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Mr. Zachary Timms, EIT
Ward, Getz & Associates, PLLC
2500 Tanglewilde, Suite 120
Houston, TX 77063

November 8, 2023

RE: Lone Star Groundwater Conservation District Hydrogeological Report – City of Montgomery – Wells No. 2, No. 3, No. 4 and No. 5

Dear Mr. Timms:

This report details the results of a hydrogeologic report to meet the guidelines mandated by the Lone Star Groundwater Conservation District (LSGCD; the District) for an operating permit application. The City of Montgomery ("the Applicant") is submitting an application for an operating permit with LSGCD to construct one replacement well of an existing Jasper Aquifer Well (Well No. 2) and one new Jasper Aquifer well (Well No. 6) and incorporate them into the water system, located in northwestern Montgomery County (Figure 1). The Applicant is also proposing to increase the pumping rate and annual volume in their existing permits.

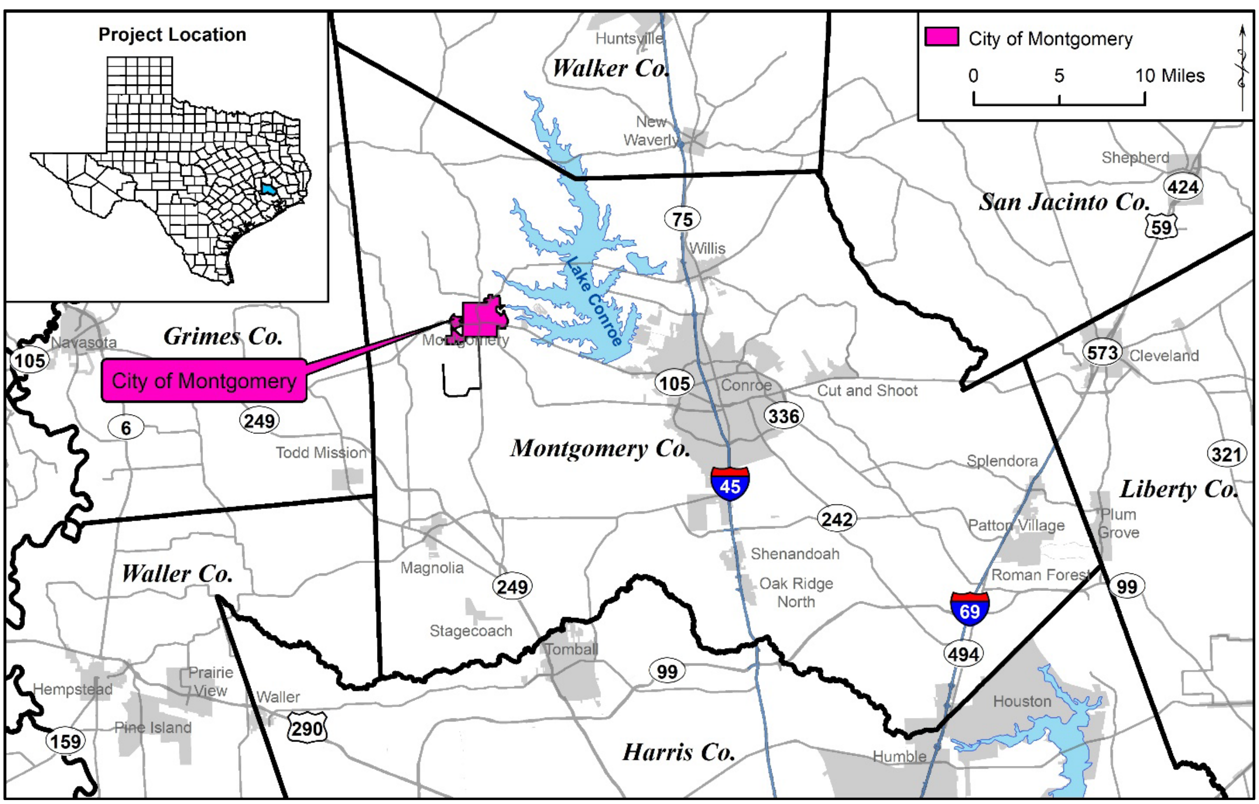


Figure 1: Location map of the City of Montgomery

The Applicant is seeking to construct a replacement well of Well No. 2 (Jasper Aquifer), which will be called Well No. 5 and complete one new well (Well No. 6) in the Jasper Aquifer. The City of Montgomery also has another existing Jasper Aquifer well (Well No. 3) and Catahoula Aquifer well (Well No. 4). Table 1 provides a summary of the existing well permits and proposed maximum allowable pumping rates and annual production limits. The total proposed annual allocation from the Jasper Aquifer is 358,750,000 gallons; the proposed annual allocation from the Catahoula Aquifer is 191,250,000 gallons.

Table 1: Summary of permits with the LSGCD and proposed changes

Well No.	LSGCD Well ID	Status	Aquifer	Permit No.	Current Max. Allowable Pumping Rate (gpm)	Current Annual Production Limit (gal.)	Proposed Max. Allowable Pumping Rate (gpm)	Proposed Annual Production Limit (gal.)
2	2004071935	Existing	Jasper	HUP040-JSPR	190	41,930,000	0	0
3	2004072104	Existing	Jasper	OP-0407210E-JSPR	500	51,000,000	500	116,875,000
4	2013012801	Existing	Catahoula	AWS-13012801B-CAT	1,208	90,000,000	1,208	191,250,000
5*	-	Proposed Replacement Well	Jasper	*	-	-	500	116,875,000
6	-	Proposed	Jasper	-	-	-	1,000	125,000,000
Notes: gpm = gallons per minute; gal. = gallons; *Proposed Well No. 5 will replace existing Well No. 2								

The purpose of this report is to provide the LSGCD with hydrogeological information addressing the impacts of the proposed well on existing wells in addition to the impacts of increased proposed production limits. According to LSGCD rules, the Hydrogeological Report Requirement will assist with the District's mission to collect data and use the best available data and science in managing aquifers of the District. Pursuant to the adopted LSGCD Rules 2.6(b)(15), 2.12 and 3.4, acquisition of an operating permit requires two hydrogeological reports: 1) prior to drilling; and 2) post drilling. The report parameter guidelines published by the District were used to structure this hydrogeologic report (Pre-Drilling). The objectives of this report are to support the Applicant's application for an operating permit by demonstrating the following:

1. The anticipated specific details of well construction;
2. A discussion of the geologic and hydrogeological properties of the Jasper Aquifer in the area near the proposed wells;
3. A discussion of known water quality in the area based on literature and well reports; and,
4. An interference analysis that shows the projected impacts from production from the proposed well and the water system as a whole for the Jasper Aquifer wells and Catahoula Aquifer well at the proposed production limits.

<u>Well Spacing</u>

Figures 2 through 5 provide maps displaying the location of the nineteen (19) registered and permitted wells within a 1/2-mile radius of the existing and proposed wells, including all surface water bodies such as streams and ponds; Tables 1, 2, and 3 provides a tabulated summary of the mapped wells. There were no records of springs in the vicinity of the City of Montgomery wells.

District spacing rules for wells completed in the Jasper Aquifer require non-exempt wells to be spaced a minimum of 1.5 feet multiplied by the Maximum Allowable Pumping Rate (500 gpm for Well No. 5; 1,000 gpm for Well No. 6); this results in a spacing of 750 feet from the Well No. 5, and 1,500 feet for Well No. 6. For wells completed in the Catahoula Aquifer, non-exempt wells need to be spaced a minimum of 1.0 feet multiplied by the Maximum Allowable Pumping Rate (1,208 gpm for Well No. 4); this results in a spacing of 1,208 feet from the Well No. 4.

According to the latest well database provided by LSGCD, there are no wells permitted within the required spacing radii of the proposed wells that are not owned/operated by the Applicant (Figures 4 and 5). The proposed Well No. 5 is within 50 feet of the nearest property boundary; prior to finalizing the well permit application, the Applicant will submit proper documentation to the District for an exception to the spacing rules.

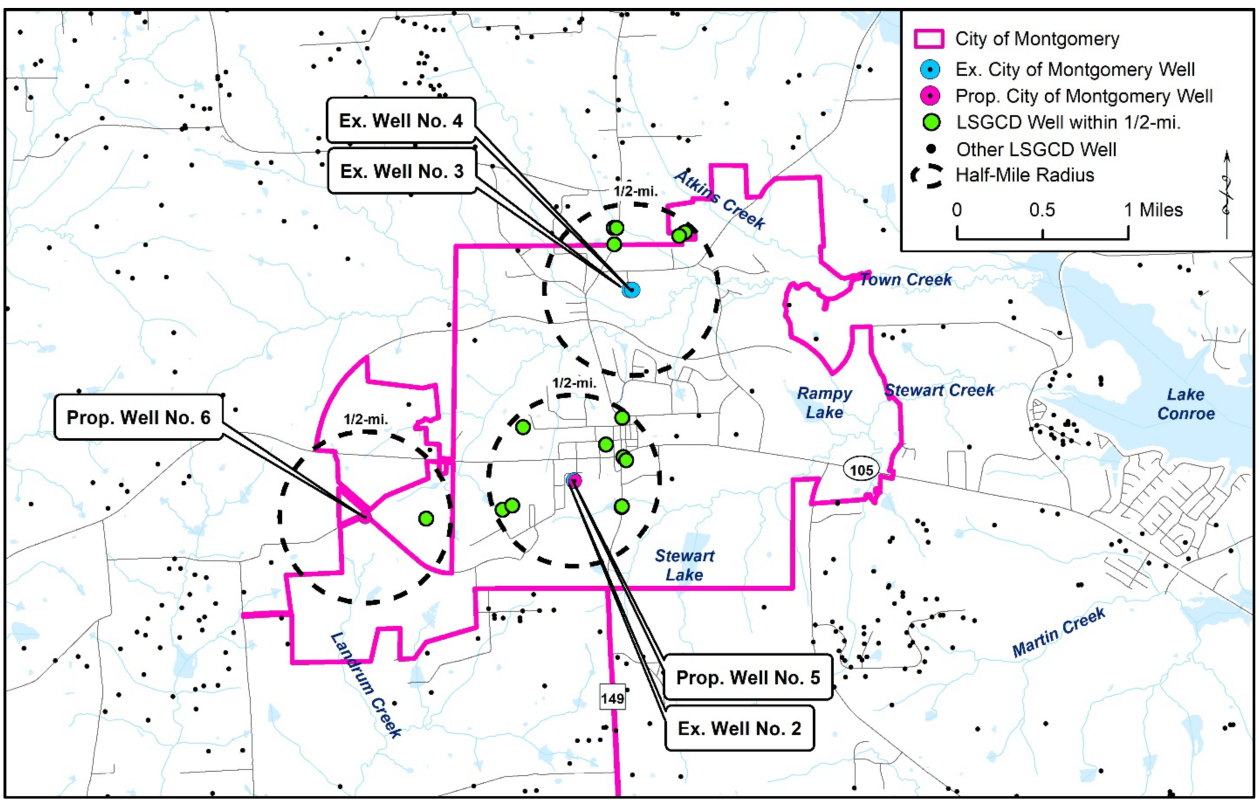


Figure 2: Location map showing reported wells & surface water near the proposed water system well

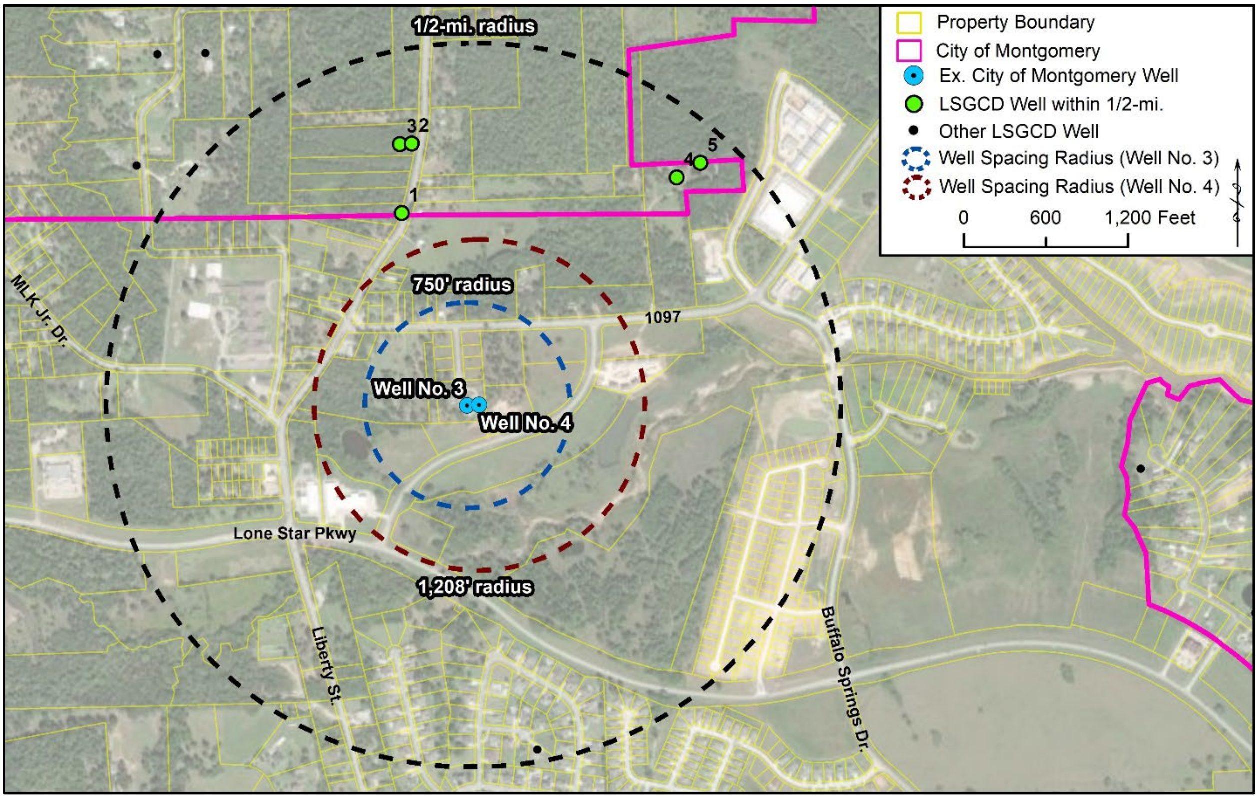


Figure 3: Large-scale map of the City of Montgomery Wells No. 3 and 4

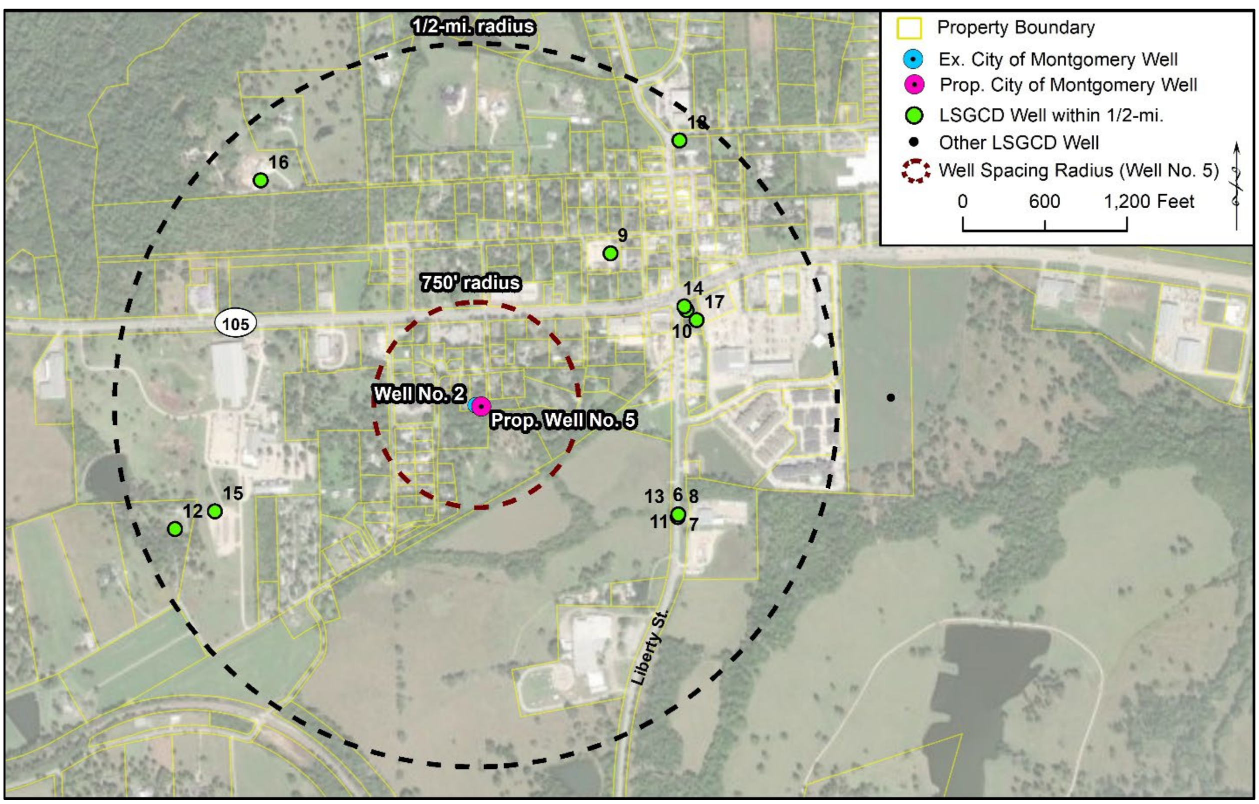


Figure 4: Large-scale map of the City of Montgomery Well No. 2 and proposed No. 5

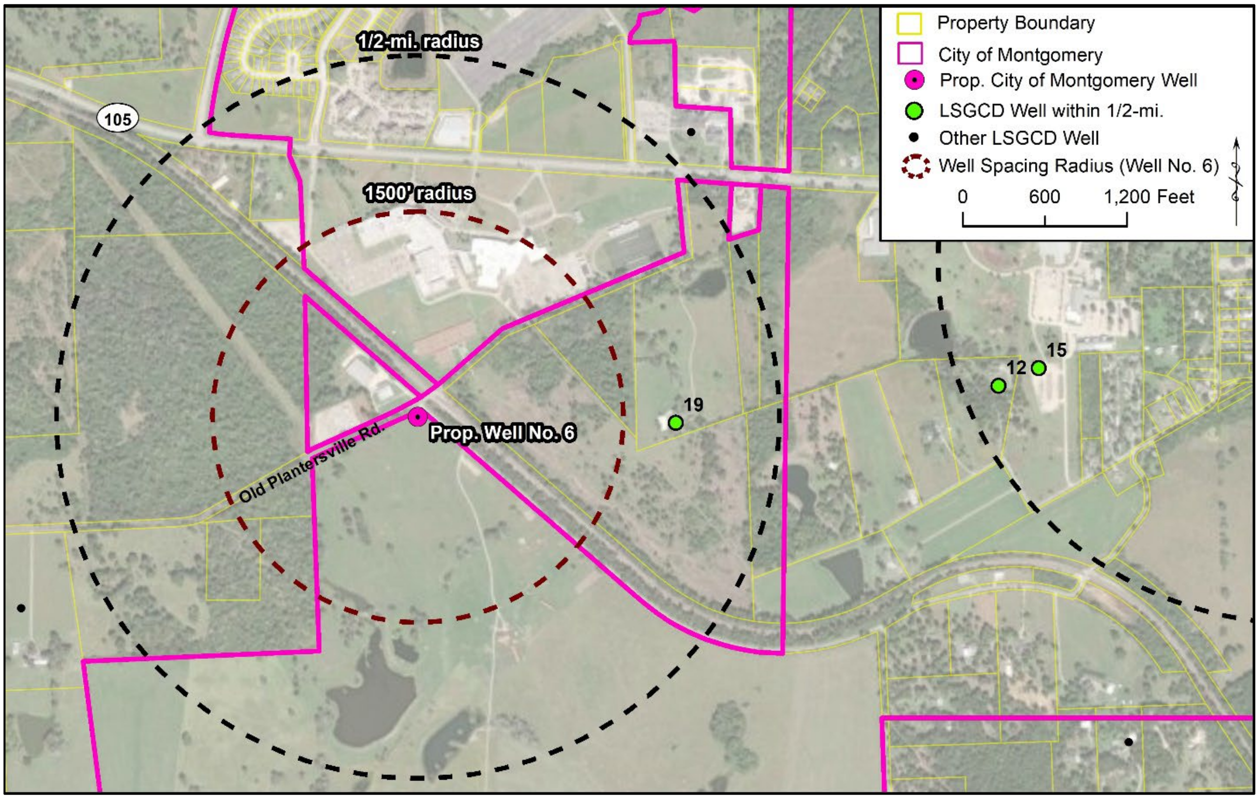


Figure 5: Large-scale map of the proposed City of Montgomery Well No. 6

Table 2: Summary of wells located within 1/2-mile of the City of Montgomery Wells No. 3 and 4

Map ID	Well Registration No.	Permit No.	Owner	Address	City	Total Depth (ft.)	Screen Interval (ft. bgl)	Aquifer	Status	Latitude	Longitude	Distance from Well No. 3 (ft.)	Distance from Well No. 4 (ft.)
Nearest Property Boundary												137	50
Well No. 3	2004072104	OP-04072101E	City of Montgomery	101 Old Plantersville Rd.	Montgomery	665	530-600 610-650	Jasper	Operating	30.4025	-95.695278	0	87
Well No. 4	2013012801	AWS-13012801B	City of Montgomery	101 Old Plantersville Rd.	Montgomery	2,580	2,450-2,480 2,486-2,535 2,548-2,560	Catahoula	Operating	30.4025	-95.695	87	0
1	2022112904	Exempt	Wedgman	15451 FM 149	Montgomery	170	140-160	Evangeline	Operating	30.4063889	-95.6966667	1,485	1,513
2	2022031503	Exempt	Arnsworth	15545 FM 149	Montgomery	160	140-160	Evangeline	Operating	30.4077778	-95.6963889	1,957	1,975
3	2021121102	Exempt	Arnsworth	15545 FM 149	Montgomery	160	140-160	Evangeline	Being drilled	30.4077778	-95.6966667	1,975	1,996
4	2005031624	Exempt	Mossier	Post Office Box 954	Montgomery	158	151-157	Evangeline	Operating	30.4069444	-95.6902778	2,260	2,200
5	2005082416	Exempt	Mossier	15308 Thomas Street	Montgomery	168	161-167	Evangeline	Operating	30.4072227	-95.6897201	2,456	2,394

Table 3: Summary of wells located within 1/2-mile of the City of Montgomery Well No. 2 and proposed No. 5

Map ID	Well Registration No.	Permit No.	Owner	Address	City	Total Depth (ft.)	Screen Interval (ft. bgl)	Aquifer	Status	Latitude	Longitude	Distance from Well No. 2 (ft.)	Distance from Well No. 5 (ft.)
Nearest Property Boundary												38	27
Well No. 2	2004071935	HUP040	City of Montgomery	101 Old Plantersville Rd.	Montgomery	783	552-595 611-653 687-709 752-771	Jasper	Operating – To Be Replaced	30.386478	-95.701283	0	5
Well No. 5	-	-	City of Montgomery	101 Old Plantersville Rd.	Montgomery	800	552-595 611-653 687-709 752-771	Jasper	Proposed	30.386449	-95.701158	5	0
6	2012051503	Exempt	Randall	13212 Liberty	Montgomery	N/A	N/A	N/A	Void - Application Withdrawn	30.3841143	-95.6966814	1,686	1,684
7	2012040202	Exempt	Randall	13212 Liberty	Montgomery	N/A	N/A	N/A	Operating	30.3841667	-95.6966667	1,680	1,678
8	2012051502	Exempt	Randall	13212 Liberty	Montgomery	N/A	N/A	N/A	Operating	30.3841667	-95.6966667	1,680	1,678
9	2009061805	Exempt	Waller	345 Ridge Lake Scenic	Montgomery	N/A	N/A	N/A	Void - Application Withdrawn	30.3894444	-95.6980591	1,484	1,479
10	2008041702	Exempt	Barber	9621 Seale Lane	Montgomery	N/A	N/A	N/A	Operating	30.3882613	-95.6963355	1,688	1,683
11	2012040203	Exempt	Randall	13212 Liberty	Montgomery	N/A	N/A	N/A	Operating	30.3841667	-95.6966667	1,680	1,678
12	2005031538	Exempt	Schock	860 Huffman	Montgomery	338	318-338	Jasper	Operating	30.3841667	-95.7083333	2,374	2,379

13	2012051501	Exempt	Randall	13212 Liberty	Montgomery	N/A	N/A	N/A	Operating	30.3841667	-95.6966667	1,680	1,678
14	2015071503	Exempt	Lesniak	7788 Aboue Rd	Montgomery	N/A	N/A	N/A	Void - Application Withdrawn	30.3883333	-95.6963889	1,683	1,678
15	2015102201	Exempt	Kiser	868 Huffman	Montgomery	345	325-345	Jasper	Operating	30.3845	-95.7073944	2,055	2,059
16	2016012702	Exempt	Walker	1140 College St	Montgomery	300	Geo-Thermal	Jasper	Operating	30.3911111	-95.7061111	2,273	2,274
17	2018082104	Exempt	Rutland	1915 Robinhood	Montgomery	254	234-254	Evangeline	Operating	30.3880556	-95.6961111	1,727	1,722
18	2020011001	Exempt	Deveraux	17723 N. FM 149	Montgomery	320	N/A	Jasper	Operating	30.3916667	-95.6963889	2,441	2,437
Notes: N/A = information not available from accessible well databases													

Table 4: Summary of wells located within 1/2-mile of the proposed City of Montgomery Well No. 6

Map ID	Well Registration No.	Permit No.	Owner	Address	City	Total Depth (ft.)	Screen Interval (ft. bgl)	Aquifer	Status	Latitude	Longitude	Distance from Well No. 6 (ft.)
Nearest Property Boundary												50
Well No. 6	-	-	City of Montgomery	101 Old Plantersville Rd.	Montgomery	700	550-700	Jasper	Proposed	30.383882	-95.721802	0
19	2014013101	Exempt	Giles	23503 Old Plantersville Rd	Montgomery	263	243-263	Evangeline	Operating	30.3836111	-95.7158333	1,882

Well Construction Details

Table 5 provides a summary of the well construction for the existing and proposed City of Montgomery wells; Figures 5 through 7 provide well profiles detailing the existing/proposed construction and the subsurface lithology encountered during drilling at the well location. The anticipated lithology in the proposed wells was interpreted from nearby wells drilled to similar or deeper depths than the proposed well. Note – proposed construction information was provided by the Applicant; specific details may vary upon commencement of construction.

Proposed Well No. 5 will replace the existing Well No. 2 with similar construction specifications. The well will be drilled to an anticipated depth of 800 feet below ground level (ft. bgl) with a 16-inch diameter borehole from 0 to 800 ft. bgl. The well will be completed with 10-inch steel casing pressure cemented to 500 ft. bgl, 10-inch stainless steel screen at various intervals from 552 to 771 ft. bgl. The targeted production zone will be the Jasper Aquifer.

Proposed Well No. 6 will be drilled to an anticipated depth of 700 ft. bgl with a 30-inch borehole from 0 to 550 ft. bgl. The well will be completed with 24-inch steel casing pressure cemented to 550 bgl, with 18-inch steel screen and liner from 550 to 700 ft. bgl within a 28-inch underreamed and filter-packed borehole. The targeted production zone will be the Jasper Aquifer.

Table 5: Well Construction Summary

Well	Coordinates	Elev. (ft. MSL)	Well Depth (ft. bgl)	Est. Static Water Level (ft. bgl)	Borehole (diameter; ft. bgl)	Casing diameter; material; ft. bgl)	Screen (diameter; material; ft. bgl)	Filter Pack Interval (ft. bgl)	Aquifer
2	30.386478 -95.701283	311	783	250	N/A	11" Steel 0-492 7" Steel 492-783*	7" Steel 552-783*	492-783	Jasper
3	30.4025 -95.695278	247	665	200	15" 0-665	10" Steel 0-528 8" Steel 490-665*	8" Steel 530-650*	-	Jasper
4	30.4025 -95.695	250	2,580	100	26" 0-2,444 24" 2,444-2,580	20" Steel 0-2,444 14" Steel 2,344-2,580*	14" Steel 2,450-2,560*	2,444-2,580	Catahoula
5	30.386449 -95.701158	311	800	250	16" 0-800	10" Steel 0-550	10" Steel 550-800*	550-800	Jasper
6	30.383882 -95.721802	318	700	250	30" 0-550 28" 550-700	24" Steel 0-550 18" Steel 550-700*	14" Steel 550-700*	525-700	Jasper
Notes: ft. = feet; bgl = below ground level; MSL = Mean Sea Level; *Various intervals									

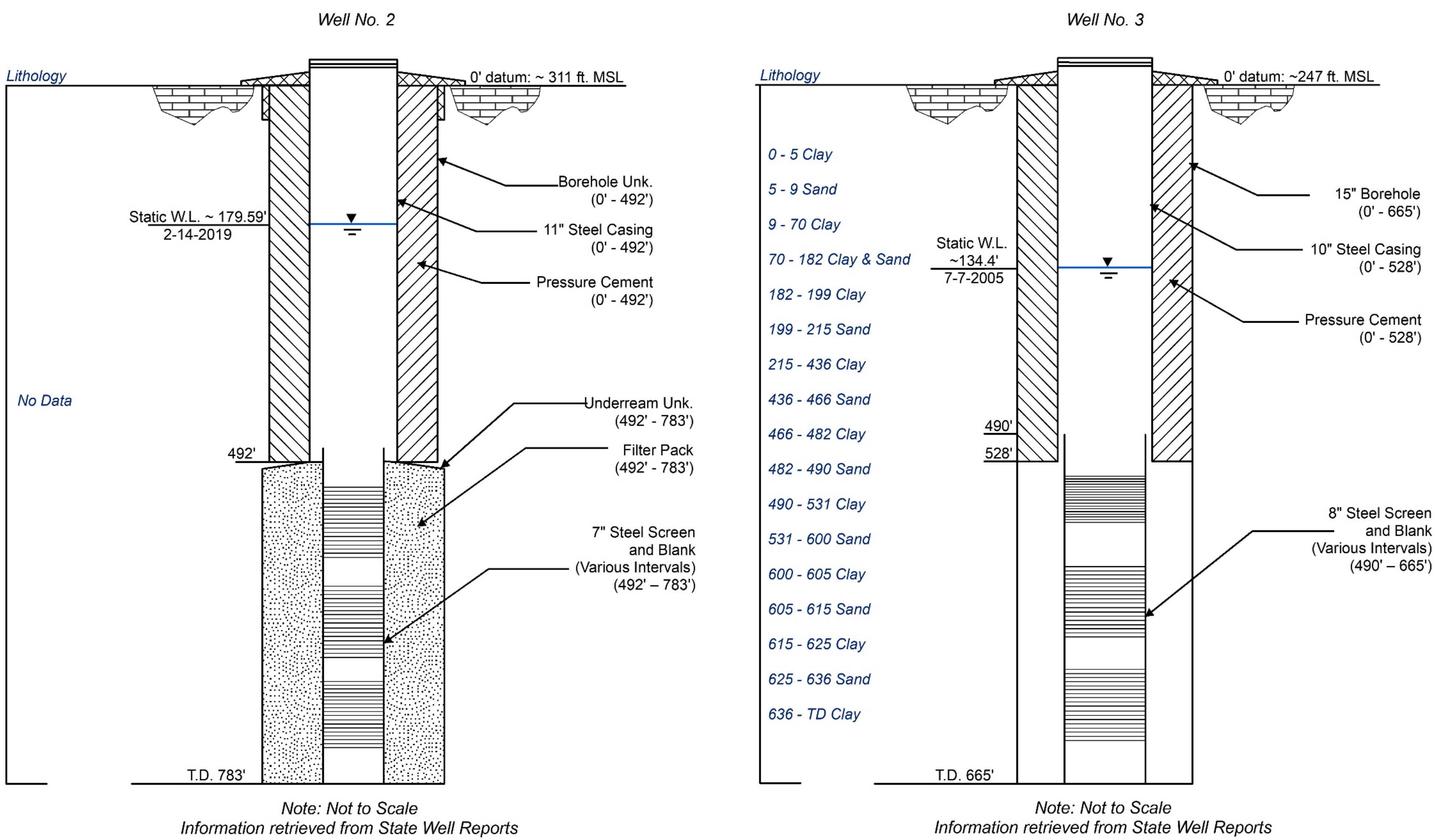


Figure 6: Well profiles the City of Montgomery Well No. 2 and Well No. 3

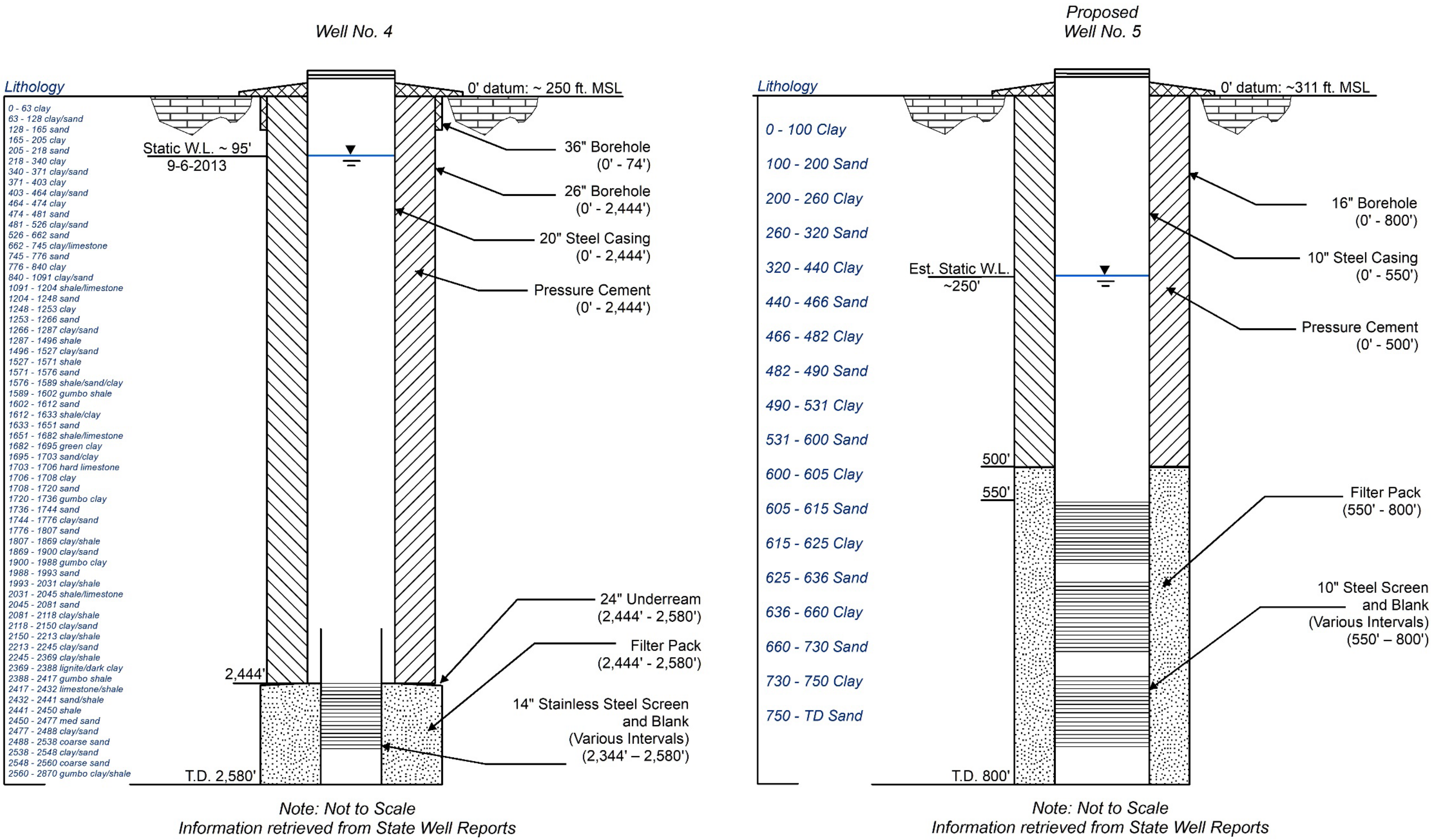


Figure 7: Well profiles for the City of Montgomery Well No. 4 and proposed Well No. 5

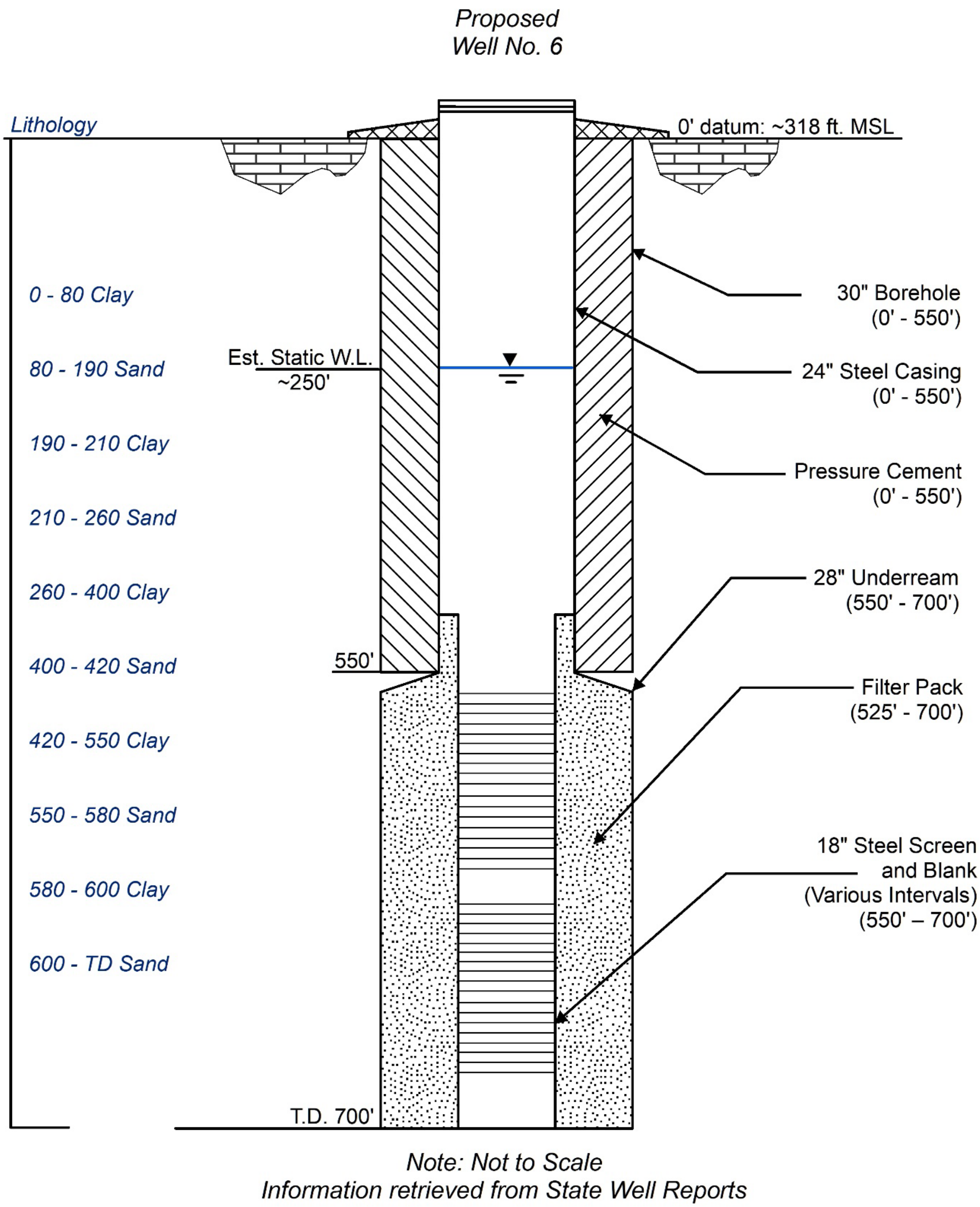


Figure 8: Well profile for the City of Montgomery proposed Well No. 6

General Hydrogeology

The Gulf Coast Aquifer is a major aquifer that provides groundwater to the Gulf Coast area of Texas. It extends from the Louisiana border to the Mexico-United States border, and is designated as a major aquifer by the Texas Water Development Board (TWDB). Stratigraphic organization of the Gulf Coast Aquifer in Texas is complex; more than seven stratigraphic classifications have been proposed and debated within the past century. However, Baker Jr.'s (1979) classification based on fauna, electric logs, facies associations, and hydraulic properties of the sediments has received widespread acceptance. He classified the Gulf Coast Aquifer into five hydrogeologic units from youngest to oldest: Chicot Aquifer, Evangeline Aquifer, Burkeville confining unit, Jasper Aquifer, and the Catahoula confining unit (Baker Jr., 1979). The TWDB collectively groups these units as the Gulf Coast Aquifer. Figure 9 provides a map of the surface geology near the proposed well and the stratigraphy of the Gulf Coast Aquifer sediments.

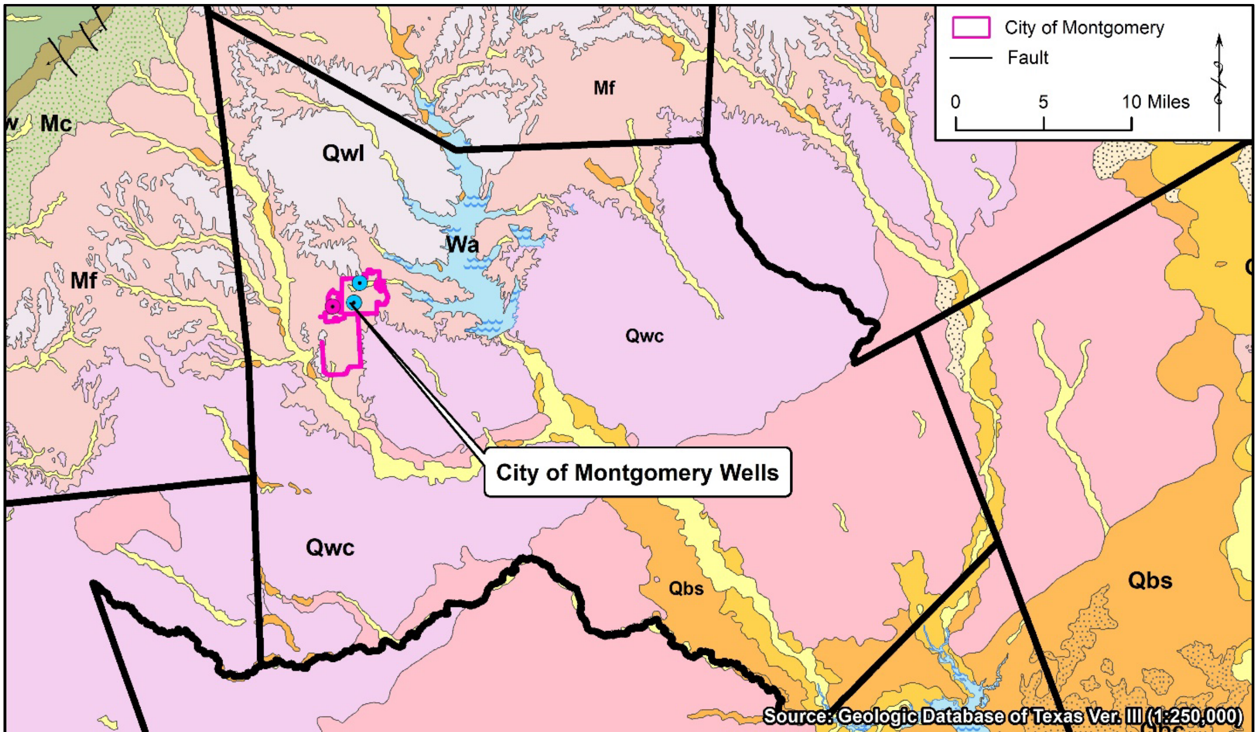
The Chicot Aquifer includes, from the shallowest to deepest, the Beaumont and Lissie formations of Pleistocene age and the Pliocene-aged Willis Formation (Figure 9). These formations consist of sand, clay and gravel layers with similar alternating patterns of sand and clay layers. Stratigraphically lower than the Chicot Aquifer, the Evangeline Aquifer is made up of the Fleming Formation and the upper and lower members of the Goliad Sand (Figure 9). The units that make up the Chicot and Evangeline aquifers are similar in lithology and are difficult to differentiate. The sediments from the Chicot Aquifer are less compacted, less cemented, and have a higher permeability than the Evangeline Aquifer.

Underlying the Evangeline Aquifer, the upper part of the Fleming Formation is comprised of clays and silts which form the Burkeville confining unit (Figure 9). The Burkeville Confining System acts as the confining zone for the two primary aquifers of the Gulf Coast Aquifer, the Evangeline and Chicot aquifers (Baker Jr., 1979).

The Jasper Aquifer includes the Lower Lagarto unit of early Miocene age, the early Miocene Oakville Sandstone member of the Fleming Group, and portions of the Oligocene-age Catahoula Formation. In some areas where the Catahoula Sandstone contains more sand, it is grouped into the Jasper Aquifer. Above the Catahoula is the Oakville Sandstone and the Fleming Formation both of which are composed of land derived sands and clays.

The Catahoula confining unit is composed of the Catahoula Sandstone (Figure 9). The Catahoula unit is made up of pyroclastic sands and clays that act as a confining unit allowing very little water to pass through. In some localities, the Catahoula is sandier, and may be targeted for large-scale supply. At greater depths, the Catahoula confining unit includes the Anahuac Formation and Frio Formation.

The surface geology in the immediate vicinity of the City of Montgomery wells consists of the sediments comprising the Fleming Formation, which makes up the upper portion of the Jasper Aquifer (Figure 9). According to the groundwater availability model (GAM) for the northern portion of the Gulf Coast Aquifer System, the Evangeline Aquifer crops out at the surface near the City of Montgomery.



ERA	System	Group	Formation	Legend	Member	Hydrogeologic Unit
Cenozoic	Quaternary	Holocene	Alluvium	Qal		Localized Alluvial Aquifers
			Deweyville Formation	Qd, Qd		
		Pleistocene	Beaumont Formation	Qbb, Qbs, Qbc		Chicot Aquifer
			Fluviatile terrace deposits	Qt		
			Lissie Formation	Ql		
		Pliocene	Willis Sand	Qw, Qwl, Qwc		
	Tertiary		Goliad Sand	Mg	Upper	Evangeline Aquifer
		Miocene			Lower	
			Fleming / Lagarto	Mf		Burkeville Confining Unit
			Oakville Sandstone	Mo		Jasper Aquifer
			Catahoula Sandstone: Anahuac Formation	Mc	Upper	
			Catahoula Sandstone: Frio Formation			Catahoula Confining Unit

Figure 9: Surface geology map and stratigraphic column (modified from Kasmarek, 2013)

Site-Specific Hydrogeology

The Evangeline and Jasper aquifers are the most utilized hydrogeologic units in the area near the City of Montgomery. According to publicly available well reports and spatial data used in Version 1.1 of the GAM for the northern portion of the Gulf Coast Aquifer System, the formations comprising the Evangeline Aquifer near the proposed well are located at the surface and extend to approximately 250 ft. bgl (Kasmarek, 2013). It is comprised of alternating layers of fine to medium sands and clay (Baker, 1979). Beneath the Evangeline Aquifer, the Burkeville aquiclude extends to approximately 500 ft. bgl, and the Jasper Aquifer extends to depths of approximately 1,300 ft. bgl.

According to publicly available data from the LSGCD, Texas Water Development Board (TWDB), the Texas Department of Licensing and Registration (TDLR), and the TCEQ well databases, the majority of the domestic wells in the area are completed within the Evangeline and Jasper aquifers to depths of approximately 200 to 300 ft. bgl., public supply wells are completed within the Jasper Aquifer at depths from 550 to 780 ft. bgl, and the Catahoula Aquifer at depths of 2,580 ft. bgl. The proposed wells will target sands within the Jasper Aquifer.

Information from the Gulf Coast Aquifer (Northern Portion) GAM and aquifer test data will be utilized to estimate the site-specific aquifer parameters. Figures 10 through 12 illustrate the transmissivity, hydraulic conductivity, and storativity, respectively from the Gulf Coast Aquifer (Northern Portion) GAM for the Jasper Aquifer (Layer 4 of the GAM). The following values are estimated for the Jasper Aquifer in the immediate vicinity of the City of Montgomery wells:

Well No. 3 (GAM Row 26; Column 110):

- Transmissivity: 9,943.0 $ft.^2$/day (Figure 10);
- Hydraulic Conductivity: 12.2 ft./day (Figure 11);
- Storativity: 3.21×10^{-4} (Figure 12).

Well No. 2 and Proposed Well No. 5 (GAM Row 27; Column 109):

- Transmissivity: 7,686.1 $ft.^2$/day (Figure 10);
- Hydraulic Conductivity: 9.4 ft./day (Figure 11);
- Storativity: 3.28×10^{-4} (Figure 12).

Proposed Well No. 6 (GAM Row 26; Column 108):

- Transmissivity: 15,892.7 $ft.^2$/day (Figure 10);
- Hydraulic Conductivity: 19.3 ft./day (Figure 11);
- Storativity: 3.3×10^{-4} (Figure 12).

For the purposes of this report, the following values will be utilized for modeling the Jasper Aquifer:

- Transmissivity: 11,173.9 $ft.^2$/day (average);
- Storativity: 3.26×10^{-4} (average).

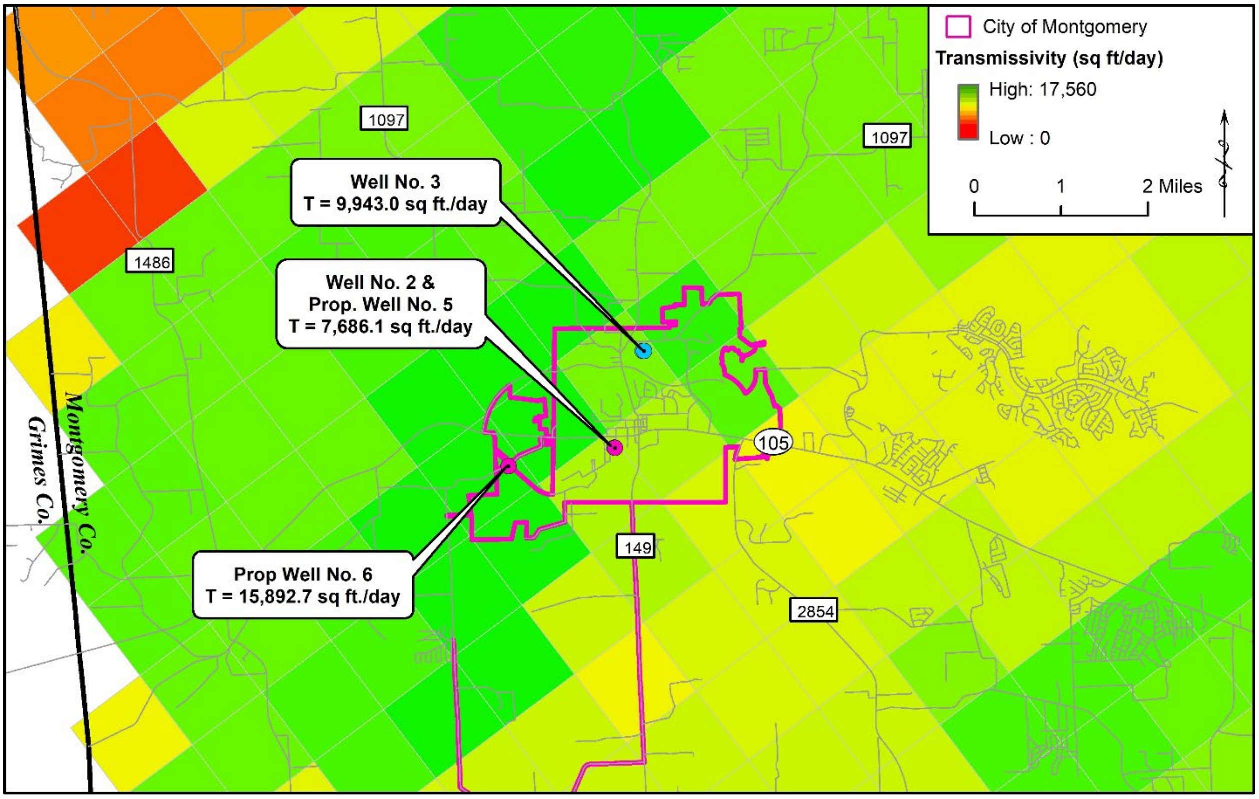


Figure 10: Jasper Aquifer transmissivity near the City of Montgomery (modified from Kasmarek, 2013)

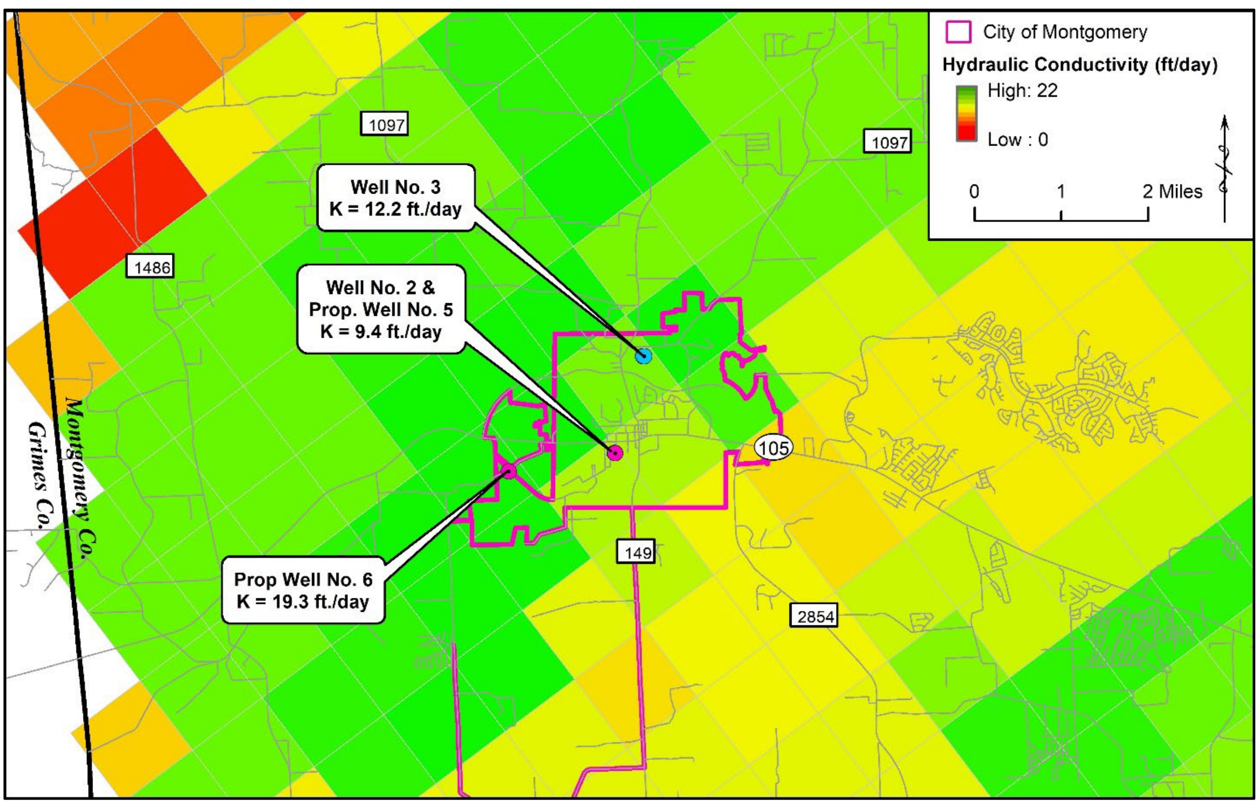


Figure 11: Jasper Aquifer hydraulic conductivity near the City of Montgomery (modified from Kasmarek, 2013)

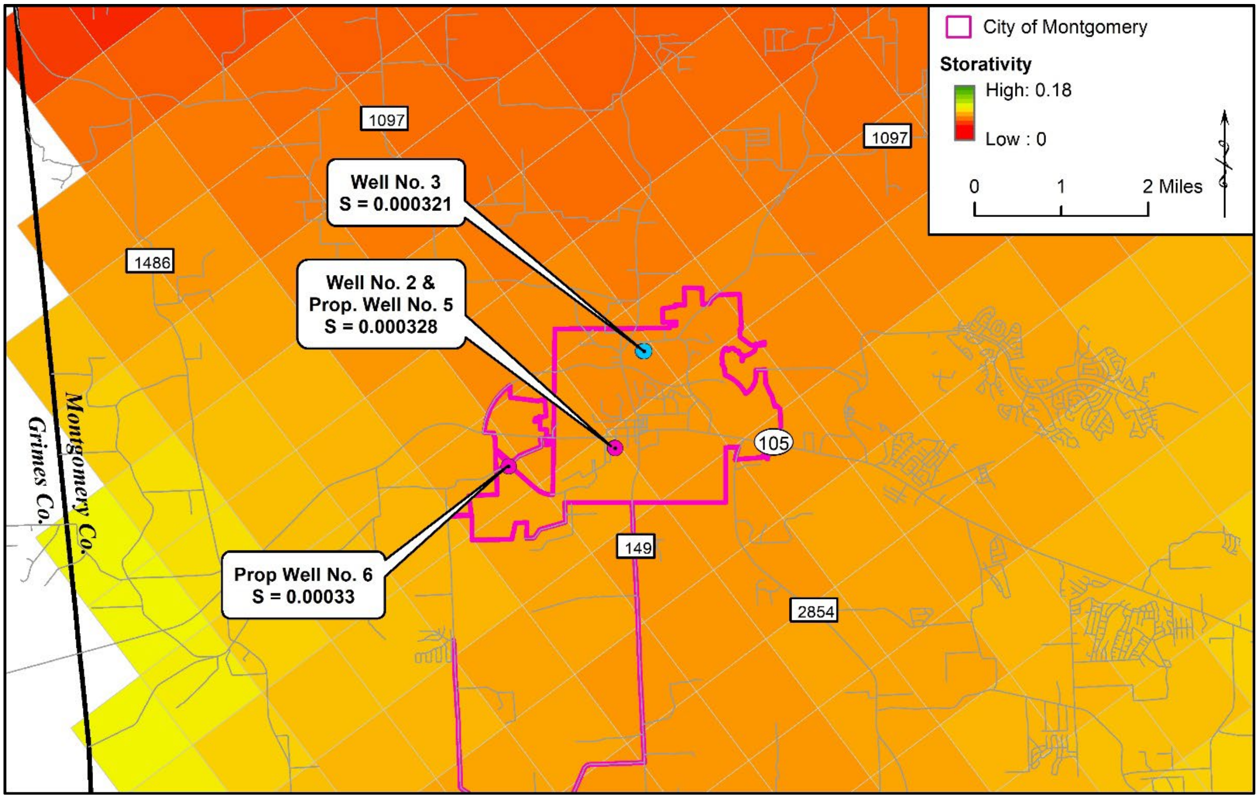


Figure 12: Jasper Aquifer storativity near the City of Montgomery (modified from Kasmarek, 2013)

The Catahoula Aquifer was not included in the GAM; therefore, no aquifer properties are available from the GAM database. Aquifer properties for the Catahoula Aquifer will be calculated from aquifer testing information provided in the Well No. 4 state well report and from an assumed storativity value that is consistent with deep, confined aquifers.

During the aquifer test on September 6, 2013 Well No. 4 was pumped at 1,208 gpm with 399 feet of drawdown after 36 hours, resulting in a specific capacity of 3.03 gpm/ft. No observation well was utilized for the aquifer test. By utilizing a combination of methods published by Mace (2001), the Theis et al., (1963) equation, and a conservative storativity of 1.0 x 10^{-5} to relate specific capacity to transmissivity (Equation 1), we were able to iteratively solve for transmissivity at Well No. 4:

$$Sc = \frac{4\pi T}{\left[ln\left(\frac{2.25Tt}{r^2 S}\right)\right]} \qquad \text{(Equation 1)}$$

Where:

S_c = specific capacity (gpm/ft);

T = transmissivity (ft^2/day);

t = time (day);

r = well radius (ft); and

S = storativity (0.0001).

The resulting transmissivity calculated at the well was:

- Well No. 4: 973 ft.^{2}/day;

Water Quality

Water quality within the Gulf Coast Aquifer varies within the different sand layers comprising the respective aquifers. Specifically, total dissolved solids (TDS), arsenic, iron, and radionuclides (gross alpha and beta particles, uranium, combined radium) may be elevated above the TCEQ standards for the Maximum Contaminant (MCL) and Secondary Contaminant Level (SCL) in some areas. Elevated arsenic concentrations are commonly found in wells that contain sediments that hold volcanic ash. According to Scanlon and others (2005), volcanic ash is a source of elevated arsenic in groundwater systems.

Total Dissolved Solids

Figure 13 provides a map displaying reported TDS concentrations from the TCEQ well database for public supply wells in the study area. In the vicinity of the proposed well, the majority of the reported TDS concentrations are under 500 mg/L except for one well east of the City, which had a TDS concentration of 700 mg/L. In wells completed at similar depths to the proposed well, the reported TDS concentration ranges from 330 to 483 mg/L (Figure 13).

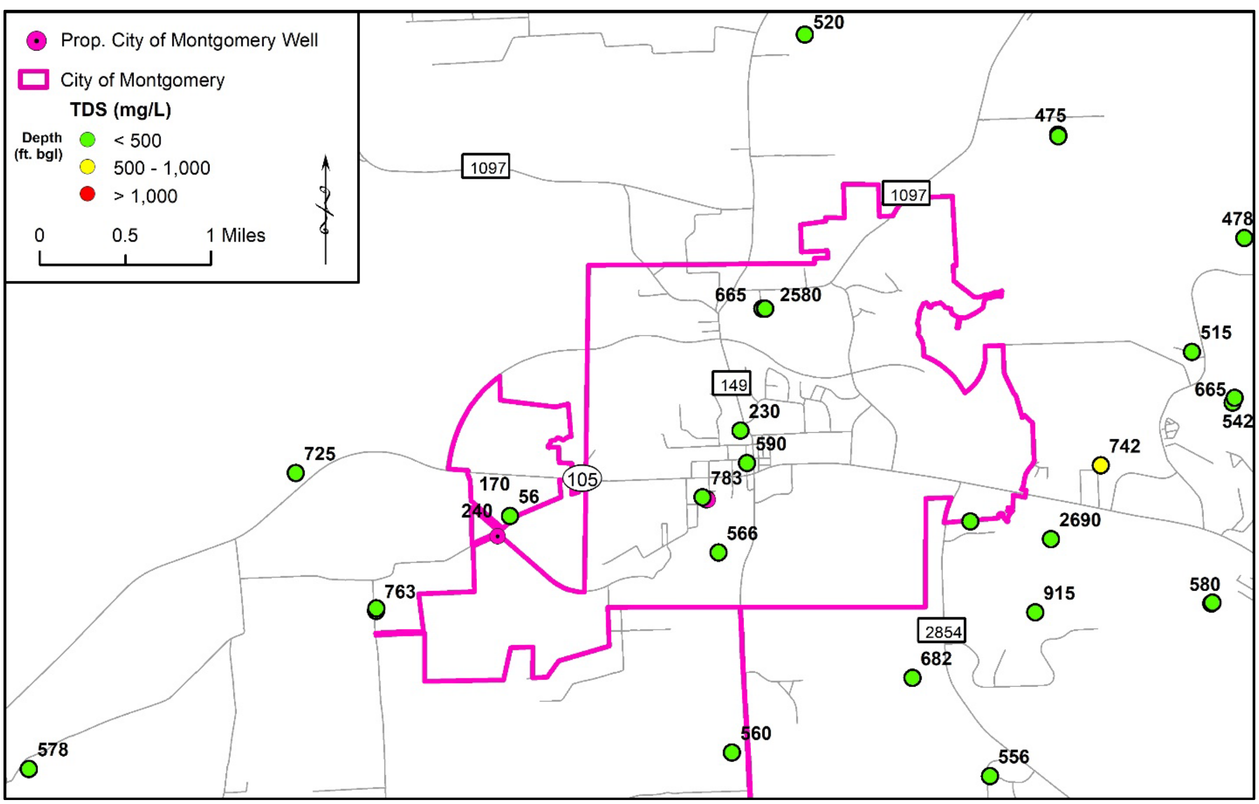


Figure 13: TDS concentrations in the vicinity of the study area

Arsenic and Iron

Figure 14 provides a map displaying reported arsenic concentrations and Figure 15 provides a map displaying reported iron concentrations from the TWDB and TCEQ well databases for the study area. In the area near the proposed wells, the reported arsenic concentrations are below the TCEQ MCL. Reported concentrations of iron are generally below the TCEQ SCL; however, to the east of the City, the reported iron concentrations increase above the SCL (Figure 15). In wells completed at similar depths to the proposed well, the reported arsenic concentrations all were below the MCL of 0.01 mg/L (Figure 14); iron concentration ranges from 0.02 to 0.3 mg/L (Figure 15);

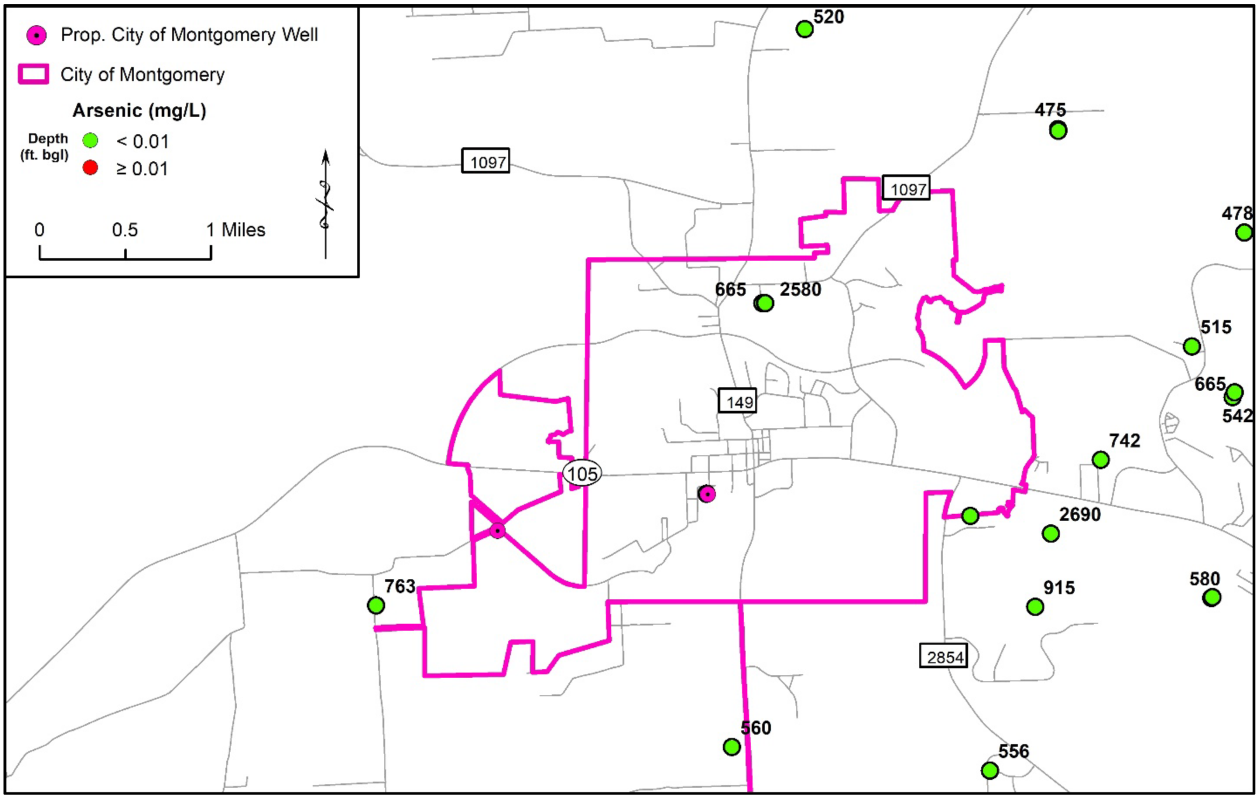


Figure 14: Arsenic concentrations in the vicinity of the study area

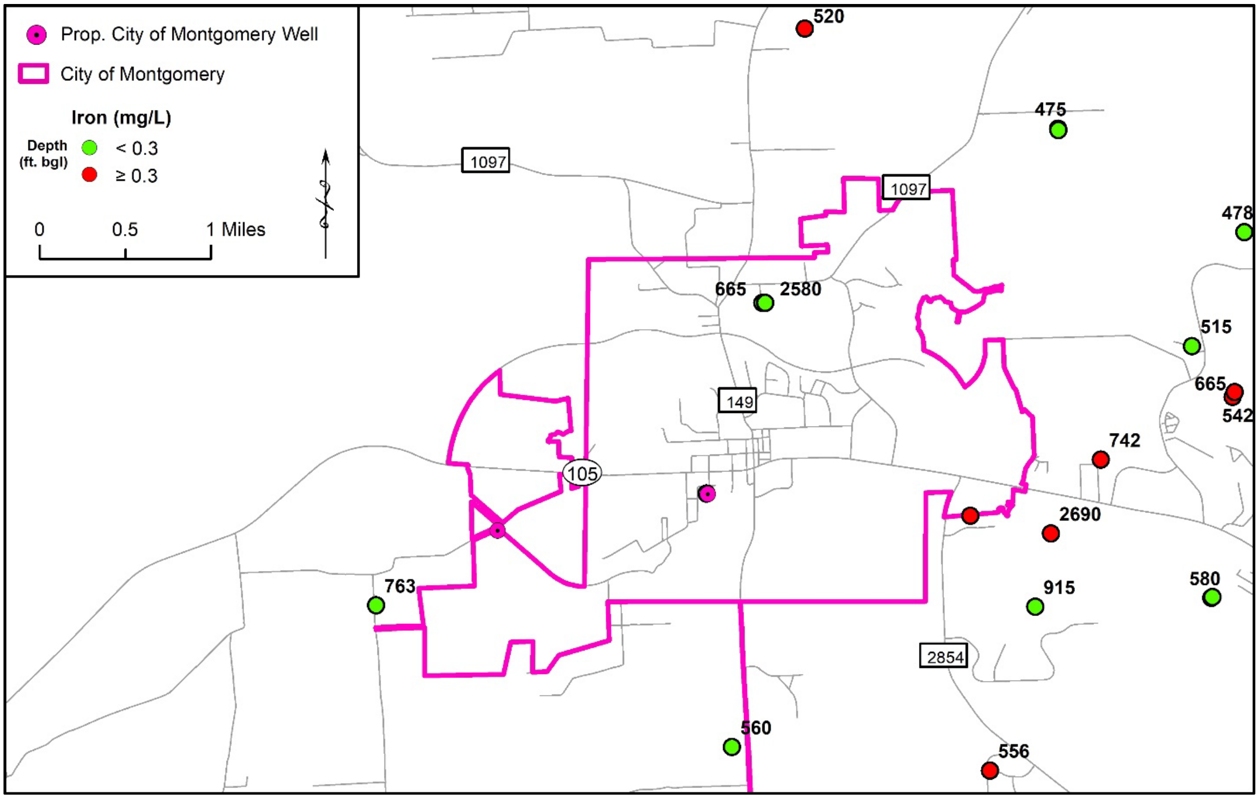


Figure 15: Iron concentrations in the vicinity of the study area

Radionuclides

Radionuclides and more specifically, combined radium are a constituent of concern in some areas of the Gulf Coast Aquifer. Radium is an alkaline-earth element that is very radioactive and has four naturally occurring isotopes (Rd 223, Rd, 224, Rd 226 and Rd 228). Rd 226 and Rd 288 are the two most common isotopes found in groundwater. The TCEQ regulates combined radium concentration with an MCL set at 5 picocuries per liter (pCi/L).

Figure 16 provides a map displaying reported combined radium concentrations from the TCEQ well database in the study area. All reported concentrations of radionuclides were below the MCL. Table 6 provides a radionuclide summary of the water sample taken at Entry Point 002 by TCEQ officials, which is directly adjacent to Well No. 2. Well No. 2 was completed to a depth of 783 ft. bgl (Jasper Aquifer). According to the reported results, the well had concentrations below all MCLs for radionuclides. Performing a gamma log and a spectral ray log on the pilot hole may allow for identification of potential sand zones producing elevated radionuclide concentrations.

Table 7 provides a water quality summary of the most recent samples taken from the nearby City of Montgomery Entry Point 002 (Well No. 2) and Entry Point 003 (Wells No. 3 and 4). The most recent water samples met all TCEQ MCLs and SCLs in the existing wells.

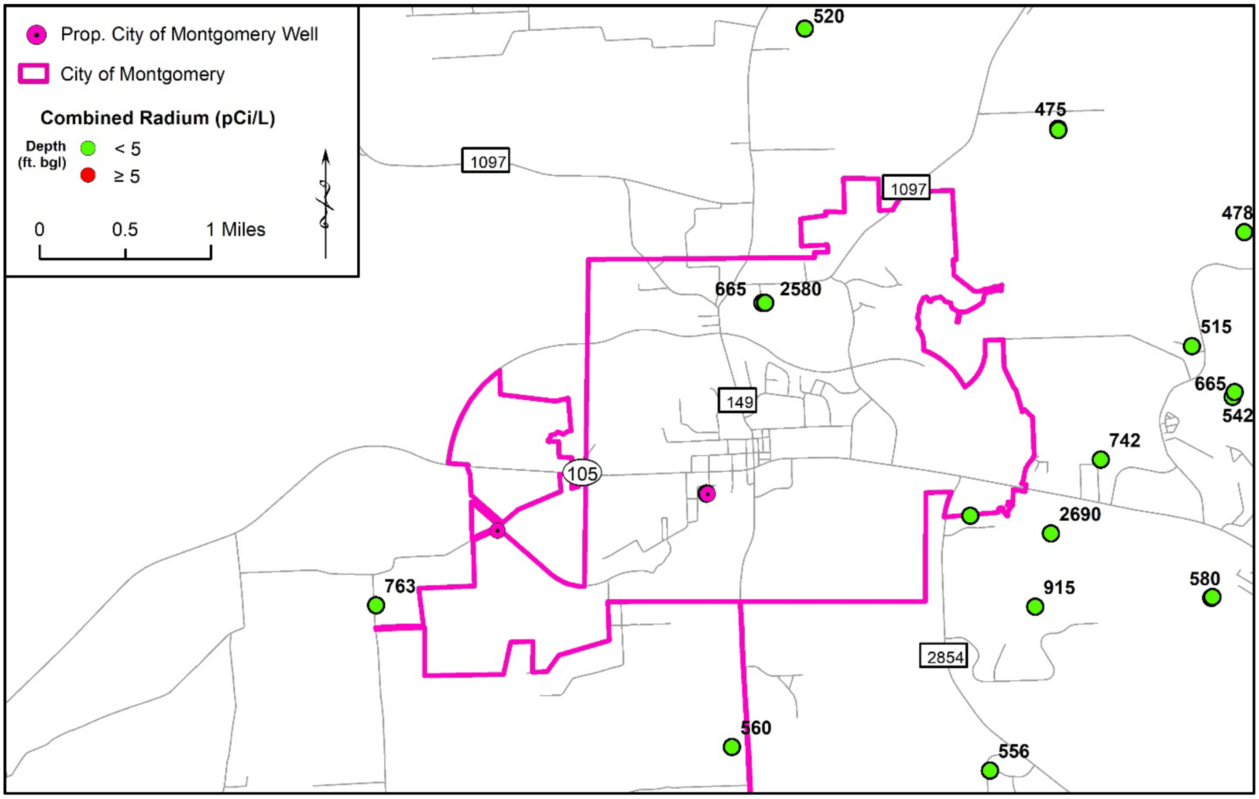


Figure 16: Combined radium concentrations in the vicinity of the study area

Table 6: Summary of radionuclides at Entry Point 002 (near Well No. 2 – Jasper Aquifer)

Facility	Sample Date	Gross Alpha	Gross Beta	Rd 226 & 228	Uranium
		TCEQ MCL (units in pCi/L except uranium; ug/L)			
		15	50	5	30
EP002	3-30-06	2.3	5.0	<1.0	< 0.001
Values in red exceed the TCEQ MCL; NA = Not Available.					

Table 7: Summary of most recent water quality sampling near the City of Montgomery

Facility	pH	TDS	NO_3	NO_2	As	F	Al	Cu	Fe	Mn	Zn	Pb	SO_4	Cl
	TCEQ MCL[1] and SCL[2] (units in mg/L except pH)													
	>7[2]	1000[2]	10[1]	1[1]	0.01[1]	2[2]/4[1]	0.2[2]	1[2]	0.3[2]	0.05[2]	5[2]	NA	300[2]	300[2]
EP002	7.2	388	<0.05	<0.05	0.0045	0.16	0.034	<0.002	0.171	0.019	0.049	<0.001	18	66
EP003	7.3	486	<0.05	<0.05	0.002	0.83	<0.02	<0.002	0.082	0.025	0.026	<0.001	17	118
ND = Not Detectable; NA = Not Available; Values in red exceed the TCEQ MCL or SCL														

Interference Analysis

A groundwater model was constructed using the Aqtesolv software suite (Version 4.5; Duffield, 2007) with the Theis (1935)/Hantush (1961) solution to determine the projected impacts from the proposed wells and increased pumping.

The model calculates drawdown using the Theis Equation,

$$s = \frac{Q}{4\pi T} W(u) \qquad \textit{(Equation 2)}$$

where:
s = drawdown (feet);
Q = discharge (gallons per minute; gpm);
T = transmissivity (ft.^{2}/day); and
W(u) = well function.
The well function W(u) is estimated by:

$$W(u) = -0.5772 - \ln u + u - \frac{u^2}{2\times 2!} + \frac{u^3}{3\times 3!} - \frac{u^4}{4\times 4} + \ldots \qquad \textit{(Equation 3)}$$

where:

$$u = \frac{r^2 S}{4Tt} \qquad \textit{(Equation 4)}$$

r = the radius at which drawdown is estimated (feet); and
S = storativity (dimensionless).

The Theis Equation has several assumptions used to derive the formula which include (Driscoll, 1986):

1. The water-bearing formation is uniform in character and the hydraulic conductivity is the same in all directions;
2. The aquifer is uniform in thickness and infinite in areal extent;
3. The aquifer receives no recharge from any source;
4. The well penetrates, and receives water from the full thickness of the aquifer;
5. The water from storage is discharged instantaneously when the head is lowered;
6. The pumping well is 100% efficient;
7. All water removed from the well comes from aquifer storage;
8. Laminar flow exists through the well and aquifer; and,
9. The water table or potentiometric surface has no slope.

The assumption that the formation receives no recharge from any source is not necessarily met in this case. Driscoll (1986) states, *"The assumption that an aquifer receives no recharge during the pumping period is one of the six fundamental conditions upon which the nonequilibrium formulas (Theis) are based. Therefore, all water discharged from a well is assumed to be taken from storage within the aquifer… It is known, however that most formations receive recharge. Hydrographs from long-term observation wells monitored by the U.S. Geological Survey, various state agencies, and similar data-gathering agencies in other parts of the world show that most water-bearing formations receive continual* *or intermittent recharge."*

Furthermore, Konikow and Leake (2014) note that with increased pumping time, the fraction of pumpage derived from storage tends to decrease, and the fraction derived from capture (recharge) increases. Eventually a new equilibrium will be achieved when no more water is derived from storage and heads or water levels in the aquifer stabilize (Figure 17). This is achieved when the initial cone of depression formed by discharge reaches a new source of water, typically the recharge zone of the aquifer. The actual response time for an aquifer system to reach a new equilibrium is a function of the dimensions, hydraulic properties, and boundary conditions for each specific aquifer. For example, the response time will decrease as the hydraulic diffusivity of the aquifer increases (Theis 1940; Barlow and Leake 2012). The response time can range from days to millennia (Bredehoeft and Durbin 2009; Walton 2011).

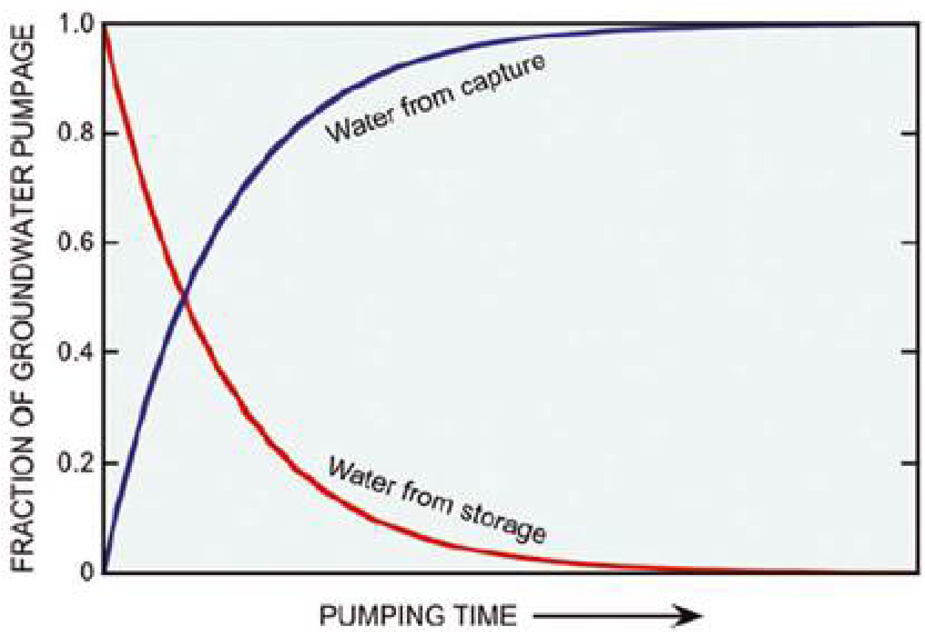


Figure 17: Water sources to a pumping well over time (from Konikow and Leake (2014)

Since the Theis equation assumes (i) that all water is derived from storage and (ii) that the aquifer receives no recharge, the Theis equation may overestimate drawdown within a well that is located in an aquifer that receives recharge. In this case, the Gulf Coast Aquifer is laterally continuous, large, and sufficiently homogeneous and isotropic to warrant the use of the Theis equation.

Interference Modeling: Well No. 3

In an effort to model the aquifer impacts from Well No. 3, the following averaged parameters from the Gulf Coast Aquifer (Northern Portion) GAM were utilized:

- Proposed Well No. 3 production rate: 500 gpm;
- Transmissivity: 11,173.9 ft.^{2}/day (average);
- Storativity: 3.26 x 10^{-4} (average).

The groundwater model was designed to estimate drawdown at full permitted capacity for Well No. 3 pumping for 24 hours (500 gpm; 720,000 gallons total) and 498.26 days (500 gpm; 358,750,000 gallons total) within and in the vicinity of the proposed well. The results of the model are summarized in Table 8, Figure 18, and Figure 19. Table 8 provides a summary of the modeling results on existing water system wells and District registered/permitted wells within a 1/2-mile radius of the proposed well with only Well No. 3 pumping. Map IDs correspond to Tables 1, 2, and 3.

Table 8: Summary of estimated drawdown from production at Well No. 3

Map ID	Well Registration No.	Owner	Total Depth (ft.)	Aquifer	Status	Distance from Well No. 3 (ft.)	Drawdown After 24-Hours Pumping (ft.)	Drawdown at Max Permit Volume (ft.)
Property Boundary						137	5.7	10.0
Well No. 2	2004071935	City of Montgomery	783	Jasper	Operating – To Be Replaced	6,145	0.7	4.7
Well No. 3	2004072104	City of Montgomery	665	Jasper	Operating	0	13.4	17.7
Well No. 5	-	City of Montgomery	800	Jasper	Proposed	6,141	0.7	4.7
Well No. 6	-	City of Montgomery	700	Jasper	Proposed	10,764	0.2	4.0
1	2022112904	Wedgman	170	Evangeline	Operating	1,485	2.4	6.7
2	2022031503	Arnsworth	160	Evangeline	Operating	1,957	2.1	6.3
3	2021121102	Arnsworth	160	Evangeline	Being drilled	1,975	2.1	6.3
4	2005031624	Mossier	158	Evangeline	Operating	2,260	1.9	6.1
5	2005082416	Mossier	168	Evangeline	Operating	2,456	1.8	6.0

Based upon the drawdown calculated from the distance-drawdown projections, the drawdown after 24 hours of production at 500 gpm from Well No. 3 results in 13.4 feet of drawdown at the well. At the nearest property boundary, the drawdown is approximately 5.7 feet. Drawdown in nearby water system and registered wells ranges from approximately 0.2 to 2.4 feet.

Based upon the drawdown calculated from distance-drawdown projections, the drawdown after pumping the well approximately 498.26 days to achieve the maximum permitted volume at 500 gpm from Well No. 3 results in 17.7 feet of drawdown at the well. At the nearest property boundary, the drawdown is approximately 10.0 feet. Drawdown in nearby water system and registered wells ranges from approximately 4.0 to 6.7 feet.

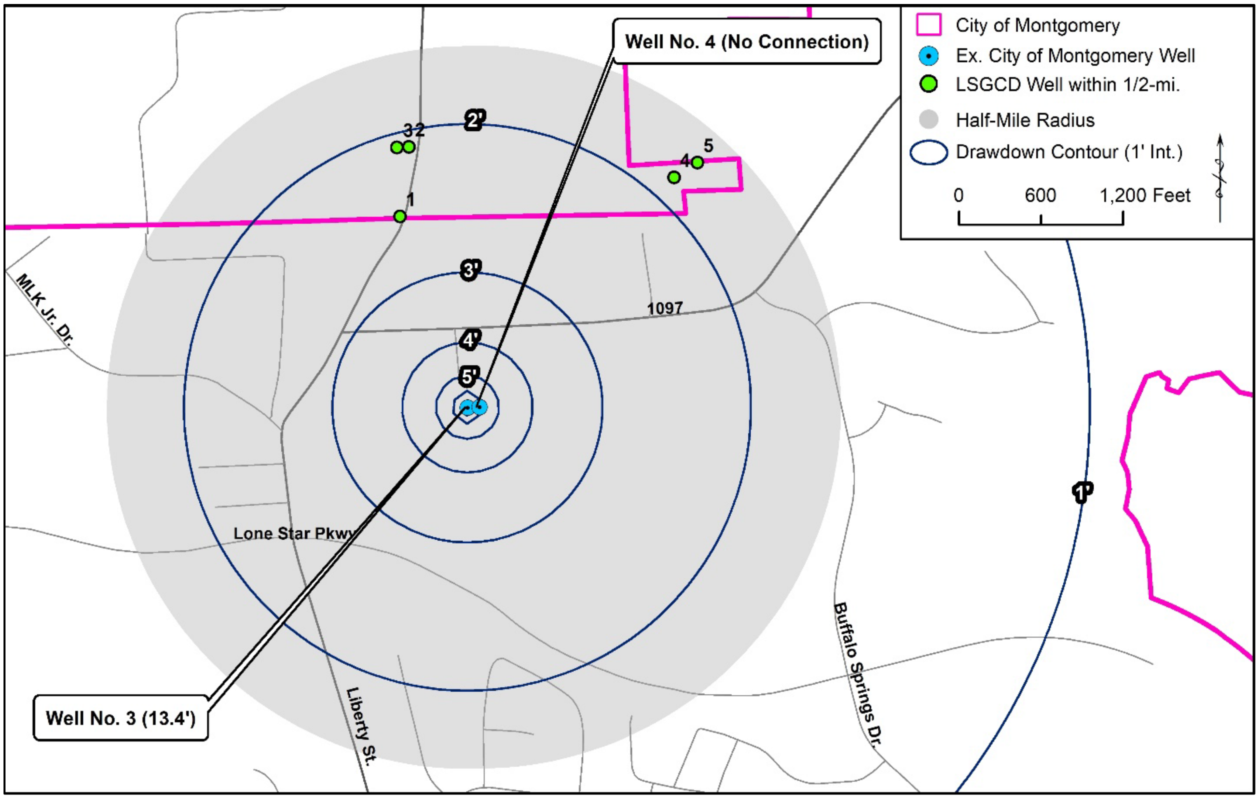


Figure 18: Modeled drawdown after 24 hours from production at the proposed Well No. 3

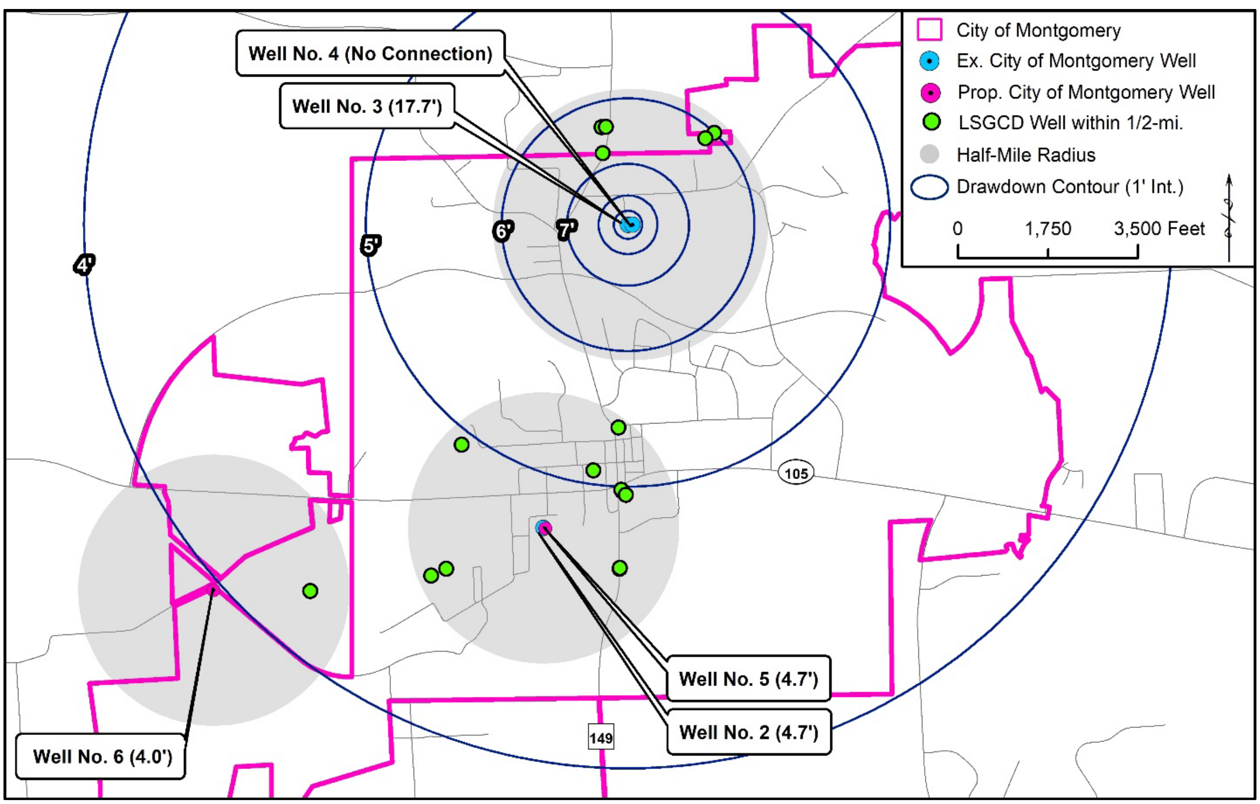


Figure 19: Modeled drawdown after 498.26 days from production at the proposed Well No. 3

Interference Modeling: Well No. 4

In an effort to model the aquifer impacts from the proposed pumping at Well No. 4, the following parameters were utilized for the Catahoula Aquifer:

- Well No. 4 production rate: 1,208 gpm;
- Transmissivity: 973 $ft.^2$/day;
- Storativity: 1.0×10^{-5}.

The groundwater model was designed to estimate drawdown at full permitted capacity for Well No. 4 pumping for 24 hours (1,208 gpm; 1,739,520 gallons total) and 109.94 days (1,208 gpm; 191,250,000 gallons total) within and in the vicinity of the well. The results of the model are summarized in Table 9, Figure 20, and Figure 21. Table 9 provides a summary of the modeling results with only Well No. 4 pumping. According to the LSGCD well database, there are no other Catahoula Aquifer wells in the water system nor in the vicinity of Well No. 4.

Table 9: Summary of estimated drawdown from production at Well No. 4

Map ID	Well Registration No.	Owner	Total Depth (ft.)	Aquifer	Status	Distance from Well No. 6 (ft.)	Drawdown After 24-Hours Pumping (ft.)	Drawdown at Max Permit Volume (ft.)
Property Boundary						50	216.4	305.8
Well No. 4	2013012801	City of Montgomery	2,580	Catahoula	Operating	0	391.6	481.0

Based upon the drawdown calculated from the distance-drawdown projections, the drawdown after 24 hours of production at 1,208 gpm from Well No. 4 results in 391.6 feet of drawdown at the well. At the nearest property boundary, the drawdown is approximately 216.4 feet.

Based upon the drawdown calculated from distance-drawdown projections, the drawdown after pumping the well approximately 109.94 days to achieve the maximum permitted volume at 1,208 gpm from Well No. 4 results in 481 feet of drawdown at the well. At the nearest property boundary, the drawdown is approximately 305.8 feet.

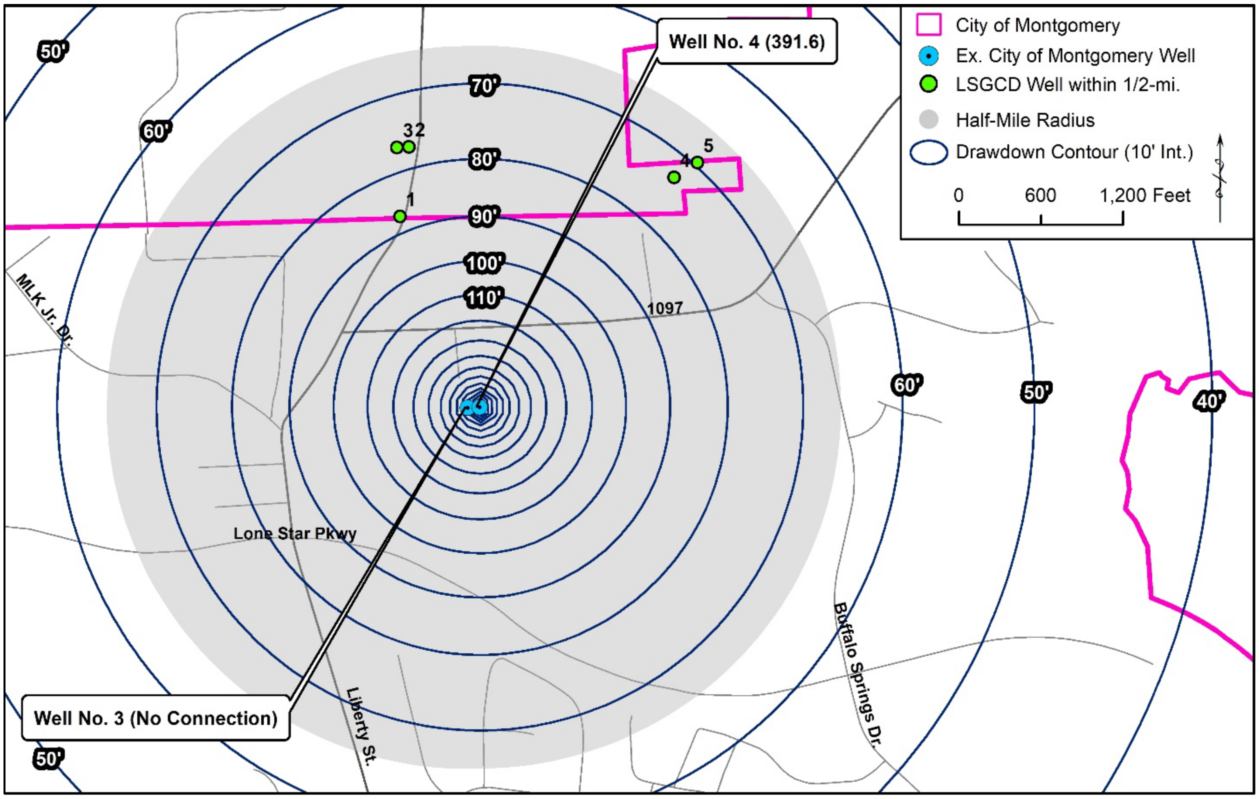


Figure 20: Modeled drawdown after 24 hours from production at Well No. 4

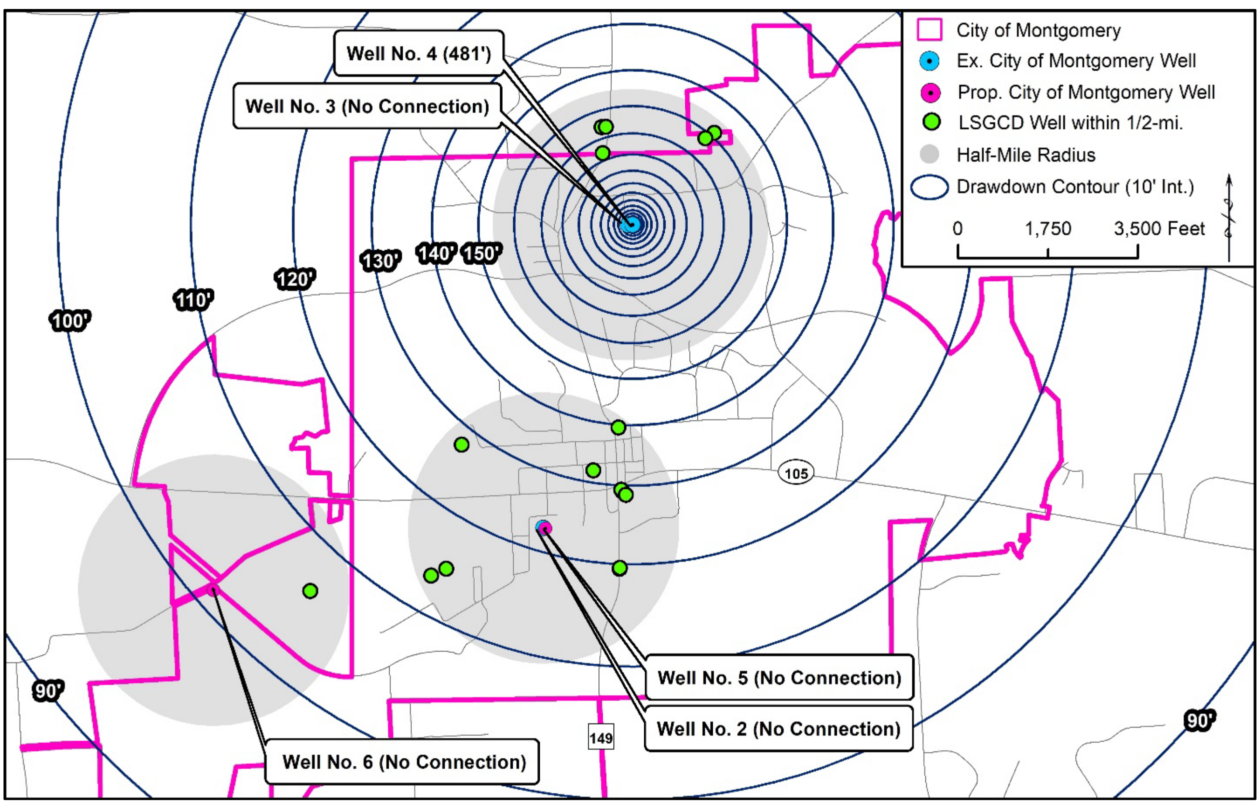


Figure 21: Modeled drawdown after 109.94 days from production at Well No. 4

Interference Modeling: Proposed Well No. 5

In an effort to model the aquifer impacts from the proposed Well No. 5, the following averaged parameters from the Gulf Coast Aquifer (Northern Portion) GAM were utilized:

- Proposed Well No. 5 production rate: 500 gpm;
- Transmissivity: 11,173.9 ft.^{2}/day (average);
- Storativity: 3.26 x 10^{-4} (average).

The groundwater model was designed to estimate drawdown at full permitted capacity for Well No. 5 pumping for 24 hours (500 gpm; 720,000 gallons total) and 498.26 days (500 gpm; 358,750,000 gallons total) within and in the vicinity of the proposed well. The results of the model are summarized in Table 10, Figure 22, and Figure 23. Table 10 provides a summary of the modeling results on existing water system wells and District registered/permitted wells within a 1/2-mile radius of the proposed well with only Well No. 5 pumping. Map IDs correspond to Tables 1, 2, and 3.

Table 10: Summary of estimated drawdown from production at the proposed Well No. 5

Map ID	Well Registration No.	Owner	Total Depth (ft.)	Aquifer	Status	Distance from Well No. 5 (ft.)	Drawdown After 24-Hours Pumping (ft.)	Drawdown at Max Permit Volume (ft.)
Property Boundary						27	7.5	11.8
Well No. 2	2004071935	City of Montgomery	783	Jasper	Operating – To Be Replaced	5	10.2	14.5
Well No. 3	2004072104	City of Montgomery	665	Jasper	Operating	6,141	0.7	4.7
Well No. 5	-	City of Montgomery	800	Jasper	Proposed	0	13.4	17.7
Well No. 6	-	City of Montgomery	700	Jasper	Proposed	6,533	0.6	4.7
6	2012051503	Randall	N/A	N/A	Void - Application Withdrawn	1,684	2.3	6.5
7	2012040202	Randall	N/A	N/A	Operating	1,678	2.3	6.5
8	2012051502	Randall	N/A	N/A	Operating	1,678	2.3	6.5
9	2009061805	Waller	N/A	N/A	Void - Application Withdrawn	1,479	2.5	6.7
10	2008041702	Barber	N/A	N/A	Operating	1,683	2.3	6.5
11	2012040203	Randall	N/A	N/A	Operating	1,678	2.3	6.5
12	2005031538	Schock	338	Jasper	Operating	2,379	1.8	6.0
13	2012051501	Randall	N/A	N/A	Operating	1,678	2.3	6.5
14	2015071503	Lesniak	N/A	N/A	Void - Application Withdrawn	1,678	2.3	6.5
15	2015102201	Kiser	345	Jasper	Operating	2,059	2.0	6.2
16	2016012702	Walker	300	Jasper	Operating	2,274	1.9	6.1
17	2018082104	Rutland	254	Evangeline	Operating	1,722	2.2	6.5
18	2020011001	Deveraux	320	Jasper	Operating	2,437	1.8	6.0

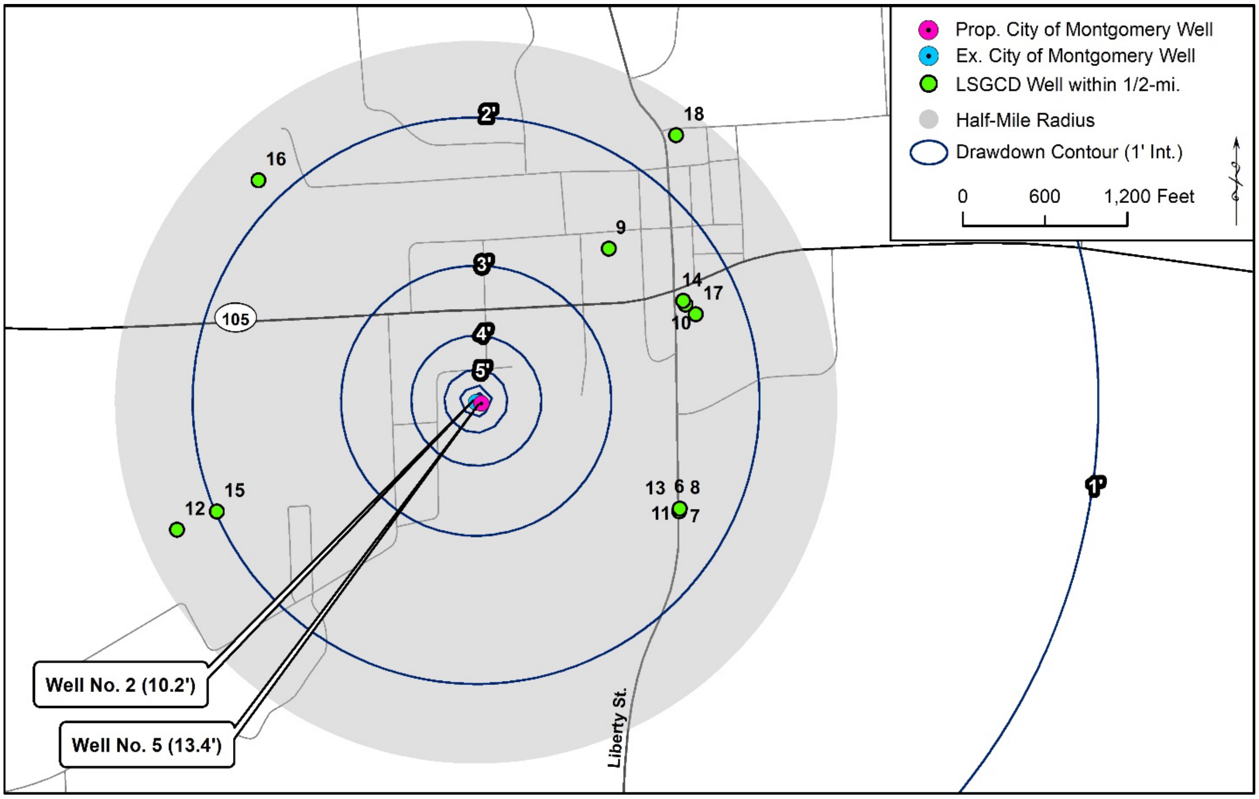


Figure 22: Modeled drawdown after 24 hours from production at the proposed Well No. 5

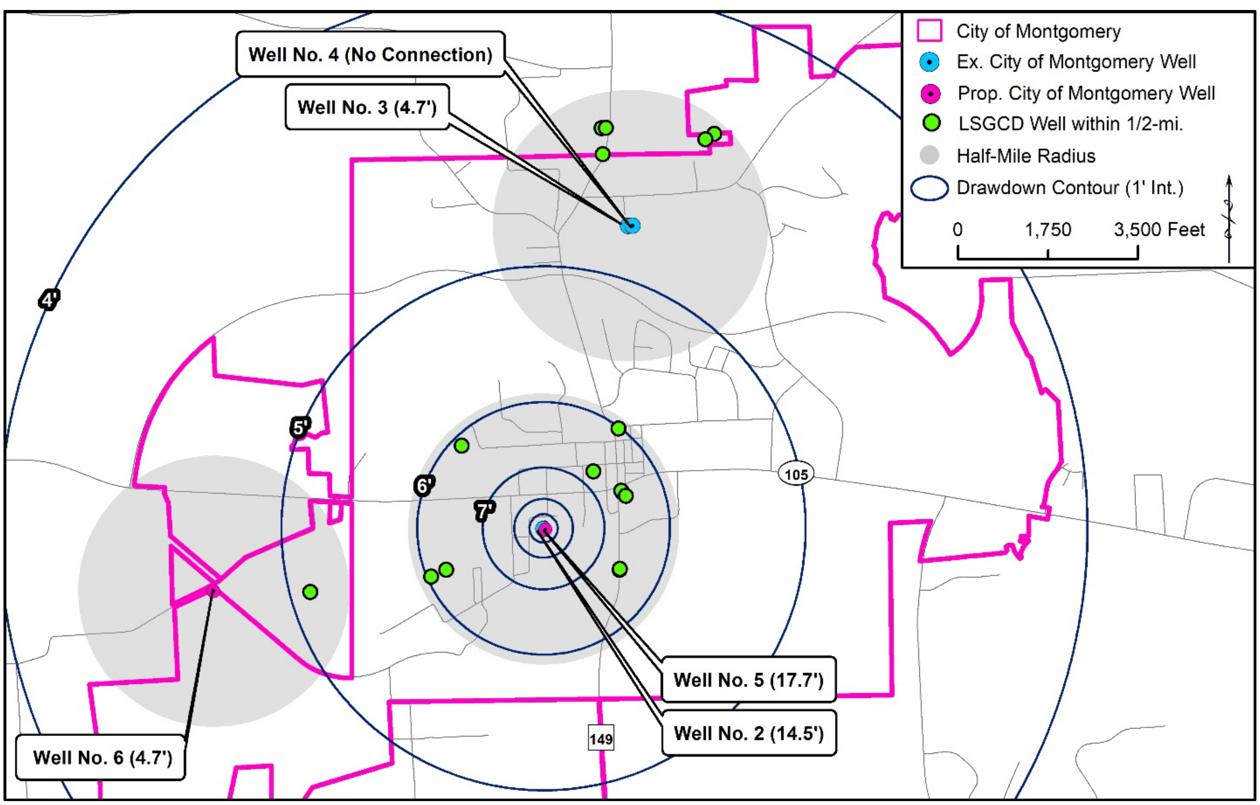


Figure 23: Modeled drawdown after 498.26 days from production at the proposed Well No. 5

Based upon the drawdown calculated from the distance-drawdown projections, the drawdown after 24 hours of production at 500 gpm from the proposed Well No. 5 results in 13.4 feet of drawdown at the well. At the nearest property boundary, the drawdown is approximately 7.5 feet. Drawdown in nearby water system and registered wells ranges from approximately 0.6 to 10.2 feet.

Based upon the drawdown calculated from distance-drawdown projections, the drawdown after pumping the well approximately 498.26 days to achieve the maximum permitted volume at 500 gpm from the proposed Well No. 5 results in 17.7 feet of drawdown at the well. At the nearest property boundary, the drawdown is approximately 11.8 feet. Drawdown in nearby water system and registered wells ranges from approximately 4.7 to 14.5 feet.

Interference Modeling: Proposed Well No. 6

In an effort to model the aquifer impacts from the proposed Well No. 6, the following averaged parameters from the Gulf Coast Aquifer (Northern Portion) GAM were utilized:

- Proposed Well No. 6 production rate: 1,000 gpm;
- Transmissivity: 11,173.9 $ft.^2$/day (average);
- Storativity: 3.26 x 10^{-4} (average).

The groundwater model was designed to estimate drawdown at full permitted capacity for Well No. 6 pumping for 24 hours (1,000 gpm; 1,440,000 gallons total) and 249.13 days (1,000 gpm; 358,750,000 gallons total) within and in the vicinity of the proposed well. The results of the model are summarized in Table 11, Figure 24, and Figure 25. Table 11 provides a summary of the modeling results on existing water system wells and District registered/permitted wells within a 1/2-mile radius of the proposed well with only Well No. 6 pumping. Map IDs correspond to Tables 1, 2, and 3.

Table 11: Summary of estimated drawdown from production at the proposed Well No. 6

Map ID	Well Registration No.	Owner	Total Depth (ft.)	Aquifer	Status	Distance from Well No. 6 (ft.)	Drawdown After 24-Hours Pumping (ft.)	Drawdown at Max Permit Volume (ft.)
Property Boundary						50	14.2	21.7
Well No. 2	2004071935	City of Montgomery	783	Jasper	Operating – To Be Replaced	6,529	1.2	8.4
Well No. 3	2004072104	City of Montgomery	665	Jasper	Operating	10,764	0.4	7.0
Well No. 5	-	City of Montgomery	800	Jasper	Proposed	6,533	1.2	8.4
Well No. 6	-	City of Montgomery	700	Jasper	Proposed	0	26.8	34.4
19	2014013101	Giles	263	Evangeline	Operating	1,882	4.3	11.8

Based upon the drawdown calculated from the distance-drawdown projections, the drawdown after 24 hours of production at 1,000 gpm from the proposed Well No. 6 results in 26.8 feet of drawdown at the well. At the nearest property boundary, the drawdown is approximately 14.2 feet. Drawdown in nearby water system and registered wells ranges from approximately 0.4 to 4.3 feet.

Based upon the drawdown calculated from distance-drawdown projections, the drawdown after pumping the well approximately 249.13 days to achieve the maximum permitted volume at 1,000 gpm from the proposed Well No. 6 results in 34.4 feet of drawdown at the well. At the nearest property boundary, the drawdown is approximately 21.7 feet. Drawdown in nearby water system and registered wells ranges from approximately 7.0 to 11.8 feet.

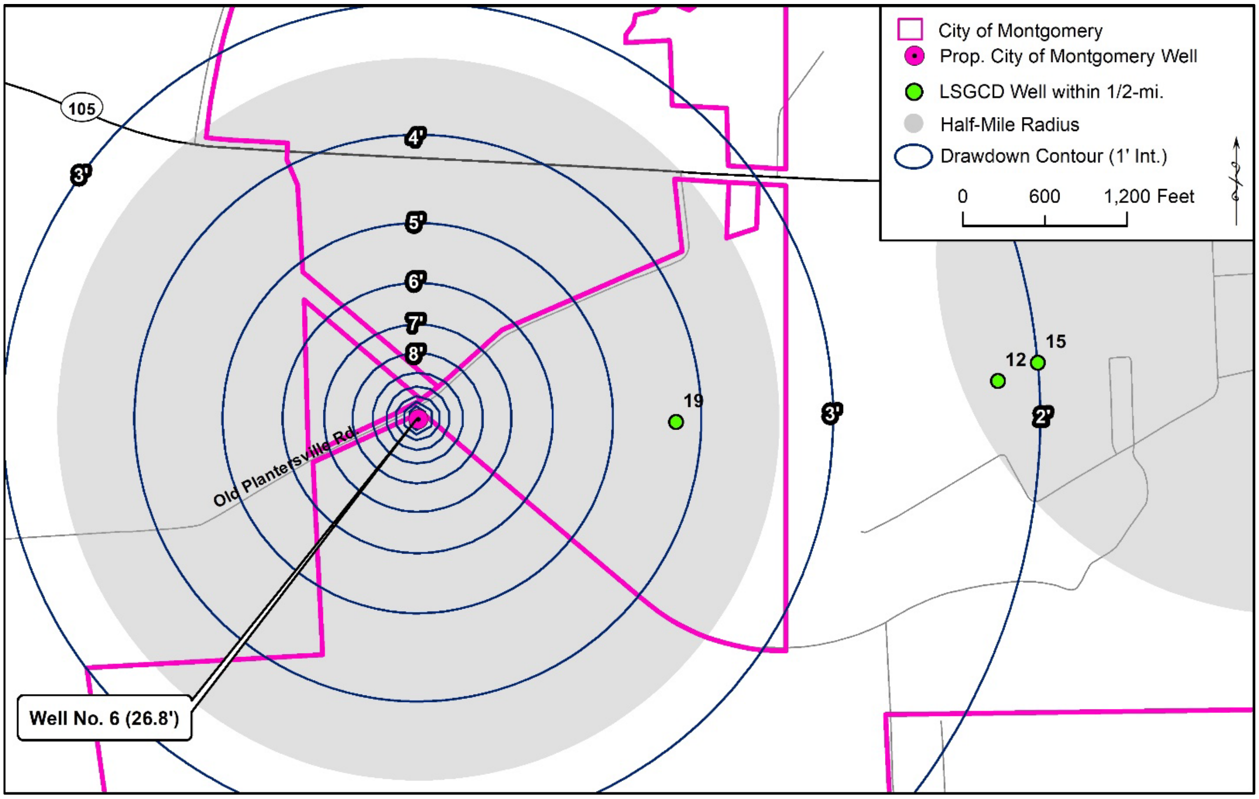


Figure 24: Modeled drawdown after 24 hours from production at the proposed Well No. 6

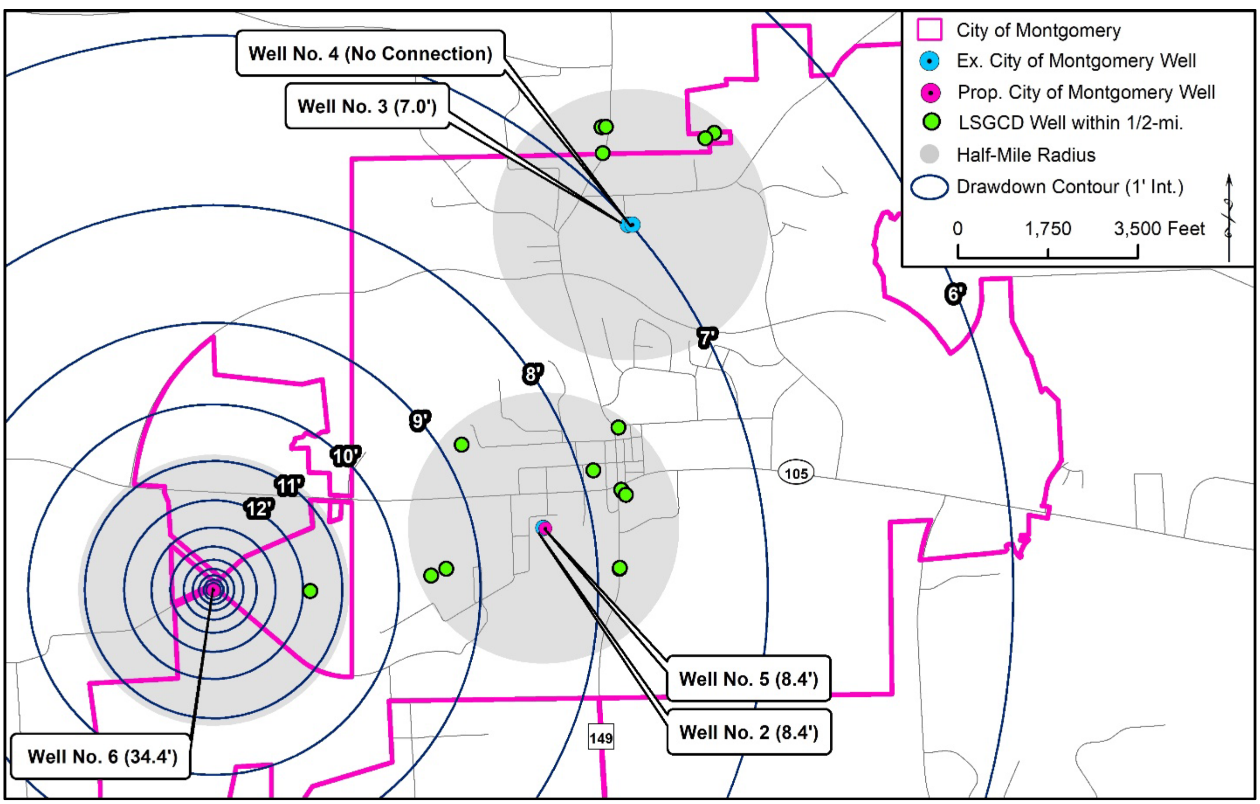


Figure 25: Modeled drawdown after 249.13 days from production at the proposed Well No. 6

Interference Modeling: Water System (Jasper Aquifer wells)

In an effort to model the aquifer impacts from the proposed pumping at Wells No. 3, 5, and 6, the following averaged parameters from the Gulf Coast Aquifer (Northern Portion) GAM were utilized:

- Well No. 3 production rate: 500 gpm;
- Proposed Well No. 5 production rate: 500 gpm;
- Proposed Well No. 6 production rate: 1,000 gpm;
- Transmissivity: 11,173.9 ft.^{2}/day (average);
- Storativity: 3.26 x 10^{-4} (average).

The groundwater model was designed to estimate drawdown at the proposed full permitted capacity for the Jasper Aquifer wells pumping for 24 hours (2,000 gpm; 2,880,000 gallons total) and 124.56 days (2,000 gpm; 358,750,000 gallons total) within and in the vicinity of the wells. The results of the model are summarized in Table 12, Figure 26, and Figure 27. Table 12 provides a summary of the modeling results on existing water system wells and District registered/permitted wells within a 1/2-mile radius of the water system wells during proposed pumping. Map IDs correspond to Tables 1, 2, and 3.

Table 12: Summary of estimated drawdown from production at the City of Montgomery Jasper Aquifer wells

Map ID	Well Registration No.	Owner	Total Depth (ft.)	Aquifer	Status	Drawdown After 24-Hours Pumping (ft.)	Drawdown at Max Permit Volume (ft.)
Property Boundary from Well No. 2 (38 ft.)						8.2	20.9
Property Boundary from Well No. 3 (137 ft.)						6.7	18.9
Property Boundary from Well No. 5 (27 ft.)						8.2	20.9
Property Boundary from Well No. 6 (50 ft.)						13.0	25.5
Well No. 2	2004071935	City of Montgomery	783	Jasper	Operating – To Be Replaced	12.3	25.0
Well No. 3	2004072104	City of Montgomery	665	Jasper	Operating	14.4	26.6
Well No. 5	-	City of Montgomery	800	Jasper	Proposed	15.4	27.9
Well No. 6	-	City of Montgomery	801	Jasper	Proposed	28	40.1
1	2022112904	Wedgman	170	Evangeline	Operating	3.2	15.1
2	2022031503	Arnsworth	160	Evangeline	Operating	2.8	14.6
3	2021121102	Arnsworth	160	Evangeline	Being drilled	2.8	14.6
4	2005031624	Mossier	158	Evangeline	Operating	2.5	14.1
5	2005082416	Mossier	168	Evangeline	Operating	2.3	13.9
6	2012051503	Randall	N/A	N/A	Void - Application Withdrawn	3.8	16.2
7	2012040202	Randall	N/A	N/A	Operating	3.8	16.2
8	2012051502	Randall	N/A	N/A	Operating	3.8	16.2
9	2009061805	Waller	N/A	N/A	Void - Application Withdrawn	4.3	16.9

10	2008041702	Barber	N/A	N/A	Operating	3.9	16.4
11	2012040203	Randall	N/A	N/A	Operating	3.8	16.2
12	2005031538	Schock	338	Jasper	Operating	4.4	17.2
13	2012051501	Randall	N/A	N/A	Operating	3.8	16.2
14	2015071503	Lesniak	N/A	N/A	Void - Application Withdrawn	3.9	16.4
15	2015102201	Kiser	345	Jasper	Operating	4.5	17.2
16	2016012702	Walker	300	Jasper	Operating	4.2	17.0
17	2018082104	Rutland	254	Evangeline	Operating	3.8	16.3
18	2020011001	Deveraux	320	Jasper	Operating	3.7	16.2
19	2014013101	Giles	263	Evangeline	Operating	5.5	18.2

Based upon the drawdown calculated from the distance-drawdown projections, the drawdown after 24 hours of full water system production results in 12.3 to 28 feet of drawdown at the water system wells. Drawdown in nearby registered wells ranges from approximately 2.3 to 5.5 feet.

Based upon the drawdown calculated from distance-drawdown projections, the drawdown after approximately 124.56 days of full water system production results in 25 to 40.1 feet of drawdown at the water system wells. Drawdown in nearby registered wells ranges from approximately 13.9 to 18.2 feet.

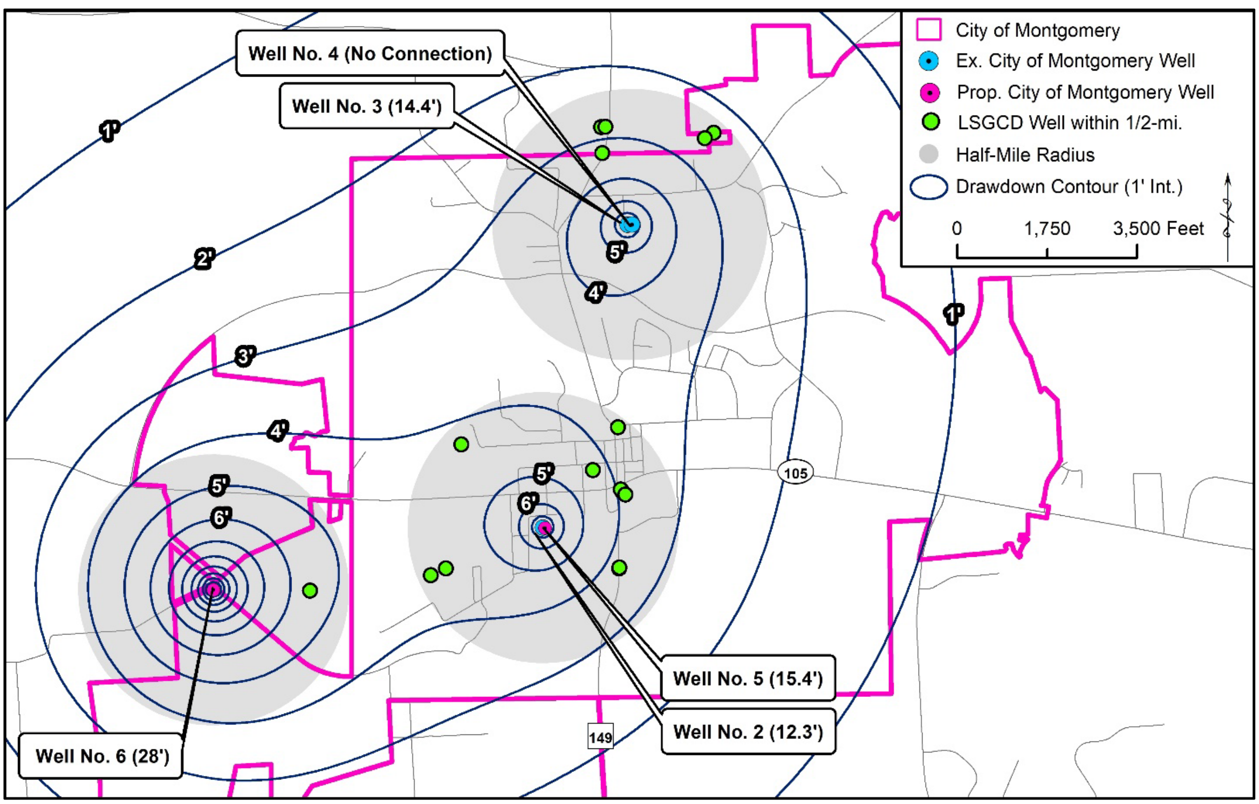


Figure 26: Modeled drawdown after 24 hours from production in the water system wells (Jasper Aquifer)

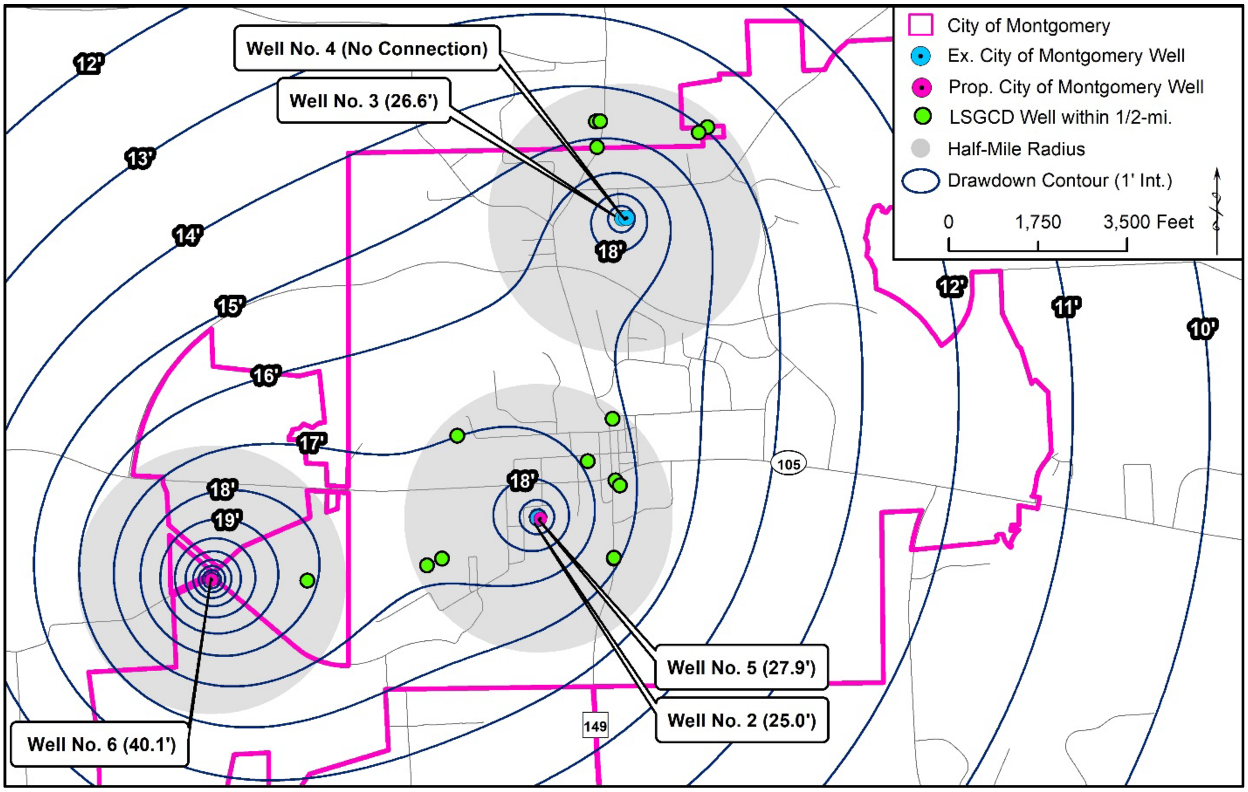
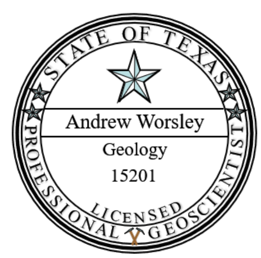


Figure 27: Modeled drawdown after 124.56 days from production in the water system wells (Jasper Aquifer)

Based upon the results of the modeling, we do not anticipate any deleterious impacts from the increased production and from the proposed City of Montgomery Wells No. 5 and 6 on nearby LSGCD wells. The modeling efforts put forth in this report utilized low-resolution data from the GAM and extreme cases of continuous pumping (over 350 million gallons of continuous pumping during the modeling scenarios); real-world results from pumping may be significantly different from the modeled results.

Respectfully,
Wet Rock Groundwater Services, L.L.C.



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Senior Hydrogeologist
Wet Rock Groundwater Services, LLC
TBPG Firm Registration No. 50038

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