Report on

Brackish Source Water Exploration

in the San Angelo, Texas Area

Prepared for:
Upper Colorado River Authority
Texas Water Development Board

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Executive Summary

This report documents the results of an exploration of potential brackish groundwater sources for desalination near San Angelo, Texas at the request of the City of San Angelo, the Upper Colorado River Authority, and the Texas Water Development Board.

The Permian-age Whitehorse Formation and Clear Fork Group were chosen for exploration based on previous work identifying these formations as potential brackish groundwater sources. In an attempt to investigate a full section of these aquifers and to target areas without established use of this brackish groundwater, exploration areas in eastern Irion and western Tom Green Counties were chosen. Because of the poor water quality in these formations and the existence of fresh water in the overlying Edwards-Trinity Aquifer, there are virtually no existing water wells completed in Permian-age formations in this area, and there is therefore very little existing water quality and production rate information for these formations in this area.

Three test sites were chosen, two targeting the Whitehorse Formation in Irion County and one targeting the Clear Fork in western Tom Green County. A test hole was completed at each of the sites. A test well was constructed at only the Clear Fork exploration site in western Tom Green County.

As a result of the two exploration test holes in the Whitehorse formation in the area of eastern Irion County, it appears that this formation does not contain water of appropriate quality for desalination in this area. Further, wells completed in the Whitehorse in this area are not likely to produce water at sufficient rates for municipal supply needs. Further exploration in the Whitehorse for a desalination source water for the City of San Angelo is not recommended.

The Clear Fork formation in the area of western Tom Green County appears to offer greater production potential than the Whitehorse, although the test well completed in the Clear Fork demonstrated relatively limited productive capacity (about 45 gpm) for municipal supply use for a city the size of San Angelo. There is very little quantitative data regarding the productive capacity of water wells completed in the Clear Fork in this area, so it cannot be determined whether areas of greater production exist in this formation with the current available data. Additional exploratory test holes and test wells might identify areas in this section of the Clear Fork with better production, but there is no guarantee of success with further exploration.

The Clear Fork test well produced a brackish water of 3,990 mg/L total dissolved solids, with an estimated desalination yield of 80%. The radium concentration of the produced water was relatively high. The radium appears to be sourced from a particular interval within the well. While this radium is efficiently removed in the desalination process, reduction of the radium concentration through site selection or through well construction controls is desirable in order to ease permitting of concentrate disposal wells.

Introduction

This report documents the results of an exploration of potential brackish groundwater sources for desalination near San Angelo, Texas at the request of the City of San Angelo, the Upper Colorado River Authority, and the Texas Water Development Board.

The City of San Angelo used an extensive public process to evaluate potential strategies to meet the City's future water needs. In February of 2004, the San Angelo City Council, the Citizen's Water Advisory Board, and City Staff published the results of this process, which identified five preferred strategies. One of these five was to "Identify and develop fresh and brackish groundwater alternatives". The Region F Water Planning Group followed by naming desalination as one of 10 potentially feasible strategies to meet the water supply needs of the City of San Angelo as a wholesale water provider. A descriptive evaluation of this strategy option appears on page 4-197 of the 2006 Region F Regional Water Plan.

A previous study (LBG-Guyton Associates, 2005) identified the Permian-age Whitehorse Formation and Clear Fork Group as possible brackish groundwater sources. These formations crop out on the eastern and central portion of Tom Green County, and dip to the west. Figure 1 presents a conceptual cross section of these formations in the San Angelo area.

There is some use of the Whitehorse Formation for wells in Coke County and in other parts of western Texas. The Clear Fork group also yields moderate to large quantities of water to wells in eastern Coke and Tom Green Counties. Figure 2 shows the location of wells completed in the Whitehorse and Clear Fork Formations in this area. Neither of these areas, however, represent a full section of the aquifer and wells are generally low-yielding as a result. Further, because these locations are near the outcrop, the water quality is generally better than in downdip locations and therefore both of these locations have established uses of this groundwater. In particular, the Clear Fork wells in eastern Tom Green County are heavily used for irrigation purposes.

In an attempt to investigate a full section of these aquifers and to target areas without established use of this brackish groundwater, exploration areas in eastern Irion and western Tom Green Counties were chosen. Because of the poor water quality in these formations and the existence of fresh water in the overlying Edwards-Trinity Aquifer, there are virtually no existing water wells completed in Permian-age formations in this area, and there is therefore very little existing water quality and production rate information for these formations in this area.

Numerous oil-field geophysical logs were used to select three test locations during the course of the exploration (Figure 3). Specifications for the exploration were prepared and the exploration drilling contract was awarded to West Texas Water Well Service of Odessa, Texas in a competitive bid process in late 2006. Drilling commenced in April 2007. The initial phase of exploration targeted the Whitehorse Formation at its full thickness in eastern Irion County. The first test hole location in this formation was near the existing artesian well completed in the top of the Whitehorse. This well had promising production and water quality, and the objective of the test hole near this well was to investigate the full thickness of the Whitehorse at this location.

A second location approximately eight miles to the north of the first was chosen with a similar objective of investigating the full thickness and spatial extent of the Whitehorse.

After the first two test holes both indicated poor water quality and production rates from the full extent of the Whitehorse, and the formation was found to have similar geologic character in both locations, a third test hole in the Whitehorse was not attempted. Instead, a location was chosen in western Tom Green County to explore a particularly thick section of the Clear Fork Group informally known as the "Clear Fork Reef." Test hole results at this location were promising enough to merit test well construction and testing.

The results of these activities are described by location in the following sections. Supplementary data are to be found in the appendices. The dates of performance of various phases of the work at the test sites are given in Table 1.

Parks-1 Test Hole

The first test hole (Parks-1) was located on the Howard Parks property near the flowing well tested by LBG-Guyton Associates in December, 2004 (Figure 4). This existing flowing well is cased to a depth of 180 ft and produces from the 180 ft to 202 ft (total depth) interval, which only represents a very small interval near the top of the Whitehorse Formation. The pumping test on this existing well indicated a negative boundary was reached early in the test, and the long-term transmissivity calculated from pumping test data was 4,130 gpd/ft.

Water chemistry analyses performed on a sample collected from the existing well indicated the water was saturated with respect to gypsum. Gypsum saturation can pose significant challenges to the desalination treatment process. The Total Dissolved Solids (TDS) result from this sample was 5,160 mg/L.

The goal of the 2007 test hole was to explore the full thickness of the Whitehorse at this location. Geophysical and lithologic logs available from historical oil test holes suggested that there was a significant amount of sand in the Whitehorse in eastern Irion County, although no water quality or production information was available from these sources.

Test hole drilling was performed with the air rotary method, which has the advantage of allowing an estimate of both production and water quality as the test hole is being drilled. Cuttings were logged at ten-foot intervals, and the entire hole was logged with a geophysical logging suite consisting of gamma, SP, caliper, and resistivity with multiple electrode spacings.

Before the test hole proceeded into the Whitehorse, a 16-inch steel surface casing was set to the top of the formation to protect the overlying fresh groundwater from any brackish water below. Unlike the existing Parks well, no artesian flow was observed from the Parks-1 test hole, although the water level in the test hole did rise very slowly to a level near the surface over a period of a few days.

The top of the Whitehorse was at a depth of 160 ft at this location, and the test hole was terminated at the base of 790 ft. The Whitehorse in this location is primarily comprised of fine gray cemented sand, with streaks of pyritic dolomite and shale. A photograph of this fine gray cemented sand under 10x magnification is given in Figure 5. When the total depth of the test hole was reached, the hole was pumped by the air rotary drill stem discharge and an informal water sample was collected and analyzed by the City of San Angelo. The analytical results indicate a sodium-chloride type of water with very high (greater than 20,000 mg/L) total dissolved solids (TDS) content that would generally offer low desalination yields. Further, the formation produced at a very low rate from this air pumping, approximately 10 gallons per minute (gpm).

The test hole was plugged by cement placed by tremie pipe under pressure from the total depth of 790 ft to a level inside the surface casing of 150 ft below ground surface. The surface casing was left open to 150 ft in order to allow the landowner the option of making a well by perforating the casing at a shallow freshwater interval. A drawing of the test hole is presented in Figure 6. Appendix A contains the formation sample descriptions, geophysical log, and water sample analytical results.

Schlinke-1 Test Hole

The second exploratory test hole (Schlinke-1) was located on the Schlinke property approximately eight miles northwest of the Parks-1 location. A location map is given in Figure 7. As with the Parks-1 location, geophysical and lithologic logs available from historical oil test holes suggested that there was a significant amount of sand at this location, and the Schlinke-1 test hole was drilled to assess the water quality and productive capacity of the Whitehorse at this location.

Test hole drilling was performed with the air rotary method, which has the advantage of allowing an estimate of both production and water quality as the test hole is being drilled. Cuttings were logged at ten-foot intervals, and the entire hole was logged with a geophysical logging suite consisting of gamma, SP, and resistivity with multiple electrode spacings.

Before the test hole proceeded into the Whitehorse, a 16-inch steel surface casing was set to the top of the formation to protect the overlying fresh groundwater from any brackish water below.

The top of the Whitehorse was at 131 ft at this location, and the test hole was terminated at the base of 790 ft. The Whitehorse in this location was found to be very similar in character to the Parks-1 location; it is primarily comprised of similarly fine gray cemented sand, with streaks of pyritic dolomite and shale. When the total depth of the test hole was reached, the hole was pumped by the air rotary drill stem discharge, but the flow was too low (approximately 3 gpm) to clean the hole out for an adequate sample. Field measurement of the discharge indicated a conductivity in excess of 50,000 µS/cm, which is an indication that the water in the formation is of too poor quality to be a feasible desalination source. The production potential is also clearly poor at this location.

The test hole was plugged by cement placed by tremie pipe under pressure from the total depth of 790 ft to a level inside the surface casing of 131 ft below ground surface. The surface casing was left open to 131 ft in order to allow the landowner the option of making a well by perforating the casing at a shallow freshwater interval. A drawing of the test hole is presented in Figure 8. Appendix B contains the formation sample descriptions and geophysical log.

Schmidt-1 Test Hole

The third exploratory test hole (Schmidt-1) was located on the Schmidt property approximately one mile south of Knickerbocker in western Tom Green County. A location map is given in Figure 9. The purpose of this test hole was to investigate a particularly thick section of the Clear Fork group known informally as the "Clear Fork Reef." An anecdotal report of an historical flowing test hole drilled by cable tools north of Knickerbocker, combined with area geophysical logs, suggested exploration of the formation at this location.

Test hole drilling was performed with the air rotary method until a depth of 530 feet was reached. Sloughing from overlying shale into the test hole made mud rotary drilling necessary from that point forward. Cuttings were logged at ten-foot intervals, and the entire hole was logged with a geophysical logging suite consisting of gamma, caliper, SP, and resistivity with multiple electrode spacings.

Although no fresh groundwater was encountered during drilling at this location, a 12-inch steel surface casing was set to the base of the Cretaceous at 145 ft to protect this formation from any brackish water below. A large aboveground clay containment structure (approximately 100 ft wide x 100 ft long x 5 feet high) was constructed to contain the brackish waters discharged during all test pumping at this site. Evaporation of the limited amount of water discharged during test pumping made further management unnecessary.

The top of the Clear Fork dolomite was at 460 ft at this location, and the test hole was terminated at a depth of 1,031 ft. A small amount of brackish water was produced during air rotary drilling beginning at a depth of 520 ft. Mud rotary drilling prevented estimates of water quality and quantity produced from the test hole for depths greater than 530 ft.

The formation samples indicated the Clear Fork is primarily comprised of a tan dolomite with interbedded shale and pyrite. Vugular porosity was evident in many of the dolomite formation cutting samples, particularly in the upper portion of the dolomite. A photograph of one of the dolomite samples under 10x magnification is presented in Figure 10. The dolomite became very hard at a depth of approximately 630 ft, significantly increasing drilling times throughout the rest of the test hole.

In order to evaluate the water quality and productive capacity of the test hole, small temporary discharge sections were constructed at three 30-ft depth intervals: 903 ft to 933 ft, 675 ft to 705 ft, and 615 ft to 645 ft. The intervals were isolated and pumped with air at a rate of 10 to 15 gpm. After the drilling fluid was removed, a water sample was collected from each interval and analyzed for selected constituents. The results of these sample analyses are summarized in Table 2. The deepest interval (903-933 ft) produced the poorest-quality water, with a TDS of 65,800 mg/L. The 675-705 ft and 615-645 ft intervals produced better quality water in general, with TDS of 8,140 mg/L and 7,040 mg/L, respectively. All three intervals produced a sodium-chloride type of water.

Based on these results, a test well was constructed by reaming the hole to a depth of 505 ft and setting and pressure cementing a 7-inch steel casing with threaded connections. Monitoring the discharge from the subsequent hole cleanout with air indicated the water quality degraded very quickly below a depth of 700 ft, and therefore cement was placed in the hole under pressure from the total depth to a depth of 687 ft to isolate the well from this poorer-quality water.

A drawing of the test well is presented in Figure 11. Appendix C contains the formation sample descriptions, geophysical log, and water sample analytical results.

This well was developed over a period of two days. The pumping rate during development was 52 gpm, with a drawdown of 375 ft after 1.5 hours. Based on this information, a constant-rate pumping test was performed at a discharge rate of 23 gpm. This rate ensured the aquifer would be adequately stressed without the risk of the pump breaking suction during the test. The pumping period for the test was 18 hours, with a 12-hour recovery data collection period.

The static water level on October 9, 2007 just before the start of the test at 8:00 AM was 51.71 ft below top of casing (BTOC). The casing height above ground surface was 1.60 ft. The drawdown at the end of the 18-hour pumping period was 187 feet, for a pumping level of approximately 239 ft below top of casing. A hydrograph of the pumping and recovery periods is shown in Figure 12. At about 4:00 PM on October 9 a sample valve was opened to fill a sample barrel, resulting in a temporary reduction in pumping head, and therefore an increase in discharge and drawdown. This event had a negligible effect on the test results.

Analysis of the pumping test suggests a slightly lower transmissivity in the near-wellbore than farther out into the formation. The estimated formation transmissivity at this location for the 505-687 ft interval is 200 gpd/ft (Figure 13). Assuming a pump setting of 505 ft, the maximum sustained pumping rate for this well is approximately 45 gpm.

The production rate from this well could potentially be improved to as much as 75 gpm by the use of well stimulation techniques such as acidization, and in a production situation (such as in a wellfield) these techniques would be recommended to maximize yield from the well. However, at this exploration stage very little if any additional information about the aquifer as a whole would be gained through the use of these techniques. Further, even increasing the yield to 75 gpm would be ineffective for demonstrative purposes. Therefore, given the cost of these techniques they were not recommended.

A water sample was collected from the Schmidt-1 test well near the end of the pumping period and submitted for analysis. The results are given in Table 3. The water was a sodium-chloride type of water with a TDS content of 3,990 mg/L. The estimated treated desalination yield of this water is 80%, which is in the upper range of that estimated in the 2006 Initial Feasibility Assessment report (Freese and Nichols and LBG-Guyton Associates, 2006).

There was a strong hydrogen sulfide odor in the water. This hydrogen sulfide reacts with the steel casing and produces pyrite if the well is not pumped for a time. The produced water from the formation itself is virtually colorless. The hydrogen sulfide is not expected to effect treatment yields, but it should be reduced in concentration during treatment for corrosion prevention, aesthetic, and possibly regulatory purposes.

The radium-226 concentration is elevated. This radium is probably due to the presence of a black organic shale in the producing interval that exhibited a strong response on the gamma log. Radium is easily removed in the treatment process, but very high radium concentrations in the reject concentrate can require additional treatment to reduce the radium concentration before the reject concentrate can be disposed of in an injection well.

The well was completed with a locking cap, and the site was returned to grade. The well may be useful in the future for water level monitoring purposes, but due to elevated levels of dissolved solids, fluoride, radium, and other constituents of concern it is not suitable as a domestic or livestock source without treatment. Caution and perhaps some monitoring equipment should also be used when opening the well casing, as there is a possibility that dangerous levels of hydrogen sulfide could develop inside the closed well casing over time.

Conclusions and Recommendations

The Whitehorse formation in the area of eastern Irion County does not contain water of appropriate quality for desalination. Further, wells completed in the Whitehorse in this area are not likely to produce water at sufficient rates for municipal supply needs. Further exploration in the Whitehorse for a desalination source water for the City of San Angelo is not recommended.

The Clear Fork formation in the area of western Tom Green County appears to offer greater production potential than the Whitehorse, although the Schmidt property test well completed in the Clear Fork demonstrated relatively limited productive capacity for municipal supply use for a city the size of San Angelo. There is very little quantitative data regarding the productive capacity of water wells completed in the Clear Fork in this area, so it cannot be determined whether areas of greater production exist in this formation with the current available data. Additional exploratory test holes and test wells might identify areas in this section of the Clear Fork with better production, but there is no guarantee of success with further exploration.

The quality of the water produced by the Schmidt property test well is treatable by desalination with an estimated yield of 80%. Hydrochemical facies and dissolved solids concentrations are generally not as spatially variable as productive capacity in a consolidated formation, and so the treatability of the water is expected to remain relatively consistent in the Clear Fork in this area.

The radium-226 concentration (39.2 pCi/L) is relatively high in waters produced by the Schmidt test well. This is due in part to the fact that the test well was constructed to capture a large formation interval for productivity testing, including some shale intervals that appear to contain high levels of radium. The radium concentration from the test well is such that if this well were used as a production well, the desalination concentrate would be above the limit specified for Class I non-hazardous underground injection (60 pCi/L for Ra-226). Desalination is very efficient at removing radium, so the potential problem with this radium concentration lies in disposal and not treatment.

If sufficient productive capacity were found elsewhere in this section of the Clear Fork to demonstrate that it is a feasible desalination source, the radium concentration in the groundwater in that area would need to be determined to address this potential disposal problem. Assuming a desalination yield of 80%, the radium concentration would need to be about 12 pCi/L or less to result in a concentrate level of less than 60 pCi/L for Class I non-hazardous disposal.

If elevated levels of radium were found elsewhere in the formation, the radium concentration in the desalination concentrate could possibly be reduced in a wellfield production setting by one or a combination of the following methods:

1. Using existing geophysical logs to identify spatial areas that do not exhibit the characteristics of high radium concentrations. UCRA is currently conducting a study of existing geophysical logs to assess the spatial extent of the radium-rich intervals.

2. Constructing the production well in such a way as to limit the amount of water produced from intervals with high radium concentrations. This would most likely involve setting casing below such intervals, and perforating above them to recover production intervals lost to the casing.

3. Reducing the radium concentration of the injectate through dilution or additional treatment. Dilution has the drawback of reducing desalination yields and increasing disposal volumes, and additional treatment has the drawback of producing a secondary waste stream that could not be injected into a Class I non-hazardous disposal well.

The primary concerns to be addressed in additional exploration, therefore, are finding greater productive capacity and limiting radium concentrations through site selection or engineering controls, if possible. As for regulatory concerns, recent rulemaking developments promise to make permitting the disposal of non-hazardous desalination concentrate through deep well injection easier.

New rules have been proposed by TCEQ that will make permitting of desalination concentrate injection wells much easier and less expensive. These rules should be published for comment in March 2008, with a target adoption date of July or August 2008. The new proposed rules would allow Class I disposal of non-hazardous desalination concentrate by general permit, which will greatly facilitate the authorization of disposal wells. Also included in the proposed rules would be a reduction of the State's technical standards for these wells to standards similar to federal standards for Class I non-hazardous injection wells. Federal standards for Class I non-hazardous wells are similar to Class II well requirements, and Class II operators may elect to obtain a dual permit for Class II and Class I injection of desalination concentrate. Further, only a Texas Railroad Commission permit would be needed for the injection of non-hazardous desalination concentrate for the purposes of enhanced oil and gas recovery.

A detailed geophysical log study should be performed to delineate the full extent and thickness of this Clear Fork "reef" structure before any further exploration is considered. Also, geophysical logs should be studied to determine whether the intervals of high radium concentration observed in the Schmidt test well are likely to be a geographically local or more widespread phenomenon. UCRA is currently performing a log study that will complete these formation delineation and radium persistence tasks.

References

Freese and Nichols and LBG-Guyton Associates, 2006. San Angelo Groundwater Evaluation Phase I Report, Initial Feasibility Assessment. Report prepared for the City of San Angelo, the Upper Colorado River Authority, and the Texas Water Development Board

LBG-Guyton Associates, 2005. An evaluation of Triassic and Permian brackish groundwater sources in the San Angelo, Texas area. Report prepared for Texas Water Development Board Planning Region F.

LBG-Guyton Associates, 2006. City of San Angelo Brackish Source Groundwater Test Program Construction Documents and Project Manual. Specifications developed for the City of San Angelo, the Upper Colorado River Authority, and the Texas Water Development Board.

FIGURES

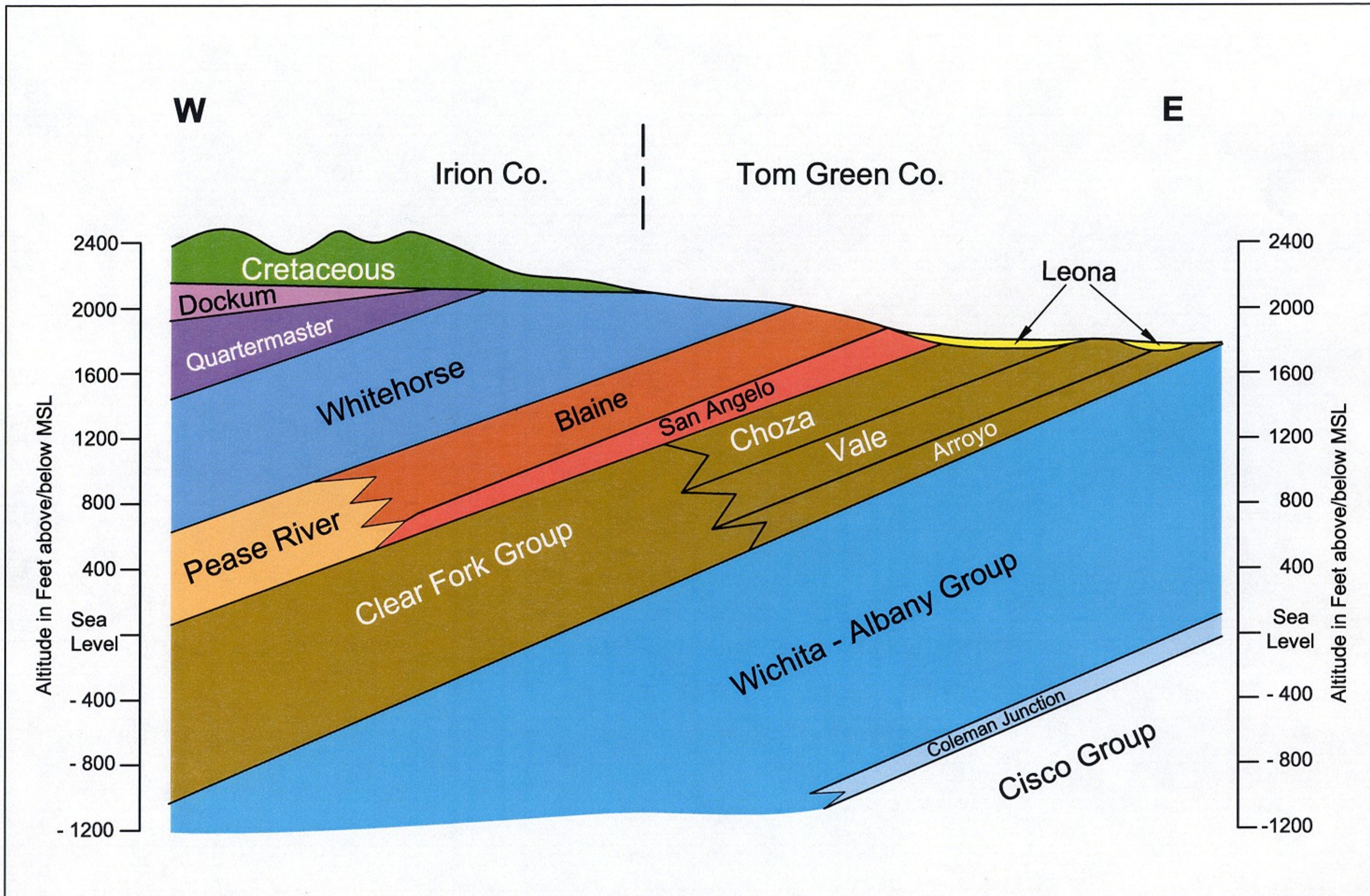

Figure 1: Conceptual Geologic Cross Section

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Figure 2: Clear Fork Group and Whitehorse Wells Near San Angelo

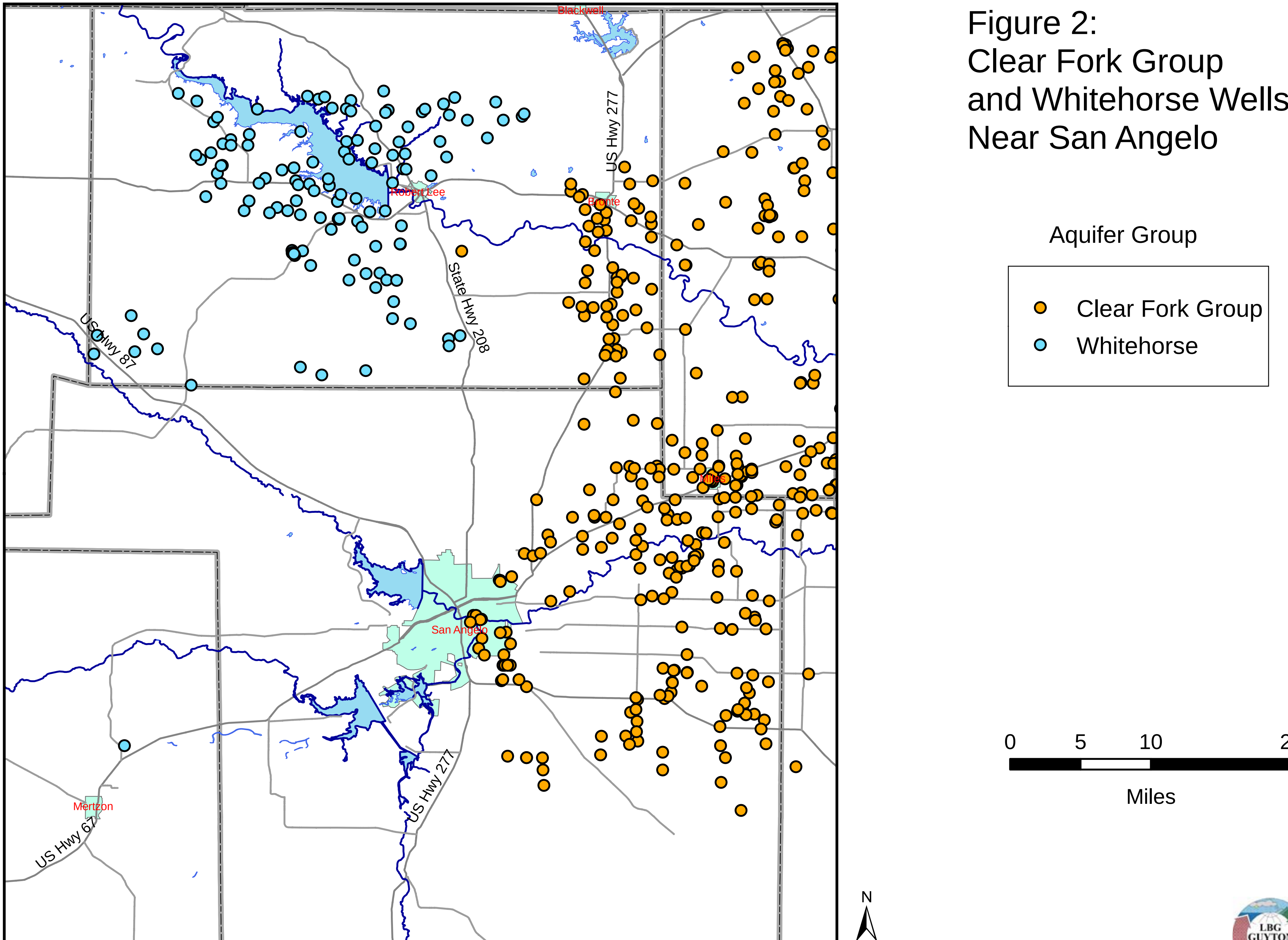
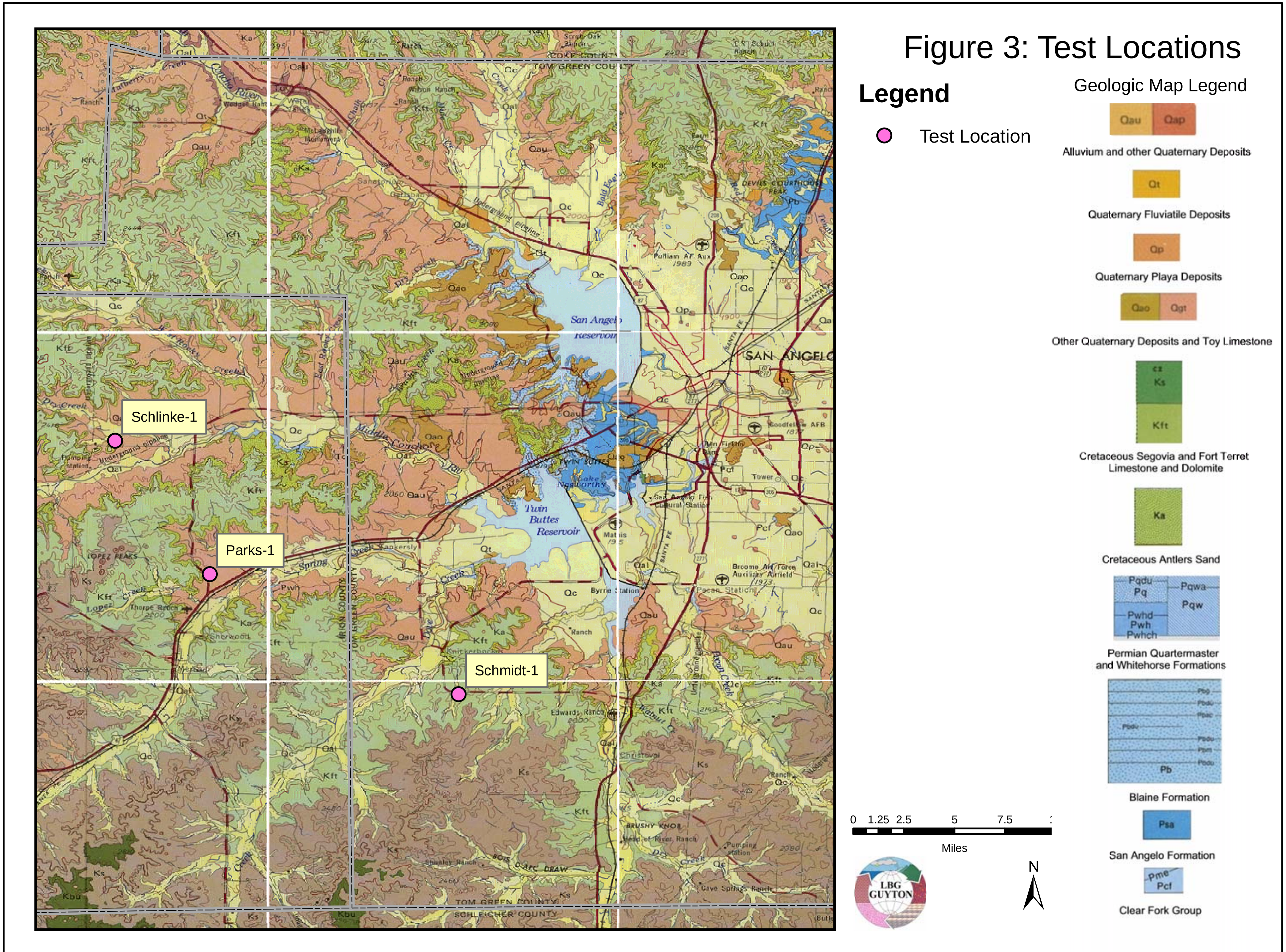
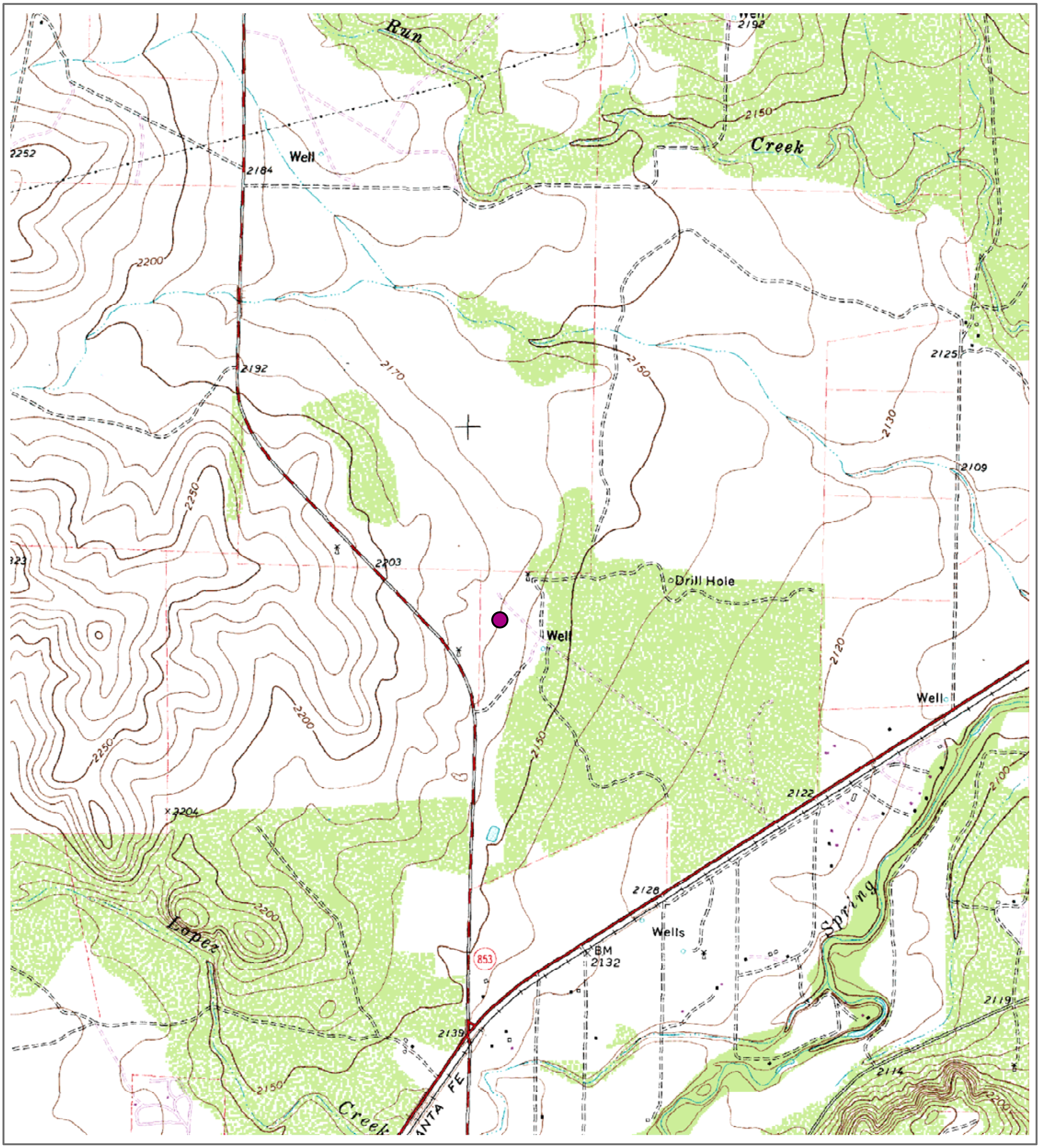


Figure 3: Test Locations





Contour Interval 10 feet

Feet 0 1,000 2,000 4,000 6,000 8,000

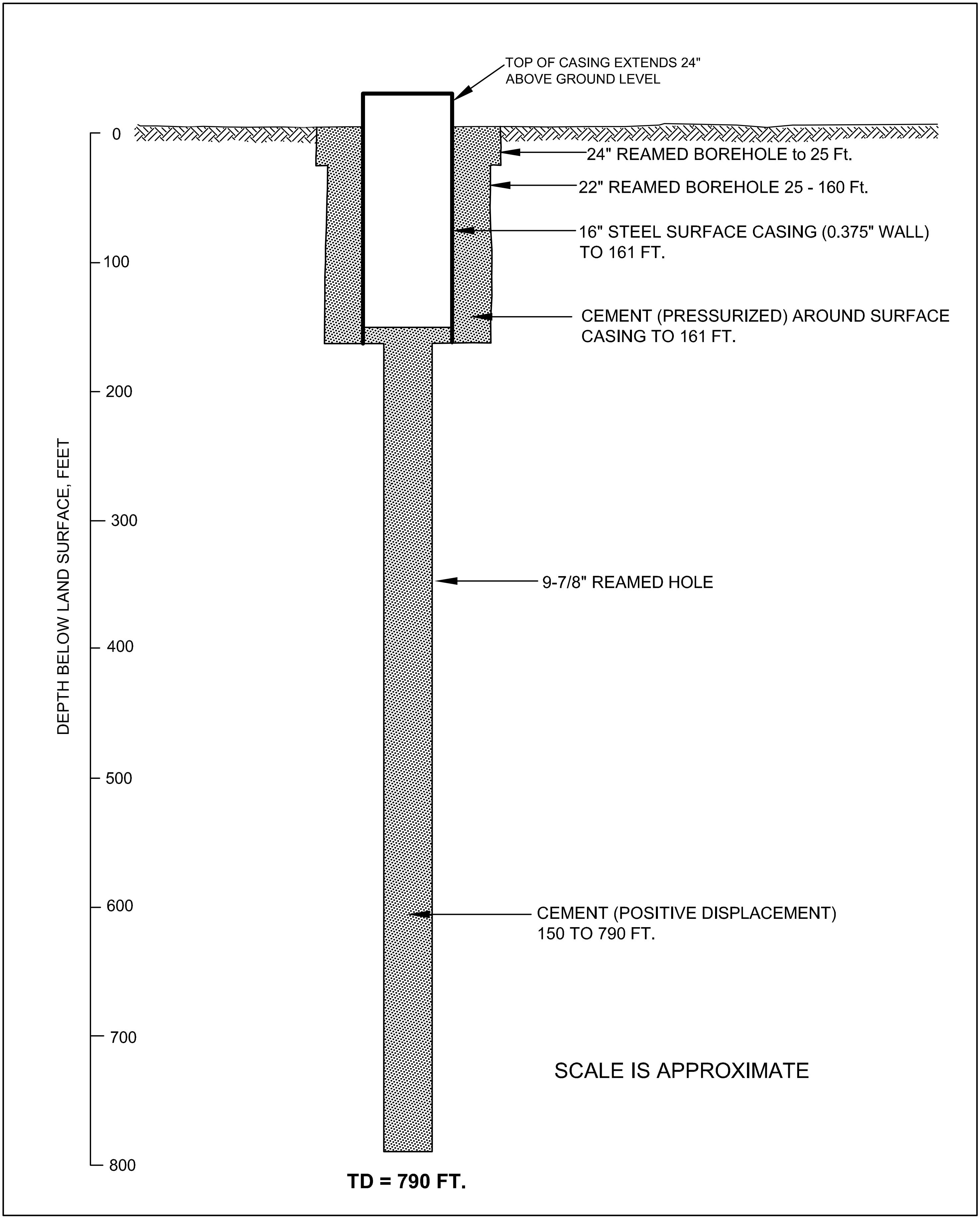
Legend

● Parks-1 Test Hole

N

Figure 4: Parks-1 Location Map
Irion County, Texas

Figure 5: Parks-1 Formation Sample, sandstone, limestone, and pyrite cuttings at 10x magnification



CITY OF SAN ANGELO
PARKS - 1 TEST HOLE - MERTZON, TEXAS

FIGURE 6

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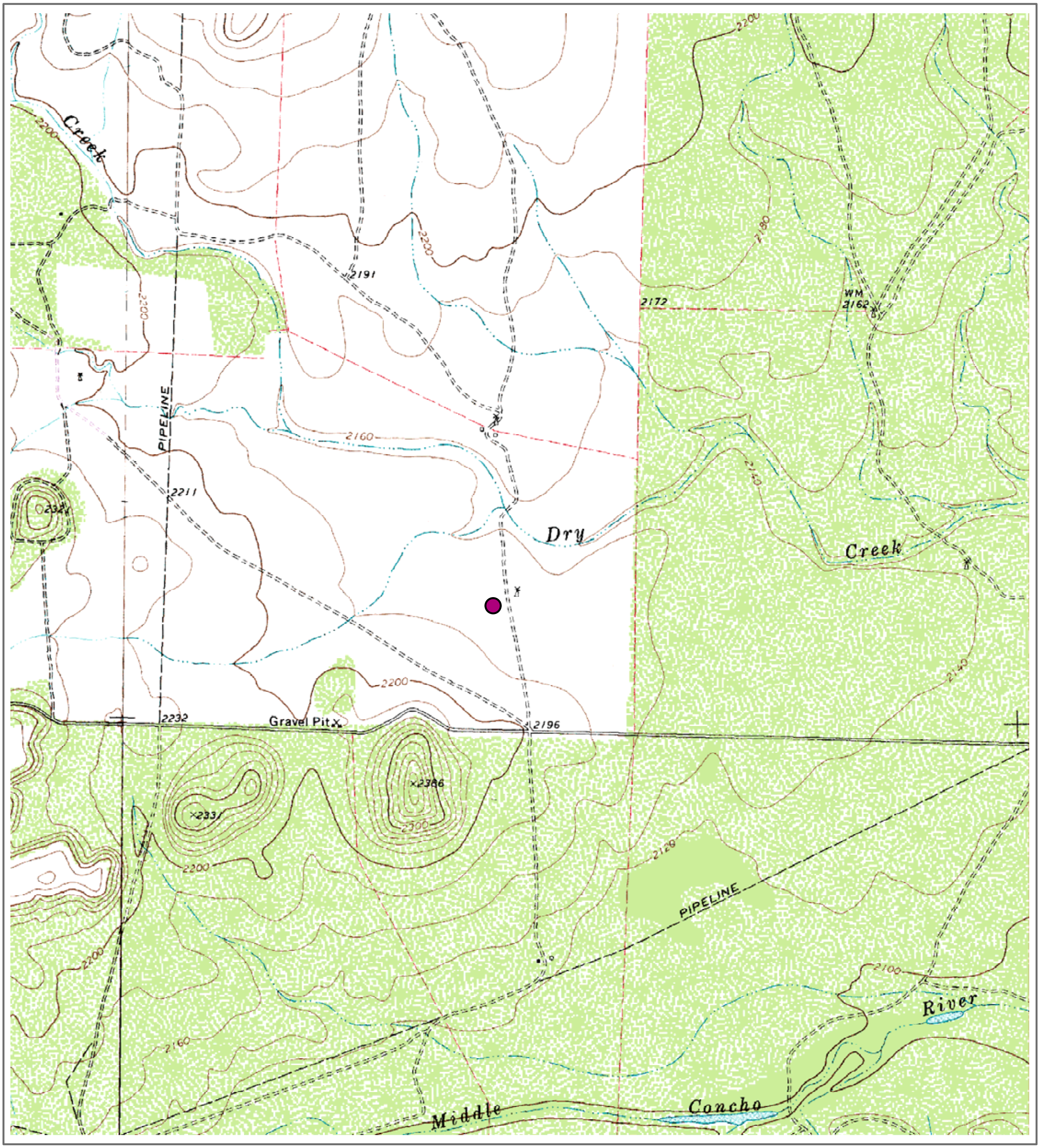

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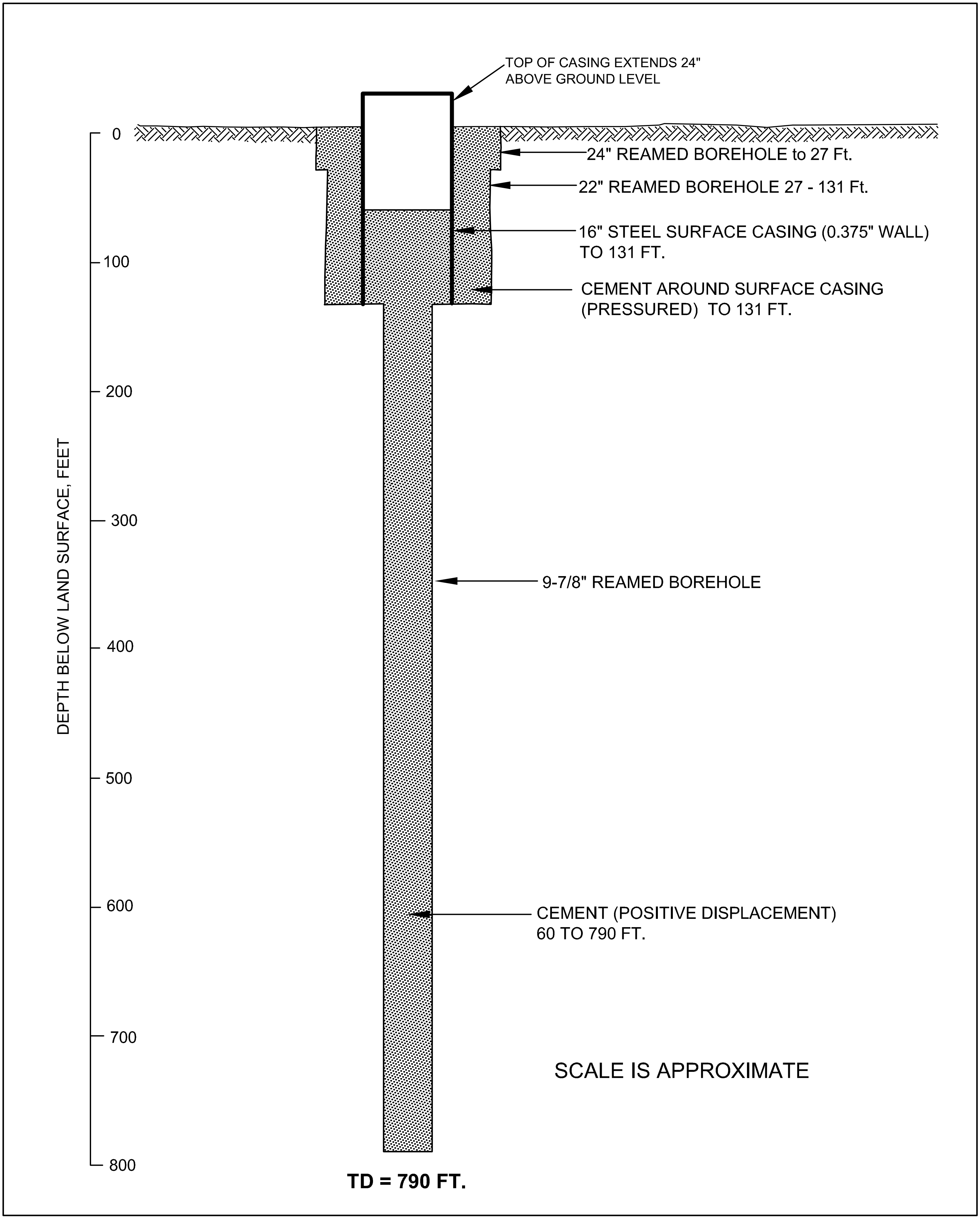
Legend

Schlinke-1 Test Hole

N

Figure 7: Schlinke-1 Location Map
Irion County, Texas



CITY OF SAN ANGELO
SCHLINKE - 1 TEST HOLE - MERTZON, TEXAS

FIGURE 8

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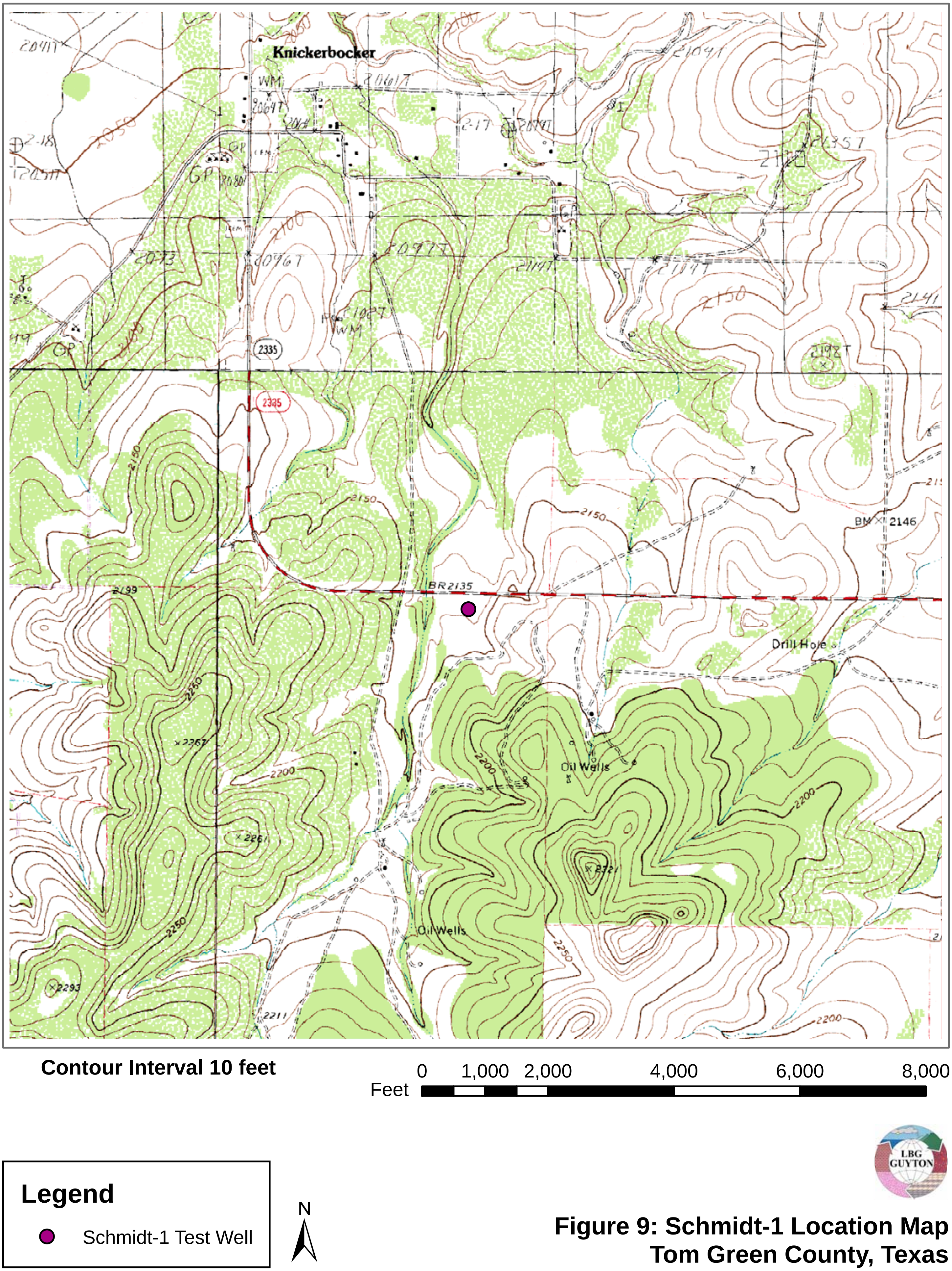
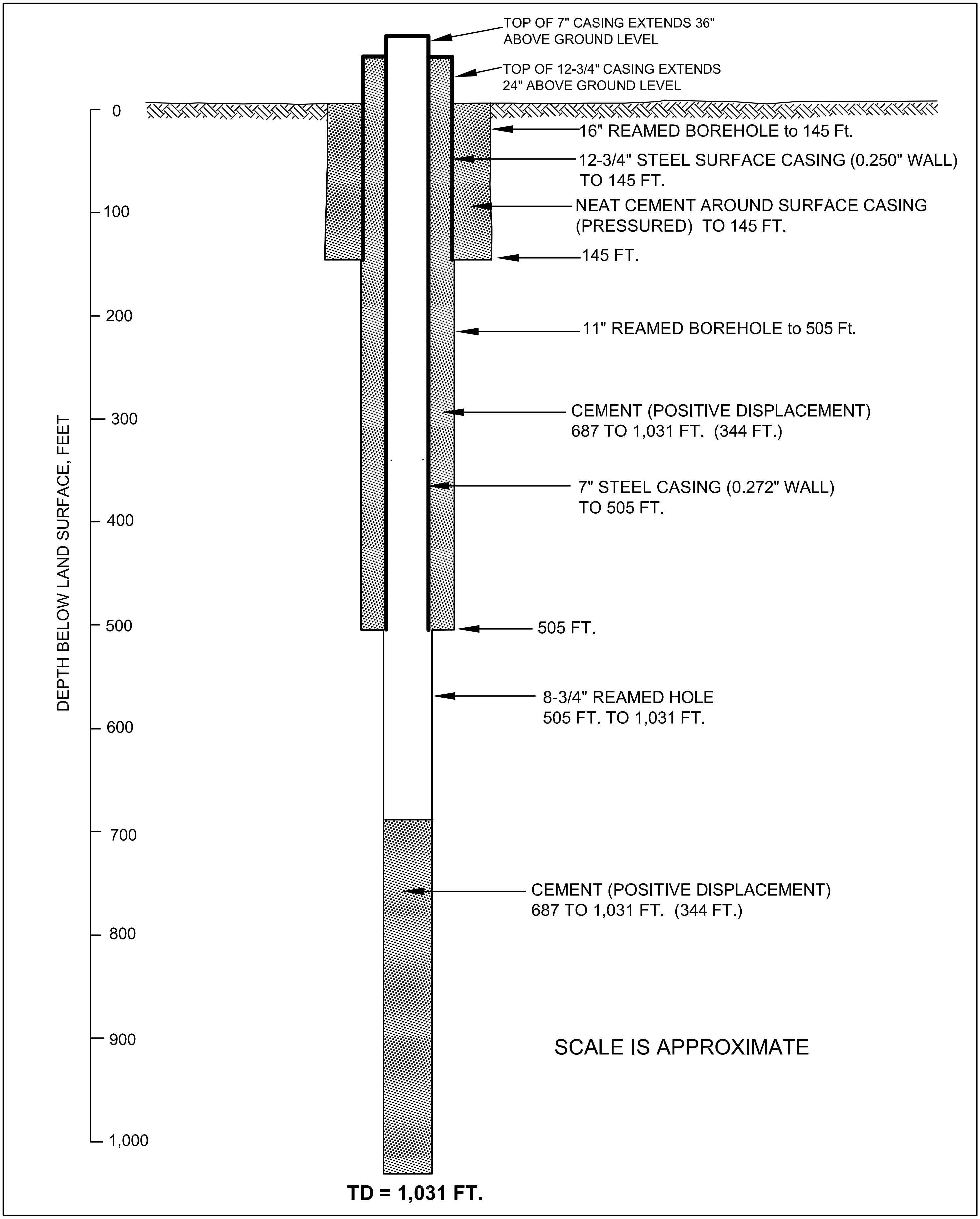


Figure 9: Schmidt-1 Location Map
Tom Green County, Texas

Figure 10: Schmidt-1 formation sample, dolomite cuttings at 10x magnification



CITY OF SAN ANGELO
SCHMIDT - 1 WELL - MERTZON, TEXAS

FIGURE 11

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Figure 12: Schmidt-1 23-gpm Constant Rate Pumping Test Hydrograph

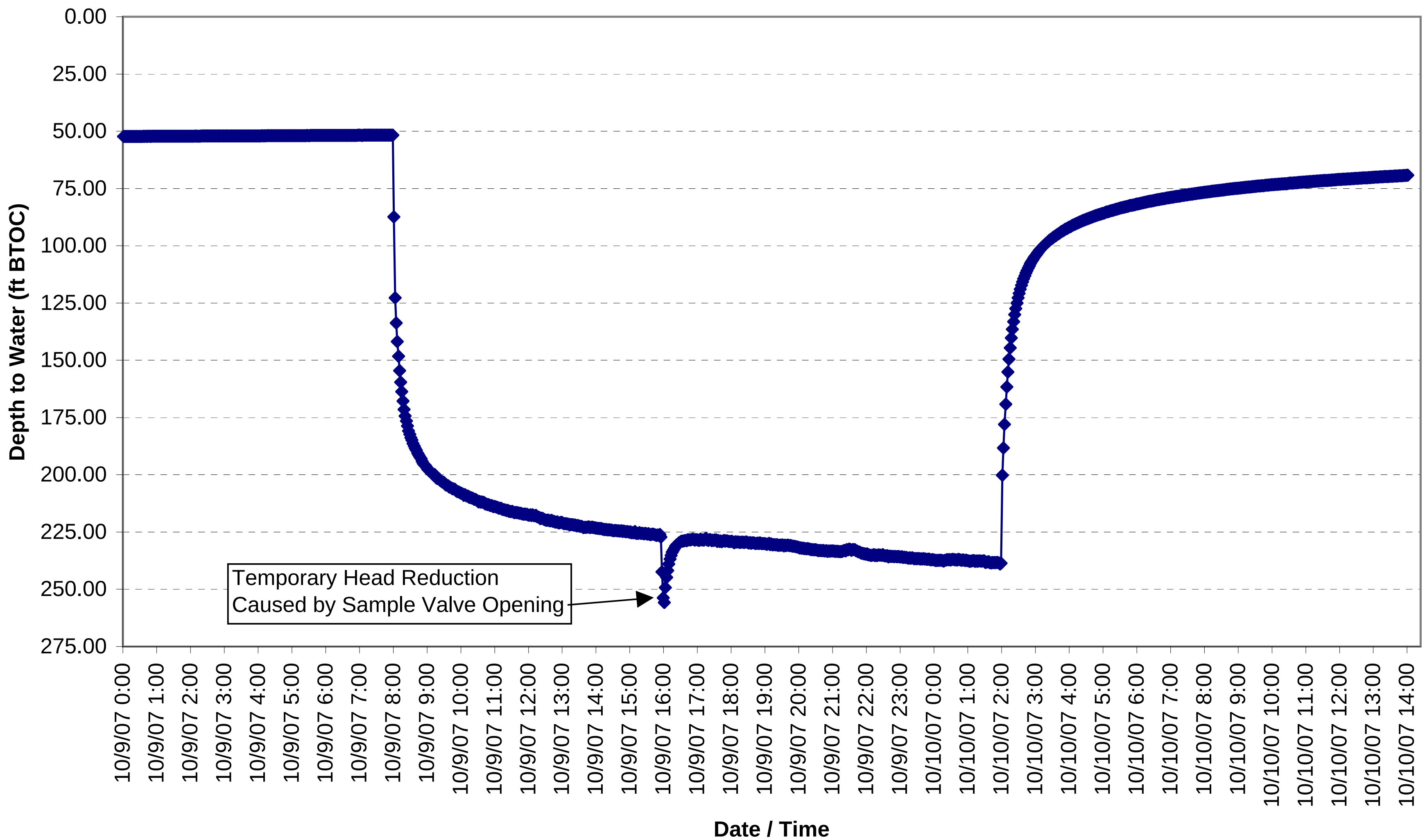
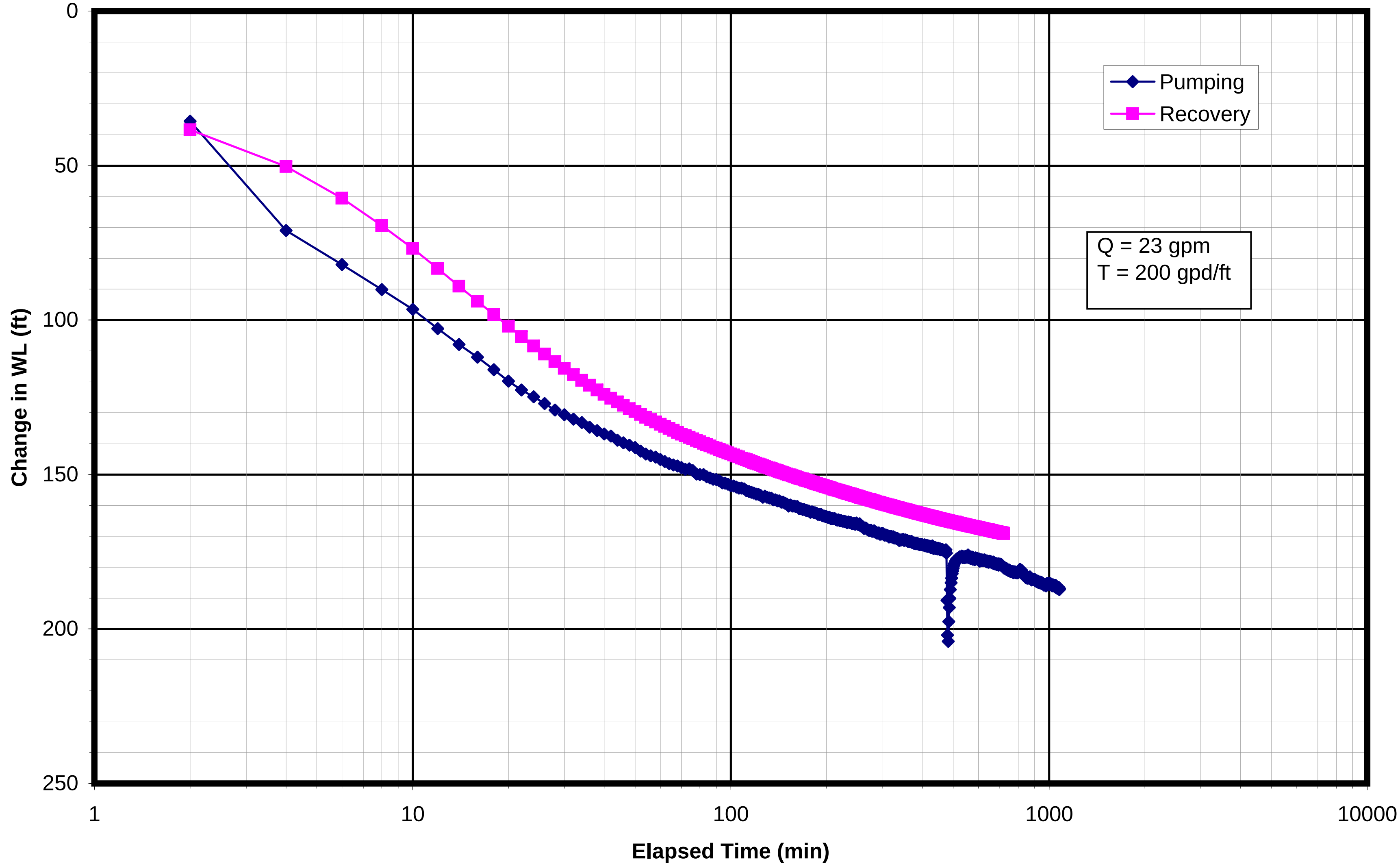


Figure 13: Schmidt-1 Pumping Test Semilog Plot



TABLES

Table 1: Test Site Dates

Test Site	Driller	Drilling Start Date	Drilling/Construction Completion Date	Water Sampling Date(s)	Plugging Date
Parks-1	West Texas Water Well Service	4/16/2007	5/7/2007	5/7/2007	5/8/2007
Schlinke-1	West Texas Water Well Service	5/19/2007	6/13/2007	Not Applicable	6/13/2007
Schmidt-1	West Texas Water Well Service	7/18/2007	9/28/2007	Sept. 8, 9, 10 (test hole intervals); Oct. 10, 2007 (test well)	Not Applicable

Table 2: Schmidt-1 Test Hole Interval Sampling Results

Cations									
Sample ID	**Sample Date**	**Barium**	**Calcium**	**Magnesium**	**Sodium**	**Potassium**	**Strontium**	**Manganese**	**Iron**
		mg/L	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**
SCHIMDT-1-903-933	9/8/2007	0.0673	1,770	678	20,200	359	38.9	0.0421	0.237
SCHIMDT-1-675-705	9/10/2007	0.0674	102	91	2,580	52.3	3.31	0.00864	< 0.100
SCHIMDT-1-615-645	9/12/2007	0.0555	90	72.9	2,140	47.4	2.86	< 0.0102	0.227

Anions						
Sample ID	**Sample Date**	**Bicarbonate**	**Carbonate**	**Sulfate**	**Chloride**	**Fluoride**
		mg/L	**mg/L**	**mg/L**	**mg/L**	**mg/L**
SCHIMDT-1-903-933	9/8/2007	489	< 1	3,120	41,000	52
SCHIMDT-1-675-705	9/10/2007	810	< 1	797	3,650	6
SCHIMDT-1-615-645	9/12/2007	880	< 1	604	3,010	5.25

Other						
Sample ID	**Sample Date**	**Dissolved Solids**	**Silica**	**Conductivity**	**pH**	**Alkalinity**
		mg/L	**mg/L**	**µS/cm**	**pH**	**mg/L $CaCO_3$**
SCHIMDT-1-903-933	9/8/2007	65,800	11.6	87,400	7.33	401
SCHIMDT-1-675-705	9/10/2007	8,140	12.1	13,300	7.91	648
SCHIMDT-1-615-645	9/12/2007	7,040	18.3	11,100	7.99	722

Notes:
1. The last two sequences of digits in the sample ID denote the depth interval of the sample.
2. Units: mg/L (milligrams per liter), µS/cm (microsiemens per centimeter), mg/L $CaCO_3$ (milligrams per liter as calcium carbonate)

Table 3: Schmidt-1 Test Well Sampling Results
Sample Date 10/10/2007, at End of Pumping Period

Cations								
Barium	Calcium	Magnesium	Sodium	Potassium	Strontium	Manganese	Iron	Arsenic
mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
0.0246	71.9	32.6	1,340	41.1	1.62	0.0281	< 0.051	< 0.002
Anions								
Bicarbonate	Carbonate	Sulfate	Chloride	Fluoride				
mg/L	mg/L	mg/L	mg/L	mg/L				
1,104	< 1	384	1,500	5.99				
Other								
Dissolved Solids	Silica	Conductivity	pH	Alkalinity				
mg/L	mg/L	µS/cm		mg/L $CaCO_3$				
3,990	32.8	6,730	7.74	905				
Radiological								
Uranium	Gross Alpha	Gross Beta	Radium-226	Radium-228				
µg/L	pCi/L	pCi/L	pCi/L	pCi/L				
0.41	105	59.0	39.2	2.0				

Note on Units: mg/L (milligrams per liter), µg/L (micrograms per liter), µS/cm (microsiemens per centimeter), pCi/L (picocuries per liter)
mg/L CaCO3 (milligrams per liter as calcium carbonate)

APPENDICES

Appendix A – Parks Test Hole

Formation Descriptions
Analytical Results
Geophysical Log

Parks-1 Test Hole Formation Sample Descriptions

Interval	Description
50-60	Red shale and white limestone
60-70	Red shale
70-80	Red shale
80-90	Red shale, most at 90'
90-100	Red shale, dry
100-110	Red shale, wet @ 100'
110-120	White shale and cemented sand. Slight reaction to acid. Tight cementation
120-130	Cemented sand and gray shale
130-140	Red clay
150-160	Gray clay, black coal chips at 150'
170-180	Cement brown and gray sandstone
180-190	Soft brown sandstone, low returns, fine grained
190-200	Brown sandstone, some red sandstone. Soft gray sandstone @ 195', very fine grained
100-210	Gray sandstone, very fine grained
210-220	Gray sandstone, very fine grained, w/some gypsum
220-230	Gypsum
230-240	Gypsum w/dolomite. Some reaction to HCl. White
240-250	Gray sandstone, very fine
250-260	Brown sandstone, fine to medium, oily
260-270	Fine gray sandstone
270-280	Fine gray sandstone
280-290	Fine gray sandstone
290-300	Fine gray sandstone
300-310	Red lime, green shale and gray sandstone
310-320	Gray sandstone, fine to medium, coarser than before
320-330	Fine to medium sand
330-340	Fine to medium sand, gray
340-350	Fine to medium sand, gray
350-360	Fine to medium sand, gray
360-370	Fine to medium sand, gray
370-380	Fine to medium sand, gray
380-390	Fine to medium sand, gray
390-400	Fine to medium sand, gray
400-410	Fine to medium sand, gray
410-420	Fine to medium sand, gray
420-430	Very fine sandstone w/lime

Parks-1 Test Hole Formation Sample Descriptions

430-440	Very fine sandstone gray, less lime
440-450	Very fine sandstone, gray, some gypsum
450-460	Very fine sandstone, gray
460-470	Darker gray sandstone, a little coarser grained
470-480	Very fine sandstone, light gray
480-490	Very fine sandstone, light gray
490-500	Very fine sandstone, light gray
500-510	Same as above w/some gypsum
510-520	Very fine sandstone, dark gray
520-530	Very fine tinted sandstone, brown to gray
530-540	Very fine tinted sandstone, brown to gray
540-550	Very fine gray and fine brown calcareous sandstone
550-560	Very fine gray and fine brown calcareous sandstone
560-570	Very fine gray and fine brown sandstone
570-580	Very fine gray and fine brown sandstone
580-590	Very fine gray and fine brown sandstone
590-600	Very fine gray and fine brown sandstone
600-610	Very fine gray and fine brown sandstone, w/gypsum
610-620	Very fine gray and fine brown sandstone w/dolomite and gypsum
620-630	Very fine gray and fine brown sandstone w/dolomite and gypsum
630-640	Very fine gray and fine brown sandstone w/dolomite and gypsum
640-650	Very fine gray and fine brown sandstone w/dolomite and gypsum
650-660	Very fine gray and fine brown sandstone w/dolomite and gypsum, w/large pyrite crystal, very fine sand less silty
660-670	Very fine gray sand w/some green shale
670-680	Very fine gray sand w/some green shale
680-690	Clean translucent fine sand w/th green shale and some gray shale. Lost oil stain, some pyrite
690-700	Pyrite and green shale, small amount of dense sand
700-710	Pyrite and green shale, small amount of dense sand, w/very hard light brown siltstone
710-720	60% sandstone, 40% shale, some soft limestone and pyrite. Some green argillaceous sand. Still a little pyrite
720-730	Same as above except 70% sandstone
730-740	70% sandstone, clear translucent white grains, calcareous to gl calcareous, fine grained. 30% green shale, silty in part, trace pyrite
740-750	Same as above, with some chunks of conglomerate
750-760	80% green shale, some sandstone
760-770	90% green shale, 10% red shale, trace sand
770-780	Mostly red shale, some green trace sandstone
780-790	Red shale

Parks Ranch Whitehorse Test Well # 1

Date of Analysis 5/11/07	Tech. Initials	mls of sample	Sample Results
pH (SU)	SM		8.24
TEMPERATURE (°C)	SM		5.5
CONDUCTIVITY (mS/cm)	SM		1.63
TURBIDITY (NTU)			
CHLORIDES (mg/L)	AH	2% 25	7.85 14,560 7.23
T. HARDNESS (mg/L)	AH	10% 25	12.48 4988 12.46
ALKALINITY (mg/L)	AH	10% 25	1.90 792 2.00
CALCIUM (mg/L)	AH	10% 25	7.51 2992 7.45

Comments:
NH_3-N
Std: 1.0
Std Read: 1.04
Actual Read: 17.7
% Recovery: 104%

NO_3-N
Std: 1.0
Std Read: 1.03
Actual Read: 20.4
% Recovery: 103%

Standard Percent Recovery = $\frac{\text{Actual Result}}{\text{Expected Result}} \times 100$

LFM Percent Recovery = $\frac{\text{LFM Result - Sample Result}}{\text{Spike}} \times 100$

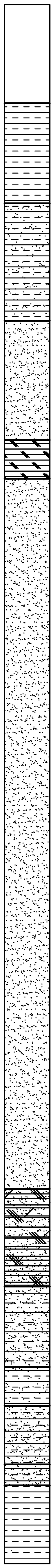
NOTE: ALL RESULTS EXCEPT pH & conductivity are expressed in mg/L or PPM (parts per million).

	Initials	mls of sample	% of Sample	Read from DR4000	Final Sample Result	Known Standard Concentration	Results of Standard Read	Percent Recovery	LFM Spike	LFM Result	Percent Recovery
SULFATE (mg/L)	AH	25	2%	64.8 67.1	3297.5	70	71.0	101.4%			
NITRATE (mg/L)											
PHOSPHATE (mg/L)	AH	10	10%	0.068 0.095	0.815	2.5	2.544	101.8%			
IRON (mg/L)	AH	10	100%	.424 .410	0.417	3.0	2.846	95%			
FLUORIDE (mg/L)	AH	10	100%	2.04 2.20	2.12	2.0	2.07	103.5%			
ALUMINUM (mg/L)	AH	25	100%	.007	0.007	0.8	0.762	95.3%			

San Angelo Desalination Project
Parks Test Test Hole No. 1

Consolidated and Simplified Field Descriptions

by LBG-Guyton Associates
See Appendix for detailed descriptions



50 - 100' Red shale

100 - 160' Gray shale with sandstone streaks

160 - 220' Brown and gray sandstone

220 - 240' Gypsum

240 - 600' Gray and brown sandstone, fine to medium-grained

600 - 650' Gray and brown sandstone, fine-grained, with streaks of dolomite and gypsum

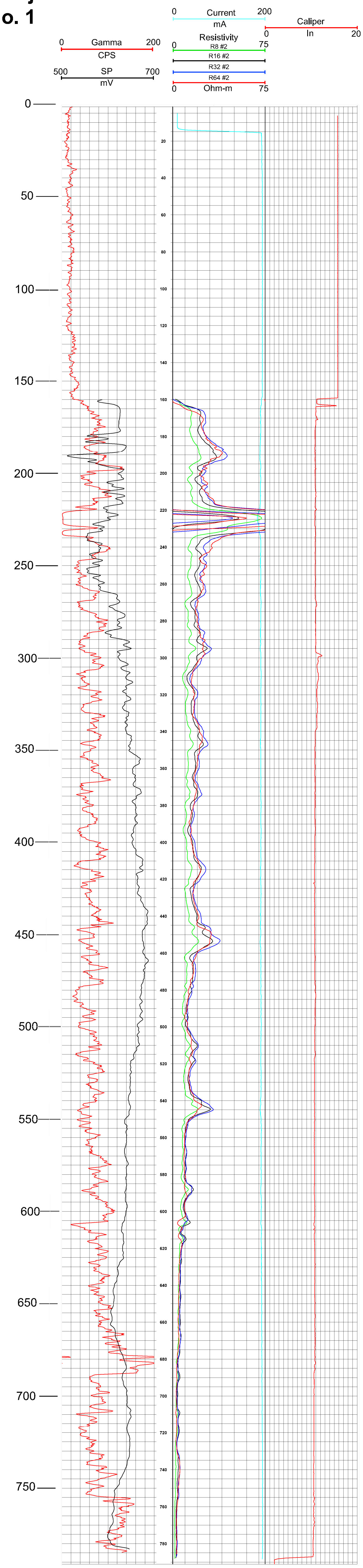
650 - 690' Gray sandstone, very fine-grained, with streaks of green shale

690 - 710' Green shale with pyrite, trace sandstone

710 - 740' Sandstone and green shale

740 - 750' Sandstone and green shale with trace of conglomerate

750 - 790' Green and red shale



LITHOLOGY AND GEOPHYSICAL LOG
CITY OF SAN ANGELO PARKS NO. 1 TEST HOLE

LBG-GUYTON ASSOCIATES

Borehole: **PARKS NO. 1**

Logs: **GAMMA, RESISTIVITY, CAL, SP**

Water Well Logging & Video Recording Services

Geo Cam, Inc. 126 Palo Duro, San Antonio, TX 210-495-9121

Project: **PARKS NO. 1** Date: 5-8-07

Client: **WEST TEXAS WATER WELL** County: IRION

Location: **N31* 19' 32.2" W100* 47' 24.3"** State: TX

BOREHOLE DATA

Drilling Contractor: WEST TEXAS WATER WELL **Driller T.D. (ft) : 791**

Elevation: 2170 GPS Logger T.D. (ft) : 790

Depth Ref: GL Date Drilled: 5-5-07

BIT RECORD				CASING RECORD		
RUN	BIT SIZE (in)	FROM (ft)	TO (ft)	SIZE/WGT/THK	FROM (ft)	TO (ft)
1	9 7/8	160	TD	16" STEEL	+3	160
2						
3						

Drill Method: AIR ROTARY Weight: **Fluid Level (ft) :** 22

Hole Medium: Mud Type: Time Since Circ:

Viscosity: Rm: at: Deg C

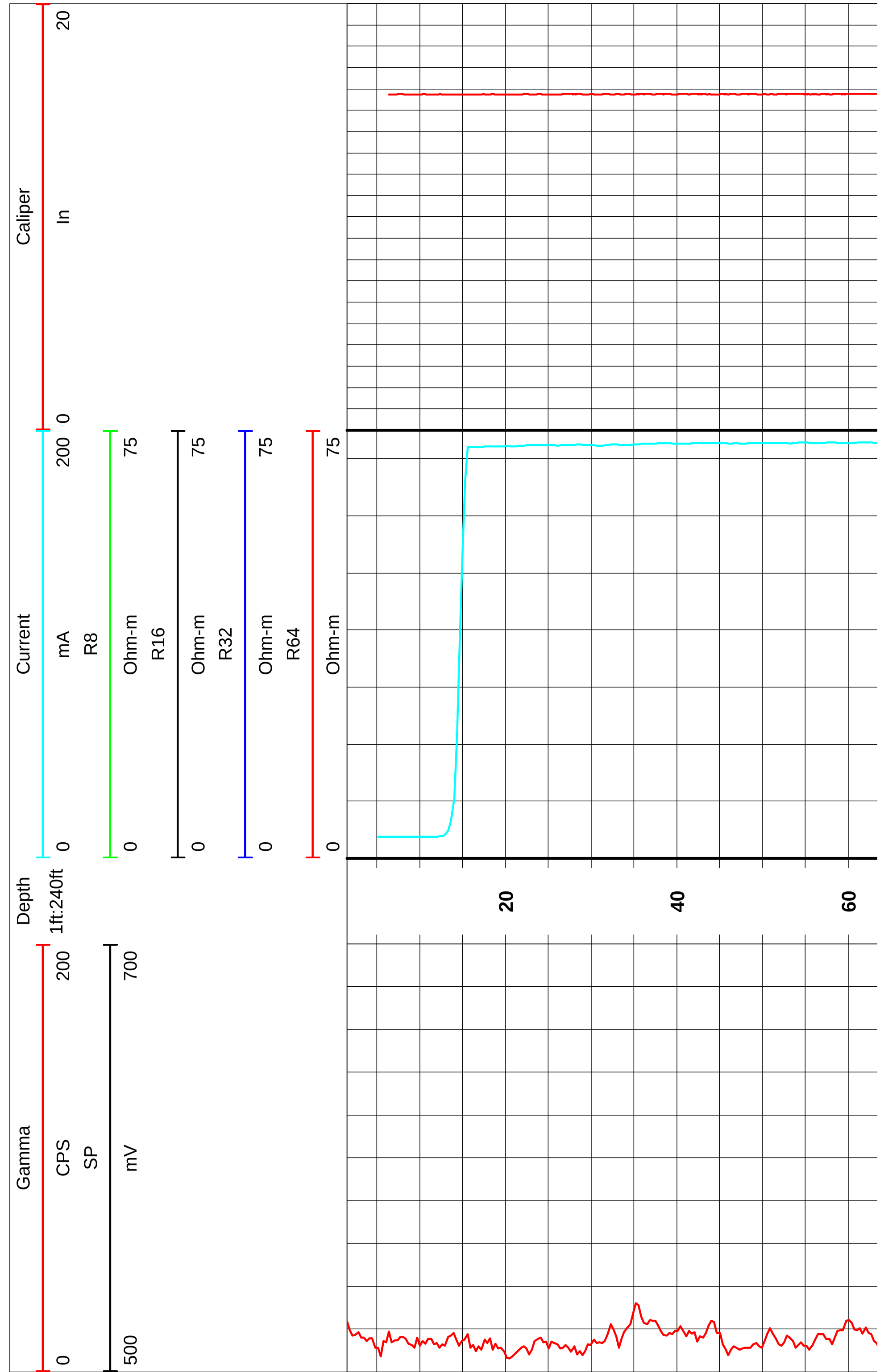
GENERAL DATA

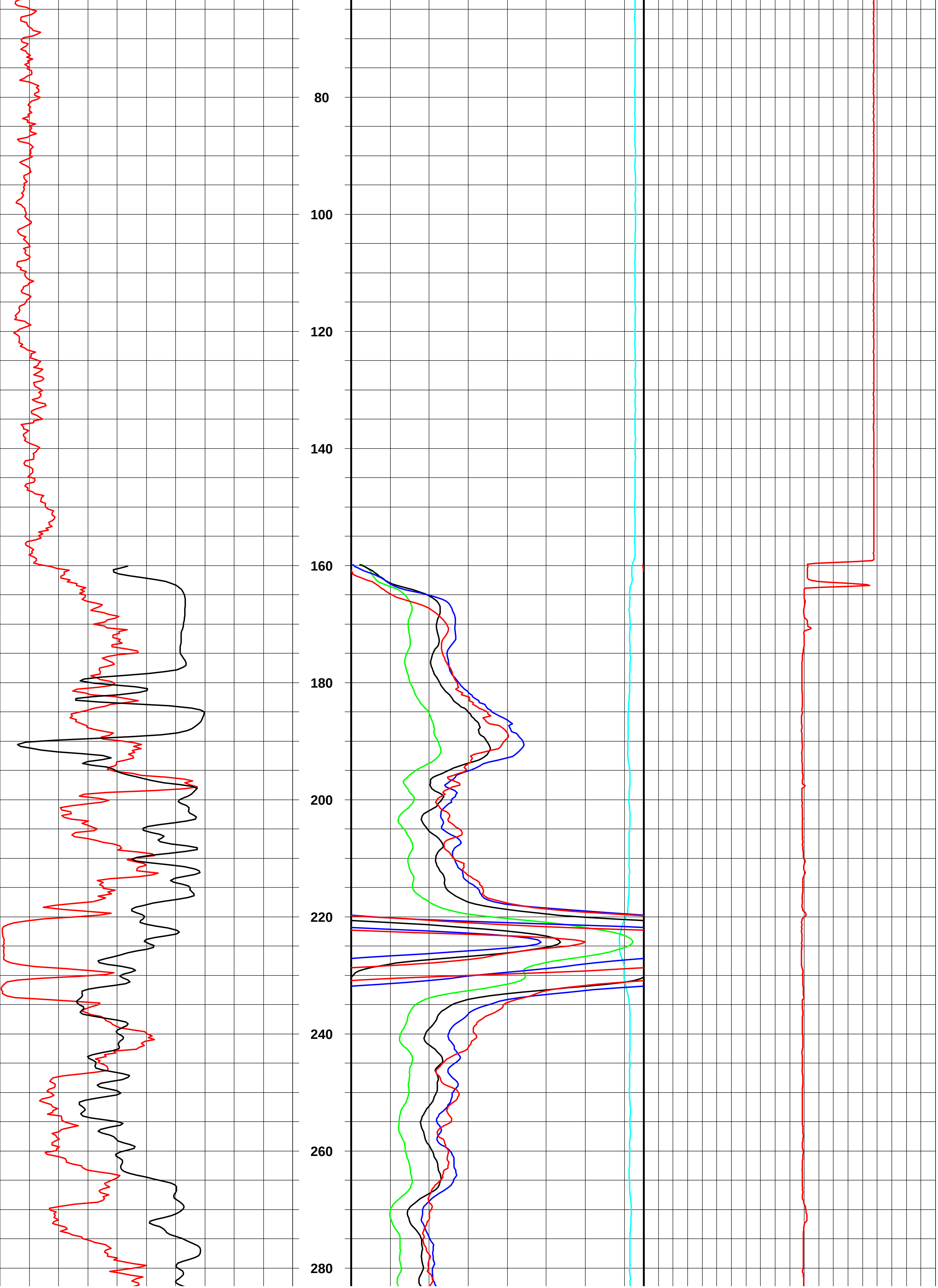
Logged by: Robert C. Becknal Unit/Truck: 04

Witness:

LOG TYPE	RUN NO	SPEED (ft/min)	FROM (ft)	TO (ft)	FT./ IN.
GAMMA	1	20	784	2	20
RESISTIVITY, SP	1	20	788	160	20
CALIPER	2	20	791	6	20

Comments:

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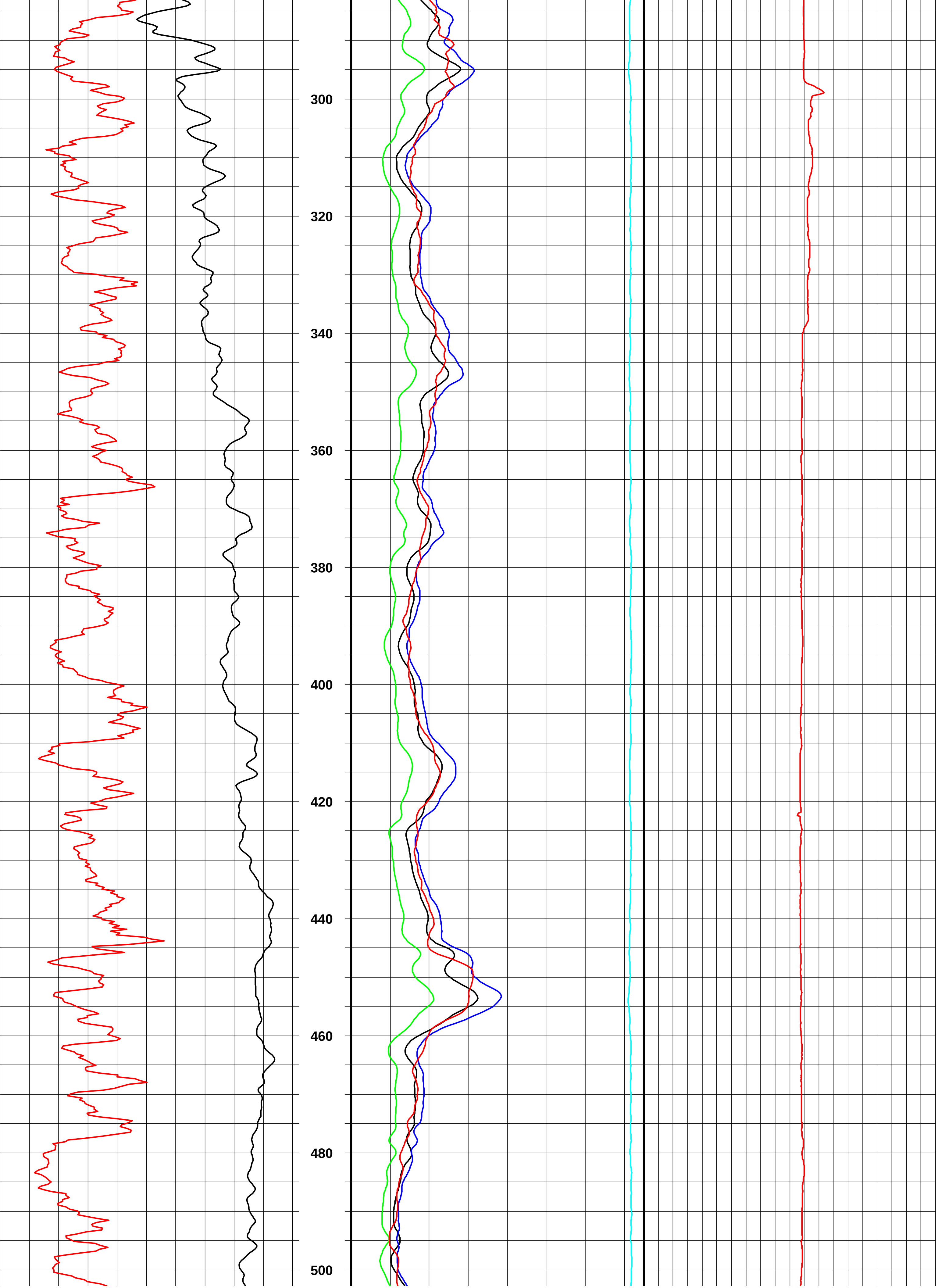
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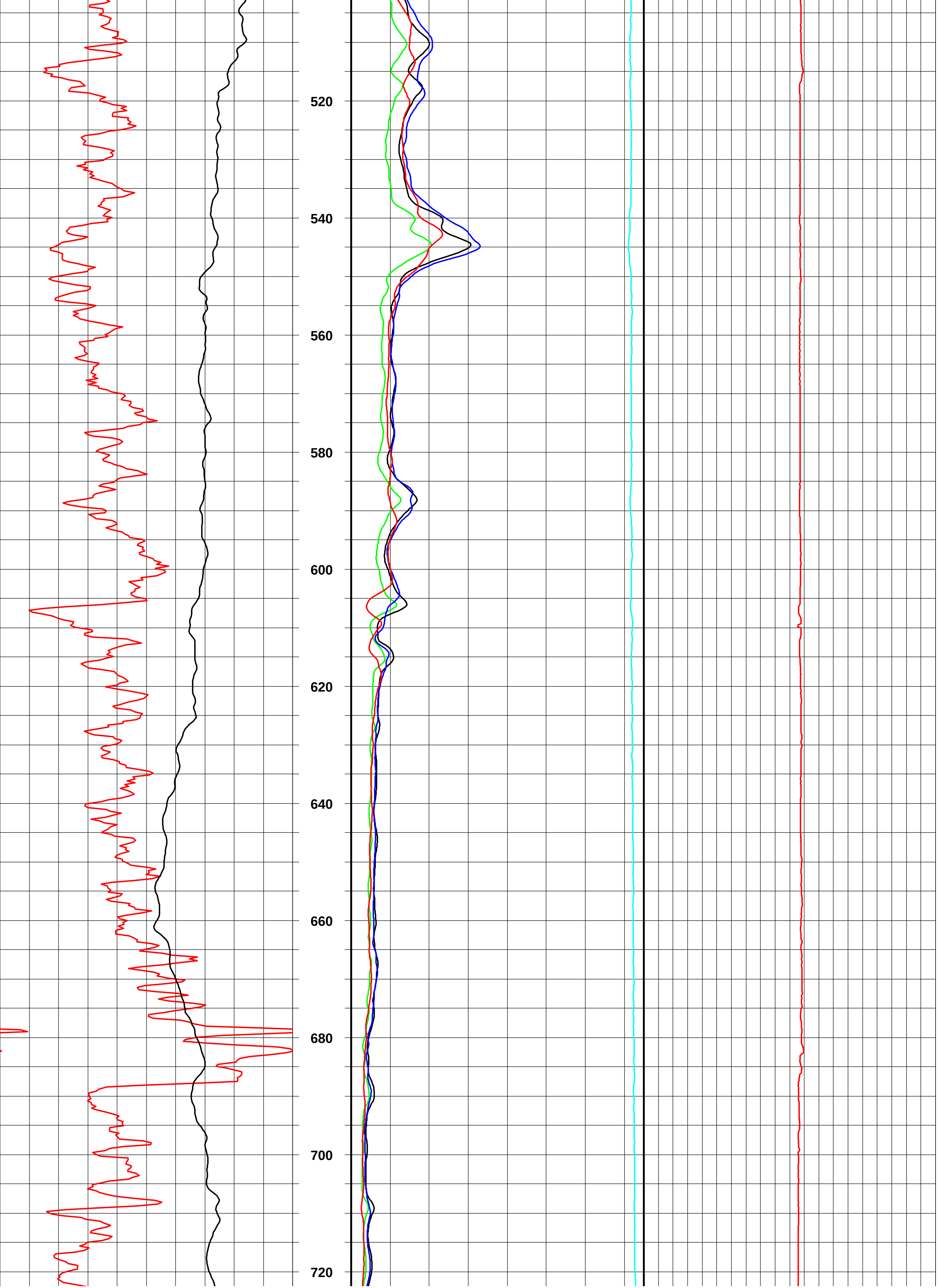
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680
700
720

740
760
780

Appendix B – Schlinke Test Hole

Formation Descriptions
Geophysical Log

Schlinke-1 Test Hole Sample Formation Descriptions

Interval	Description
35-45	White and brown, shale red coarse sandstone, calcareous. Water @ 42'. (Conglomerate) Base Antlers?
45-55	Coarse sandstone gray shale 55', red shale @ 60'
55-65	Red shale, sandy
65-75	Red shale
75-85	Red shale and gray micaceous sandstone, fine grained. Very little reaction to acid.
85-100	Red sandy shale, 10% light gray fine grained sand
100-110	Argillaceous sand, poorly sorted, dark red and some gray sand, fine. Only very slightly calcareous. Trace gypsum
110-120	Similar to above, more gypsum
120-130	40% red sandy-silty shale, 30% fine gray sand, fine friable, 25% gypsum, crystalline, massive fibrous, 5% green shale, very soft
130-140	Same as previous
140-150	Same as previous, only no more green shale
150-160	Sandy less shale still gypsum
160-170	Same as above, 10% red sandy shale, 40% light gray sand, 40% red sand, 10% gypsum
170-180	Red sandstone, gray sandstone, pink limestone, silt
180-190	Same as above, hole still unloading
190-200	Same as above, w/gray milky white limestone
200-210	32% gypsum, red sandstone, gray sand, lime, not calcareous
210-220	32% gypsum, red sandstone, gray sand, lime, not calcareous
220-230	80% red sandy shale, 10% gypsum, 5% very fine gray sand, 5% gray shale
230-240	60% gypsum, 40% red sandy silty shale
240-250	80% gypsum, 10% red shale, 10% very fine gray sandstone
250-260	70% gypsum, 10% red shale, 20% very fine gray shale, w/oil stain
260-270	Fine gray sand, trace pink sandstone
270-280	90% gray sand, 5% gypsum, 5% red shale
280-290	90% gray sand, 5% gypsum, 5% red shale
290-300	90% gray sand, 5% gypsum, 5% red shale
300-310	90% gray sand, 5% gypsum, 5% red shale
310-320	90% gray sand, 5% gypsum, 5% red shale
320-330	Same as above w/more gypsum, oil stain
330-340	Gray fine sandstone, light brown medium sandstone w/oil stain and gypsum
340-350	25% gypsum, 75% gray sandstone
351-359	Hard gypsum, 75%, 25% very fine sand, trace lime
360-370	80% gypsum, 10% very fine gray sandstone, calcareous
370-380	Very fine gray sand 90%, 10% gypsum. Some of sand is oil stained.
380-390	95% very fine gray sandstone, 5% gypsum
390-400	90% very fine gray sandstone, 10% gypsum

Schlinke-1 Test Hole Sample Formation Descriptions

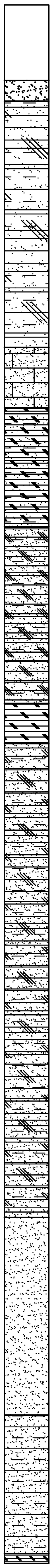
400-410	90% very fine gray sandstone, 10% gypsum
410-420	90% very fine gray sandstone, 10% gypsum
420-430	100% very fine gray sand
430-440	100% very fine gray sands clear Oil
440-450	100% very fine gray sands clear Oil
450-460	100% very fine gray sands clear Oil
460-470	10% gray shale, 90% very fine gray sandstone.
470-480	90% very fine gray sand, 10% gray shale
480-490	90% very fine gray sand, 10% gray shale
490-500	90% very fine gray sand, 10% gray shale
500-510	100% very fine gray sand
510-520	90% very fine gray sand, 10% gypsum white cla
520-530	100% very fine gray sand, very friable and soft
530-540	100% very fine gray sand, very friable and soft
540-550	100% very fine gray sand, very friable and soft
550-560	80% very fine gray sand, friable, 20% gypsum
560-570	95% very fine gray sand, becoming less friable, 5% gypsum
570-580	95% very fine gray sand, becoming less friable, 5% gypsum
580-590	95% very fine gray sand, becoming less friable, 5% gypsum
590-600	90% very fine sand, 20% gypsum
600-610	95% very fine sand, 5% gypsum
610-620	100% very fine sand
620-630	100% very fine sand
630-640	100% very fine sand
640-650	100% very fine sand
650-660	100% very fine sand
660-670	Very fine gray sand, trace gypsum
670-680	Very fine gray sand, trace gypsum
680-690	Very fine gray sand, trace gypsum
690-700	Very fine gray sand, trace gypsum
700-710	Very fine gray sand, trace gypsum
710-720	Same as above, becoming shaley and oil-stained
720-730	As above, except very fine gray sand becoming pyritic
730-740	90% very fine gray sand, argillaceous, 10% fine grained clean oil stained sand, some embedded coarse grains
740-750	70% sand as above, 20% oil-stained AA, 10% gypsum, free cubic pyrite
750-760	95% very fine gray sand, as above 5% clear sand w/oil stain
760-770	90% very fine grained sand becoming shaley, very pyritic, 10% gray shale

Schlinke-1 Test Hole Sample Formation Descriptions

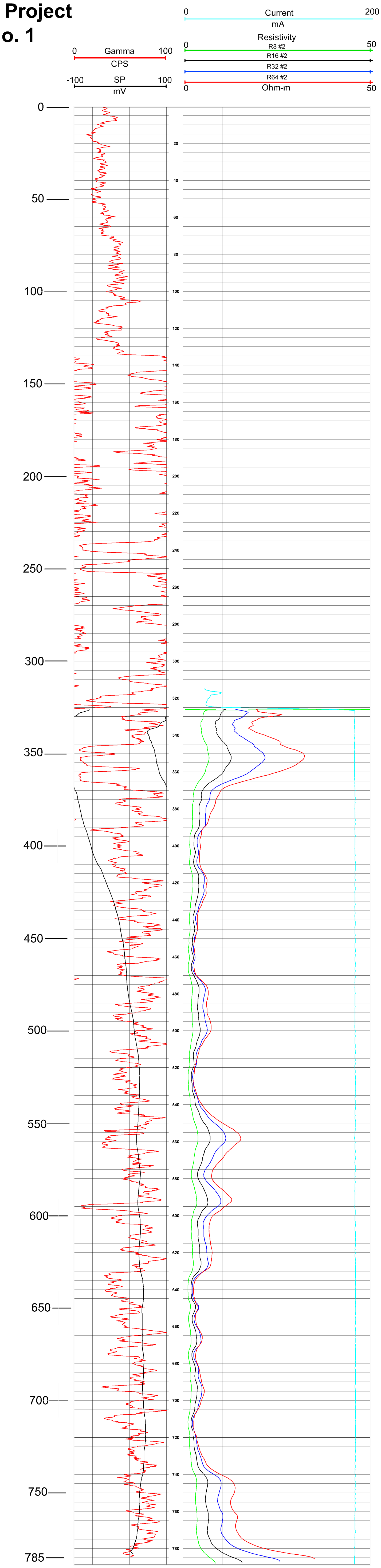
770-780	75% very fine grained sand as above, 25% gray shale
780-788	60% gray shale, 20% red shale, 10% very fine grained sand, 10% gypsum

San Angelo Desalination Project
Schlinke Test Hole No. 1

Consolidated and Simplified Field Descriptions
by LBG-Guyton Associates
See Appendix for detailed descriptions



35 - 45'	White and brown coarse sandstone
45 - 170'	Red sandy shale, streaks of sandstone and gypsum
170 - 200'	Red and gray sandstone with limestone
200 - 260'	Gypsum with streaks of shale and sandstone
260 - 350'	Gray sandstone, fine-grained, with thin streaks of gypsum and red shale
350 - 370'	Gypsum
370 - 610'	Gray sandstone, very fine-grained, with thin streaks of gypsum and shale
610 -710'	Gray sandstone, very fine-grained
710 -780'	Gray sandstone and shaley sand, very fine-grained, pyrite in part
780 -785'	Gray and red shale, trace gypsum



LITHOLOGY AND GEOPHYSICAL LOG
CITY OF SAN ANGELO - SCHLINKE TEST HOLE NO. 1

LBG-Guyton Associates

GEO CAM

Borehole: SCHLINKE WELL NO. 1

Logs: GAMMA, RESISTIVITY, SP

Water Well Logging & Video Recording Services

Geo Cam, Inc. 126 Palo Duro, San Antonio, TX 210-495-9121

Project: DRY CREEK RANCH - SCHLINKE WELL Date: 06-14-07

Client: **WEST TEXAS WATER WELLS** County: IRION

Location: N 31* 25' 16.4" W 100* 51' 28.0" State: TX

BOREHOLE DATA

Drilling Contractor: WEST TEXAS **Driller T.D. (ft) :**

Elevation: 2185' GPS Logger T.D. (ft) :

Depth Ref: G.L. Date Drilled:

	BIT RECORD			CASING RECORD		
RUN	BIT SIZE (in)	FROM (ft)	TO (ft)	SIZE/WGT/THK	FROM (ft)	TO (ft)
1	9 7/8"	0	789	16" STEEL	+ 2	130
2						
3						

Drill Method: MUD ROTARY Weight: **Fluid Level (ft) :** 326

Hole Medium: Mud Type: Time Since Circ:

Viscosity: Rm: at: Deg C

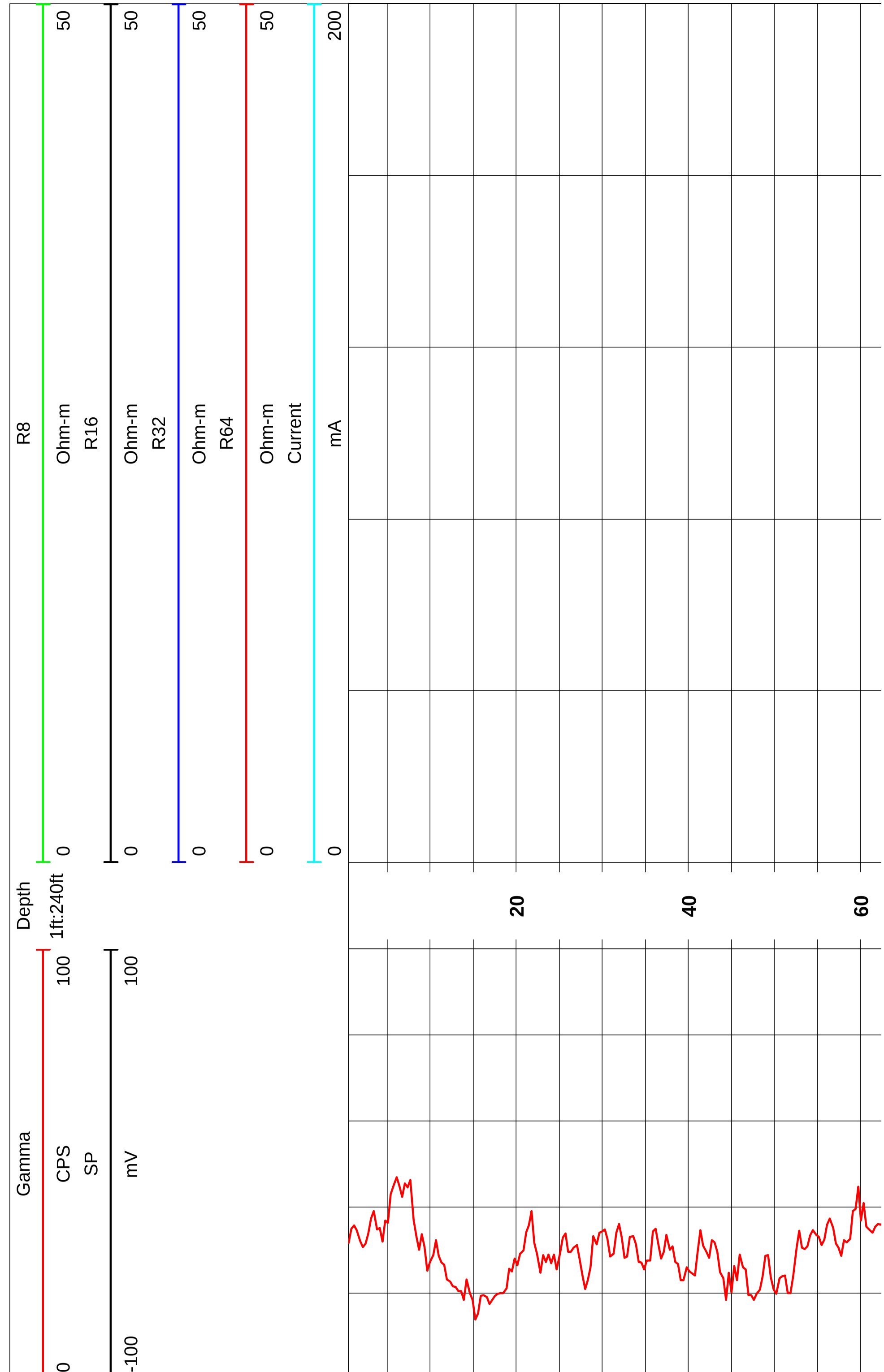
GENERAL DATA

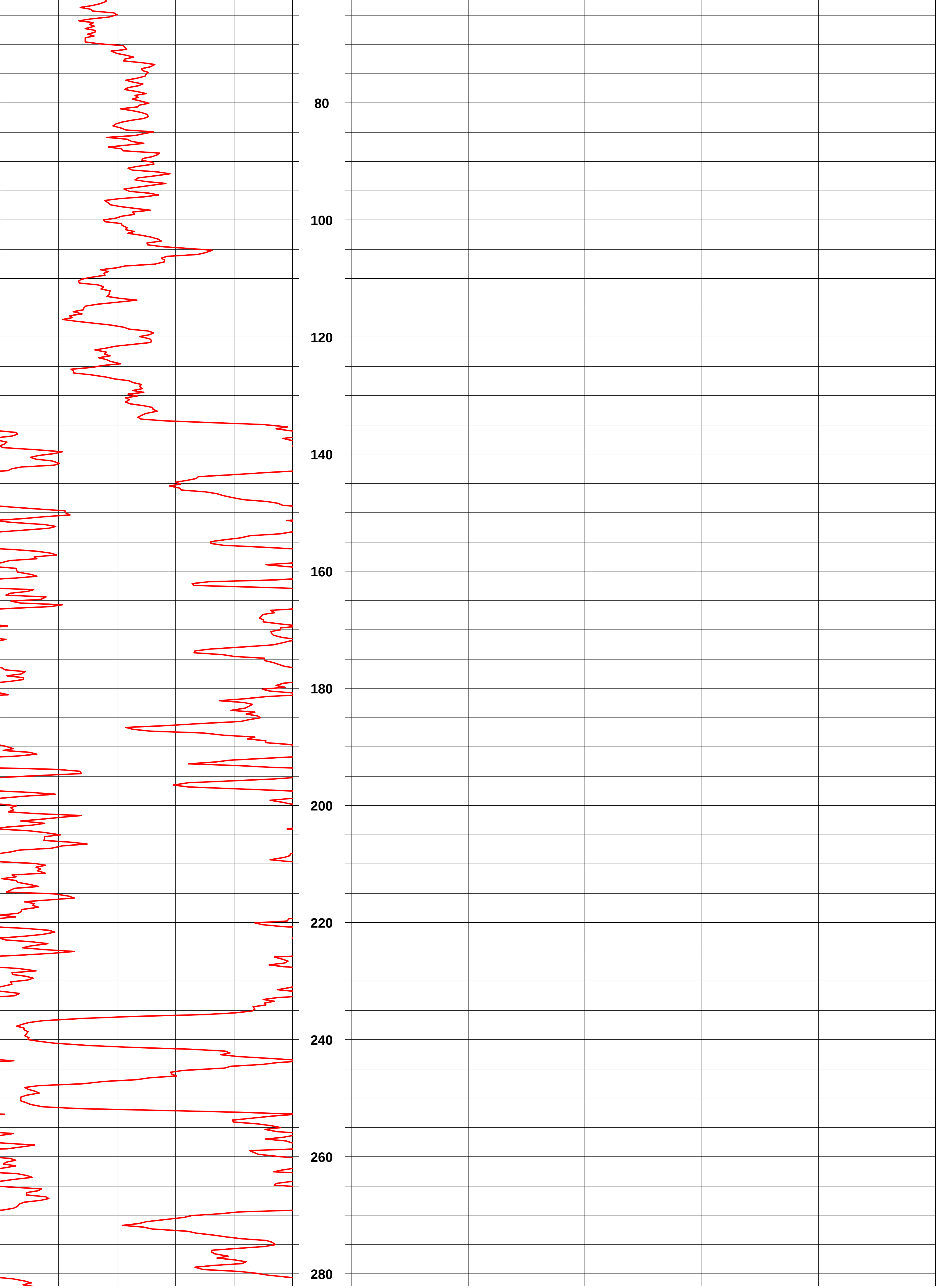
Logged by: Kelly O. Tuten Unit/Truck: 04

Witness:

LOG TYPE	RUN NO	SPEED (ft/min)	FROM (ft)	TO (ft)	FT./ IN.
GAMMA	2	21	785	.5	20
RESISTIVITY, SP, SPR	2	21	788	326	20

Comments:

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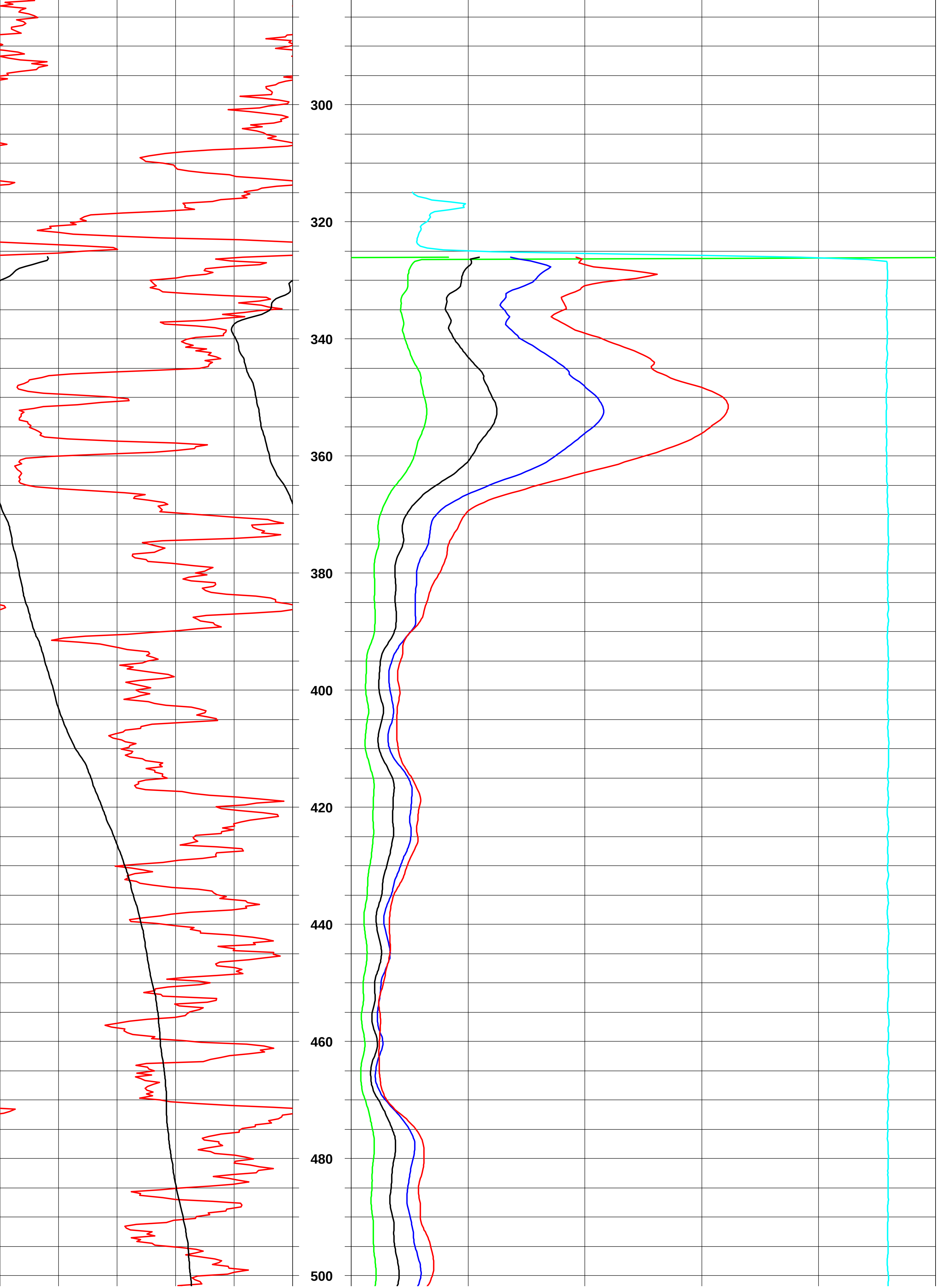
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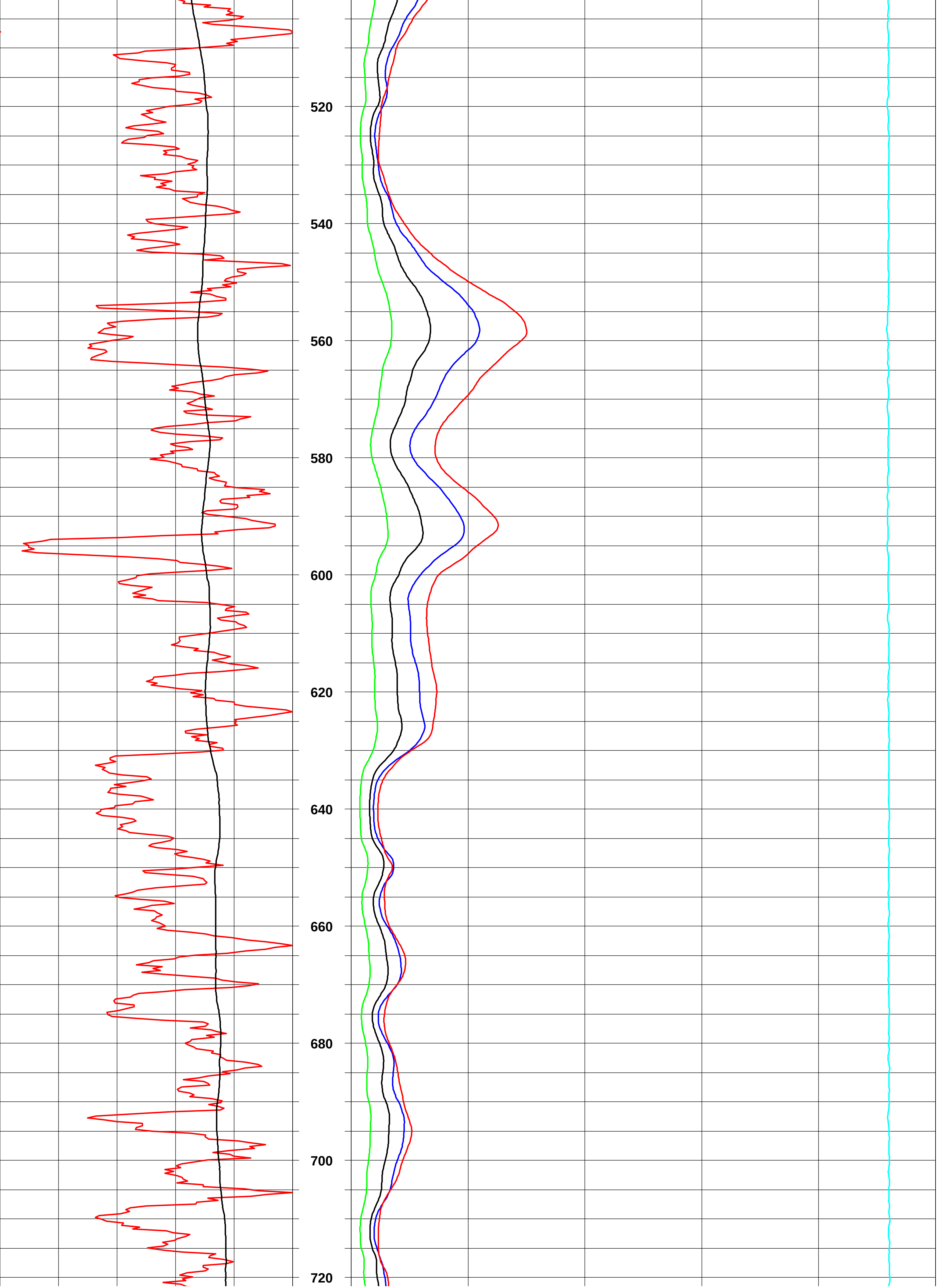
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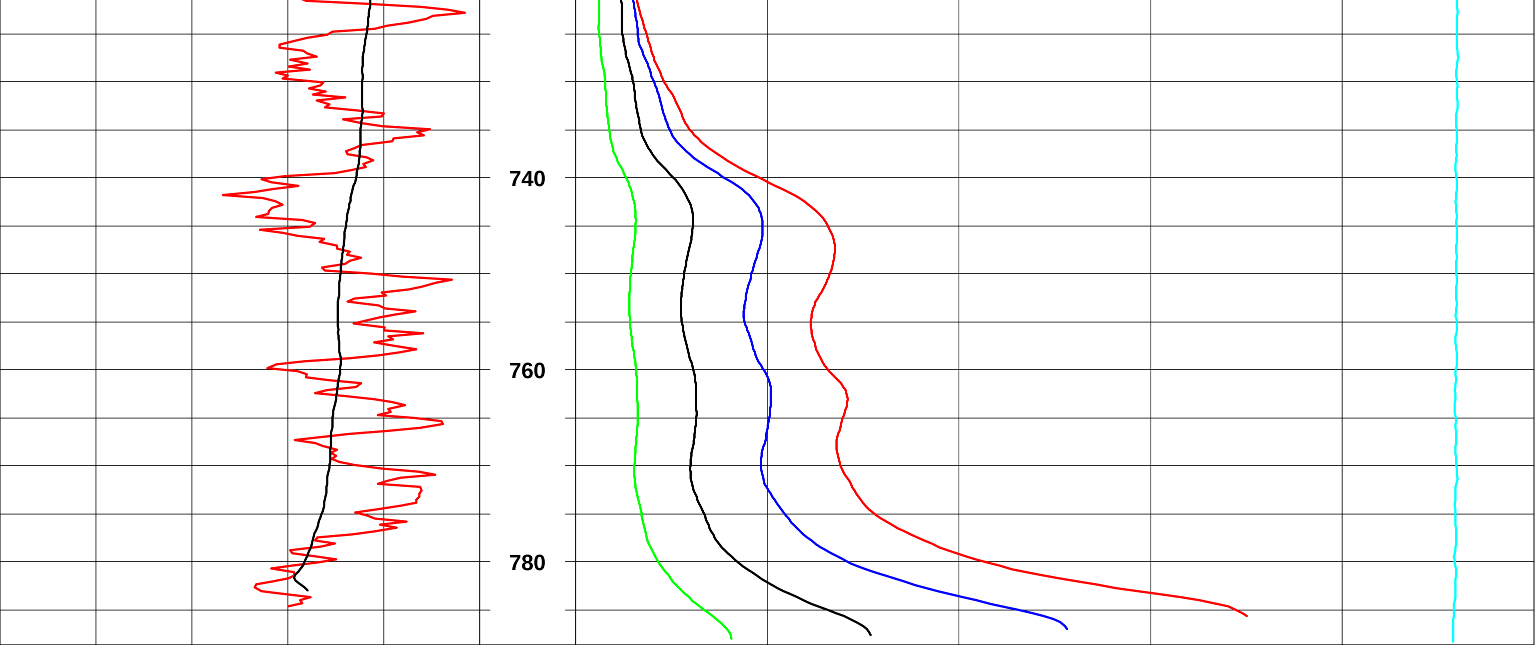
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Appendix C – Schmidt Test Hole and Test Well

Formation Descriptions
Geophysical Log
Analytical Results

Schmidt-1 Test Hole Formation Sample Descriptions

Interval	Description
0-4.5	Topsoil
30-40	Limestone, white, tan, orange, yellow, mostly dense
40-50	80% gray limestone, hard, 20% same as above
50-60	80% gray fossiliferous lime, 10% tan dolomite, vugular porosity, 10% white lime
60-70	100% lime, gray, sandy, in part, very fossiliferous, dolomitic in part
70-80	70% gray lime, as above, 30% sand, off-white, clear, poorly sorted, very fine to medium, oil stained in part
80-90	55% lime as above, becoming less fossiliferous, 15% sand as above.
90-100	100% limestone, light to dark gray, some fossils, pyritic in part, hard trace sand, no oil staining
100-110	Loose sand, very fine, white
110-120	80% as above, 10% gray limestone, 10% yellow limestone
120-130	Medium to very fine white sandstone, pyritic
130-140	40% sand as above, 40% blue green clay, pyritic, 20% gray limestone, pyritic
140-150	10% sand as above, 90% clay as above.
150-160	100% sandy gray clay, trace limestone
160-170	Very fine gray sand, 50%, oil stained, very friable, trace gray clay
170-180	90% blue gray sandy clay, low sand, 10% oil stained as above
180-190	90% gray sand, 10% lime, sandy in part, oil saturated, trace green clay
190-200	Very fine to fine, light gray sand, not as soft
200-220	Cement and uphole junk, no sample
220-230	60% fine - very fine sandstone w/calcitic cement, grains: black, brown, yellow, clear, 20% conglomeratic sandstone, grains as above, 20% limestone, dense, pyritic in part, mostly off-white
230-240	90% sand as above, 10% limestone, white, off-white. Sandstone is pyritic in part.
240-250	50% sand as above, 50% conglomeratic sandstone
250-260	60% green shale, 20% conglomeratic, sand as above, 20% lime, orange, brown, black, pink
260-270	70% very fine grain sandstone, hard, argillaceous, 30% green shale, high quantity pebble, trace limestone and pyrite
270-280	60% light gray shale, 30% green shale, 10% sand as above, trace limestone and pyrite
280-290	60% green shale, 40% dolomite, mostly tan colored, pyritic in part
290-300	50% shale, mostly green, gray in part, sandy in part, 50% dolomite yellowish brown, pyritic, fossiliferous, oil-bearing in part, trace sand, trace lime
300-310	80% shale, mostly green, some gray, pyritic, 20% dolomite, sandy in part
310-320	50% shale as above, 50% dolomite, mostly dense
320-330	70% green and gray shale, 30% dolomite, as above, very pyritic, trace sand
330-340	95% shale, green gray, 5% dolomite, trace lime, trace sand
340-350	As above
350-360	100% green shale, trace dolomite pyritic, trace gypsum
360-370	90% green shale, 10% dolomite, more pyrite

Schmidt-1 Test Hole Formation Sample Descriptions

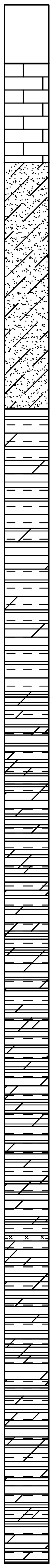
370-380	90% green shale, 5% dolomite, 5% pyrite
380-390	80% green and gray shale, 20% pyrite, trace dolomite
390-400	80% green shale, 10% pyrite, 10% dolomite
400-410	70% shale, green, gray, some dark gray, 20% dolomite, trace lime, trace pyrite
410-420	As above
420-430	80% shale, green, gray, dark gray, 20% dolomite, trace pyrite
430-440	As above
440-450	90% shale, mostly gray, some green, sandy, very fine grain, off-white to light gray, 10% dolomite
450-460	As above
460-470	70% dolomite, light brown to tan, 20% shale, green, 10% sand, very fine grained, pyrite
470-480	80% dolomite, 20% green shale. Dolomite - gray, tan, vugular, porosity, secondary crystallization. Trace dead oil.
480-490	90% green shale, very soft. 20% dolomite, off-white, tan, trace limestone, trace pyrite
490-500	Same as above except no limestone
500-510	Same as above, fossill in part
510-520	80% dolomite, hard, vugular, porosity, 20% green shale, trace pyrite, Fossil in part
520-530	90% dolomite, tan, vugular, some gray, 10% green shale, trace pyrite, water reported by driller. Fossil in part
530-540	Same as above. Fossiliferous in part
540-550	50% dolomite, 20% shale, trance sand, trace limestone. Fossiliferous
550-560	70% dolomite, becoming low vugular, 20% shale, green, dark gray, dark gray is sandy, 10% pyrite
560-570	80% dolomite, 20% shale, trace gypsum, trace argillaceous sand
572	Switch to mud, resume drilling @ 572'
572-580	90% dolomite, light brown, off-white, fossiliferous, visible porosity in part, 10% green shale, trace very fine gray sand, trace very fine clear sand with oil, some of sample probably from uphole, clean sand is calcitic
580-590	100% dolomite, off-white, light brown, fossiliferous in part, granular in part, visible porosity in part, trace green shale, pyritic, trace black lime, calcite crystals
590-600	As above, except no limestone
600-610	70% pyrite, 30% dolomite. H. bar, massive, pyritic, trace dark gray shale, trace sand w/slight oil sheen
610-620	90% dolomite, vugular porosity in part, tan, fossiliferous in part, brown, gray (massive), 10% pyrite, trace green shale
620-630	100% dolomite, brown, gray, H gray, mottled, some dense, some granular, visible porosity in part, fossiliferous in part, some with calcite crystals
630-640	Same as above, with trace black shale, and trace pyrite
640-650	80% dolomite as above, 20% pyrite, trace sand, trace green shale, trace black limestone
650-660	90% dolomite, same as above, 10% pyrite, trace green shale, trace red limestone, rounded, fossiliferous
660-670	100% dolomite, slight visible porosity, some dense, some granular, fossiliferous in part, calcite crystals
670-680	As above with trace pyrite, green shale
680-690	80% dolomite as above, fewer calcite crystals, 20% pyrite, trace black, brown shale, trace sulfur, trace gypsum

Schmidt-1 Test Hole Formation Sample Descriptions

690-700	100% dolomite, mostly massive, fossiliferous in part, pyritic in part, off-white, brown, mottled, gray. Vugular porosity in part, trace green shale, trace pyrite
700-710	100% dolomite, tan, massive. Almost no visible porosity, trace pyrite, green shale
710-730	90% dolomite, medium to dark gray, slightly porous in part, 10% green shale, trace pyrite
730-740	As above
740-750	100% dolomite as above, trace green shale
750-760	80% dolomite as above, slightly more porosity, 20% green shale
760-770	100% dolomite as above, somewhat less porosity, trace green shale
770-780	As above, very little visible porosity
780-790	100% dolomite, tan, massive, very little porosity
790-800	As above, very little porosity
800-810	100% dolomite, tan, calcite crystals in part, slightly porous in part, massive
810-820	As above, very little porosity
820-830	As above
830-840	As above
840-850	100% light brown dolomite, dense in part, fossiliferous in part, visible porosity in part, trace limestone, trace pyrite
850-860	100% light brown dolomite, massive, fossiliferous in part, very little porosity, trace pyrite
860-870	As Above
870-880	As Above
880-890	As Above
890-900	As Above
900-910	As Above, still very little porosity
910-920	95% dolomite, light brown, dense, very little visible porosity, 5% pyrite, trace petrified wood
920-930	100% dolomite, light brown, dense, very little visible porosity, trace calcite, trace pyrite
930-940	As above
940-950	As above, slight visible porosity in part, trace sulfur
950-960	As above, slight visible porosity
960-970	Dolomite, light brown, dense, very little visible porosity, trace light gray sandstone, fine grain
970-980	As Above
980-990	100% light brown dolomite, dense very little visible porosity, trace gray shale
990-1000	100% light brown, dolomite, dense very little visible porosity, trace lignite
1000-1010	Light brown dolomite, dense, very little visible porosity, trace black shale
1010-1020	Light brown dolomite, dense, very little visible porosity
1020-1030	As above, trace brown sand w/dead oil

San Angelo Desalination Project
Schmidt No. 1

Consolidated and Simplified
Field Descriptions
by LBG-Guyton Associates
See Appendix for detailed descriptions

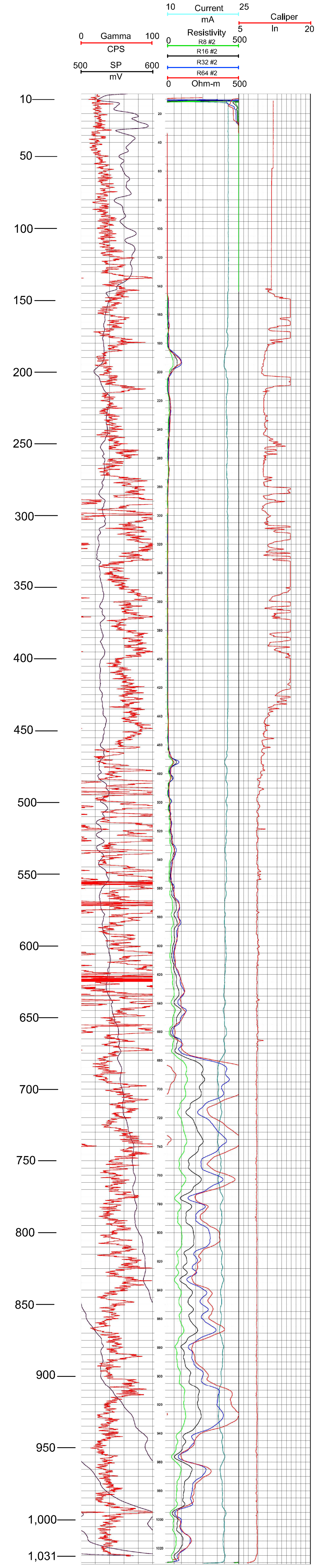


30 - 100' White and gray limestone

100 - 270' White and gray sandstone with clay streaks, pyrite in part

270 - 460' Green and gray shale, streaks of tan dolomite, mostly pyrite

460 - 1,031' Tan dolomite, porous in part, pyritic in part, with streaks of green and gray shale



LITHOLOGY AND GEOPHYSICAL LOG
CITY OF SAN ANGELO - SCHMIDT TEST HOLE NO. 1

LBG-GUYTON ASSOCIATES

GEO CAM

Water Well Logging & Video Recording Services

Geo Cam, Inc. 126 Palo Duro, San Antonio, TX 210-495-9121

Borehole: SCHMIDT NO.1

Logs: GAMMA, CALIPER, RESISTIVITY,SP

Project: SCHMIDT NO.1 Date: 08-27-07

Client: **WEST TEXAS WATER WELLS** County: TOM GREEN

Location: N31* 14' 22.6" W100* 36' 44.0" State: TX

BOREHOLE DATA

Drilling Contractor: WEST TEXAS

Elevation: 2158' GPS

Depth Ref: GL

Driller T.D. (ft) : 1031'

Logger T.D. (ft) : 1031'

Date Drilled: 08-25-07

BIT RECORD				CASING RECORD		
RUN	BIT SIZE (in)	FROM (ft)	TO (ft)	SIZE/WGT/THK	FROM (ft)	TO (ft)
1	9 7/8"	0	480'	NA		
2	8 3/4"	480	TD			
3						

Drill Method: MUD Weight: **Fluid Level (ft) :** 12'

Hole Medium: Mud Type: Time Since Circ:

Viscosity: Rm: at: Deg C

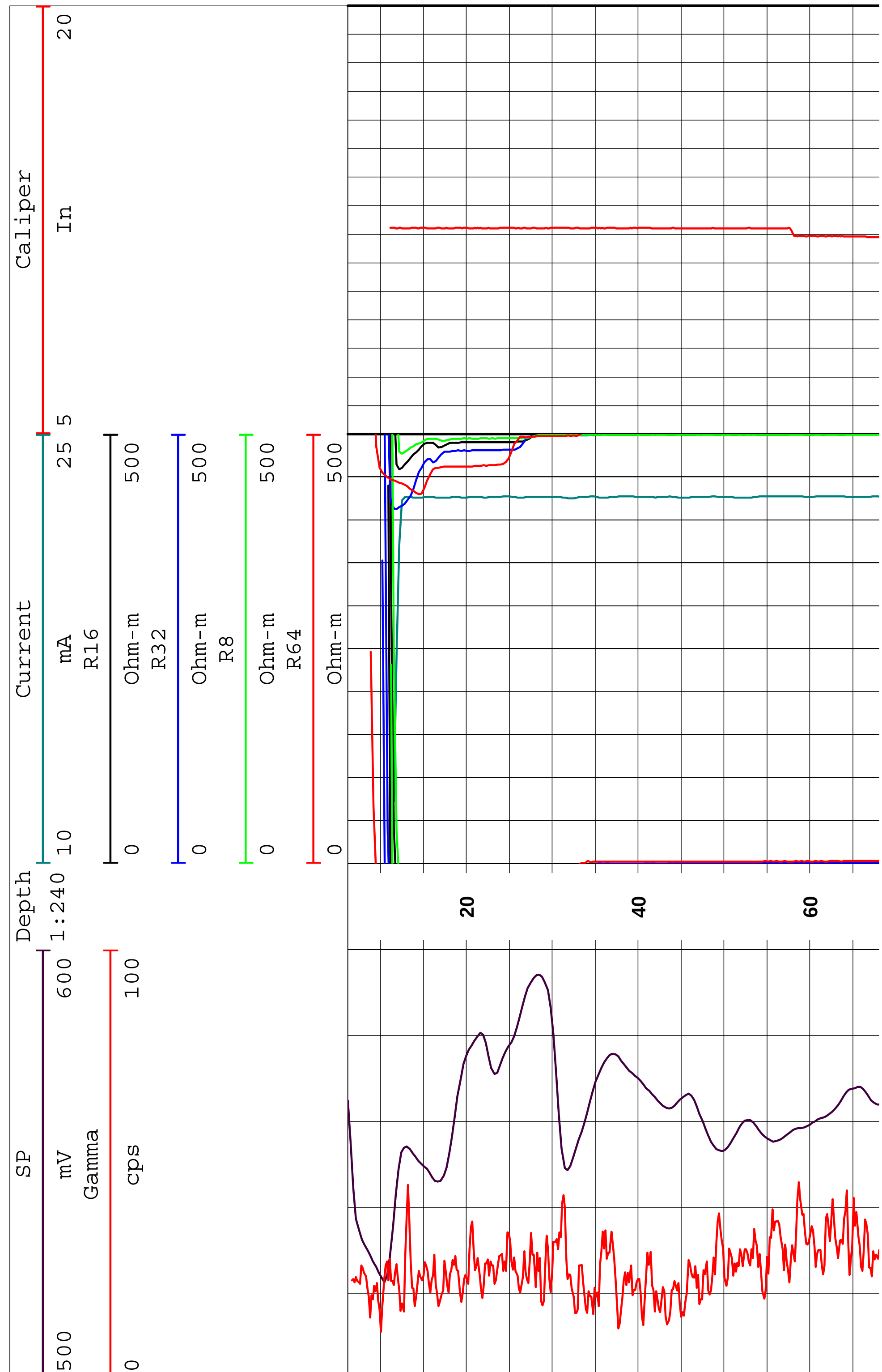
GENERAL DATA

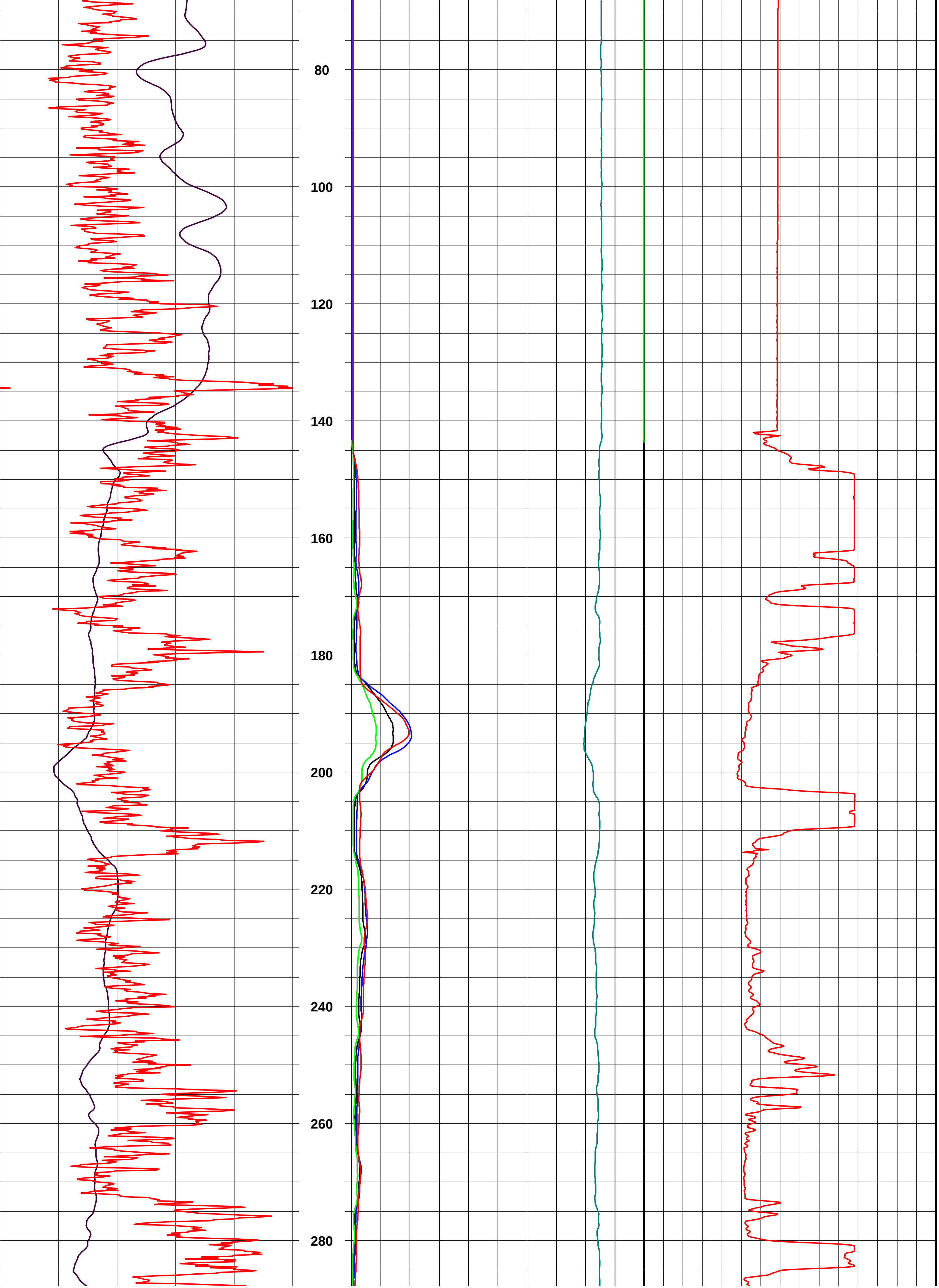
Logged by: Robert C. Becknal Unit/Truck: 02

Witness: TYLER DAVIDSON, SCOTT MCWILLIAMS

LOG TYPE	RUN NO	SPEED (ft/min)	FROM (ft)	TO (ft)	FT./ IN.
GAMMA	1	30	1027	8	20
CALIPER	1	30	1030	11	20
RESISTIVITY	1	30	1029	11	20

Comments:

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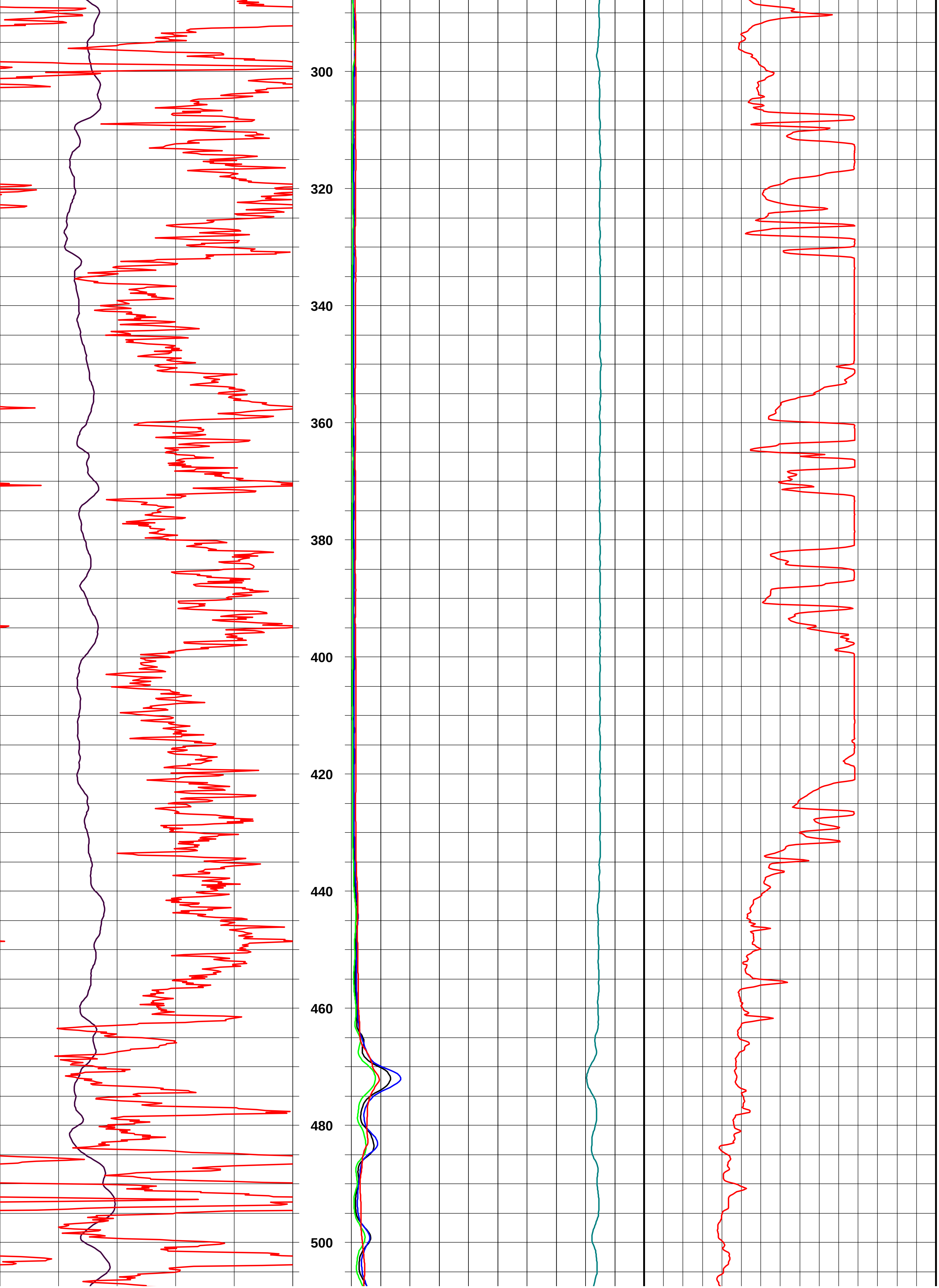
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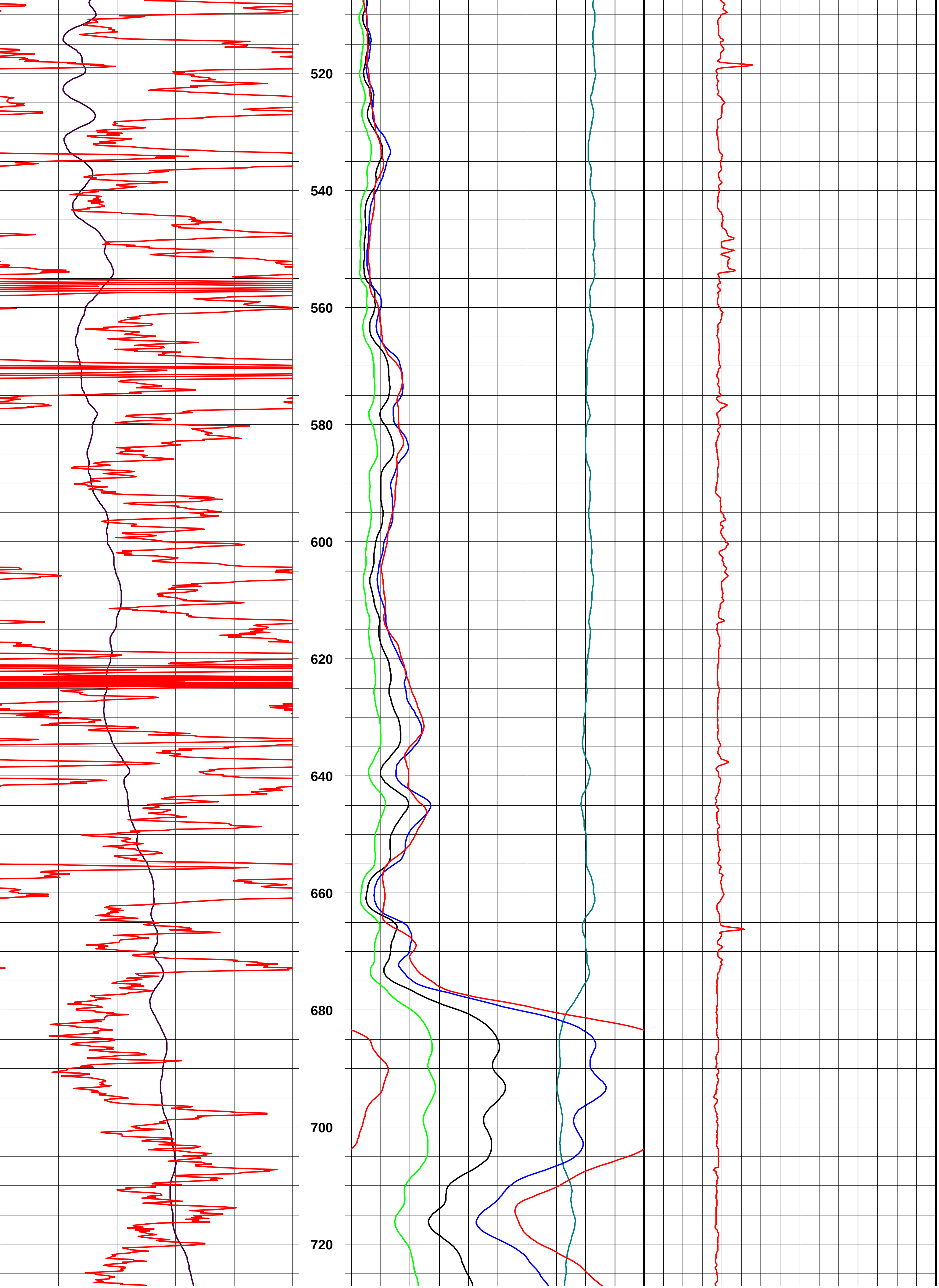
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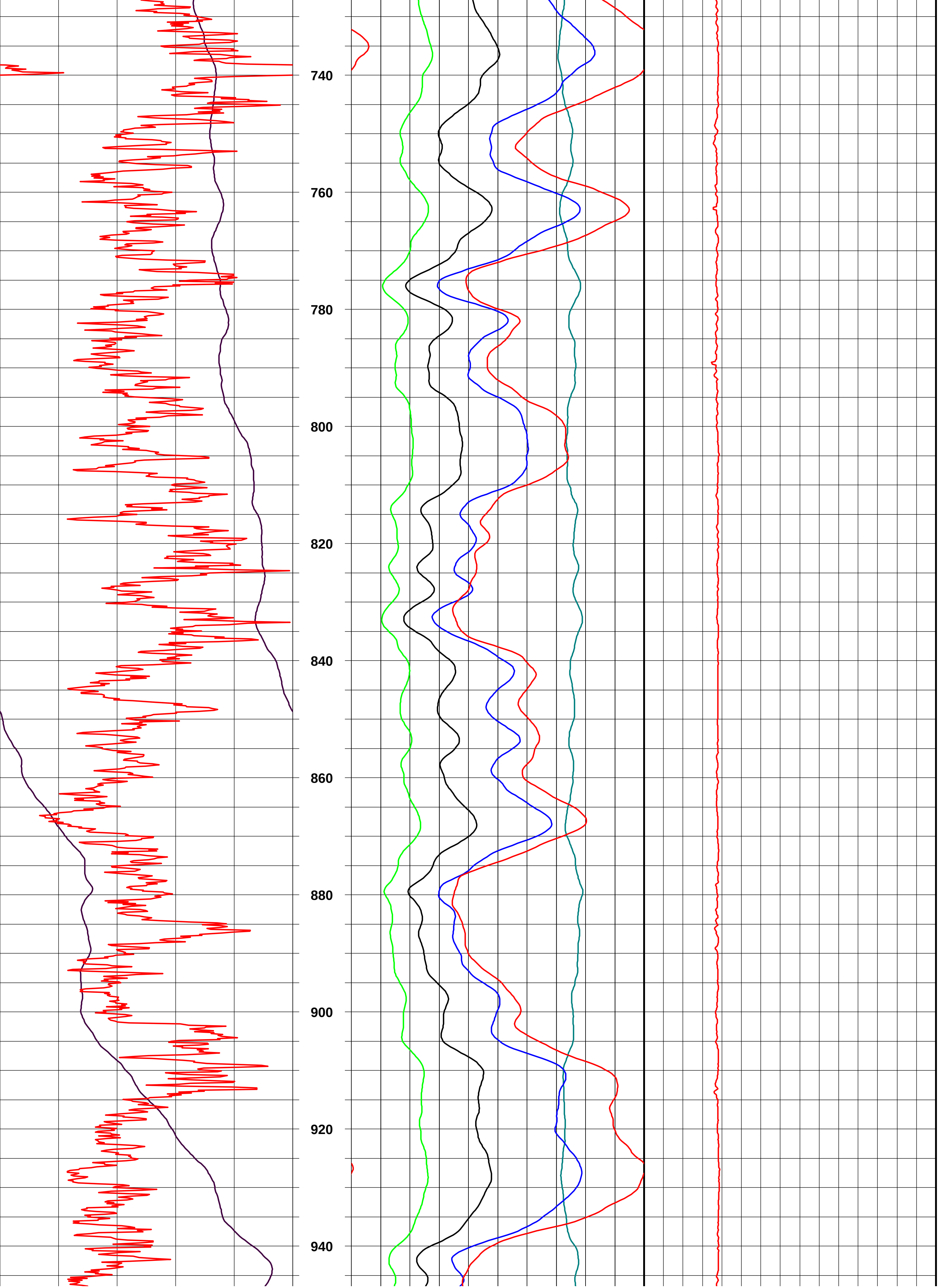
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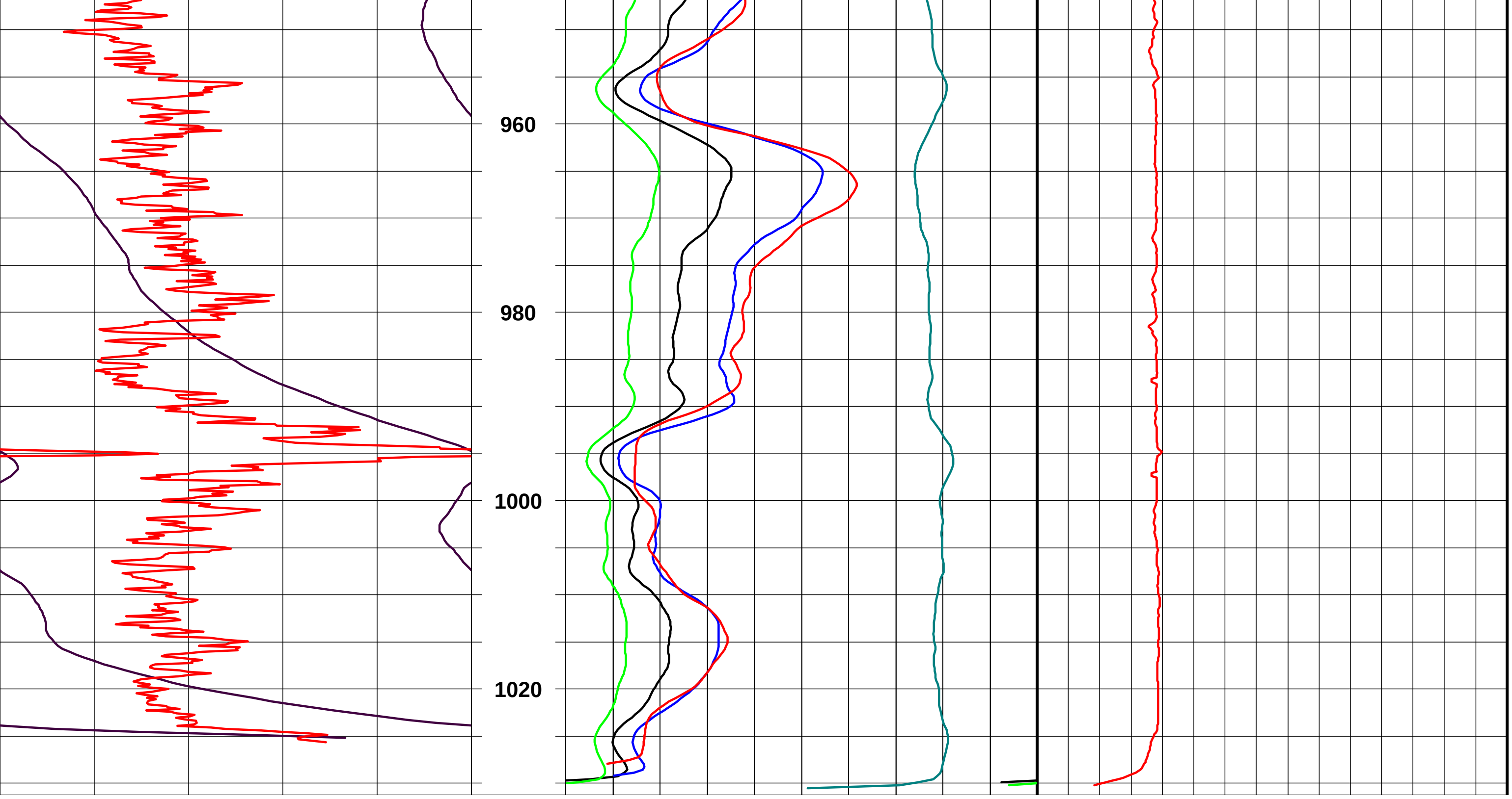

960
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1000
1020

Schmidt-1 Test Well Sampling Analytical Results

Final Analysis Report

LCRA Environmental Laboratory Services

Date: *04-Dec-07*

CLIENT:	LBG-Guyton Associates	**Client Sample ID:**	SCHMIDT-1
Lab Order:	0710367	**Collection Date:**	10/10/2007 1:30:00 AM
Project:	SCHMIDT-1	**Matrix:**	AQUEOUS
Lab ID:	0710367-001	**Tag No:**	

Analyses	Result	Qual	MCL	PQL	Units	DF	BatchID	Date Analyzed
TNRCC METHOD 1005-TPH			**TX1005**		**(TX1005)**			Analyst: **CO**
>C12-C28	ND		0	4.6	mg/L	1	51744	10/17/2007 6:58:00 PM
>C28-C35	ND		0	4.6	mg/L	1	51744	10/17/2007 6:58:00 PM
C6-C12	ND		0	4.6	mg/L	1	51744	10/17/2007 6:58:00 PM
C6-C35	ND		0	4.6	mg/L	1	51744	10/17/2007 6:58:00 PM
ICP METALS, DISSOLVED			**E200.7**					Analyst: **TRO**
Boron	5.11		0	0.0510	mg/L	1	51668	10/15/2007 8:29:14 PM
Calcium	71.9		0	0.204	mg/L	1	51668	10/15/2007 8:29:14 PM
Iron	ND		0	0.0510	mg/L	1	51668	10/15/2007 8:29:14 PM
Magnesium	32.6		0	0.204	mg/L	1	51668	10/15/2007 8:29:14 PM
Potassium	41.1		0	0.204	mg/L	1	51668	10/15/2007 8:29:14 PM
Sodium	1340		0	25.0	mg/L	50	51694	10/16/2007 6:36:45 PM
ICPMS METALS, DISSOLVED			**E200.8**					Analyst: **SW**
Arsenic	ND		0	2.04	µg/L	1	51675	10/15/2007
Barium	24.6		0	1.02	µg/L	1	51675	10/15/2007
Manganese	28.1		0	1.02	µg/L	1	51696	10/16/2007
Strontium	1620		0	102	µg/L	100	51696	10/16/2007
ANIONS BY ION CHROMATOGRAPHY			**E300.0**					Analyst: **WR**
Chloride	1500		0	50.0	mg/L	50	51664	10/12/2007 5:23:00 PM
Fluoride	5.99		0	0.100	mg/L	10	51603	10/11/2007 7:58:00 PM
Nitrogen, Nitrate (As N)	ND		10	0.100	mg/L	10	51603	10/11/2007 7:58:00 PM
Sulfate	384			10.0	mg/L	10	51603	10/11/2007 7:58:00 PM
ALKALINITY			**SM2320 B**					Analyst: **WR**
Alkalinity, Bicarbonate (As CaCO3)	905			2	mg/L CaCO3	1	51712	10/16/2007
Alkalinity, Carbonate (As CaCO3)	ND		0	2	mg/L CaCO3	1	51712	10/16/2007
Alkalinity, Total (As CaCO3)	905			2	mg/L CaCO3	1	51712	10/16/2007
CONDUCTANCE			**E120.1**					Analyst: **ML**
Specific Conductance @ 25°C	6730		0	0	µmhos/cm	1	51627	10/15/2007
HYDROGEN SULFIDE			**SM4500-S2**					Analyst: **JB**
Hydrogen Sulfide	ND			1.0	mg/L	1	51637	10/15/2007
AMMONIA AS N			**E350.1**					Analyst: **WR**
Nitrogen, Ammonia (As N)	2.72		0	0.040	mg/L	2	51707	10/15/2007
PH			**SM4500-H+-B**					Analyst: **JB**
pH @ 25°C	7.74		8.5	0	pH units	1	51652	10/15/2007
SILICA			**SM4500-SIO2-C**					Analyst: **ML**

Qualifiers:				
	B	Analyte detected in the associated Method Blank	E	Value above quantitation range
	H	Holding times for preparation or analysis exceeded	ND	Not Detected at the Reporting Limit
	S	Spike Recovery outside accepted recovery limits	X	Value exceeds Maximum Contaminant Level

LCRA Environmental Laboratory Services

Date: *04-Dec-07*

CLIENT:	LBG-Guyton Associates	**Client Sample ID:**	SCHMIDT-1
Lab Order:	0710367	**Collection Date:**	10/10/2007 1:30:00 AM
Project:	SCHMIDT-1	**Matrix:**	AQUEOUS
Lab ID:	0710367-001	**Tag No:**	

Analyses	Result	Qual	MCL	PQL	Units	DF	BatchID	Date Analyzed
SILICA			**SM4500-SIO2-C**					Analyst: **ML**
Silica, Dissolved (as SiO2)	32.8		0	2.50	mg/L	5	51609	10/12/2007
SULFIDE			**SM4500-S2-D**					Analyst: **JB**
Sulfide	13			1.0	mg/L	1	51637	10/15/2007
TOTAL DISSOLVED SOLIDS			**SM2540C**					Analyst: **KK**
Total Dissolved Solids (Residue, Filterable)	3990		0	50.0	mg/L	10	51557	10/11/2007
TOTAL SUSPENDED SOLIDS			**SM2540D**					Analyst: **KK**
Suspended Solids (Residue, Non-Filterable)	1.0		0	1.0	mg/L	1	51678	10/16/2007

Qualifiers:

B	Analyte detected in the associated Method Blank	E	Value above quantitation range
H	Holding times for preparation or analysis exceeded	ND	Not Detected at the Reporting Limit
S	Spike Recovery outside accepted recovery limits	X	Value exceeds Maximum Contaminant Level

the standard in safety

Underwriters Laboratories

Laboratory Report

Client: LCRA Environmental Laboratory

Attn: Susan Benavidez
3505 Montopolis Drive
EL101
Austin, TX 78744

Copies to: None

Report: 190992
Priority: Standard Written
Status: Final
PWS ID: Not Supplied

Sample Information

UL ID #	Client ID	Method	Collected Date / Time	Collected By:	Received Date / Time
1727486	0710367-002A	200.8	10/10/07 13:30	Client	10/18/07 09:15
1727487	0710367-002A	7110 B	10/10/07 13:30	Client	10/18/07 09:15
1727487	0710367-002A	7110 C	10/10/07 13:30	Client	10/18/07 09:15
1727488	0710367-002A	7500-Ra B	10/10/07 13:30	Client	10/18/07 09:15
1727488	0710367-002A	7500-Ra D	10/10/07 13:30	Client	10/18/07 09:15

Report Summary

Note: See attached page for additional comments.

Note: Sample containers were provided by the client.

Detailed quantitative results are presented on the following pages.

We appreciate the opportunity to provide you with this analysis. If you have any questions concerning this report, please do not hesitate to call Jim Vernon at (574) 233-4777.

Note: This report may not be reproduced, except in full, without written approval from Underwriters Laboratories (UL).
UL is accredited by the National Environmental Laboratory Accreditation Program (NELAP).

Authorized Signature ___ Title: PM ___ Date: 11-27-07

Client Name: LCRA Environmental Laboratory
Report #: 190992

Underwriters Laboratories Inc.
110 S. Hill Street, South Bend, IN 46617-2702 USA
T:: 800.332.4345 / F:: 574.233.8207 / W:: ul.com

Client Name: LCRA Environmental Laboratory　　　　Report #: 190992

Sampling Point: 0710367-002A　　　　PWS ID: Not Supplied

Radionuclides

Analyte ID #	Analyte	Method	Reg Limit	DL**	Result	Units	Preparation Date	Analyzed	UL ID #
7440-61-1	Uranium	200.8	30 *	1.00	0.41 ± 0.03	ug/L	---	10/23/07 16:05	1727486
---	Gross Alpha	7110 C	15 *	2	**105 ± 2**	pCi/L	11/02/07 05:20	11/03/07 13:01	1727487
---	Gross Beta	7110 B	50 *	4.1	**59.0 ± 6.0**	pCi/L	10/23/07 11:00	10/24/07 08:33	1727487
13982-63-3	Radium-226	7500-Ra B	---	0.2	**39.2 ± 1.7**	pCi/L	10/31/07 06:15	11/21/07 09:18	1727488
15262-20-1	Radium-228	7500-Ra D	---	0.7	**2.0 ± 0.5**	pCi/L	10/31/07 06:15	11/11/07 13:48	1727488
---	Combined Radium	calc.	5 *	---	**41.2 ± 1.8**	pCi/L	10/31/07 06:15	11/21/07 09:18	1727488

** Detection Limit (DL) shall be that concentration which can be counted with a precision of plus or minus 100% at the 95 % confidence level.

† UL has demonstrated it can achieve these report limits in reagent water, but can not document them in all sample matrices.

Reg Limit Type:	MCL	SMCL	AL
Symbol:	*	^	!

Schmidt-1 Interval Sampling Analytical Results

Final Analysis Report

LCRA Environmental Laboratory Services

Date: *20-Sep-07*

CLIENT:	LBG-Guyton Associates	**Client Sample ID:**	Schmidt-1-903-933
Lab Order:	0709306	**Collection Date:**	9/8/2007 4:30:00 PM
Project:	Schmidt	**Matrix:**	AQUEOUS
Lab ID:	0709306-001	**Tag No:**	903-933

Analyses	Result	PQL	Qual	Units	DF	Date Analyzed
ICPMS METALS, DISSOLVED		**E200.8**				Analyst: **SW**
Barium	67.3	10.2		µg/L	10	9/18/2007
Manganese	42.1	10.2		µg/L	10	9/18/2007
Strontium	38900	1020		µg/L	1000	9/19/2007
ANIONS BY ION CHROMATOGRAPHY		**E300**				Analyst: **WR**
Chloride	41000	1000		mg/L	1000	9/19/2007 2:01:00 PM
Fluoride	52.0	10.0		mg/L	1000	9/19/2007 2:01:00 PM
Sulfate	3120	1000		mg/L	1000	9/19/2007 2:01:00 PM
ALKALINITY		**SM2320 B**				Analyst: **WR**
Alkalinity, Bicarbonate (As CaCO3)	401	2		mg/L CaCO3	1	9/19/2007
Alkalinity, Carbonate (As CaCO3)	ND	2		mg/L CaCO3	1	9/19/2007
Alkalinity, Total (As CaCO3)	401	2		mg/L CaCO3	1	9/19/2007
CONDUCTANCE		**E120.1**				Analyst: **ML**
Specific Conductance @ 25°C	87400	0		µmhos/cm	1	9/20/2007 8:59:00 AM
PH		**SM4500-H+-B**				Analyst: **JB**
pH @ 25°C	7.33	0		pH units	1	9/13/2007
SILICA		**SM4500-SIO2-C**				Analyst: **ML**
Silica, Dissolved (as SiO2)	11.6	0.50		mg/L	1	9/14/2007
TOTAL DISSOLVED SOLIDS		**SM2540C**				Analyst: **KK**
Total Dissolved Solids (Residue, Filterable)	65800	100		mg/L	20	9/14/2007

Qualifiers:

B	Analyte detected in the associated Method Blank	E	Value above quantitation range
H	Holding times for preparation or analysis exceeded	ND	Not Detected at the Reporting Limit
S	Spike Recovery outside accepted recovery limits	X	Value exceeds Maximum Contaminant Level

LCRA Environmental Laboratory Services

Date: *20-Sep-07*

CLIENT:	LBG-Guyton Associates	**Client Sample ID:**	Schmidt-1-675-705
Lab Order:	0709306	**Collection Date:**	9/10/2007 4:30:00 PM
Project:	Schmidt	**Matrix:**	AQUEOUS
Lab ID:	0709306-002	**Tag No:**	675-705

Analyses	Result	PQL	Qual	Units	DF	Date Analyzed
ICPMS METALS, DISSOLVED		**E200.8**				Analyst: **SW**
Barium	67.4	1.02		µg/L	1	9/18/2007
Manganese	8.64	1.02		µg/L	1	9/18/2007
Strontium	3310	10.2		µg/L	10	9/18/2007
ANIONS BY ION CHROMATOGRAPHY		**E300**				Analyst: **WR**
Chloride	3650	100		mg/L	100	9/19/2007 2:13:00 PM
Fluoride	6.00	1.00		mg/L	100	9/19/2007 2:13:00 PM
Sulfate	797	100		mg/L	100	9/19/2007 2:13:00 PM
ALKALINITY		**SM2320 B**				Analyst: **WR**
Alkalinity, Bicarbonate (As CaCO3)	648	2		mg/L CaCO3	1	9/19/2007
Alkalinity, Carbonate (As CaCO3)	ND	2		mg/L CaCO3	1	9/19/2007
Alkalinity, Total (As CaCO3)	648	2		mg/L CaCO3	1	9/19/2007
CONDUCTANCE		**E120.1**				Analyst: **ML**
Specific Conductance @ 25°C	13300	0		µmhos/cm	1	9/20/2007 8:59:00 AM
PH		**SM4500-H+-B**				Analyst: **JB**
pH @ 25°C	7.91	0		pH units	1	9/13/2007
SILICA		**SM4500-SIO2-C**				Analyst: **ML**
Silica, Dissolved (as SiO2)	12.1	0.50		mg/L	1	9/14/2007
TOTAL DISSOLVED SOLIDS		**SM2540C**				Analyst: **KK**
Total Dissolved Solids (Residue, Filterable)	8140	50.0		mg/L	10	9/14/2007

Qualifiers:				
	B	Analyte detected in the associated Method Blank	E	Value above quantitation range
	H	Holding times for preparation or analysis exceeded	ND	Not Detected at the Reporting Limit
	S	Spike Recovery outside accepted recovery limits	X	Value exceeds Maximum Contaminant Level

LCRA Environmental Laboratory Services

Date: *20-Sep-07*

CLIENT:	LBG-Guyton Associates	**Client Sample ID:**	Schmidt-1-615-645
Lab Order:	0709306	**Collection Date:**	9/12/2007 4:30:00 PM
Project:	Schmidt	**Matrix:**	AQUEOUS
Lab ID:	0709306-003	**Tag No:**	615-645

Analyses	Result	PQL	Qual	Units	DF	Date Analyzed
ICPMS METALS, DISSOLVED		**E200.8**				Analyst: **SW**
Barium	55.5	10.2		µg/L	10	9/18/2007
Manganese	ND	10.2		µg/L	10	9/18/2007
Strontium	2860	10.2		µg/L	10	9/18/2007
ANIONS BY ION CHROMATOGRAPHY		**E300**				Analyst: **WR**
Chloride	3010	50.0		mg/L	50	9/19/2007 2:24:00 PM
Fluoride	5.25	0.50		mg/L	50	9/19/2007 2:24:00 PM
Sulfate	604	50.0		mg/L	50	9/19/2007 2:24:00 PM
ALKALINITY		**SM2320 B**				Analyst: **WR**
Alkalinity, Bicarbonate (As CaCO3)	722	2		mg/L CaCO3	1	9/19/2007
Alkalinity, Carbonate (As CaCO3)	ND	2		mg/L CaCO3	1	9/19/2007
Alkalinity, Total (As CaCO3)	722	2		mg/L CaCO3	1	9/19/2007
CONDUCTANCE		**E120.1**				Analyst: **ML**
Specific Conductance @ 25°C	11100	0		µmhos/cm	1	9/20/2007 8:59:00 AM
PH		**SM4500-H+-B**				Analyst: **JB**
pH @ 25°C	7.99	0		pH units	1	9/13/2007
SILICA		**SM4500-SIO2-C**				Analyst: **ML**
Silica, Dissolved (as SiO2)	18.3	0.50		mg/L	1	9/14/2007
TOTAL DISSOLVED SOLIDS		**SM2540C**				Analyst: **KK**
Total Dissolved Solids (Residue, Filterable)	7040	50.0		mg/L	10	9/14/2007

Qualifiers:

B	Analyte detected in the associated Method Blank	E	Value above quantitation range
H	Holding times for preparation or analysis exceeded	ND	Not Detected at the Reporting Limit
S	Spike Recovery outside accepted recovery limits	X	Value exceeds Maximum Contaminant Level

LCRA Environmental Laboratory Services

Date: *24-Sep-07*

CLIENT: LBG-Guyton Associates
Project:
Lab Order: 0709615

Work Order Sample Summary

Lab Sample ID	Client Sample ID	Tag Number	Date Collected	Date Received
0709615-001A	903-933	Schmidt - 1	9/8/2007 4:30:00 PM	9/13/2007 4:00:00 PM
0709615-002A	675-705	Schmidt - 1	9/10/2007 4:30:00 PM	9/13/2007 4:00:00 PM
0709615-003A	615-645	Schmidt - 1	9/12/2007 4:30:00 PM	9/13/2007 4:00:00 PM

Final Analysis Report

LCRA Environmental Laboratory Services

Date: *24-Sep-07*

CLIENT:	LBG-Guyton Associates	**Client Sample ID:**	903-933
Lab Order:	0709615	**Collection Date:**	9/8/2007 4:30:00 PM
Project:		**Matrix:**	AQUEOUS
Lab ID:	0709615-001	**Tag No:**	SCHMIDT - 1

Analyses	Result	PQL	Qual	Units	DF	Date Analyzed
ICP METALS, DISSOLVED		**E200.7**				Analyst: **TRO**
Sodium	20200	51.0		mg/L	100	9/21/2007 7:34:39 PM

Qualifiers:	B	Analyte detected in the associated Method Blank	E	Value above quantitation range
	H	Holding times for preparation or analysis exceeded	ND	Not Detected at the Reporting Limit
	S	Spike Recovery outside accepted recovery limits	X	Value exceeds Maximum Contaminant Level

LCRA Environmental Laboratory Services

Date: *24-Sep-07*

CLIENT: LBG-Guyton Associates
Lab Order: 0709615
Project:
Lab ID: 0709615-002

Client Sample ID: 675-705
Collection Date: 9/10/2007 4:30:00 PM
Matrix: AQUEOUS
Tag No: SCHMIDT - 1

Analyses	Result	PQL	Qual	Units	DF	Date Analyzed
ICP METALS, DISSOLVED		**E200.7**				Analyst: **TRO**
Sodium	2580	51.0		mg/L	100	9/21/2007 7:40:29 PM

Qualifiers:

B	Analyte detected in the associated Method Blank	E	Value above quantitation range
H	Holding times for preparation or analysis exceeded	ND	Not Detected at the Reporting Limit
S	Spike Recovery outside accepted recovery limits	X	Value exceeds Maximum Contaminant Level

LCRA Environmental Laboratory Services

Date: *24-Sep-07*

CLIENT:	LBG-Guyton Associates	**Client Sample ID:**	615-645
Lab Order:	0709615	**Collection Date:**	9/12/2007 4:30:00 PM
Project:		**Matrix:**	AQUEOUS
Lab ID:	0709615-003	**Tag No:**	SCHMIDT - 1

Analyses	Result	PQL	Qual	Units	DF	Date Analyzed
ICP METALS, DISSOLVED		**E200.7**				Analyst: **TRO**
Sodium	2140	51.0		mg/L	100	9/21/2007 7:45:56 PM

Qualifiers:

B	Analyte detected in the associated Method Blank	E	Value above quantitation range
H	Holding times for preparation or analysis exceeded	ND	Not Detected at the Reporting Limit
S	Spike Recovery outside accepted recovery limits	X	Value exceeds Maximum Contaminant Level

DHL Analytical

Date: 09/20/07

CLIENT:	LCRA Env. Services Lab	Client Sample ID:	0709306-001B
Project:		Lab ID:	0709148-01
Project No:		Collection Date:	09/08/07 04:30 PM
Lab Order:	0709148	Matrix:	Aqueous

Analyses	Result	MDL	RL	Qual	Units	DF	Date Analyzed
Dissolved Metals-ICPMS (0.45µ)	E200.8						Analyst: KDT
Calcium	1770000	20000	20000		µg/L	200	09/19/07 07:56 PM
Iron	237	50.0	100		µg/L	1	09/19/07 08:00 PM
Magnesium	678000	20000	20000		µg/L	200	09/19/07 07:56 PM
Potassium	359000	20000	20000		µg/L	200	09/19/07 07:56 PM

Qualifiers:				
	*	Value exceeds TCLP Maximum Concentration Level	J	Analyte detected between MDL and RL
	B	Analyte detected in the associated Method Blank	MDL	Method Detection Limit
	C	Sample Result or QC discussed in the Case Narrative	N	Parameter not NELAC certified
	DF	Dilution Factor	ND	Not Detected at the Method Detection Limit
	E	TPH pattern not Gas or Diesel Range Pattern	RL	Reporting Limit
			S	Spike Recovery outside control limits

CLIENT:	LCRA Env. Services Lab	Client Sample ID:	0709306-002B
Project:		Lab ID:	0709148-02
Project No:		Collection Date:	09/10/07 04:30 PM
Lab Order:	0709148	Matrix:	Aqueous

Analyses	Result	MDL	RL	Qual	Units	DF	Date Analyzed
Dissolved Metals-ICPMS (0.45µ)	E200.8						Analyst: KDT
Calcium	102000	2000	2000		µg/L	20	09/19/07 03:49 PM
Iron	ND	100	200		µg/L	2	09/20/07 11:21 AM
Magnesium	91000	2000	2000		µg/L	20	09/19/07 03:49 PM
Potassium	52300	2000	2000		µg/L	20	09/19/07 03:49 PM

Qualifiers:

*	Value exceeds TCLP Maximum Concentration Level	J	Analyte detected between MDL and RL
B	Analyte detected in the associated Method Blank	MDL	Method Detection Limit
C	Sample Result or QC discussed in the Case Narrative	N	Parameter not NELAC certified
DF	Dilution Factor	ND	Not Detected at the Method Detection Limit
E	TPH pattern not Gas or Diesel Range Pattern	RL	Reporting Limit
		S	Spike Recovery outside control limits

DHL Analytical

Date: 09/20/07

CLIENT:	LCRA Env. Services Lab	Client Sample ID:	0709306-003B
Project:		Lab ID:	0709148-03
Project No:		Collection Date:	09/12/07 04:30 PM
Lab Order:	0709148	Matrix:	Aqueous

Analyses	Result	MDL	RL	Qual	Units	DF	Date Analyzed
Dissolved Metals-ICPMS (0.45µ)	E200.8						Analyst: KDT
Calcium	89700	2000	2000		µg/L	20	09/19/07 03:57 PM
Iron	227	50.0	100		µg/L	1	09/19/07 08:15 PM
Magnesium	72900	2000	2000		µg/L	20	09/19/07 03:57 PM
Potassium	47400	2000	2000		µg/L	20	09/19/07 03:57 PM

Qualifiers:

*	Value exceeds TCLP Maximum Concentration Level	J	Analyte detected between MDL and RL
B	Analyte detected in the associated Method Blank	MDL	Method Detection Limit
C	Sample Result or QC discussed in the Case Narrative	N	Parameter not NELAC certified
DF	Dilution Factor	ND	Not Detected at the Method Detection Limit
E	TPH pattern not Gas or Diesel Range Pattern	RL	Reporting Limit
		S	Spike Recovery outside control limits

Texas Water Development Board Comments on Final Draft Report

Attachment I
Draft Final Report Review
TWDB Contract No. 0604830580
Upper Colorado River Authority

Comments on Reports for the San Angelo Brackish Groundwater Exploration Project

Brackish Groundwater Exploration Guidance Manual

General Comments:

Please verify by means of a sign/seal that the geoscientific work performed for this project was done by or under the supervision of a Texas-licensed geoscientist.

Article V, Item 2 of the Contract requires that TWDB be acknowledged in any publication relating to work performed under the contract. Please include this acknowledgement.

Article III, Item 3 of the Contract requires an Executive Summary in the report. Please include an Executive Summary.

Please consider including a reference list in the manual.

TWDB would appreciate receiving a copy of high-resolution images taken during the course of the project. We will, of course, acknowledge UCRA and LBG-Guyton Associates when we use these images.

Specific Comments:

Introduction: Page 1, paragraph 1, lines 7 to 9. Please check the accuracy of the statement "In the most recent round of regional water planning (2007), 10 of the 16 regional water planning groups recommended desalination as a water management strategy". Table 10.6, SWP 2007, shows eight regional water planning groups recommending desalination as a water management strategy.

What is Brackish Water?: Page 2, paragraph 1, line 3. Please verify the volume of "in-place" brackish groundwater in Texas. Table 6, LBG-Guyton Associates, 2003, lists the volume as 2.707 billion acre-feet. This is the number that is being used by the TWDB.

Getting Started: Page 2, paragraph 4. Please consider mentioning the brackish groundwater desalination guidance manual currently being developed by NRS Engineers for the North Cameron Regional Water Supply Corporation. The manual is being prepared as part of a TWDB-funded project and is expected to be available in March/April 2008.

Getting Started: Page 6, paragraph 2, lines 3 to 5. The word "encountering" as used in the sentence is misleading. Please rewrite the sentence.

Regulatory Considerations: Page 7, Figure 3. The GCD map is dated. Currently, there are 95 GCDs in Texas. Please update the map.

Regulatory Considerations: Page 8, paragraph 1, line 10. Please change the spelling of "filled" to "filed".

Regulatory Considerations: Page 8, paragraph 1, line 11. Please consider adding a page number after the reference to the Test Well Abandonment and Site Remediation section. It will be useful to the reader.

Regulatory Considerations: Page 8, paragraph 2. Please consider adding a short paragraph on the brackish groundwater desalination guidance manual currently being developed by NRS Engineers for the North Cameron Regional Water Supply Corporation. The manual is being prepared as part of a TWDB-funded project and is expected to be available in March/April 2008. It will contain a wealth of information on regulatory requirements for permitting desalination plants in Texas.

Identifying a Brackish Groundwater Source: Please consider adding a discussion on other exploration tools such as aerial photos and remotely sensed imagery to this section.

Identifying a Brackish Groundwater Source: Page 10. Please consider adding an additional list of sources for information on brackish groundwater resources. This list could be entitled "Other Sources" and could include sources such as local water well drillers, groundwater conservation districts, etc.

Identifying a Brackish Groundwater Source: Page 10, paragraph 2, line 6. Please consider adding page numbers after the reference to the Data Collection Procedures and Water Quality Sampling sections. They will be useful to the reader.

Identifying a Brackish Groundwater Source: Page 11, paragraph 3, line 2. Typically, a desalination plant will be built after a brackish groundwater source is established. Please consider rewriting the sentence to reflect this.

Selecting a Drilling Contractor – The Bid Process: Page 13, paragraph 1, lines 3 to 4. Please clarify if a bid package is required to be prepared or supervised by a professional engineer licensed in Texas.

Selecting a Drilling Contractor – The Bid Process: Page 13, paragraph 1, line 6. Please correct the spelling of "preformed". It should be "performed".

Selecting a Drilling Contractor – The Bid Process: Page 13, paragraph 2, line 3. Please correct the spelling of "schedules". It should be "scheduled".

Selecting a Drilling Contractor – The Bid Process: Page 13, paragraph 2. Please consider including a sample bid sheet for the benefit of the user of this manual.

Selecting a Drilling Contractor – The Bid Process: Page 14, paragraph 1. Please add a question mark (?) after each bulleted item in the list.

Design and Installation of Test Wells: Please consider including unit cost estimates for drilling and installing wells. A real life example of costs from a drilling project such as the San Angelo project would be helpful. Also, it would be useful for the user to have a schematic of a test well, monitoring well, and a production well included in the manual.

Design and Installation of Test Wells: Page 16, paragraph 2, line 2. What is the TAC reference for? Please clarify.

Design and Installation of Test Wells: Page 16, paragraph 4, line 5. Please correct the spelling of "manor". It should be "manner".

Data Collection Procedures at the Well Site: Page 17, paragraph 3, line 6. The Keys and MacCary reference is not listed in the Reference section. In fact, there is no Reference section in the manual. Please consider including one.

Design Performance and Evaluation of Pumping Tests: Please consider including a discussion on other types of hydraulic tests available such as slug tests.

Design Performance and Evaluation of Pumping Tests: page 23, paragraph 3, line 7. Please change the spelling of "contacted" to "contact".

Water Quality Sampling, Analysis and Evaluation: Page 25. This section discusses the characteristics of brackish water, its causes, and its effect on desalination membranes. It does not, however, address groundwater sample collection methods, typical field and laboratory analytical tests, and cost estimates for conducting these tests. Please consider including this information in the section.

Test Well Abandonment and Site Remediation: Page 27, figure 13. Please match the caption with the label in the figure: test well or production well?

What's Next?: Page 30. Please consider adding a short paragraph on the brackish groundwater desalination guidance manual currently being developed by NRS Engineers for the North Cameron Regional Water Supply Corporation. The manual is being prepared as part of a TWDB-funded project and is expected to be available in March/April 2008. It would be an appropriate transition from this manual to the desalination manual.

Brackish Source Water Exploration in the San Angelo Area

General Comments:

Please verify by means of a sign/seal that the geoscientific work performed for this project was done by or under the supervision of a Texas-licensed geoscientist.

Article V, Item 2 of the Contract requires that TWDB be acknowledged in any publication relating to work performed under the contract. Please include this acknowledgement.

Article III, Item 3 of the Contract requires an Executive Summary in the report. Please include an Executive Summary.

Please include (as an appendix) the specifications for the test holes and test wells that were prepared prior to drilling. This is Task 2 of the Scope-of-Work.

For the three test sites, please provide start and end dates of drilling, name of the drilling company, dates of water sampling, and well-plugging dates, where applicable.

For the three test sites, please consider including a lithologic interpretation of the geophysical logs included in the appendices.

Specific Comments:

Introduction: Page 1. Please provide some background information for the project in terms of the regional water planning process (water supply needs in San Angelo, recommended water management strategy, etc.).

Introduction: Page 1. Please consider including a geologic map of the San Angelo area showing the locations of the test holes.

Schmidt-1 Test Hole: Page 6, paragraph 3. How was the pumped water managed? Was a TCEQ discharge permit necessary? Please provide this information.

Figure 5: Please identify the rock or sediment shown in the photograph. Also, please include the magnification of the image.

Figure 10: Please identify the rock particle shown in the photograph. Also, please include the magnification of the image.

Table 1: Please identify the nature of the sample that was analyzed and explain what the Sample ID numbers denote (different depths?). Please spell out (in a Notes section below the table) the short forms of the units used in the measurements.

Table 2: Please identify the nature of the sample that was analyzed. Also, please spell out (in a Notes section below the table) the short forms of the units used in the measurements.

Schmidt-1 Interval Sampling Analytical Results: Please explain why the results from these samples were not included in the discussion in the main body of the text nor listed in Table 2.