Pumping Test and Sampling of Headwaters Groundwater Conservation District

Monitor Well #17

Kerr County, Texas

LBG-Guyton Associates

Professional Groundwater and Environmental Engineering Services

A Division of Leggette, Brashears & Graham, Inc.

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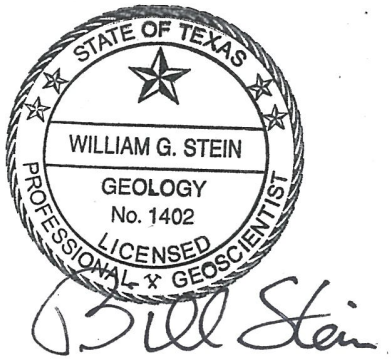
Prepared For

Mr. Gene Williams
General Manager
Headwaters Groundwater Conservation District



March 31, 2017

LBG-GUYTON ASSOCIATES
Professional Groundwater and Environmental Services
12702 Toepperwein Road, Suite 212
San Antonio, Texas 78233

INTRODUCTION

At the request of Mr. Gene William, General Manager of the Headwaters Groundwater Conservation District, LBG-Guyton Associates has performed a pumping test and retrieved a water sample for analyses from a newly constructed Monitor Well #17. This report summarizes the findings of this testing and sampling. Appreciation is also extended to Mr. Matt McKenzie with the District for his assistance during testing and sampling of the well.

The well was constructed by McKinley Drilling of San Antonio, Texas from November 11 to December 20, 2016. The well is located in the northeast corner of Kerr County just west of Highway 87 (Figure 1). The latitude and longitude for the monitor well are listed in the following table, along with surface elevations and water level measured on February 20, 2017:

Well	**Latitude**	**Longitude**	**Approximate Surface Elevation** (feet above MSL)	**Total Depth** (feet below land surface)	**Water-Level Depth** (feet below land surface)
Monitor Well #17	30º 07' 52.1"	99º 55' 23.6"	1927	1,153	361

The approximate surface elevations listed is taken from Google Earth.

The well is completed into the Ellenburger Limestone at a total depth of 1,153 feet below land surface. McKinley set 12-inch diameter casing to 563 feet and drilled 9-7/8-inch open hole to a total depth of 1,153 feet. The Driller's report is included in Appendix 1.

PUMPING TEST ANALYSES

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When a well is pumped and water is withdrawn from an aquifer, water levels in the vicinity are drawn down to form an inverted cone with its apex located at the pumping well.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.

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.

Monitor Well #17 Pumping Test

Peerless installed a line-shaft turbine pump with 11 stages using about 90-horsepower. The bottom of the pump was set at a depth of 550 feet. The pump was powered by a diesel motor (seen on photo on cover of report). An orifice weir with 4.75-inch opening was installed in the 6-inch diameter discharge line. The average level in the piezometer of the orifice weir during the pumping test was about 35-inches, which correlates to about 600 gallons per minute (gpm). A totalizing water meter was also installed in the discharge line. However, the readings from the totalizing meter appeared to be off as compared to the orifice weir, so those readings were not utilized.

During the pumping test, LBG-Guyton Associates installed an In-Situ Level Troll transducer in the well just above the pump. The transducer is rated for 100 pounds per square inch (psi) (2.31 feet/psi x 100 psi = 231 feet) and records water pressure, which is converted to feet of water above the probe. These data are then converted to depth of water from land surface by comparing the transducer readings to measurements made with a calibrated electrical tape. Data from the pumping test 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).

Hydrographs of the water levels measured in Monitor Well #17 are shown in Figures 2. The results are graphed on a semi-log scale and calculations are shown in Figures 3. Two water level trends were selected on the pumping data curve. A change in slope occurs in the data after about 300 minutes of pumping, which may indicate that the cone of depression from pumping has reached out to a more permeable part of the aquifer. The following table lists the pumping rate and summarizes the results calculated from the pumping tests:

Date Pumping Test Started	**Average Pumping Rate** (gpm)	**24-hour Draw-down** (feet)	**24-hour Specific Capacity** (gpm/ft)	**Transmissivity** (gpd/ft)
2/20/17	600	69.1	8.68	7,920 12,670

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 re-tards the flushing action of water moving through the aquifer and causes the water to become more stagnant and highly mineralized. The Ellenburger Aquifer in Central Texas generally yield water that ranges from fresh, which is less than 1,000 milligrams per liter (mg/l) total dissolved solids (TDS), to slightly saline (1,000 to 3,000 mg/l TDS).

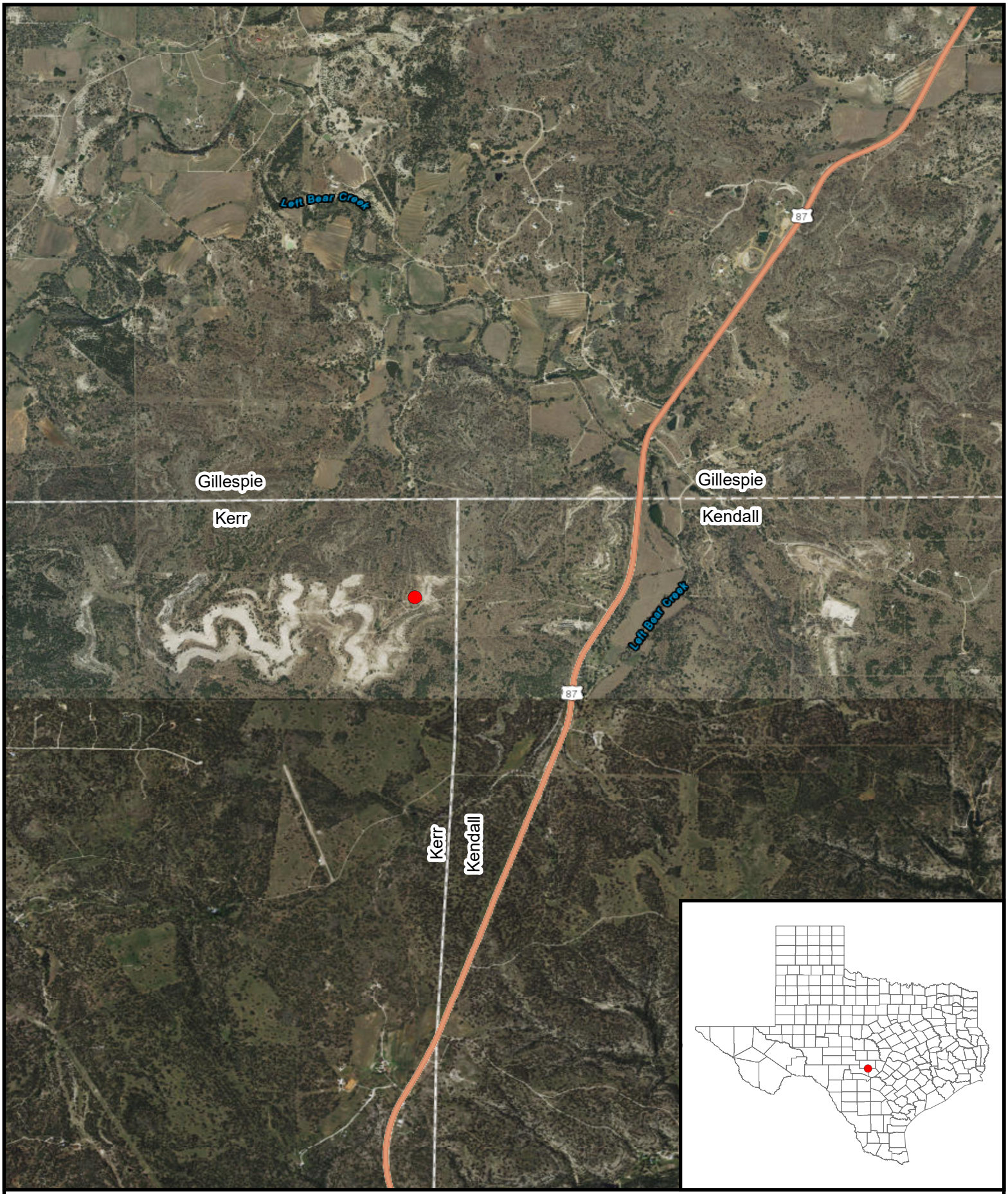
LBG-Guyton Associates collected a water sample from the well near the end of the pumping test. Even though this is a monitor well with the water not intended for public consumption, the Primary and Secondary Safe Drinking Water Standards mandated by the U. S. Environmental Protection Agency and the Texas Commission on Environmental Quality (TCEQ) are listed below for comparison. 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).

The samples were analyzed for metals (calcium, iron, magnesium, potassium and sodium), minor metals (aluminum, arsenic, copper, manganese, and zinc), anions (chloride, fluoride, nitrate and nitrite as N, sulfate and bicarbonate alkalinity as $CaCO_3$), total dissolved solids and radionuclide. The Lower Colorado River Authority Environmental Laboratory Service in Austin, Texas performed the analyses. The summary pages of the laboratory reports for these analyses are provided in Appendix 2. The full QA/QC lab reports have been sent to the District separate from this report. All constituents analyzed appear to be better than the drinking water standards generally accepted by TCEQ for public water supplies. The results are summarized in the following tables listed with standards for public drinking water for comparison:

Primary Standards		**MW #17 (mg/l)**
Constituent		
Fluoride (mg/l)	4	1.10
Nitrate (mg/l as N)	10	<0.01
Nitrite (mg/l as N)	1	<0.01
Arsenic (mg/l)	0.05	0.00198
Secondary Standards		
Constituent		
Aluminum (mg/l)	0.2	0.005
Chloride (mg/l)	300	111
Copper (mg/l)	1	0.194
Fluoride (mg/l)	2	1.10
Iron (mg/l)	0.3	0.092
Manganese (mg/l)	0.05	0.0026
Sulfate (mg/l)	300	43.3
Zinc (mg/l)	5.0	0.0149
Dissolved Solids (mg/l)	1,000	498

Radionuclide Primary Standards		MW #17
Constituents	**pCi/l**	**pCi/l**
Gross alpha (pCi/l)	15	9.31
Radium-226/228 (pCi/l)	5	1.79 + (< 1) = <2.79
Beta particle (pCi/l)	50	6.65
Uranium (µg/l)	30	3.21

FIGURES



LBG GUYTON

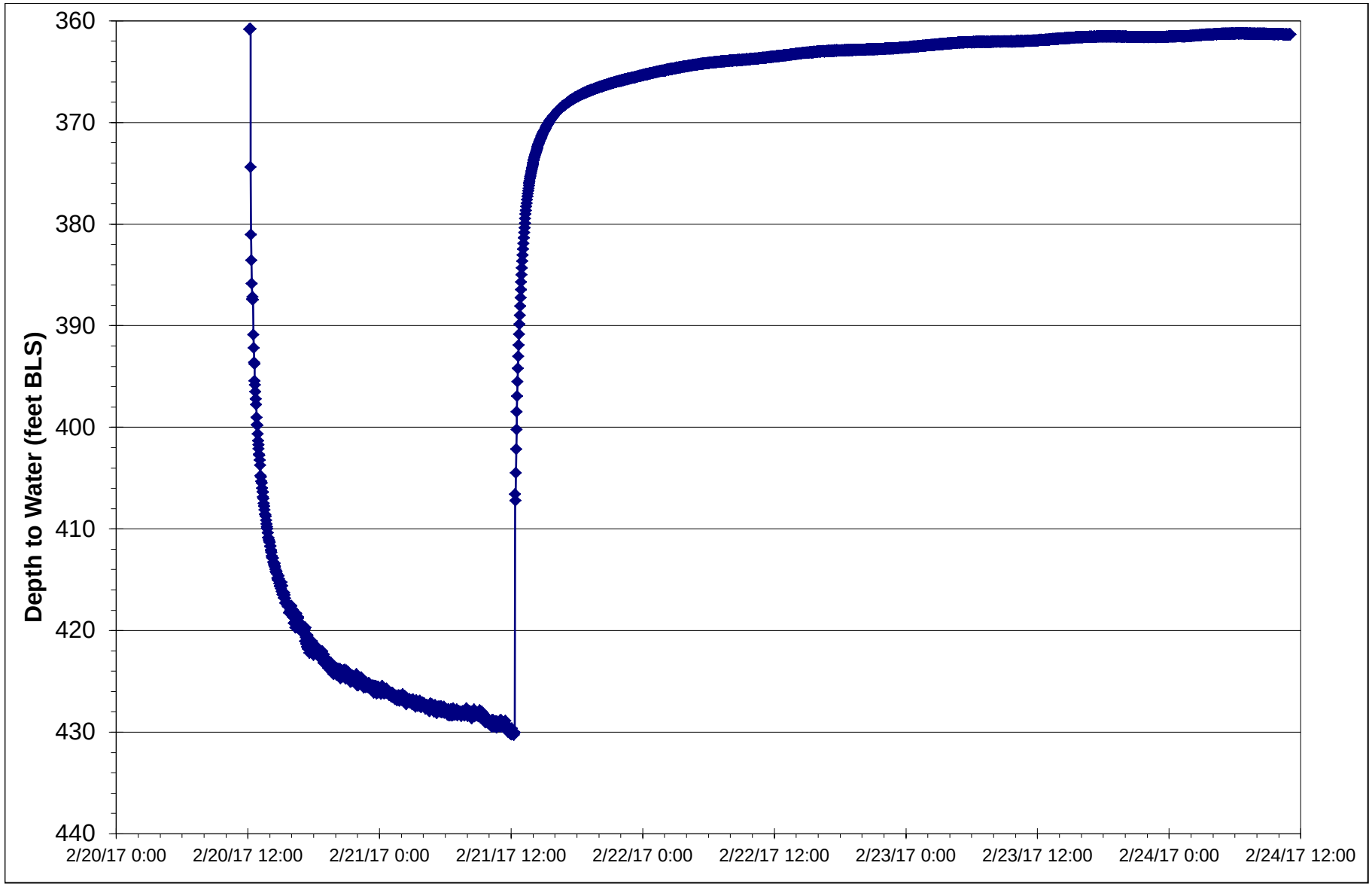
Legend

Well Location

N

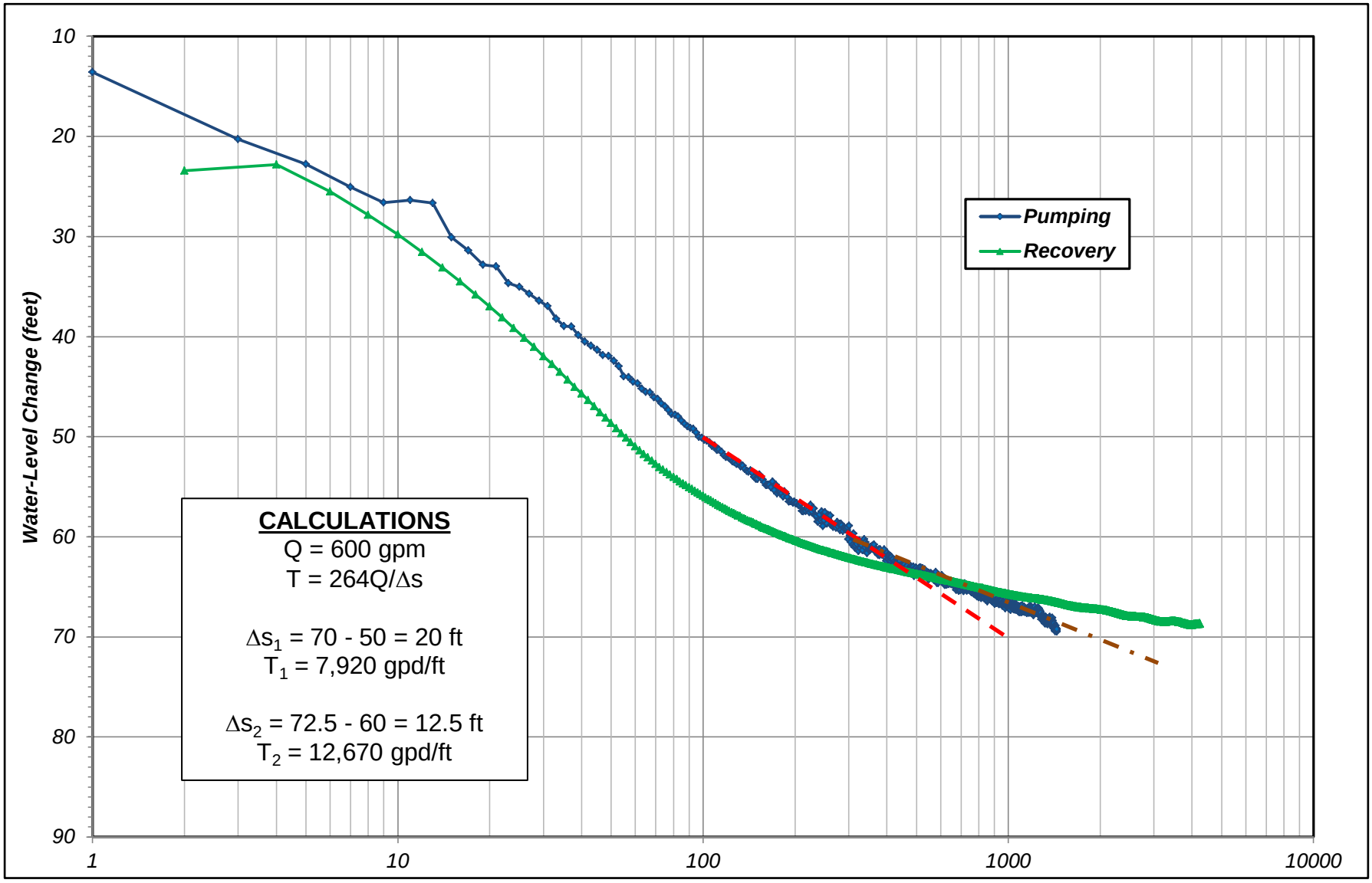
0 4,000 Feet

Figure 1
Well Location Map



HYDROGRAPH OF PUMPING TEST FOR
HEADWATERS GCD
MONITOR WELL #17

FIGURE 2



SEMI-LOG PLOT AND CALCULATIONS FOR HEADWATERS GCD MONITOR WELL #17

FIGURE 3

APPENDIX 1 - DRILLER'S REPORT

STATE OF TEXAS WELL REPORT for Tracking #445164

Owner:	**Hardwaters Underground Water Conservation District**	Owner Well #:	**#17**
Address:	**125 Lehmann Dr Suite 202 kerrville, TX 78028**	Grid #:	**57-49-8**
Well Location:	**Hwy 87 South Comfort, TX 78013**	Latitude:	**30° 07' 53.08" N**
	From San Antonio take I10 west to Comfort, Tx. Head Noth on Hwy 87 for Approx 12 miles. There will be a red pipe gate on the left hand side. once in the gate, follow dirt road towards the middle of the property. Well will have a cement slab around it	Longitude:	**098° 55' 41.99" W**
		Elevation:	**1926 ft. above sea level**
Well County:	**Kerr**		

Type of Work: **New Well** Proposed Use: **Monitor**

Drilling Start Date: **11/10/2016** Drilling End Date: **12/20/2016**

Borehole:

Diameter (in.)	*Top Depth (ft.)*	*Bottom Depth (ft.)*
17.5	**0**	**593**
9.875	**593**	**1153**

Drilling Method: **Air Rotary; Mud (Hydraulic) Rotary**

Borehole Completion: **Straight Wall**

Annular Seal Data:

Top Depth (ft.)	*Bottom Depth (ft.)*	*Description (number of sacks & material)*
0	**560**	**Cement 330 Bags/Sacks**

Seal Method: **Pressure**

Sealed By: **Driller**

Distance to Property Line (ft.): **No Data**

Distance to Septic Field or other concentrated contamination (ft.): **No Data**

Distance to Septic Tank (ft.): **No Data**

Method of Verification: **No Data**

Surface Completion: **Surface Slab Installed** **Surface Completion by Driller**

Water Level: **353 ft.** below land surface on **2017-01-10** Measurement Method: **Electric Line**

Packers: **No Data**

Type of Pump: **No Data**

Well Tests: **No Test Data Specified**

Water Quality:

Strata Depth (ft.)	Water Type
No Data	**No Data**

Chemical Analysis Made: **Yes**

Did the driller knowingly penetrate any strata which contained injurious constituents?: **No**

Certification Data: The driller certified that the driller drilled this well (or the well was drilled under the driller's direct supervision) and that each and all of the statements herein are true and correct. The driller understood that failure to complete the required items will result in the report(s) being returned for completion and resubmittal.

Company Information: **McKinley Drilling**

10315 Mill Path
San Antonio, TX 78254

Driller Name: **Andrew Stevenson** License Number: **59646**

Comments: **No Data**

Lithology:
DESCRIPTION & COLOR OF FORMATION MATERIAL

Top (ft.)	Bottom (ft.)	Description
0	**65**	**Limestone (white, light tan)**
65	**285**	**Marl & Limestone (Light Gray)**
285	**347**	**Marly Silt & Limestone (Light Gray)**
347	**515**	**Marly Silt & Sand (light Gray)**
515	**540**	**Sand (white, light orange)**
540	**548**	**sand and Gravel (very coarse sand and gravel)**
548	**590**	**Dolomite**
590	**1153**	**Ellenburger formation (very hard white sandstone with red breaks)**

Casing:
BLANK PIPE & WELL SCREEN DATA

Dia (in.)	Type	Material	Sch./Gage	Top (ft.)	Bottom (ft.)
12	**Blank**	**New Steel**	**.375**	**0**	**563**

APPENDIX 2 - LABORATORY REPORTS

Environmental Laboratory Services
The Solution Lab

LCRA Environmental Laboratory Services
3505 Montopolis Drive
Austin, TX 78744
Phone: (512)356-6022
Fax: (512)356-6021

ANALYTICAL RESULTS

Workorder: Q1707101

Lab ID: **Q1707101001**
Sample ID: **MW 17**
Project ID: **TCEQ PWS INTERIM**

Date Received: 2/21/2017 15:40
Date Collected: 2/21/2017 12:00

Matrix: Drinking Water
Sample Type: SAMPLE

Parameters	Results	Units	LOQ	LOD	ML	DF	Prepared	By	Analyzed	By	Qual
INORGANICS											
Analysis Desc: E2340B, Hardness	Preparation Method: E2340B, Hardness Analytical Method: E2340B, Hardness										
Hardness, Calcium	173	mg/L				1	02/27/17 15:34	CW	02/27/17 15:34	CW	
Analysis Desc: E200.7 Metals, Trace Elements	Preparation Method: E200.7 Prep Analytical Method: E200.7 Metals, Trace Elements										
Calcium Total	69.2	mg/L	0.200	0.0700		1	02/23/17 10:44	BS	02/24/17 14:21	FO	N
Iron Total	0.0919	mg/L	0.0500	0.0200		1	02/23/17 10:44	BS	02/24/17 14:21	FO	
Magnesium Total	41.6	mg/L	0.200	0.0700		1	02/23/17 10:44	BS	02/24/17 14:21	FO	
Potassium Total	8.19	mg/L	0.200	0.0700		1	02/23/17 10:44	BS	02/24/17 14:21	FO	
Sodium Total	68.1	mg/L	0.200	0.0700		1	02/23/17 10:44	BS	02/24/17 14:21	FO	
Analysis Desc: E200.8, ICP-MS	Preparation Method: E200.8, ICP-MS Prep Analytical Method: E200.8, ICP-MS										
Aluminum Total	0.00501	mg/L	0.00500	0.00200		1	02/23/17 10:49	BS	02/27/17 16:04	SLW	
Arsenic Total	0.00198	mg/L	0.00100	0.000400	0.01	1	02/23/17 10:49	BS	02/27/17 16:04	SLW	
Barium Total	0.0902	mg/L	0.00100	0.000400	2	1	02/28/17 13:09	BS	03/01/17 16:33	SLW	
Copper Total	0.194	mg/L	0.00100	0.000400	1	1	02/23/17 10:49	BS	02/27/17 16:04	SLW	
Lead Total	0.0160	mg/L	0.00100	0.000400	0.015	1	02/23/17 10:49	BS	02/27/17 16:04	SLW	M
Manganese Total	0.00262	mg/L	0.00100	0.000400		1	02/23/17 10:49	BS	02/27/17 16:04	SLW	
Strontium Total	7.43	mg/L	0.100	0.0400		100	02/23/17 10:49	BS	02/27/17 16:34	SLW	N
Zinc Total	0.0149	mg/L	0.00500	0.00200		1	02/28/17 13:09	BS	03/01/17 16:33	SLW	
Analysis Desc: E300.0, Anions	Preparation Method: E300.0, Anions Analytical Method: E300.0, Anions										
Chloride	111	mg/L	5.00	2.50		5	02/21/17 20:36	ML	02/21/17 20:36	ML	
Fluoride	1.10	mg/L	0.0100	0.00500	4	1	02/21/17 20:17	ML	02/21/17 20:17	ML	
Nitrite (as N)	<0.0100	mg/L	0.0100	0.00500	1	1	02/21/17 20:17	ML	02/21/17 20:17	ML	
Nitrate (as N)	<0.0100	mg/L	0.0100	0.00500	10	1	02/21/17 20:17	ML	02/21/17 20:17	ML	
Sulfate	43.3	mg/L	1.00	0.500		1	02/21/17 20:17	ML	02/21/17 20:17	ML	
TOTAL DISSOLVED SOLIDS											
Analysis Desc: SM2540C, TDS	Preparation Method: SM2540C, TDS Analytical Method: SM2540C, TDS										

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Matrix: Drinking Water
Sample Type: SAMPLE

Parameters	Results	Units	LOQ	LOD	ML	DF	Prepared	By	Analyzed	By	Qual
Total Dissolved Solids(TDS)	498	mg/L	25.0	10.0		10	02/23/17 15:43	CG	02/23/17 15:43	CG	
ALKALINITY											
Analysis Desc: SM2320B, Alkalinity		Preparation Method: SM2320B, Alkalinity Analytical Method: SM2320B, Alkalinity									
Bicarbonate Alkalinity	296	mg/L..	20.0	20.0		1	02/24/17	ADG	02/24/17	ADG	N
Total Alkalinity (CaCO3)	296	mg/L..	20.0	20.0		1	02/24/17	ADG	02/24/17	ADG	N
Conductance @ 25°C											
Analysis Desc: SM2510B, Conductance		Preparation Method: SM2510B, Conductance Analytical Method: SM2510B, Conductance									
Specific Conductance	953	umhos/cm	10.0	10.0		1	02/24/17 12:17	ADG	02/24/17 12:17	ADG	
pH											
Analysis Desc: SM4500-H+B, pH		Preparation Method: SM4500-H+B, pH Analytical Method: SM4500-H+B, pH									
pH	7.58	pH	0.00	0.00		1	02/24/17 14:57	ADG	02/24/17 14:57	ADG	N
Temperature	21.2	C				1	02/24/17 14:57	ADG	02/24/17 14:57	ADG	N
INORGANICS											
Analysis Desc: SM1030B Cation/Anion Balance		Preparation Method: SM1030B Cation/Anion Balance Analytical Method: SM1030B Cation/Anion Balance									
Cation/Anion Balance	-1.030	%				1	03/02/17	PJO	03/02/17	PJO	N

Summit Environmental Technologies, Inc.
3310 Win St.
Cuyahoga Falls, Ohio 44223
TEL: (330) 253-8211 FAX: (330) 253-4489
Website: http://www.settek.com

Analytical Report

(consolidated)

WO#: **17030113**

Date Reported: **3/22/2017**

CLIENT: LCRA Environmental Laboratory Services **Collection Date:** 2/21/2017 12:00:00 PM

Project: Q1707102

Lab ID: 17030113-001 **Matrix:** DRINKING WATER

Client Sample ID Q1707102001

Analyses	Result	PQL	Qual	Units	Uncertainty	DF	Date Analyzed
GROSS ALPHA / GROSS BETA RADIOACTIVITY (EPA 900.0)					**E900.0**	**E900**	Analyst: **BRD**
ALPHA, Gross	9.31	3.00		pCi/L	± 4.18	1	3/9/2017 12:09:00 PM
BETA, Gross	6.65	4.00		pCi/L	± 2.07	1	3/9/2017 12:09:00 PM
RADIUM-226 (903.0)					**E903.0**	**E903-904**	Analyst: **BRD**
Radium-226	1.79	1.00		pCi/L	± 0.3	1	3/17/2017 1:15:00 PM
Yield	1.00					1	3/17/2017 1:15:00 PM
RADIUM-228 (904.0)					**E904.0**	**E903-904**	Analyst: **BRD**
Radium-228	ND	1.00		pCi/L	± 0.47	1	3/16/2017
Yield	1.00					1	3/16/2017

Qualifiers:

*	Value exceeds Maximum Contaminant Level.	E	Value above quantitation range
H	Holding times for preparation or analysis exceeded	M	Manual Integration used to determine area response
MC	Value is below Minimum Compound Limit.	N	Tentatively identified compounds
ND	Not Detected at the Reporting Limit	O	RSD is greater than RSDlimit
P	Second column confirmation exceeds	PL	Permit Limit