>
<td>Detection Limit = 4</td>
</tr>
<tr>
<td>Water Type: raw/well</td>
<td></td>
</tr>
<tr>
<td>Turbidity, NTU's: S: 0.12 E: 0.31</td>
<td>Amorphous Debris: Confluent</td>
</tr>
<tr>
<td>pH: S: - E: 7.06</td>
<td>Rotifers: BDL</td>
</tr>
<tr>
<td>Treatment: none</td>
<td>Vegetative Debris -</td>
</tr>
<tr>
<td>Distance From Surface Water: &gt;1 mile</td>
<td>with chlorophyll: BDL</td>
</tr>
<tr>
<td>Volume Filtered: 1000 gallons</td>
<td>Rotifer Eggs: BDL</td>
</tr>
<tr>
<td>Filter: Commercial Honeycomb 1 µm</td>
<td>without chlorophyll: BDL</td>
</tr>
<tr>
<td>Filter Color: tan</td>
<td>Crustaceans: BDL</td>
</tr>
<tr>
<td>Sediment Volume: 50 µL</td>
<td>Diatoms -</td>
</tr>
<tr>
<td></td>
<td>with chlorophyll: BDL</td>
</tr>
<tr>
<td></td>
<td>Invertebrate Eggs: BDL</td>
</tr>
<tr>
<td></td>
<td>without chlorophyll: BDL</td>
</tr>
<tr>
<td></td>
<td>Water Mites: BDL</td>
</tr>
<tr>
<td></td>
<td>Other Algae*: BDL</td>
</tr>
<tr>
<td></td>
<td>Gastrotrichs: BDL</td>
</tr>
<tr>
<td></td>
<td>Fungal Hyphae: 4</td>
</tr>
<tr>
<td></td>
<td>Tardigrades: BDL</td>
</tr>
<tr>
<td></td>
<td>Spores: 4</td>
</tr>
<tr>
<td></td>
<td>Nematodes: BDL</td>
</tr>
<tr>
<td></td>
<td>Pollen: 16</td>
</tr>
<tr>
<td></td>
<td>Nematode Eggs: BDL</td>
</tr>
<tr>
<td></td>
<td>Iron Bacteria**: BDL</td>
</tr>
<tr>
<td></td>
<td>Annelids: BDL</td>
</tr>
<tr>
<td></td>
<td>Protozoa: 16</td>
</tr>
<tr>
<td></td>
<td>Insects/Larvae: BDL</td>
</tr>
<tr>
<td></td>
<td>Amoebae: BDL</td>
</tr>
</tbody>
</table>

* = Below Detection Limit

*Algae Identifications: NA
**Iron Bacteria: NA

NA = Not Applicable

Project No.: 99104-003
### GIARDIA AND CRYPTOSPORIDIUM

<table>
<thead>
<tr>
<th>Analytical Result</th>
<th>Analyte</th>
<th>Numbers/ 1.3 x 10^5 L</th>
<th>Number/ 100 L</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Giardia</strong></td>
<td>Empty <em>Giardia</em> cysts detected</td>
<td>ND</td>
<td>&lt;0.77</td>
</tr>
<tr>
<td></td>
<td><em>Giardia</em> Cysts with Amorphous Structure detected</td>
<td>ND</td>
<td>&lt;0.77</td>
</tr>
<tr>
<td></td>
<td><em>Giardia</em> Cysts with one Internal Structure detected</td>
<td>ND</td>
<td>&lt;0.77</td>
</tr>
<tr>
<td></td>
<td><em>Giardia</em> Cysts with more than one Internal Structure detected</td>
<td>ND</td>
<td>&lt;0.77</td>
</tr>
<tr>
<td></td>
<td>Total IFA <em>Giardia</em> Count</td>
<td>ND</td>
<td>&lt;0.77</td>
</tr>
<tr>
<td><strong>Cryptosporidium</strong></td>
<td>Empty <em>Cryptosporidium</em> Oocysts detected</td>
<td>ND</td>
<td>&lt;0.77</td>
</tr>
<tr>
<td></td>
<td><em>Cryptosporidium</em> Oocysts with Amorphous Structure detected</td>
<td>ND</td>
<td>&lt;0.77</td>
</tr>
<tr>
<td></td>
<td><em>Cryptosporidium</em> Oocysts with Internal Structure detected</td>
<td>ND</td>
<td>&lt;0.77</td>
</tr>
<tr>
<td></td>
<td>Total IFA <em>Cryptosporidium</em> Count</td>
<td>ND</td>
<td>&lt;0.77</td>
</tr>
</tbody>
</table>

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
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:

<table>
<thead>
<tr>
<th>Lab ID</th>
<th>Sample ID</th>
<th>Table 1</th>
<th>Table 2</th>
<th>Total</th>
<th>Risk Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>99113-001</td>
<td>Tierra del Lago (Amistad) Well #1 Del Rio, TX</td>
<td>Algae = 7.9 x 10² = EH Rotifers = 6 = R</td>
<td>EH = 14 R = 1</td>
<td>15</td>
<td>Moderate</td>
</tr>
</tbody>
</table>

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
### Section II.

**Sample No.: 99113-001**

#### Analytical Results

<table>
<thead>
<tr>
<th>Sample ID:</th>
<th>Tierra del Lago (Amistad) Well #1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample Site:</td>
<td>Del Rio, TX</td>
</tr>
<tr>
<td>Water Type:</td>
<td>raw/well</td>
</tr>
<tr>
<td>Turbidity, NTU’s:</td>
<td>S: 0.23  E: 0.54</td>
</tr>
<tr>
<td>pH:</td>
<td>S: 7.14  E: 7.19</td>
</tr>
<tr>
<td>Treatment:</td>
<td>none</td>
</tr>
<tr>
<td>Distance From Surface Water:</td>
<td>~ 0.5 mile</td>
</tr>
<tr>
<td>Volume Filtered:</td>
<td>1023 gallons</td>
</tr>
<tr>
<td>Filter:</td>
<td>Commercial Honeycomb 1 μm</td>
</tr>
<tr>
<td>Filter Color:</td>
<td>off-white</td>
</tr>
<tr>
<td>Sediment Volume:</td>
<td>50 μL</td>
</tr>
</tbody>
</table>

**Numbers reported are per 100 gallons**

**Detection Limit = 6**

<table>
<thead>
<tr>
<th>Category</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amorphous Debris</td>
<td>Confluent</td>
</tr>
<tr>
<td>Rotifers</td>
<td>6</td>
</tr>
<tr>
<td>Vegetative Debris -</td>
<td></td>
</tr>
<tr>
<td>with chlorophyll</td>
<td>BDL</td>
</tr>
<tr>
<td>without chlorophyll</td>
<td>BDL</td>
</tr>
<tr>
<td>Crustaceans</td>
<td></td>
</tr>
<tr>
<td>Crustacean Eggs</td>
<td>BDL</td>
</tr>
<tr>
<td>Diatoms -</td>
<td></td>
</tr>
<tr>
<td>with chlorophyll</td>
<td>BDL</td>
</tr>
<tr>
<td>without chlorophyll</td>
<td>BDL</td>
</tr>
<tr>
<td>Invertebrate Eggs</td>
<td>BDL</td>
</tr>
<tr>
<td>Water Mites</td>
<td>BDL</td>
</tr>
<tr>
<td>Other Algae</td>
<td>7.9 x 10²</td>
</tr>
<tr>
<td>Gastrotichs</td>
<td>BDL</td>
</tr>
<tr>
<td>Fungal Hyphae</td>
<td>BDL</td>
</tr>
<tr>
<td>Tardigrades</td>
<td>BDL</td>
</tr>
<tr>
<td>Spores</td>
<td>32</td>
</tr>
<tr>
<td>Nematodes</td>
<td>6</td>
</tr>
<tr>
<td>Pollen</td>
<td>38</td>
</tr>
<tr>
<td>Nematode Eggs</td>
<td>BDL</td>
</tr>
<tr>
<td>Iron Bacteria**</td>
<td>BDL</td>
</tr>
<tr>
<td>Annelids</td>
<td>BDL</td>
</tr>
<tr>
<td>Protozoa</td>
<td>2.6 x 10³</td>
</tr>
<tr>
<td>Insects/Larvae</td>
<td>BDL</td>
</tr>
<tr>
<td>Amoebae</td>
<td>BDL</td>
</tr>
<tr>
<td>BDL = Below Detection Limit</td>
<td></td>
</tr>
</tbody>
</table>

*Algae Identifications: filamentous Cyanophyta, unicellular Chlorophyta

**Iron Bacteria: NA

**Annelids: NA

Comments:**

*NA = Not Applicable
Section III.

GIARDIA AND CRYPTOSPORIDIUM

<table>
<thead>
<tr>
<th>Analytical Result</th>
<th>Analyte</th>
<th>Numbers/ 77 L</th>
<th>Number/ 100 L</th>
</tr>
</thead>
<tbody>
<tr>
<td>Giardia</td>
<td>Empty <em>Giardia</em> cysts detected</td>
<td>ND</td>
<td>&lt;1.3</td>
</tr>
<tr>
<td></td>
<td><em>Giardia</em> Cysts with Amorphous Structure detected</td>
<td>ND</td>
<td>&lt;1.3</td>
</tr>
<tr>
<td></td>
<td><em>Giardia</em> Cysts with one Internal Structure detected</td>
<td>ND</td>
<td>&lt;1.3</td>
</tr>
<tr>
<td></td>
<td><em>Giardia</em> Cysts with more than one Internal Structure detected</td>
<td>ND</td>
<td>&lt;1.3</td>
</tr>
<tr>
<td></td>
<td>Total IFA <em>Giardia</em> Count</td>
<td>ND</td>
<td>&lt;1.3</td>
</tr>
<tr>
<td>Cryptosporidium</td>
<td>Empty <em>Cryptosporidium</em> Oocysts detected</td>
<td>ND</td>
<td>&lt;1.3</td>
</tr>
<tr>
<td></td>
<td><em>Cryptosporidium</em> Oocysts with Amorphous Structure detected</td>
<td>ND</td>
<td>&lt;1.3</td>
</tr>
<tr>
<td></td>
<td><em>Cryptosporidium</em> Oocysts with Internal Structure detected</td>
<td>ND</td>
<td>&lt;1.3</td>
</tr>
<tr>
<td></td>
<td>Total IFA <em>Cryptosporidium</em> Count</td>
<td>ND</td>
<td>&lt;1.3</td>
</tr>
</tbody>
</table>

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
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
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 indicate 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, R.S., Chief
Surveillance and Technical Assistance Branch
Division of Water Hygiene

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

Address:

Patient's Ident. No.:

PHYSICIAN: Tony Bennett
STREET: Winter Highne
CITY: Austin
TEXAS

Specimen suspected or test desired:

Type of onset: Date collected: 7/15/89

Type of specimen:
- [ ] Feces
- [ ] Blood
- [X] Other: Enterobius vermicularis

Condition of specimen:
- [ ] Unpreserved
- [ ] PVA
- [ ] Other: Cl 0.0
- X Turbidity < 0.5 NTU

LABORATORY REPORT (DO NOT WRITE BELOW)

CES EXAMINATION
- [X] No parasites found
- [ ] Entamoeba histolytica
- [ ] Entamoeba hartmanni
- [ ] Entamoeba coli
- [ ] Endolimax nana
- [ ] Iodamoeba butschili
- [ ] Chilomastix mesnili
- [ ] Dientamoeba fragilis
- [ ] Giardia lamblia
- [ ] Hookworm
- [ ] Ascaris lumbricoides
- [ ] Strongyloides stercoralis
- [ ] Trichuris trichuria
- [ ] Hymenolepis nana
- [ ] Other

PINWORM SWAB EXAMINATION
- [X] No Pinworm Eggs found
- [ ] Pinworm (Enterobius vermicularis) found

BLOOD EXAMINATION
- [X] No Parasites found
- [ ] Parasites found

TISSUE EXAMINATION
- [X] No Parasites found
- [ ] Parasites found

OTHER EXAMINATION

WATER:
- [X] No Giardia, Cryptosporidium seen

(Many free-living protozoa/aqueous film +
SPECIMEN UNSATISFACTORY: 2/20/89)

Please submit another specimen.

Results of bacteriological studies will be reported separately.
EXAMINATION FOR PARASITES
Form No. G-31

Texas Department of Health
Bureau of Laboratories

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

Patient's Name: Dell Rio  (Vital Sign: 6'2" 232 lbs)

Last  First  Middle  Age  Sex  Race

Address: __________________________ County: __________________________

Patient's Ident. No: __________________________

Send report to:

PHYSICIAN: Tony Bennett

STREET: Water Hygiene - TDD

CITY: Austin  TEXAS  (Zip Code:)

Disease suspected or test desired: Protozoa

Date of onset: ___________ Date Collected: ___________

Type of specimen:
- [ ] Feces
- [ ] Pinworm swab
- [ ] Blood
- [ ] Other: Water Filter

Condition of specimen:
- [ ] Unpreserved
- [ ] PVA
- [ ] Formalin
- [ ] Other:


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:

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: polynuclear 175 ml

Please submit another specimen.

Results of bacteriological studies will be reported separately.
Submitter copy to:

TWC/WATER UTILITIES - FAX-00000010
P O BOX 13007
AUSTIN, TX  00001

Spec #:  E95WF000029
Subm #:  
Lab:  ENVIRONMENTAL
Tel #:  (512)458-7570

Source

DEC 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:  E95WF0000029
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. Masarang, 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:

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

* Page 1 of 1 *
Date: 6/7/95

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

Source
DEL RIO, CITY OF

Date Recvd: 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 #: 23300001
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. Masereag, Ph.D.
Chief, Bureau of Laboratories
CLIA License Number 4500660644
Submitter copy to:

TWC/WATER UTILITIES - FAX-00000010
P.O. BOX 13087
AUSTIN, TX 78708

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

Date: 6/7/95

Source: DEL RIO, CITY OF

<table>
<thead>
<tr>
<th>Date Rcvd:</th>
<th>5/26/95</th>
<th>System ID #:</th>
<th>2330001</th>
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</thead>
<tbody>
<tr>
<td>Time Rcvd:</td>
<td>1600</td>
<td>Turbidity (NTU):</td>
<td>6.00 NTU - 10.5 NTU</td>
</tr>
<tr>
<td>Time Coll:</td>
<td>2030</td>
<td>Water temp:</td>
<td>23.8</td>
</tr>
<tr>
<td>Spec Type:</td>
<td>WATER FILTER</td>
<td>pH:</td>
<td>6.99</td>
</tr>
<tr>
<td>Amt filtered:</td>
<td>500 GAL</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Collected at:</td>
<td>SAN FELIPE SPRINGS-EAST SPRINGS</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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. Masleng, Ph.D.
Chief, Bureau of Laboratories
CLIA License Number 45D0660644
Submitter copy to:      Date: 5/20/94

TWC/WATER UTILITIES - FAX-00000010
P O BOX 13087
AUSTIN, TX  787563194

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

Source
CITY OF DEL RIO/WEST SPRING

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

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

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

---

**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

* Page 1 of 1 *
Date: 9/21/94

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

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

Source
DELRIO, CITY OF

Date Rcvd: 9/19/94
Time Rcvd: 1345
Spec Type: WATER FILTER
Coll By: ML
Amt filtered: 500 gal
Chlorine: raw water

Collected at: west spring
Contact time: 1000
Turbidity(NTU): 2.3-1.6
Water temp: 23.8 C
pH: 6.89

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. Maher, Ph.D.
Chief, Bureau of Laboratories
CLIA License Number 45D0660644
Submitter copy to: WATER UTILITIES, DIVISION OF 92270722
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   |
| Time Rcvd: | 1350       |
| Time Coll: | 1145       |
| Spec Type: | WATER FILTER |
| Amt filtered: | 500 GAL |

Collected at: WEST WELL-SPRING
Turbidity (NTU): .42 NTU - .20 NTU
pH: 6.68
Test Reas: ROUTINE

--- 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. Hager, Ph.D.
Chief, Bureau of Laboratories
CLIA License Number 45D0660644
Submitter copy to: Date: 6/24/93

TEXAS WATER COMM/WATER UTILITIES-00000010 Spec #: E93WF000019
P O BOX 13087 Subm #: Lab: ENVIRONMENTAL
AUSTIN, TX 78701 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
Submission copy to:

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
Time Rcvd: 0915
Time Col1: 2310
Spec Type: WATER FILTER

Air temp: 24.1 C
Collected at: AGARITA WELL
Turbidity (NTU): 5.80 NTU
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 78756-3194

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
Time Rcvd: 0915
Time Coll: 1936
Spec Type: WATER FILTER

Air temp: 24.8 C
Collected at: EAST SPRINGS
Turbidity (NTU): 0.24 NTU
pH: 5.16

Final Results

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

FILTER EXAM
Protozoa N/A
Nematodes N/A
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 45D06600644
Submitter copy to:

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

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

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

BUREAU OF LABORATORIES
CLIA #45D0660644
CONFIDENTIAL LABORATORY REPORT

Submitter copy to:

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

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

CITY OF DEL RIO

Date Rcvd: 9/9/98
Time Rcvd: 1430
Spec Type: WATER FILTER
Collected at: EAST SPRINGS EP001
Coll By: DON WHITEL
Last rain: 14-15 DAYS
Air temp: 85 F
Sample Is: Raw
System ID #: 2330001
Turbidity (NTU): 3.28
Water temp: 23 C
Test Reas: ROUTINE

Final Results

Specimen Numbers: E98WF000033
Date Collected: 9/6/98

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
BUREAU OF LABORATORIES
CLIA #5D0660644
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

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 EPO01
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: 9/9/98

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 4D0660644
** Texas Department of Health **

** 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 #: E96WF000030
Subm #: 2330001
Lab: ENVIRONMENTAL
Tel #: (512)458-7578

---

** CITY OF DEL RIO **

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<td>Spec Type: WATER FILTER</td>
<td>System ID #: 2330001</td>
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<tr>
<td>Coll By: DON WHITE</td>
<td>Turbidity (NTU): 2.91</td>
</tr>
<tr>
<td>Air temp: 85 F</td>
<td>Water temp: 24 C</td>
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<tr>
<td>Amt filtered: 500 GALS</td>
<td>pH: 7.3</td>
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<tr>
<td>Chlorine: 0.0 mg/l</td>
<td>Test Reas: ROUTINE</td>
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<td>Collected at: WEST SPRINGS EP002</td>
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** Final Results **

Specimen Numbers: E96WF000030
Date Collected: 9/5/98

---

** FILTER EXAM **

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<tr>
<th>Protozoa</th>
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<tr>
<td>Nematodes</td>
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<td>Debris</td>
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<td>Pellet size (ml): 6.0</td>
<td></td>
</tr>
<tr>
<td>Smears examined (#): 2</td>
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</tr>
</tbody>
</table>

---

No Cryptosporidium or Giardia present.

---

David L. Maserang, Ph.D.
Chief, Bureau of Laboratories
CLIA License Number 45D0660644
TWC/WATER UTILITIES - FAX-00000010
F O BOX 13087
AUSTIN, TX 00001

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

CITY OF DEL RIO

Date Rcvd: 9/8/98
Time Rcvd: 1300
Time Coll: 1000
Spec Type: WATER FILTER
Coll By: DON WHITE
Air temp: 86F
Amt filtered: 500
Chlorine: 0.0 MG/L

Collected at: WEST SPRINGS E P 002
Last rain: 14
Sample Is Raw
System ID #: 2330001
Turbidity(NTU): 2.60 NTU
Water temp: 23C
Test Reas: ROUTINE

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
** DUPLICATE REPORT **  Date: 9/15/98

** Del Rio Utilities **

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

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

Final Results

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 Crypto sporidium or Giardia seen.

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

**Date:** 9/19/98

**Source:** DEL RIO UTILITIES

**Time Rcvd:** 0700

**Time Coll:** 1150

**Spec Type:** WATER FILTER

**Coll By:** JAY DON JOHNSON

**Spec #:** E98WF000035

**Subm #:**

**Lab:** ENVIRONMENTAL

**Tel #:** (512) 458-7578

**Date Rcvd:** 9/11/98

**Collected at:** EAST SPRING EP#001

**Last rain:** 2 WEEKS

**Sample Is:** Raw

**System ID #:** 2330001

**Turbidity (NTU):** 2.6

**Test Reas:** ROUTINE

**Amount filtered:** 460

**Chlorine:** 0

---

**Final Results**

**Specimen Numbers:** E98WF000035

**Date Collected:** 9/10/98

**FILTER EXAM**

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<thead>
<tr>
<th>Pellet size (ml)</th>
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<td>Spores examined (#)</td>
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</tbody>
</table>

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 **

BUROE OF LABORATORIES
CLIA #45D0660644
CONFIDENTIAL LABORATORY REPORT

TWC/WATER UTILITIES - FAX-0000001G
P O BOX 13087
AUSTIN, TX 78707

Spec #: E95WF000031
Subm #: 233001
Lab: ENVIRONMENTAL
Tel #: (512)458-7578

<table>
<thead>
<tr>
<th>Source</th>
<th>CITY OF UVALDE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rio</td>
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</tr>
</tbody>
</table>

---

** Date Rcvd:** 9/7/98  
** Time Coll:** 1045  
** Spec Type:** WATER FILTER  
** Coll By:** DON WHITE  
** Air temp:** 85 F  
** Amt filtered:** 500 GAL  
** Chlorine:** 0.0 M3/L  
** Collected at:** EAST SPRINGS EP 001  
** Last rain:** 13 DAYS  
** Sample IS:** Raw  
** System ID #:** 233001  
** Turbidity(NTU):** 2.44 NTU  
** Water temp:** 23 C  
** Test Reas:** ROUTINE

---

** Specimen Numbers:** E95WF000031  
** Date Collected:** 9/6/98

---

** FILTER EXAM **  
Protozoa Not Tested  
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 seen.

David L. Maserang, Ph.D.  
Chief, Bureau of Laboratories  
CLIA License Number 45D0660644
DATE: 5/27/99

TO: Larry Mitchell
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
Specimen Inquiry

Spec Status: Closed
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 13987
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 report.
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<td>Debris</td>
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</tbody>
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Pellet size 4.05 μm # Slides exam.

[Handwritten notes:]

6 23 93 BK
Received 6 23 93 BK
Water + 2
June 17, 1993 - 500 gallon filtration test

<table>
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City of Dekalb System #235001
109 W Broadwy
P.O. Box 78649
<table>
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RD SD: Run Daily Sampling and Determinations SD. 
RD-SD: Run Daily Sampling and Determinations Present.
RD: Run Daily.
RD Turbidity Daily Present Daily.
B: Bacteriological.
A: Analysis Test.
A: Anion Exch. for Cr, Fe, Mn.