Pumping Test Report for the

Lagro Well (# 1973)

Kerr County, Texas

Prepared for

Headwaters Groundwater Conservation District

LBG-GUYTON ASSOCIATES

Professional Groundwater and Environmental Engineering Services

A Division of Leggette, Brashears & Graham, Inc.

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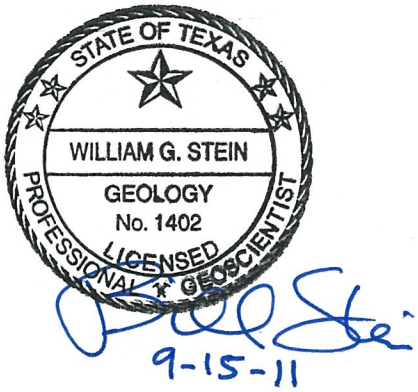

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INTRODUCTION

At the request of Mr. Gene Williams of the Headwaters Groundwater Conservation District (District), LBG-Guyton Associates performed a pumping test on a recently constructed domestic well located in eastern Kerr County, Texas about 9 miles east of the City of Kerrville. Figure 1 shows the well location and surface geology near the well site. The well is owned by Mr. Henry Lagro and is referred to as the Lagro Well. Appreciation is extended to Mr. Lagro for allowing access to the well and assistance during the testing.

H.W. Schwope & Sons, Inc. of Boerne, Texas constructed the new well in April and May of 2011 at a depth of 380 feet into the Trinity Aquifer. The Driller's Report by Schwope for this well is in Appendix 1 as reference. Coordinates of the Lagro Well were measured with a Garmin 11 global positioning system (GPS) and land surface elevation is estimated from Google Earth, which are:

Latitude	Longitude	Surface Elevation
30° 03' 35.5"	98° 59' 52.2"	1690

Geo Cam, Inc. performed geophysical logging of the well on April 14, 2011 to a depth of 361 feet using multi-point resistivity and gamma ray. The log is in Appendix 2 at the end of this report as reference.

PUMPING TESTS

General Information on Pumping Tests

When a well is pumped and water is withdrawn from an aquifer, water levels in the vicinity are drawn down to form an inverted cone with its apex located at the pumping well.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. Groundwater 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. The shape and size of the cone is directly related to the aquifer parameters. When more than one well is pumped, each well superimposes its cone of water-level depression on the cones created by the pumping of neighboring wells. When the cone of one well overlaps the cone of another, interference occurs and the lowering of water levels is additive because both wells are

competing for the same water in the aquifer. 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 to make a quantitative evaluation of an aquifer. The primary aquifer characteristics of concern are transmissivity (T), which is an index of the aquifer's ability to transmit water measured in gallons per day per foot (gpd/ft), and its storage coefficient (unitless), which is 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 T by the aquifer thickness; the unit of measurement is gallons per day per foot squared (gpd/ft^2). Important measurements made during a pumping test are well 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 having the same properties in all directions. In properly applying the results, however, one must be mindful of their limitations and take into consideration the physical characteristics of the aquifer, which are usually not the same in all directions.

Lagro Pumping Test

For the purpose of performing the pumping-test, Schwope installed a 10-horsepower submersible-pump (owned by Headwaters GCD) at a depth of 357 feet in the well. A portable generator supplied the power for the pump. A picture of the well during testing is shown on the photograph on the cover of the report. A totalizing water meter was installed in the discharge line to monitor flow rate and total number of gallons discharged during testing. Static water level was at a depth of about 184 feet below land surface on August 25, 2011.

An In-Situ transducer, model 500 Level TROLL, was utilized during testing for water-level measurements. The transducer is rated for 100 pounds per square inch (psi) (2.31 feet/psi x 100 psi = 231 feet). The transducer was placed in a 1-inch diameter PVC pipe installed at a depth of 340 feet in the well. The units were programmed to record water pressure every 2 minutes. The pressure data are converted to feet of water above the probe and then depth of water from the surface by comparing to sounding measurements made with a calibrated electrical tape.

The constant-rate pumping test of the Lagro Well began August 29, 2011 and continued for just over 24-hours. The pump was turned off after 24-hours and the well was allowed to recover for over 26-hours. The hydrograph for the pumping and recovery of the testing of this well is shown in Figure 2.

Data from pumping and recovery were analyzed using the Cooper-Jacob method. This method is described in detail in a number of hydrology textbooks, including Freeze and Cherry (1979) and Driscoll (1986). The graphed results and calculations from the pumping and recovery are provided in Figure 3. The following table lists the pumping rate, drawdown and specific capacity, and summarizes the results of transmissivity in gallons per day per foot (gpd/ft) calculated from the pumping tests.

Average Pumping Rate (gpm)	Total Drawdown (feet)	Specific Capacity (gpm/ft)	Calculated Transmissivity (gpd/ft)
61.3	136.5	0.45	575

WATER-QUALITY ANALYSES

All groundwater 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 dissolved solids depend upon the solubility of the minerals present in the rocks through which the water moves, 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 groundwater increases with depth. This is especially true 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.

For public supply and human consumption, the concentrations of certain constituents should not exceed the maximum levels of the Primary and Secondary Safe Drinking Water Standards mandated by the U. S. Environmental Protection Agency and the Texas Commission on Environmental Quality (TCEQ). The recommendations for maximum concentrations of some common inorganic constituents in milligrams per liter (mg/l) are as follows:

Safe Drinking Water Standards

Primary Standards	
Constituent	**mg/l**
Arsenic	0.05
Nitrate (as N)	10
Secondary Standards	
Constituent	**mg/l**
Chloride	300
Iron	0.3
Sulfate	300
Total Dissolved Solids	1,000
Fluoride	2.0

Primary Standards are concerned with dissolved constituents that are known to have adverse effects on human health. Secondary Standards are concerned with aesthetic qualities of drinking water (e.g., taste and odor). Often, water is consumed with concentrations higher than the Secondary Standards, especially when this is the only water available. Generally, water that contains more than 2,000 mg/l dissolved solids is not used for human consumption. Treatment, such as reverse osmosis, can be used to lower concentrations and remove many undesired constituents.

LBG-Guyton Associates collected a water sample from the Lagro Well at 12:15 pm after extensive purging during the pumping test on August 30, 2011. This sample was placed in an appropriate container and left on ice until it was delivered to the lab. The following field parameters were measured near the time of sample retrieval:

Specific Conductivity	1,240 μmhos
Temperature	74.0 ^{o}F
pH	7.6

An odor of hydrogen sulfide was detected during well purging.

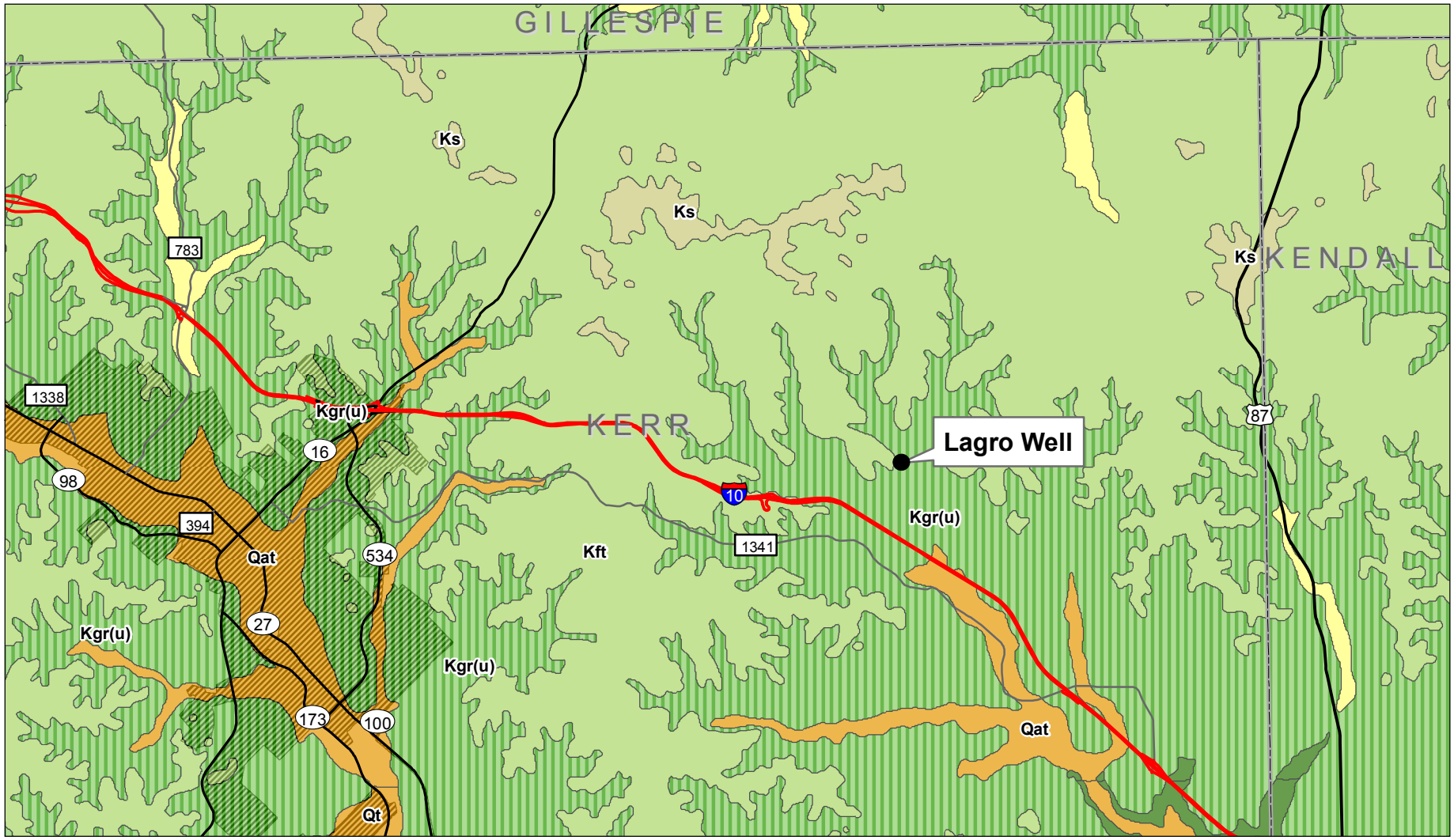
The samples retrieved from the well near the end of the pumping test on August 30, 2011 were analyzed for metals (calcium, magnesium, sodium, potassium, and iron), minor metals (aluminum, arsenic, copper, manganese and zinc), anions (chloride, sulfate and bicarbonate alkalinity as $CaCO_3$, nitrate, nitrite and fluoride), and total dissolved solids (TDS). LCRA Environmental Laboratory of Austin, Texas performed the inorganic analyses. Underwriters Laboratories, Inc. analyzed the radioactive chemistry

consisting of gross alpha and beta, radium and uranium. The laboratory reports for the water analyses are provided in Appendix 3. Measurements for TDS, sulfate, fluoride and iron are shown in the following table along with state secondary standards:

	Water Analyses from Lagro Well	**TCEQ Secondary Standard**
Total Dissolved Solids (mg/l)	873	1,000
Sulfate (mg/l)	321	300
Fluoride (mg/l)	1.88	2.0
Iron (mg/l)	0.34	0.3

The analyses indicate that sulfate and iron slightly exceed state secondary standards for public drinking water.

Figures



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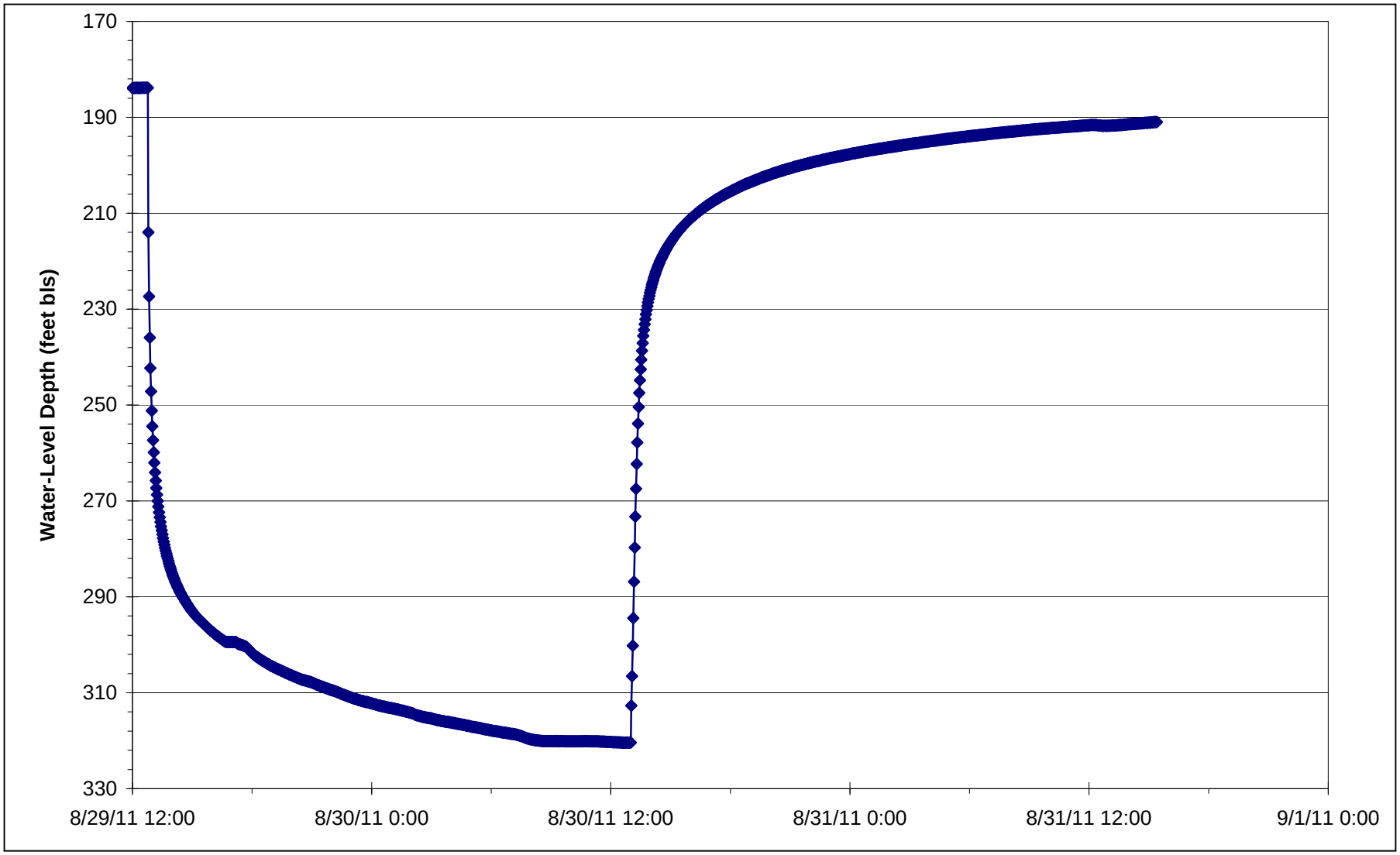
Surface Geology and Location Map for Lagro Well (#1973), Kerr County, Texas

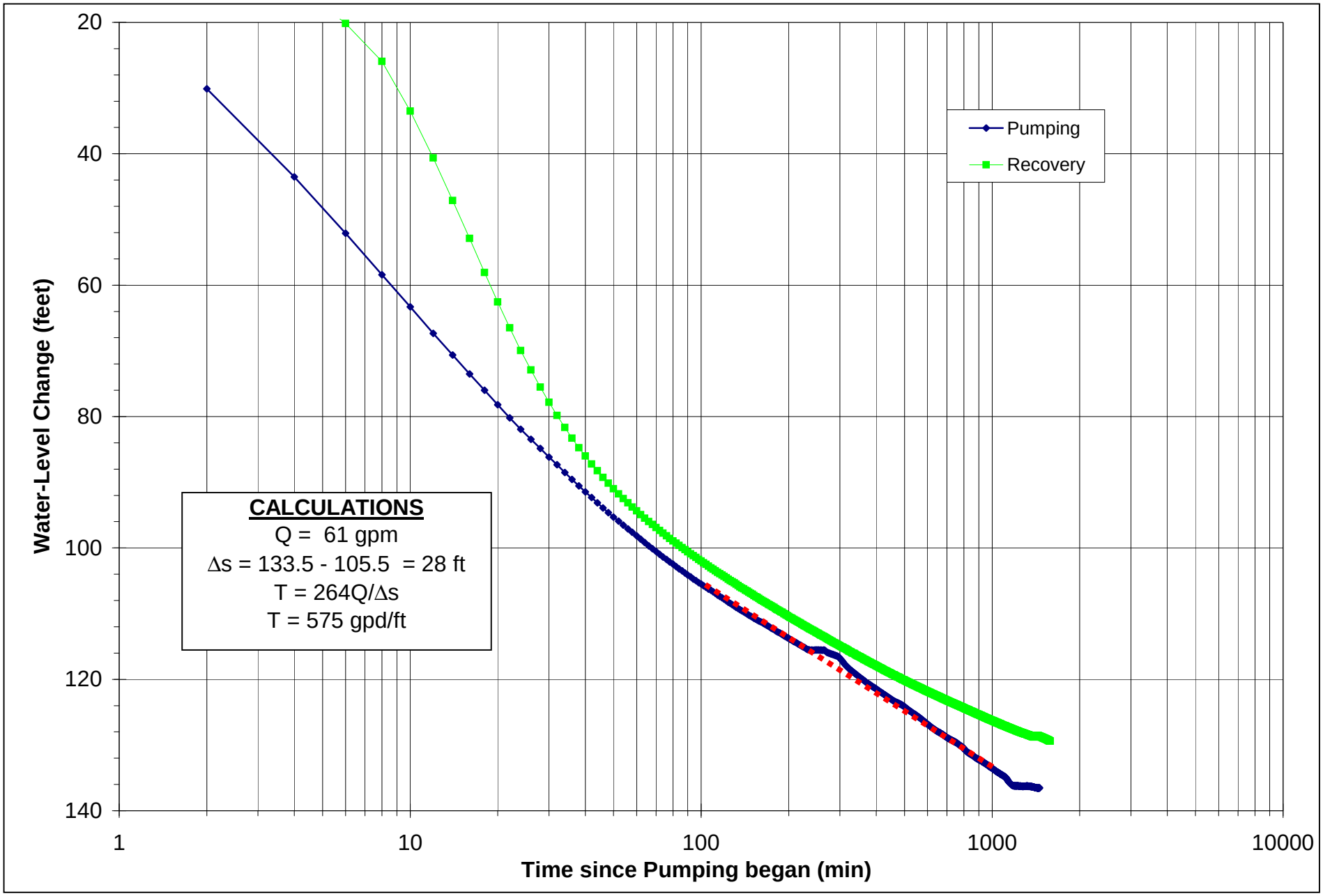
FIGURE 1



HYDROGRAPH OF PUMPING TEST FOR LAGRO WELL (HEADWATERS # 1973)

LBG-GUYTON ASSOCIATES

FIGURE 2



SEMILOG PLOT AND CALCULATIONS OF PUMPING TEST FOR LAGRO WELL (# 1973)

LBG-GUYTON ASSOCIATES

FIGURE 3

Appendix 1

Driller's Well Report

Attention Owner: Confidentiality Privilege Notice on reverse side of owner's copy.

Texas Department of Licensing and Regulation

Water Well Driller/Pump Installer Section
P.O. Box 12157 Austin, Texas 78711 (512)463-7880 FAX (512)463-8616
Toll free (800)803-9202
Email address: water.well@license.state.tx.us Web address: www.license.state.tx.us

This form must be completed and filed with the department and owner within 60 days upon completion of the well.

WELL REPORT

A. WELL IDENTIFICATION AND LOCATION DATA

1) OWNER

Name:	Address:	City:	State:	Zip:
HENRY LACRO	321 BLUE QUAIL CT	BEDFORD	TX	76021

2) WELL LOCATION

Well # or # of wells drilled	County:	Physical Address:	City:
1973	KERR	480 ALLERKAMP RD	COMFORT

Lat. 30° 03 35.74 Long. 98° 59 52.16 Grid #

3) Type of Work
☑ New Well ☐ Reconditioning ☐ Replacement ☐ Deepening

4) Proposed Use (check) ☐ Monitor ☐ Environmental Soil Boring ☑ Domestic ☐ Extraction
☐ Industrial ☐ Irrigation ☐ Injection ☐ Closed-Loop Geothermal ☐ De-watering ☐ Testwell
☐ Rig Supply ☐ Stock ☐ Public Supply – If Public Supply, were plans approved? ☐ Yes ☐ No

5) NT

6) Drilling Date
Started 4 / 8 / 11
Completed 5 / 10 / 11

Diameter of Hole

Dia.(in)	From (ft)	To (ft)
	Surface	
9 5/8	0	390

7) Drilling Method (check)
☐ Driven ☑ Air Rotary ☐ Mud Rotary ☐ Bored ☐ Air Hammer ☐ Cable Tool ☐ Jetted ☐ Hollow Stem Auger ☐ Reverse Circulation ☐ Other

From (ft)	To (ft)	Description and color of formation material
0	9	CALICHE W/ LIME LAYERS
9	33	CALICHE + CLAY YELLOW
33	39	GRAY SHALEY LIME
39	43	BLUE GRAY SHALE
43	70	BLUE GRAY SHALEY LIME
70	85	GRAY SHALE W BLUE GRAY LIME
85	120	BLUEISH GRAY SHALEY LIME
120	128	BLUE GRAY SHALE W GRAY TAN LIMEY
128	169	BLUE - GRAY SHALEY LIME
169	180	BLUE GRAY + TAN LIME SHALEY W/ GYPSUM

(Use reverse side of Well Owner's copy, If necessary)

8) Borehole Completion ☐ Open Hole ☐ Straight Wall ☐ Under-reamed ☑ Gravel Packed ☐ Other
Gravel packed interval from: ft. to: ft. Size:

Casing, Blank Pipe, and Well Screen Data

Dia. (in.)	New or Used	Steel, Plastic, etc. Perf., Slotted, etc Screen Mfr., if commercial	Setting (ft) From	Setting (ft) To	Gage Casing Screen
5"	SDR 17 PVC. CASING		380	378	
5"	.032	FACTORY SCREEN	378	298	
5"	SDR 17 PVC. CASING		298	0	
		TOTAL 382 FT			

9) Annular Seal Data: i.e. (from 0 ft to 100 ft Sacks & material (3 cement)
from 0 ft. to 248 ft. #sacks & material 2.50/LBS
from ft. to ft. #sacks & material
from ft. to ft. #sacks & material
Method Used PRESSURE Performed By H.W. SCHWOPE
Distance to septic field or other concentrated contamination 1057 ft.
Distance to Property Line 1807 ft
Method Verified: MEASURE

10) Surface Completion (If steel cased, leave blank)
☐ Surface Slab Installed ☑ Surface Sleeve Installed ☐ Pitless Adapter Used ☐ Alternative Procedure Used

11) Water Level
Static level 184 ft. Date: / /
Artesian Flow gpm

12) Packers:

Type	Depth	Type	Depth

13) Plugged ☐ Well plugged within 48 hours

Casing left in well: From (ft)	To (ft)	Cement/Bentonite placed in well: From (ft)	To (ft)	# Sacks & Material used

14) Type Pump
☐ Turbine ☐ Jet ☑ Submersible ☐ Cylinder ☐ Other
Depth to pump bowls, cylinder, jet etc. ft

15) Water Test
Type test ☐ Pump ☐ Bailer ☑ Jetted ☐ Estimated
Yield: 60 gpm with ft. drawdown after hrs.

16) Water Quality
Type of water Depth of Strata: Was a chemical analysis made? ☐ Yes ☑ No
Did you knowingly penetrate a strata which contains undesirable constituents? ☐ Yes ☑ No If yes, Continue:
Check One: ☐ Naturally poor-quality groundwater – type ☐ Hydrocarbons (i.e. gas, oil, etc.)
☐ Hazardous material/waste contamination encountered ☐ Other (describe)

☐ *I certify that while drilling, deepening, or otherwise altering the above described well, undesirable water or constituents was encountered and the landowner was informed that such well must be completed or plugged in such a manner as to avoid injury or pollution.*

By signing this well report, I certify that I drilled or supervised the drilling of this well and that each and all of the statements herein are true and correct.

Company & Individual's Name: (type or print) H.W. SCHWOPE + SONS INC. Lic. No.:
Address: P.O BOX 364 City: BOERNE State: TX Zip 78006
Signature: John C. Schwope / / Signature: [illegible]
KAREN L. SCHWOPE Date Driller/Pump Installer

DLR FORM 001WWD/7-08 TDLR (Original) Landowner (copy) Driller/Pump Installer (copy) Applicable Reg. Numbers

Additional information or comments:

WELL REPORT CONFIDENTIALITY NOTICE

TEX. OCC. CODE Title 12, Chapter 1901.251, authorizes the owner (owner or the person for whom the well was drilled) to keep information in Well Reports confidential. The Department shall hold the contents of the well log confidential and not a matter of public record, if the department receives by certified mail, a written request from the owner.

From (ft)	To (ft)	Description and color of formation material
180	185	BLUE GRAY TAN LIME W/GYPSUM
185	192	DARKER BLUE GRAY LIME W/SHALE
192	202	BLUE GRAY LIME & GYPSUM
202	217	GRAY TAN LIME
217	222	BROWN LIME
222	226	LIGHT GRAY TAN LIME
226	245	GRAY SHALEY LIME
245	255	GRAY & TAN LIME W/SHALE
255	265	GRAY W TAN LIME
265	278	GRAY SHALEY LIME
278	285	LIGHT GRAY TAN LIME
285	307	GRAY - TAN LIME
307	316	SOFT GRAY SANDSTONE W/QUARTZ
316	325	LIGHT GRAY & GRAY LIME
325	328	LIGHT GRAY - PINK CONGLOMERATE SANDSTONE W BIGGER QUARTZ
328	337	CREAM TAN & GOLD LIME
337	342	CONGLOMERATE SANDSTONE W/QUARTZ
342	345	CONGLOMERATE LIME LIGHT GRAY TAN
345	353	LIGHT GRAY & CREAM TAN LIME
353	367	LIGHT GRAY & PINK QUARTZ LOOSE SAND
367	385	CONGLOMERATE PINK GRAY SANDSTONE

Appendix 2

Geophysical Log

GEO CAM

Borehole: LAGRO WELL

Logs: GAMMA, RESISITIVITY

Water Well Logging & Video Recording Services

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

Project: LAGRO WELL

Client: **HEADWATERS**

Location: **N30* 03' 35.45'' W98* 59' 52.22''**

Date: 04-14-11

County: KERR

State: TX

BOREHOLE DATA

Drilling Contractor: SCHWOPE AND SONS

Driller T.D. (ft) : 385'

Elevation: 1590' GPS

Logger T.D. (ft) : 361'

Depth Ref: G.L.

Date Drilled: 04-14-11

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

Drill Method: AIR ROTARY

Weight:

Fluid Level (ft) : 185'

Hole Medium:

Mud Type:

Time Since Circ:

Viscosity:

Rm: at: Deg C

GENERAL DATA

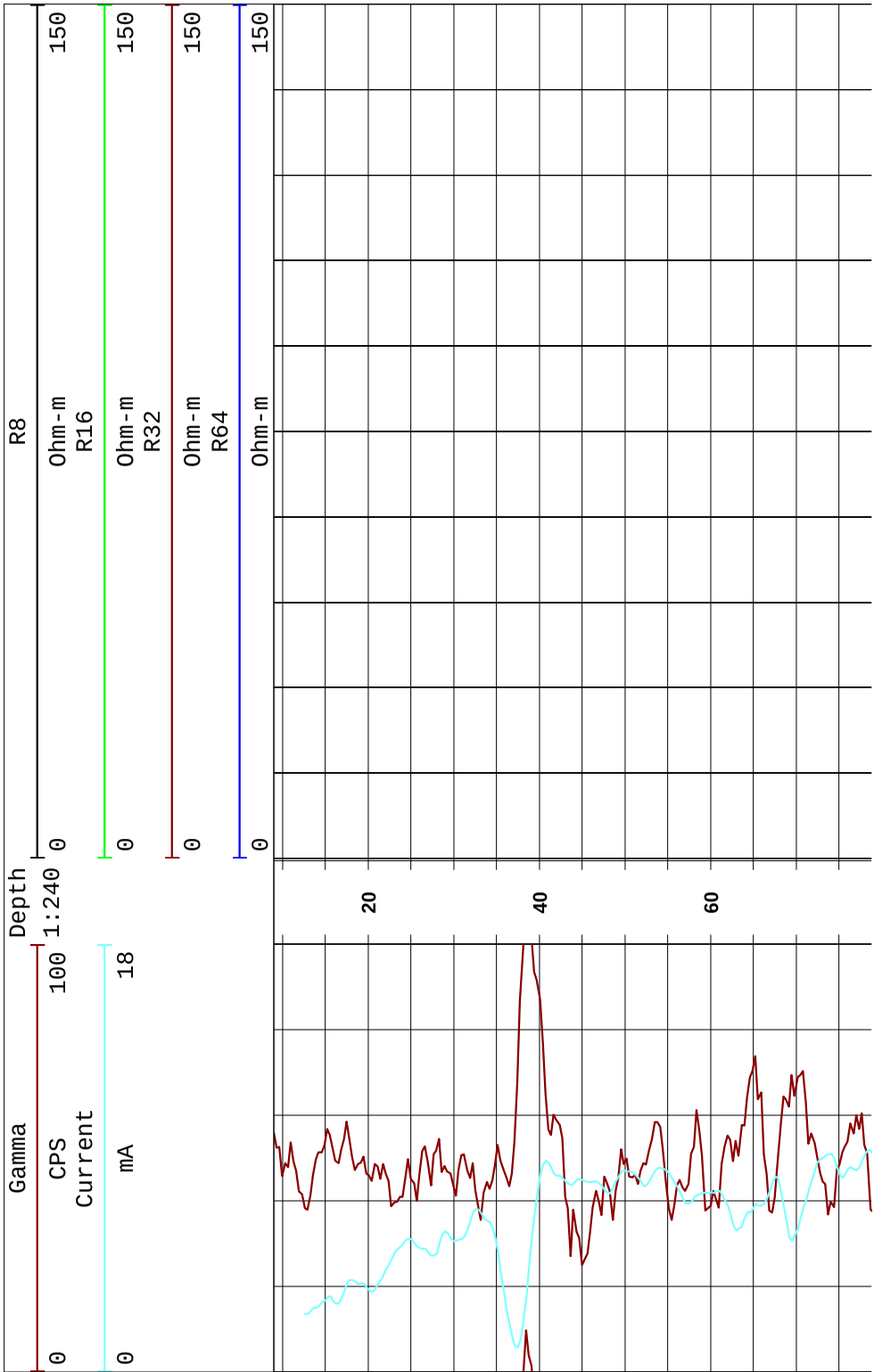
Logged by: Robert C. Becknal

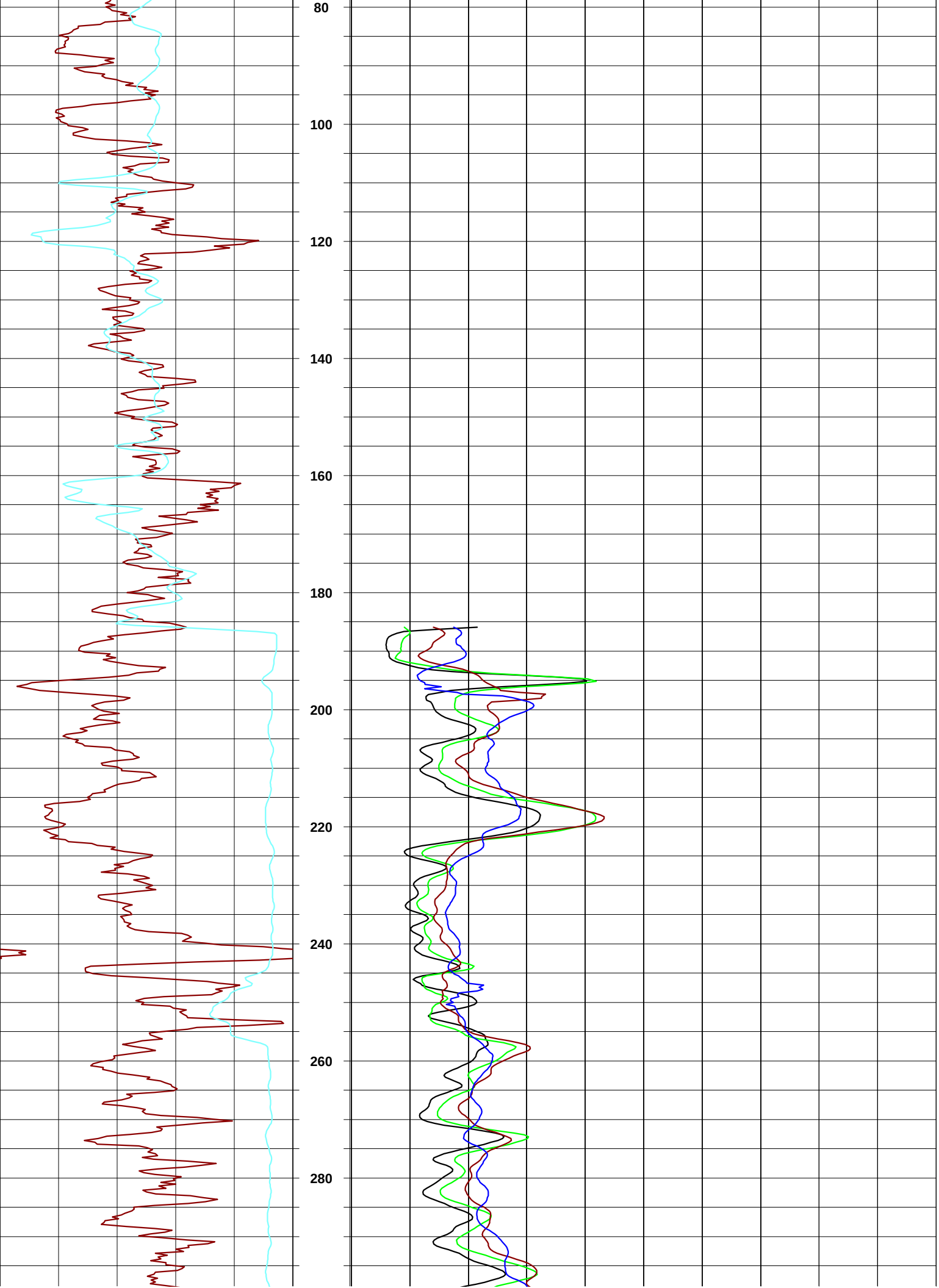
Unit/Truck: 03

Witness:

LOG TYPE	RUN NO	SPEED (ft/min)	FROM (ft)	TO (ft)	FT./ IN.
GAMMA	2	22	357'	9'	20
RESISITIVITY	2	22	360'	186'	20

Comments:

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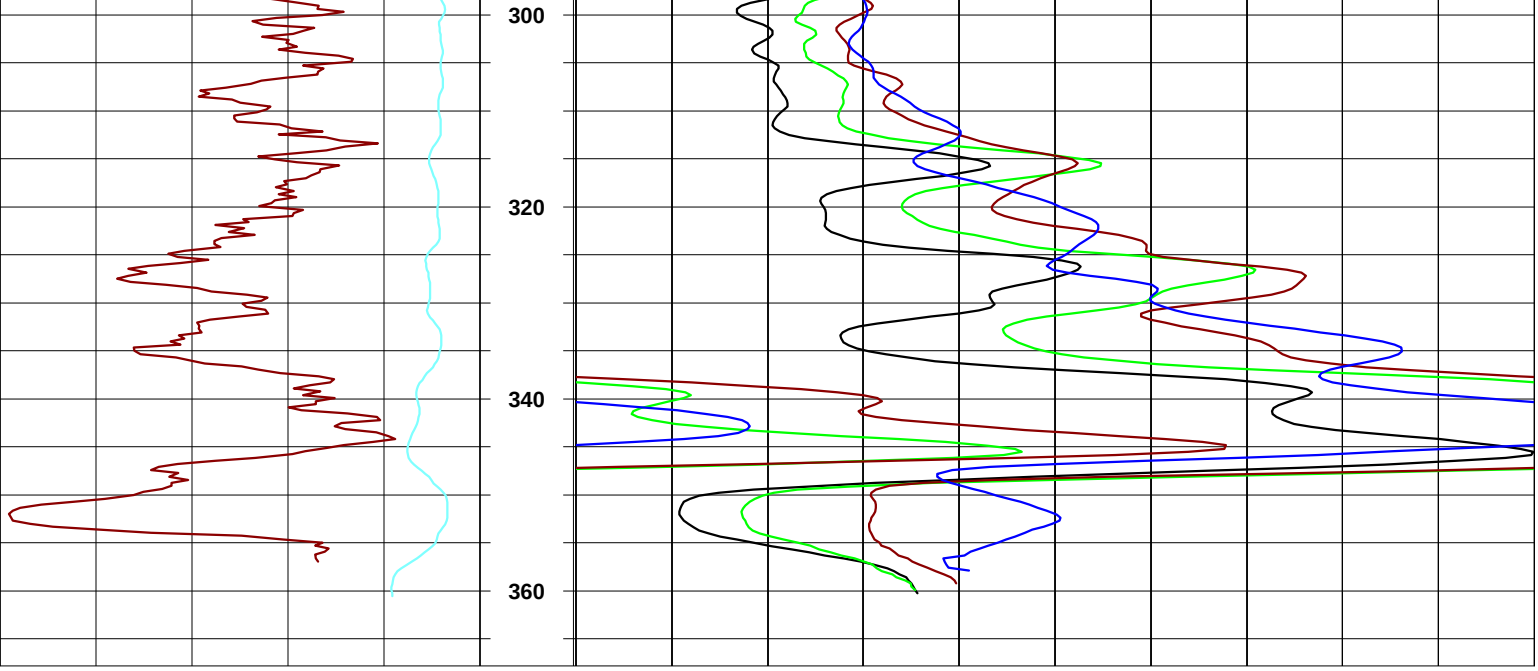
300
320
340
360

Appendix 3

Laboratory Reports

Final Analysis Report

LCRA Environmental Laboratory Services

Date: *13-Sep-11*

CLIENT:	LBG-Guyton Associates	**Client Sample ID:**	Lagro - Headwaters
Lab Order:	1108C50	**Collection Date:**	8/30/2011 12:15:00 PM
Project:	Lagro Headwaters/Nutrients	**Matrix:**	DRINKING WATER
Lab ID:	1108C50-001	**Tag No:**	

Analyses	Result	PQL	Qual	Units	DF	Date Analyzed
ICP METALS IN DRINKING WATER		**E200.7**				Analyst: **MV**
Calcium	120	0.200	A	mg/L	1	9/6/2011 12:10:05 PM
Iron	0.341	0.0500	X	mg/L	1	9/6/2011 12:10:05 PM
Magnesium	58.1	0.200		mg/L	1	9/6/2011 12:10:05 PM
Potassium	12.1	0.200		mg/L	1	9/6/2011 12:10:05 PM
Sodium	63.0	0.600		mg/L	1	9/6/2011 12:10:05 PM
ICPMS METALS IN DRINKING WATER		**E200.8**				Analyst: **SW**
Aluminum	0.0917	0.00500		mg/L	1	9/2/2011 11:10:42 AM
Arsenic	< 0.00200	0.00200		mg/L	1	9/2/2011 3:05:22 PM
Copper	< 0.00200	0.00200		mg/L	1	9/2/2011 11:10:42 AM
Manganese	0.0135	0.00100		mg/L	1	9/2/2011 11:10:42 AM
Zinc	0.0802	0.00500		mg/L	1	9/2/2011 11:10:42 AM
ANIONS BY ION CHROMATOGRAPHY		**E300.0**				Analyst: **JB**
Chloride	84.4	5.00		mg/L	5	8/31/2011 2:57:00 PM
Fluoride	1.88	0.050		mg/L	5	8/31/2011 2:57:00 PM
Nitrogen, Nitrate (As N)	< 0.050	0.050		mg/L	5	8/31/2011 2:57:00 PM
Nitrogen, Nitrite	< 0.050	0.050		mg/L	5	8/31/2011 2:57:00 PM
Sulfate	321	5.00		mg/L	5	8/31/2011 2:57:00 PM
ALKALINITY		**SM2320 B**				Analyst: **KH**
Alkalinity, Bicarbonate (As CaCO3)	268	2	A	mg/L CaCO3	1	9/1/2011
Alkalinity, Total (As CaCO3)	268	2	A	mg/L CaCO3	1	9/1/2011
CATION/ANION BALANCE		**CALCULATION**				Analyst: **JB**
Cation/Anion Balance	2.48	5.0	A	%	1	9/12/2011
PH		**SM4500-H+-B**				Analyst: **KH**
pH @ 25°C [for information only]	7.6	0	A	pH Units	1	8/31/2011
TOTAL DISSOLVED SOLIDS		**SM2540C**				Analyst: **ZP**
Total Dissolved Solids (Residue, Filterable)	873	25.0		mg/L	10	8/31/2011

Qualifiers:

A Not Available for Accreditation
B Analyte Detected in Method Blank
E Value Above Quantitation Range
H Holding Time Exceeded
N Not Accredited
S Spike Recovery Outside Recovery Limits
X Value Exceeds Maximum Contaminant Level (MCL)

PQL: Practical Quantitation Limit

Values Below PQL Considered Estimated