Hydrogeological Evaluation

City of Glen Rose, Somervell County

Prepared for

Enprotec/Hibbs & Todd, Inc.

Prepared by

R W HARDEN & ASSOCIATES INC

GROUNDWATER RESOURCE PROFESSIONALS

STATE OF TEXAS
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Geology
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The seal appearing on this document was authorized by James E. Bené, P.G. 2089 on December 6, 2024. R.W. Harden & Associates, Inc. TBPG Firm No. 50033.

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EXECUTIVE SUMMARY

As requested by Enprotec/Hibbs & Todd, Inc. (eHT), R.W. Harden & Associates (RWH&A) performed a hydrogeological and regulatory evaluation of groundwater resources beneath the City of Glen Rose (City) in Somervell County, Texas.

The City's current water demands are approximately 600 acre-feet per year (ac-ft/yr) and are predicted to remain relatively stable over the next several decades. At present, the City obtains most of its water from the Somervell County Water District (SCWD), which treats and distributes surface water diverted from the Paluxy River. The City is also supplied by five wells that produce groundwater from geologic formations comprising the lower portion of the Trinity Group (Trinity) aquifer. The Trinity extends throughout eastern Texas, is considered a "major" aquifer, and has been widely utilized since the 1800s.

In March 2009, the City entered into a 20-year water purchase agreement with SCWD that restricts the City's groundwater usage. The original agreement states that the City must purchase all water up to a maximum of 690.5 ac-ft/yr from SCWD; however, it was amended in February 2020 to allow the City to use groundwater produced from its existing wells to provide up to 50% of the annual demand during the months of April through September. A temporary waiver of all contract restrictions on groundwater use was provided by SCWD in September 2023 while improvements to the existing surface water treatment infrastructure are completed.

This evaluation included an assessment of the City's five production wells (Wells 2 through 6) and performance of three pumping tests utilizing the wells that are designed and equipped to allow for wellbore water level measurements (Well 4, Well 5, and Well 6) during pumping.

Groundwater use in Somervell County is regulated by the Prairielands Groundwater Conservation District (PGCD or District). The City holds "historic use" permits to produce 534.6 ac-ft/yr, which is approximately 90% of the current annual usage. Historic use permits are granted to entities with documented groundwater use prior to the initiation of the PGCD. In general, the amount of groundwater assigned to historic use permits cannot be changed; a new permit application process is required if increased groundwater production is desired. However, new permits are subject to the District's annual allocation rules, which tie production values to the amount of surface acreage controlled by a permittee. The City limits footprint covers approximately 2,522 acres, which according to the current PGCD rules only allows for production of about 387 ac-ft/yr. This rate of production is about 72% of the production currently authorized by the City's historic use permit. Consequently, unless additional land acreage is acquired or the PGCD allocation rules are changed, the City's groundwater use will be limited to the rate allowed by the City's historic use permit.

Using data obtained from the well testing performed for this study and from publicly available state planning models and databases, groundwater modeling was performed to estimate the potential long-term production capacity of the City's wells from a hydrogeologic standpoint.

Groundwater modeling conducted for this evaluation indicates that the City's wells cannot fully provide for the City's expected demands. The model results indicate that the City's five existing wells can reliably produce approximately 420 ac-ft/yr over the short term but the annual production volume declines rapidly to about 234 acre-feet over a ten year period of continuous use.

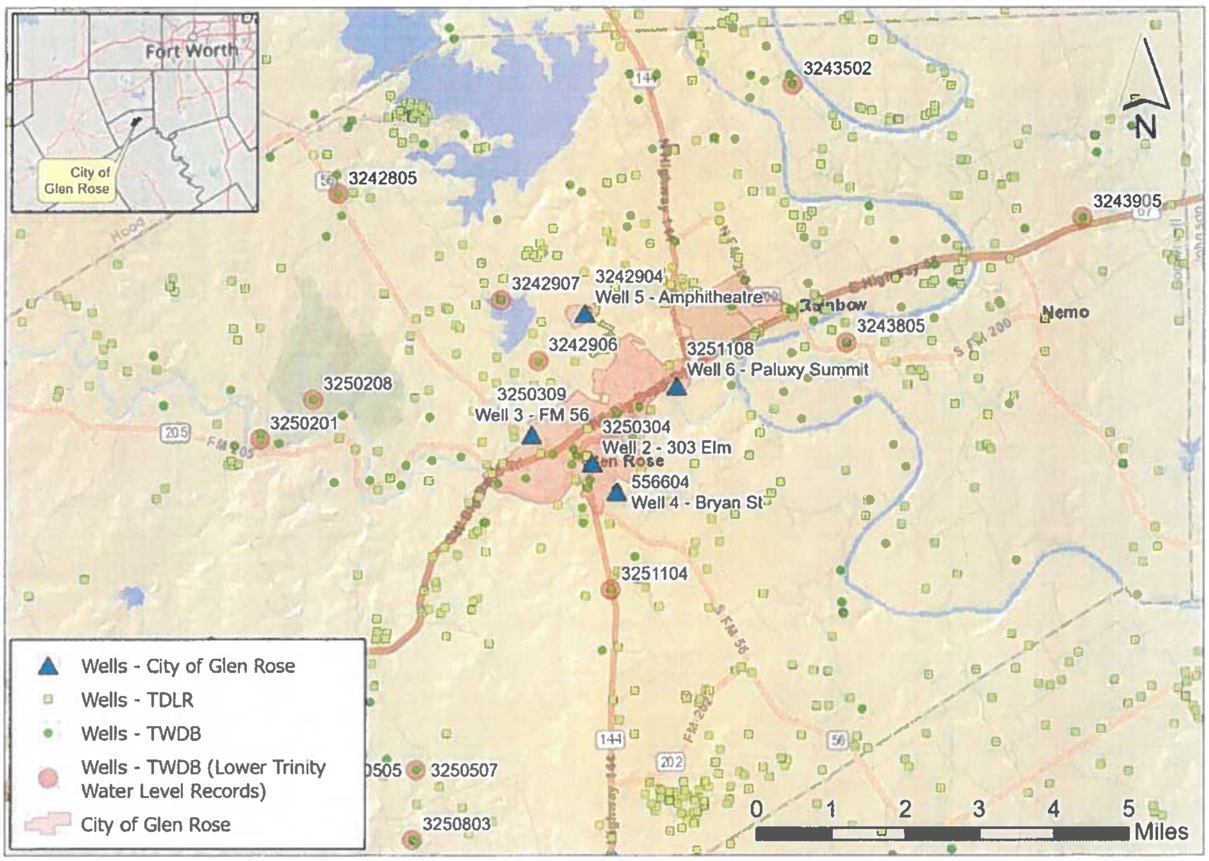
INTRODUCTION

RWH&A performed a hydrogeological and regulatory evaluation of groundwater resources beneath the general area encompassed by the City of Glen Rose (City) in Somervell County, Texas. The goal of the study is to assess the current and potential future groundwater resources available to the City and to estimate the potential long-term productivity of the City's current groundwater infrastructure.

For this evaluation, RWH&A compiled and analyzed available information from the City, the Texas Water Development Board (TWDB), the Texas Department of Licensing and Regulation (TDLR), the Prairielands Groundwater Conservation District (PGCD), the University of Texas Bureau of Economic Geology (BEG), the United States Geological Survey (USGS), RWH&A records, and published reports and literature.

Figure 1 shows the location of the City's five production wells and other wells in the Somervell County area that are included in the TWDB and TDLR groundwater/well information databases.

Figure 1. Location Map



The City currently uses approximately 600 ac-ft/yr and provides for most of its demand through a water supply contract with SCWD, which treats Paluxy River water that is diverted to and stored in the Wheeler Branch Reservoir located approximately one mile northwest of the City. The 20-year term of the agreement began in March 2009, ends in March 2029, and includes the following terms:

- The City must purchase all water from SCWD up to a maximum of 225 million gallons per year, which is equivalent to 690.5 ac-ft/yr or an average of 0.62 million gallons per day (MGD).
- SCWD's infrastructure must be able to provide up to 1.5 million gallons per day
- The City may use groundwater to provide for demands exceeding 225 million gallons per year

The agreement was amended in February 2020 such that the City may utilize groundwater to provide up to 50% of its annual usage but must limit the production of groundwater to the interval between the beginning of April through the end of September. In September 2023, SCWD temporarily waived the provision that the City must purchase water from SCWD while the SCWD performs system improvements needed to resolve trihalomethane issues in its treated water.

The City currently operates five wells of various ages and depths that produce from the Lower Trinity aquifer. RWH&A evaluated the City's existing wells and performed aquifer testing of three wells that are configured to allow for water level measurements during pumping and recovery. A detailed discussion of the results of those tests is presented herein.

The City currently holds a "historic use" permit from the Prairielands Groundwater Conservation District (PGCD) that allows production of up to 534.6 acre-feet per year (ac-ft/yr) or an average of 0.48 million gallons per day (MGD) from the City's five existing wells. RWH&A reviewed current PGCD rules and management plan to identify rules/policies that may affect the historic use permit or acquisition of additional permits for increased groundwater production in the future.

Using data and aquifer parameters derived from the existing well tests and from the sources described above, RWH&A performed model simulations to estimate the long-term availability of groundwater from the City's existing wells. The assessment of long-term availability incorporated regional declines estimated from water level measurements reported for area wells.

The following sections provide discussions of general geology, water quality, well assessment/testing, groundwater modeling, regulatory permitting and limitations, and recommendations.

HYDROGEOLOGIC SETTING

The primary water-bearing units beneath the City are the Hensell and Hosston Formations that comprise the lower portion of the Trinity Group aquifer system (Trinity). Figure 2 shows the surface geologic formations in relation to the City boundaries and local roadways. Also shown on Figure 2 is the location of the cross section diagram (Figure 3), which depicts a vertical "slice" into the formations beneath the City.

The Lower Trinity was deposited in the early Cretaceous Period and is primarily composed of interbedded clay and quartz sandstone beds that are present from approximately 300 feet to 500 feet below ground level in the City area. The thickness of the sand-rich, productive portions of these aquifers of the Lower Trinity ranges between approximately 50 to 150 feet, outcrop (i.e. occur at the surface) in areas northwest of the City, and dip toward the southeast at about 30 to 50 feet per mile. The Lower Trinity is the most heavily developed aquifer in the region; the overwhelming majority of the neighboring wells shown on Figure 1 are completed in the Lower Trinity sands. Infiltration of precipitation in outcrop zones is the primary source of groundwater recharge. Once water enters the aquifer, it slowly percolates downdip within the pore spaces between the sand grains that comprise it.

It should be noted that the vertical boundaries of the Hensell and Hosston are often not distinct in the subsurface in the Somervell County region; where this is the case, the terms Travis Peak Formation (Travis Peak) or Twin Mountains Formation (Twin Mountains) are commonly applied to the combined lowermost productive portions of the Trinity.

Figure 2. Surface Geology

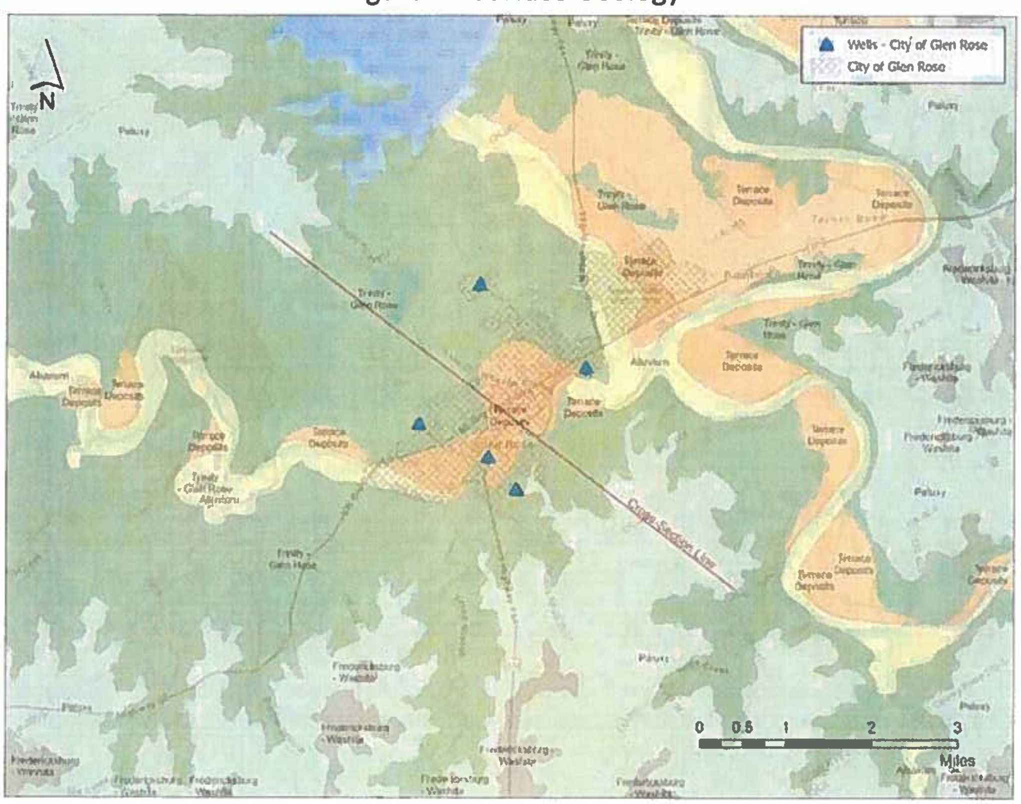
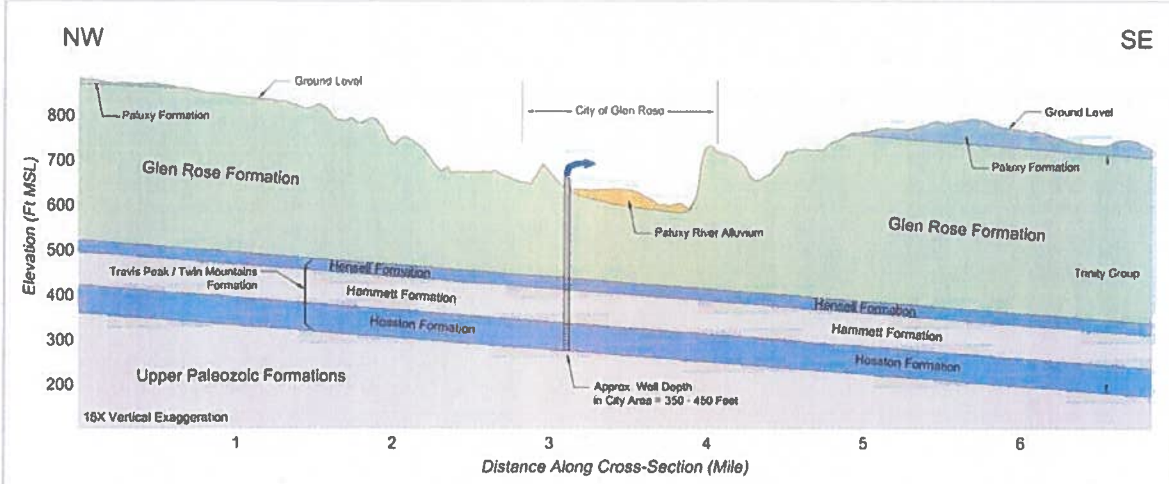


Figure 3. Cross-Section Diagram



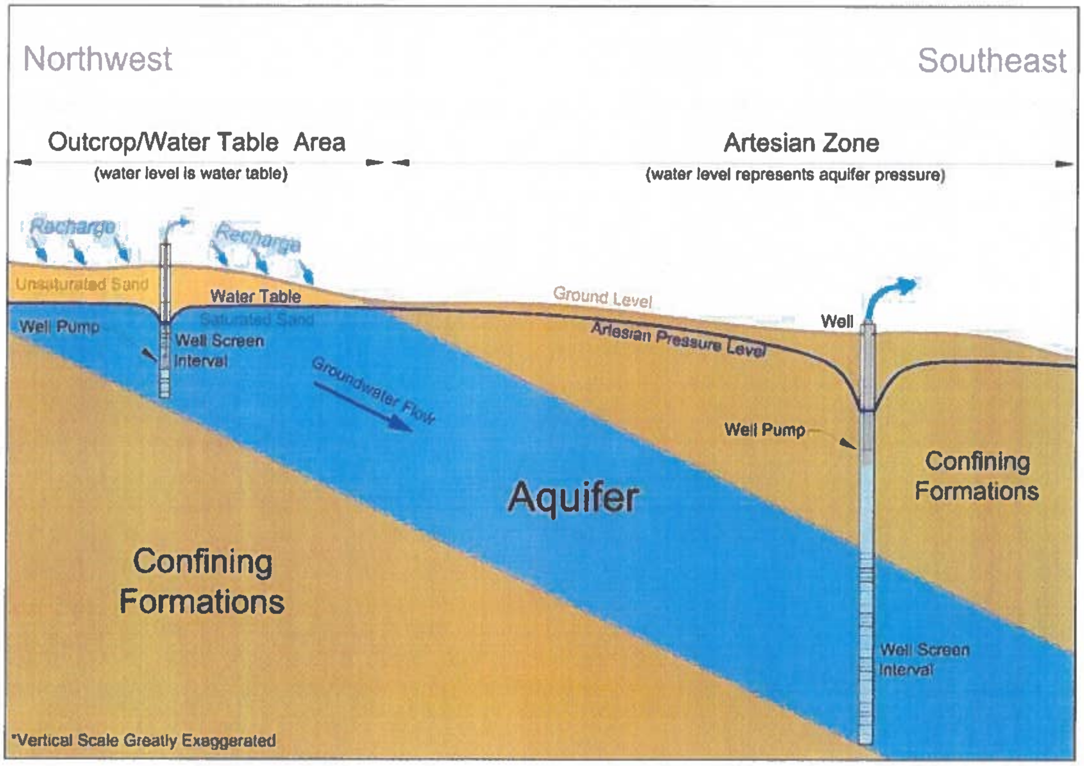
Water level records obtained from the TWDB database for wells reportedly screened in the Lower Trinity aquifer in Somervell County indicate water levels are declining by about 1.8 feet per year, on average. Water level records were included for evaluation if water level observations spanned at least five years and contained observations within the past five years. Figure 1 shows the distribution of TWDB wells with reported water level records from which the average regional water level decline was estimated.

Water Table vs. Artesian Pressure

It is important to account for the hydrogeologic setting in which wells operate when assessing long-term availability. Figure 4 diagrams the fundamental properties of wells completed in different aquifer zones. The Trinity is primarily recharged by infiltration of precipitation in outcrop areas. In these areas, the term "water table" is commonly used to denote the boundary between overlying unsaturated sediments and underlying saturated aquifer materials. When a well is pumped in an outcrop area, well bore water levels drop and these declines are transmitted outward from the well, desaturating aquifer materials near the well. This directly influences the amount of water stored locally and the saturated paths available for groundwater flow through the aquifer.

Wells that are completed in downdip areas to the southeast of the aquifer outcrop zones (such as wells in the City area) behave very differently. Groundwater is vertically confined within the Trinity underlying the City by relatively impermeable formations. The downward weight of groundwater in aquifer outcrop/recharge zones pressurizes the groundwater beneath the City. Consequently, aquifer (artesian) pressure drives well bore water levels above the top of the aquifer in the City wells. Like water table wells, pumping a well completed in downdip artesian zones will result in the lowering of well bore water levels. However, unlike water table wells, this decline is transmitted outward from the well in the form of a reduction in artesian pressure. Aquifer materials in the confined portion of the aquifer remain fully saturated near the well bore during pumping while artesian pressure levels remain above the top of the aquifer.

Figure 4. Schematic Water Table/Artesian Cross-Section Diagram



Aquifer Transmissivity, Well Efficiency, and Available Drawdown

Maximum well productivity is primarily a function of three parameters: 1) aquifer transmissivity, 2) well efficiency, and 3) available drawdown. The term "transmissivity" describes an aquifer's ability to transmit water through a vertical section of sediments and is used as a general measure of its productivity. All other aspects of a groundwater system being equal, an aquifer with twice the transmissivity of another aquifer can sustain about twice as much production.

Well efficiency is a measure of the ease with which an individual well can transmit water from the aquifer through the screen/gravel pack to the well. Well efficiencies are defined by calculating the ratio of the declines predicted to occur in a theoretical, "perfect" well to the measured drawdown in a real-world well. Typical efficiencies range from about 50% for wells with inexpensive straightwall construction, to greater than 80% for wells constructed for higher-capacity municipal applications.

The vertical distance between the static (non-pumping) wellbore water level and the deepest acceptable pumping water level is commonly referred to as "available drawdown." This distance is important with respect to groundwater availability because, as is the case with aquifer transmissivity, a well with twice as much available drawdown can produce groundwater at twice the rate.

CITY WELLS

The City operates five wells that produce groundwater from the Lower Trinity that were constructed at various times over the past 70 years and range in depth from 352 to 500 feet. Table 1 lists the well names, identification numbers, and general construction information, while Table 2 lists the City well hydraulic parameters calculated from data recorded during testing performed for this evaluation, information included in available state well records, and values estimated from the Northern Trinity-Woodbine Groundwater Availability Model (GAM) maintained by the TWDB (Kelley, et al., 2014).

Well 4 included in Tables 1 and 2 is the current operational Well 4, which was constructed as a replacement for the original Well 4 (TWDB Well Number 3251105). The original Well 4 is no longer used by the City for water production but serves as a District monitoring well. The current Well 4 is not configured to allow water level measurements; consequently, water levels were monitored in the original Well 4 during testing conducted for this evaluation. The water level included in Table 2 was estimated from measurements in the original Well 4 and adjusted for the approximate 4-foot elevation difference between the sites. Similarly, the efficiency listed in Table 2 was calculated from data measured in the original Well 4 during testing and initial testing data included in the State Well Report for the current Well 4.

Table 1. City Well General Information

Well	TWDB/ TDLR ID	PGCD ID	Year Drilled	Casing Diam (in)	Pump Depth (ft)	Screen Interval (ft)	Well Depth (ft)
Well 2 – 303 Elm	3250304	000926	1954	8	294	284 to 352	352
Well 3 – FM 56	3250309	000925	1974	11	359	405 to 465	472
Well 4 – Bryan St.	556604	002156	2020	8-5/8	442	316 to 351; 401 to 457	477
Well 5 - Amphitheater	3242904	000927	1991	7	470	460 to 500	500
Well 6 – Paluxy Summit	3251108	000924	2000	9	357	370 to 410	410

Table 2. City Well Hydraulic Parameters

Well	Static DTW (ft)[1]	Artesian Pressure (ft)	Transmissivity (gal/day/ft)	Efficiency (%)
Well 2 - 303 Elm	197	87	4,300[2]	Not Measured
Well 3 - FM 56	286	119	3,900[2]	Not Measured
Well 4 - Bryan St.	283	118	4,600	59%
Well 5 - Amphitheater	343	117	3,600	57%
Well 6 - Paluxy Summit	236	134	5,500	66%

1) "Static DTW" means non-pumping depth to water

2) Transmissivity obtained from the GAM layer representing the Hosston (Layer 8)

Well Evaluations and Testing

RWH&A personnel visited the five City wells in July 2024 in coordination with City staff to assess the viability of conducting pumping tests at each site. Changes in wellbore water levels measured during pumping tests are typically used to determine the hydraulic characteristics of an aquifer and to detect the presence of hydraulic boundaries, such as geologic faults or outcrop recharge areas, that may affect long-term well yields. To conduct a test at a well, discharge from the well is typically maintained at a constant rate while water levels are measured within the casing for the duration of the pumping and post-pumping recovery period.

Well configurations at each site varied, but all sites were in need of equipment that would allow accurate data collection during testing. With the exception of Well 6, all sites lacked flow meters to monitor the instantaneous pumping rate during testing. None of the wells were equipped with water level measuring tubes that allow for installation of downhole sensors that can record precise measurements of wellbore water levels during testing. During summer and fall 2024, RWH&A worked with the City to design a discharge assembly equipped with an instantaneous digital flow meter and totalizer that could be temporarily attached to the wells during testing. RWH&A also worked with the City to determine whether any of the wells could be retrofitted with small diameter PVC measuring tubes for testing; however, it was found that there was insufficient space between the casings and pump column pipes to install the tubes.

As an alternative to measuring wellbore water levels with sensors lowered into dedicated measuring tubes, water levels can be calculated using an "airline" assembly, which is installed with the pumping equipment in some wells. Larger water level changes can be estimated from measured changes in airline air pressure during testing but, in general, airline measurements lack the accuracy to capture smaller fluctuations in water levels as pumping tests progress. Three wells (Wells 3, 5, and 6) are equipped with airline measuring equipment; however, it was found that the airline installed in Well 3 was not functional.

In October 2024, RWH&A proceeded with pumping tests at the three sites equipped to allow wellbore water level measurements: Wells 4, 5, and 6. Appendix A contains photos of the wellhead infrastructure taken during the initial site visit in July, and the temporary discharge assembly used during each of the three well tests. As discussed above, water levels were monitored using a downhole e-line in the original Well 4 during testing of the current Well 4. Water level declines in Wells 5 and 6 were measured using the existing airlines. The pumping portion of the tests continued until either a consistent drawdown trend was established or until no changes in depth to water could be measured. The duration of the pumping tests ranged from 2.5 hours to 6 hours, after which the pumps were shut down and water level recovery measurements were made. Field water quality parameters (pH, conductance, temperature, and turbidity) were measured periodically during the pumping portion of each test.

Test results were analyzed using the Theis solution (Theis, 1940) and the Cooper-Jacob straight-line method (Cooper & Jacob, 1946) to estimate transmissivity. A correction was applied to the water level drawdown measured in the original Well 4 to account for a pre-test water level recovery trend observed in the data. It should be noted that calculation of an aquifer storage coefficient (storativity) requires water level data from an offset monitoring site during testing; consequently, no storativity values are listed in Table 3 for Wells 5 and 6.

Table 3 summarizes test results and Table 4 lists the average field water quality parameters. Appendix B contains well drawdown charts. A faint "rotten egg" odor was apparent from the discharging water at all of the City wells, which is relatively common for wells completed in the Trinity and typically indicates the presence of naturally occurring, dissolved hydrogen sulfide in the produced water.

Table 3. Summary of Pumping Tests

Well	Pumping Duration (min)	Average Pumping Rate (gpm)	1-Hour Specific Capacity (gpm/ft)	Transmissivity (gal/day/ft)	Storativity (unitless)
Well 4 - Bryan St.	360	201	1.99	4,610	3.9×10^{-4}
Well 5 - Amphitheater	210	156	1.56	3,580	N/A
Well 6 - Paluxy Summit	150	199	2.66	5,530	N/A

min = minutes; gpm = gallons per minute; gal/day/ft = gallons per day per foot.

Table 4. Summary of Field Water Quality Parameters

Well	Average Field Water Quality Parameters			
	pH (SU)	Conductivity (µS/cm)	Temperature (°F)	Turbidity (NTU)
Well 4 - Bryan St.	7.76	624	74	11.22
Well 5 - Amphitheater	8.22	647	75	6.94
Well 6 - Paluxy Summit	8.12	618	74	1.61

SU = standard units; µS/cm = microSiemens per centimeter; °F = degrees Fahrenheit; NTU = nephelometric turbidity units

Groundwater Quality

Table 5 lists the concentrations of some of the commonly reported chemical constituents and parameters from samples collected from the City's wells and wells completed in the Lower Trinity within approximately five miles of the City, as reported in the groundwater database maintained by the TWDB. Table 5 also lists TCEQ primary and secondary standards for public drinking water supplies. Concentrations exceeding primary standards are considered health hazards requiring treatment before use as public drinking water supplies. Though exceedance of secondary standards also requires treatment prior to use in a public water system, these represent aesthetic concerns and do not constitute health hazards.

Total dissolved solids (TDS) concentration is commonly used as a general indicator of water quality. Water with TDS concentrations below 1,000 milligrams per liter (mg/L) is considered fresh, brackish water contains TDS concentrations between 1,000 and 10,000 mg/L, and water with TDS concentrations greater than 10,000 mg/L is considered saline. For reference, the average TDS of sea water is approximately 35,000 mg/L. As shown in Table 5, reported water quality in the Lower Trinity is generally fresh, with average TDS concentrations of 389 mg/L and 399 mg/L reported for the City's wells and other regional wells, respectively. The available data indicate that the chemical quality of the water contained in the Lower Trinity in Central Somervell County is relatively consistent and meets (TCEQ) public supply standards for all reported constituents.

Table 5. Lower Trinity Water Quality within Approximately Five Miles versus City Wells

Parameter	Units	TCEQ Limit	TCEQ Standard	City Min.	City Max.	City Avg.	5 Mile Min.	5 Mile Max.	5 Mile Avg.	5 Mile Count*
Alkalinity	mg/L		None	305	312	308	305	312	308	1
Aluminum	ug/L	200	Secondary	1	<50	1	1	<50	1	4
Antimony	ug/L	6	Primary	<1	<1		<1	<2		3
Arsenic	ug/L	10	Primary	<1	<10		<1	<10		7
Barium	ug/L	2,000	Primary	126	200	149	50	200	101	7
Beryllium	ug/L	4	Primary	<1	<1		<1	<2		3
Bicarbonate	mg/L		None	369	403	383	315	403	371	22
Cadmium	ug/L	5	Primary	<1	<10		<0.5	<10		7
Calcium	mg/L		None	21	26	23	11	31	22	7
Chloride	mg/L	300	Secondary	13	17	15	10	60	22	7
Chromium	ug/L	100	Primary	<1	<20		<1	<20		7
Copper	ug/L	1,000	Secondary	<1	<20		<1	<20		7
Fluoride	mg/L	2	Secondary	0.3	0.4	0.3	0.2	0.6	0.4	17
Iron	ug/L	300	Secondary	<20	<50	22	<20	76	49	4
Lead	ug/L	10	Secondary	<1	<50		<1	<50		7
Magnesium	mg/L		None	20	23	21	6.0	25.0	17.0	7
Manganese	ug/L	50	Secondary	3	<20	4	3	<20	4	4
Mercury	ug/L	2	Primary	<0.2	<0.2		<0.13	<0.2		6
Nitrate (as N)	mg/L	10	Primary	<0.01	<0.01		0	0	0	2
Nitrite (as N)	mg/L	1	Primary	<0.01	<0.01		0.0	0.0	0.0	2
pH	SU	>7	Secondary	7.1	8.3	7.8	6.8	8.7	8.0	20
Selenium	ug/L	50	Primary	<1	<5		<1	<5		7
Silver	ug/L	100	Secondary	<1	<10		<1	<10		6
SAR	Unitless		None	3.1	4.1	3.7	0.84	10.00	5.30	18
Sodium	mg/L		None	90	106	100	86	170	113	7
Sulfate	mg/L	300	Secondary	15	26	21	15	53	31	7
Thallium	ug/L	2	Primary	<1	<1		<1	<2		3
TDS	mg/L	1,000	Secondary	376	401	389	355	466	399	20
Zinc	ug/L	5,000	Secondary	<1	<20	14	<1	57	35	7
Radium 226	PC/L		None	0.70	1.40	1.00	0.70	1.40	1.00	2
Radium 228	PC/L		None	<1	1.5	1.5	<1	1.5	1.5	3
Uranium	ug/L	30	Primary	<1	<1		<1	<1		1

* Number of wells within approximately five miles of the City with laboratory analysis results reported for the indicated chemical parameter.

GROUNDWATER MODELING

RWH&A conducted analytical groundwater modeling using proprietary CAD-based software that utilizes the Theis non-equilibrium solution to estimate wellbore aquifer responses and long-term potential production from the Lower Trinity aquifer beneath the City. Production was modeled over a 30-year period at target artesian pressure levels, which allows for assessment of well field productivity through time based on variations in the acceptable amount of available drawdown to be utilized at each well site.

Model Parameters and Assumptions

RWH&A estimated Lower Trinity aquifer characteristics using data obtained during testing of the City's wells, information compiled from driller's reports submitted to TDLR, and data extracted from the GAM. Table 6 lists the hydraulic parameter and well efficiency values applied to the model simulations conducted for this evaluation.

Note that TWDB Report 98 (Meyers, 1969) includes the results of a Well 2 pumping test conducted in 1947. The results of that test indicate a Lower Trinity transmissivity that is approximately double the values obtained during recent testing of Wells 4, 5, and 6. Because the methodology of and accuracy of the Well 2 test in 1947 cannot be confirmed, RWH&A applied transmissivities included in the GAM for Wells 2 and 3. While no recent water level data are available from Wells 2 or 3, a 50% well efficiency was applied to those sites to account for the decreased efficiency typically observed in older wells.

For each well, the saturated thickness was assigned as the well's screened length across the Hosston. As discussed above, RWH&A included 1.8 feet per year of regional drawdown to all model simulations to account for the ongoing interference effects from other groundwater users in the region.

Table 6. Model Parameters

Well	Transmissivity (gal/day/ft)	Storativity	Initial Artesian Pressure (ft)	Saturated Thickness (ft)	Efficiency (%)
Well 2 - 303 Elm	4,300	3.9×10^{-4}	87	68	50%
Well 3 - FM 56	3,900		119	60	50%
Well 4 - Bryan St.	4,610		118	56	59%
Well 5 - Amphitheater	3,580		117	40	57%
Well 6 - Paluxy Summit	5,530		134	40	66%

When developing public supply well fields and estimating long-term groundwater availability, RWH&A applies a "safety factor" when determining the amount of available drawdown that it is acceptable to utilize over the expected lifespan of the project. In areas such as the City where groundwater is under artesian pressure, RWH&A typically limits available drawdown to 50% of the current artesian pressure at each site. This approach allows for a greater certainty that well field production can be maintained even if increased aquifer development by other groundwater users occurs near the City in the future. In addition, maintaining a reserve of artesian pressure at each well site allows for future increases in peak summer production from the well field.

Using the model parameters in Table 6, RWH&A conducted three model simulations that illustrate the potential increase in overall well field production that may be achieved with decreasing available drawdown safety factor. For each, the available drawdown was limited to a portion of the initial artesian pressure and aquifer saturated thickness to be reserved over a total simulation length of 30 years:

- **Simulation 1 (Typical well field planning safety factor)** – available drawdown is set to 50% of the initial artesian pressure at each well site (the aquifer remains fully saturated)

- **Simulation 2 (Lower well field planning safety factor)** – available drawdown is set to 80% of the initial artesian pressure at each well site (the aquifer remains fully saturated)

- **Simulation 3 (No well field planning safety factor)** – available drawdown is set to 100% of the initial artesian pressure plus 25% of the aquifer saturated thickness at each well site (all artesian pressure is utilized and the saturated thickness of the aquifer at each well is allowed to decline to 75% of the initial, fully saturated value)

Please note that for the purposes of long-term planning RWH&A does not recommend relying on the production amounts associated with Simulations 2 and 3 because those rates and volumes may not be achievable if neighboring pumpage increases in the future. The results of those simulations provide perspective with respect to the maximum well field production that may be achieved from a hydrogeologic standpoint assuming current conditions are maintained over the next 30 years. In addition to the elimination of the available drawdown/artesian pressure safety factor applied to Simulation 3, that model run maintains pumping water levels below the top of the well screen zone, which results in the dewatering of aquifer materials near the well and aeration of the produced groundwater. Introduction of air into the produced groundwater may promote corrosion and bacterial growth within the wellbore.

Model Results

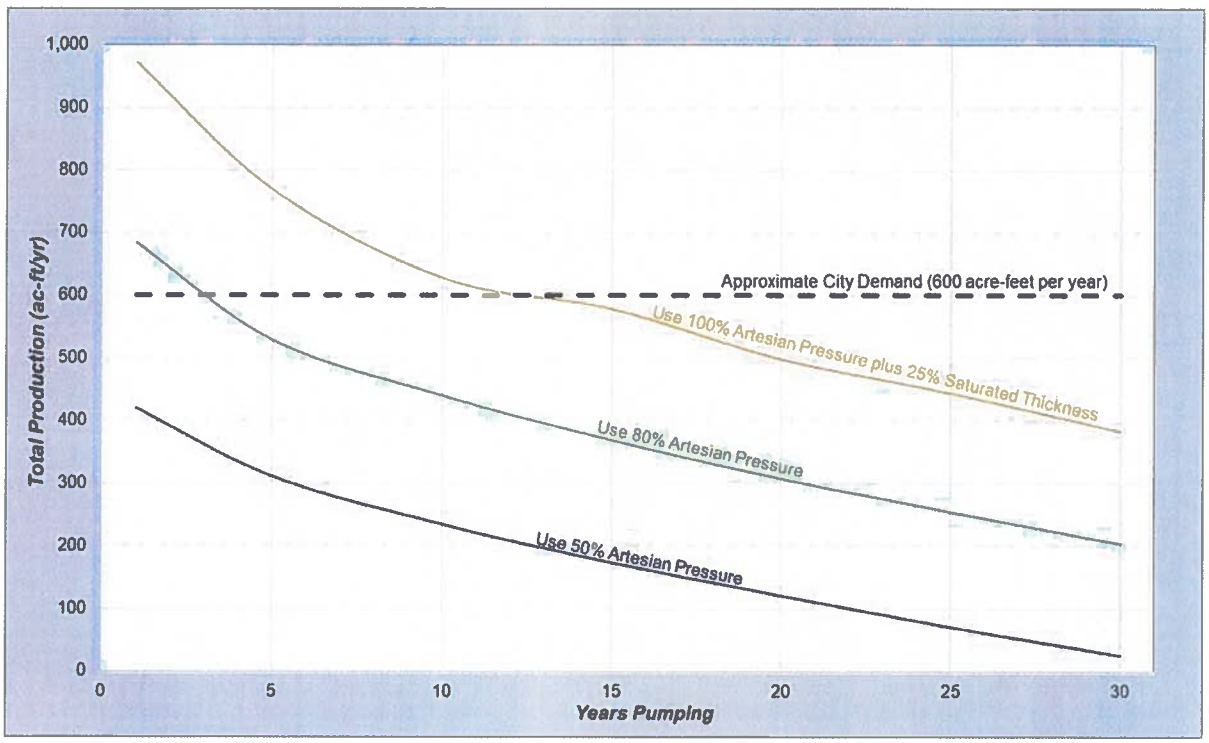
Table 7 and Figure 5 show the results of Simulations 1, 2, and 3. The model results predict that the City's wells may be capable of producing from approximately 420 to 970 ac-ft/yr over the short term, but that production is expected to decline relatively rapidly with ongoing water level declines from the City's wells and interference effects from other groundwater users in the region. The total 30-year estimated production from the City's wells is estimated to range from about 25 to 383 ac-ft/yr, depending on the amount of available drawdown assigned to each well. Please note that the values presented in Table 7 and Figure 5 represent the total production on an annual basis assuming all of the City's wells are running continuously. In practice, more production can be achieved over shorter intervals when all wells are operational, while less water can be produced when wells are pumped for longer intervals or are offline for maintenance or repair.

Table 7. Simulation Results

Simulation Time (Years)	Production (ac-ft/yr)		
	Simulation 1 – Use 50% AP*	Simulation 2 – Use 80% AP*	Simulation 3 – Use 100% AP* plus 25% ST**
1	420	684	972
5	311	531	769
10	234	439	627
15	173	369	577
20	121	307	497
25	70	254	443
30	25	203	382

*AP = Artesian Pressure; **ST = Saturated Thickness

Figure 5. Well Field Production Through Time



GROUNDWATER REGULATION AND PERMITTING

Groundwater use in Ellis, Hill, Johnson, and Somervell counties is regulated by the PGCD. RWH&A reviewed the PGCD Rules (Amended September 18, 2023) to identify regulatory limits on production from the City's existing wells and/or expansion of future production.

Data published by the TWDB (Texas Water Development Board, 2023) indicates that the City's current water demands are approximately 600 ac-ft/yr and are not expected to rise significantly over the coming decades. The City currently holds "historic use" permits issued by the PGCD that allow production of 178,208,000 gallons per year from the City's five existing wells, which is equivalent to 534.6 ac-ft/yr or about 89% of the City's demands.

The amount of water allocated through a historic use permit is determined by a permittee's documented use during the interval between 2004 and 2018. Consequently, historic use permit values cannot be increased once issued; a new operating permit is required if the City wishes to increase future groundwater production above the currently permitted levels. Unlike historic use permits, the PGCD allocates annual groundwater production for new operating permits using a "correlative rights" approach, by which permitted water production is tied to the surface acreage owned/controlled by the permittee. Rule 5.2(b) establishes an initial allocation rate of 50,000 gallons per year per contiguous acre, although Rule 5.2(c) allows the District to modify the allocation rate based on aquifer conditions.

As a member of GMA-8, the PGCD must engage in joint planning with other northern Texas groundwater conservation districts to develop aquifer impact limits and associated groundwater production amounts, which are termed "desired future conditions" (DFC) and "modeled available groundwater" (MAG), respectively. Table 8 lists the MAG values and allocation rates for the aquifers in Somervell County.

Table 8. Aquifer MAG Values and Allocation Rates for Somervell County

Aquifer	***MAG 2020-2080 (Ac-Ft/Yr)***	***Allocation Rate – Rule 5.2(b) (Gal/Ac/Yr)***	***"True" Allocation Rate – Rule 5.2(d) (Gal/Ac/Yr)***
Paluxy	14	50,000	77
Glen Rose	146	50,000	384
Twin Mountains	65	50,000	171
Travis Peak	1,763	50,000	4,642
Hensell	217	50,000	571
Hosston	930	50,000	2,449

It should be noted that the District also establishes a "true" allocation rate (Rule 5.2(d)) by dividing the MAG determined by the TWDB by the area overlying the aquifer footprint. The true allocation rate represents the smallest potential allocation value that may be assigned in the future if the District determines that rates must be reduced in order to achieve an aquifer DFC. As shown, reduction in pumpage equivalent to the true allocation rate would likely result in large cutbacks in associated groundwater production.

PGCD Rule 5.3 allows retail public utilities to apply service area or corporate boundary acreage when permitting correlative rights acreage. PGCD staff have confirmed that the City's area for permitting purposes is the City limit footprint, not the City's extra-territorial jurisdiction (ETJ). The City limits do not encompass sufficient land area to fulfill permit requirements for additional pumpage. The City limits include approximately 2,522 acres, which equates to about 124.421 million gallons per year or about 387 ac-ft/yr. This value is about 72% of the pumpage allowed under the current historic use permit and provides only about two-thirds of the City's current and future demands. Consequently, the City would need to acquire an additional 1,388 acres in order to obtain enough acreage to be able to obtain a new (non-historic use) permit for production of the 600 ac-ft/yr needed to meet the City's demands.

While there are land acquisition hurdles to be overcome to obtain a new permit for 600 ac-ft/yr, the additional 65.4 ac-ft per year required to increase the City's currently permitted amount of 534.6 ac-ft/yr to 600 ac-ft/yr represents a relatively small portion of the MAG values assigned to the target aquifers. Consequently, with respect to regional water planning projections, permitting the proposed supply would likely not meet significant resistance from the District or other users in the region.

CONCLUSIONS

The City's current water demands are approximately 600 acre-feet per year (ac-ft/yr) and are predicted to remain relatively stable over the next several decades. At present, the City obtains most of its water through an agreement with the Somervell County Water District (SCWD), which delivers treated water diverted from the Paluxy River. The SCWD agreement allows the City to use groundwater produced from its existing wells to provide up to 50% of the annual demand during the months of April through September, although all agreement restrictions were temporarily waived in September 2023 during work on SCWD's treatment infrastructure. The City is also supplied by five wells that produce groundwater from the Trinity aquifer.

The City holds "historic use" permits with the PGCD to produce 534.6 ac-ft/yr, which is approximately 90% of the current annual usage. Historic use permit amounts cannot be increased once issued; a new operating permit is required if the City wishes to increase future groundwater production above the currently permitted levels. The PGCD allocates annual groundwater production for new permits based on land acreage. The area within the current City limits is sufficient to obtain a new permit for approximately 387 ac-ft/yr, acquisition of an additional 1,388 acres would be required to obtain a permit for production of the City's full annual demands.

Groundwater modeling conducted for this evaluation indicates that the City's wells cannot fully provide for the City's expected demands over the long-term. Three model simulations were run that applied various well field planning safety factors over a 30-year operational period. When well field planning methodologies typically applied by RWH&A are applied, approximately 420 ac-ft/yr can be produced in the first year from the City's five existing wells, while the modeled annual production volume declines to about 234 acre-feet over a ten year period. Production from the wells is predicted to continue to fall as aquifer artesian pressure levels are impacted by the City's production and pumpage by other groundwater users in the region.

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