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Board of Commissioners Agenda Memo

From: Tim James, P.E. – City Manager

Date: July 16, 2012

Item: Discuss and take any action necessary on Well and Hydrogeological Evaluation Report

Background

The Board of Commissioners approved the contract with R.W. Harden and Associates in November 2011 to complete a study for the potential of increasing the groundwater supply to the City of Burkburnett. The study was to evaluate the existing well field, research the potential for an alternate deep aquifer, and to make recommendations to the City for increasing our groundwater supply. The Well and Hydrogeological Evaluation Report has been completed. The results show that there may be potential for increasing our groundwater supply from the existing aquifer through reconstruction or rehabilitation of the shallow wells. The report also shows that a deeper aquifer (Petrolia formation) around 800 ft was located through research on oil drilling logs. To increase the groundwater supply, the report recommends reconstructing or rehabilitating the existing wells, improving the operation of the well field through optimization, and installing a test well to evaluate the quality and available quantity of the deep aquifer.

R.W. Harden and Associates indicated that the report was to be completed within 60-90 days. An initial report was submitted in February 2012 but did not meet the terms of the agreement so staff directed the consultant to complete the study in accordance with the approved agreement. A revised study was completed in June 2012 and the submitted report met the terms of the agreement. Staff had also requested a proposal for services to move to the next phase of the project which included the necessary resistivity testing, drilling, and installation of test wells to determine the quantity and quality of the deeper aquifer. The proposal was received late and was not in conformance with the request so it was not included on this agenda for consideration.

Fiscal Impact

The funds for the Water Well project were included in the 2010 Revenue Bond which currently has $630,711.39 remaining.

Options

- There is no action needed for the review of the report

Staff Recommendation

N/A

Attachments

Well and Hydrogeological Evaluation Report

Well and Hydrogeological Evaluation Report

Prepared For:

The City of Burkburnett

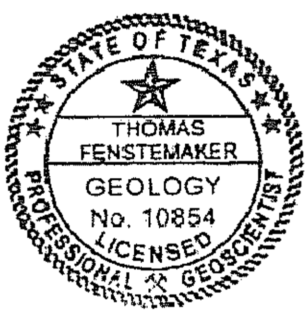
Prepared By:

R. W. Harden & Associates, Inc.

Hydrologists • Geologists • Engineers

Austin, Texas

May 2012



Thomas Fenstemaker

The seal appearing on this document was authorized by Thomas Fenstemaker, P.G. 10854 on May 31, 2012. R.W. Harden & Associates, Inc. TBPG Firm Registration 50033.

Well and Hydrogeological Evaluation Report

Introduction

R.W. Harden & Associates (RWH&A) has completed an initial evaluation of existing wells and subsurface conditions in the City of Burkburnett (City). The City is interested in expanding their existing groundwater supplies in order to reduce their dependence on surface water purchased from the City of Wichita Falls. The purpose of this study is to evaluate the current condition and performance of the City's well fields to determine what, if any, improvements would be useful and to propose a methodology for the City to obtain additional supplies. This study was conducted through performance of the four tasks described below:

> **Task 1** – Compile and review existing information on the aquifers and well fields. Identify any additional aquifers that have the potential to be used as sources for the City's water supply system.
>
> **Task 2** – Familiarize ourselves with the current condition and operation of existing the City wells, well fields, and water treatment facility.
>
> **Task 3** – Conduct preliminary well testing to assist in determining well efficiencies and aquifer characteristics.
>
> **Task 4** – Provide recommendations for development of a total supply of two million gallons per day (MGD), either by rehabilitating the existing wells or installing new wells or a combination of these methods.

A general summary of the findings from each task is provided in the following sections.

Review of Existing Information

The information used to summarize the hydrogeology of the aquifer currently used to supply the existing well field include available well records from the Texas Water Development Board (TWDB), the Texas Department of Licensing and Registration (TDLR), geophysical logs from the oil and gas industry, RWH&A files and information received from City personnel. This information was also used to identify deeper, currently untapped aquifers that may have the potential to provide additional supplies that meet the City's quantity and quality criteria.

Well Yields

The rate of production that may be obtained from a well is dependent on numerous factors including: 1) the amount of groundwater pressure, 2) the vertical distance between the non-pumping (static) water level in a well and the desired maximum pumping level (available drawdown), 3) the ability of an aquifer to transmit groundwater (transmissivity), and 4) the ability of a well to convey water from the aquifer to the surface (well efficiency). Well yields are directly proportional to the amount of available drawdown at the well site and the aquifer transmissivity.

All of the City's wells withdraw from shallow alluvial sediments that are under "unconfined" or "water table" conditions. In this type of aquifer, saturated sediments underlie unsaturated sediments, and a water table represents the boundary between the two zones. When groundwater is pumped from an unconfined well, the saturated thickness of the aquifer is reduced near the well bore as pumping water levels drop, reducing the area through which groundwater can flow to the well. In general, as the saturated thickness declines, groundwater velocity must increase in order to maintain well yields.

Maintaining constant rates of flow through a reduced section of aquifer can result in increased velocity and turbulence in the groundwater flow, which may cause turbidity, and possibly sand production that can lead to premature pump failure. In addition, groundwater may exhibit a milky appearance through aeration as water and air in and near the well bore are mixed when water levels drop below the top of the screen interval.

Typically, wells are designed so that the pumping water level remains above the top of the aquifer production zone, which may coincide with the screened interval in a well. Drawdown below the top of the screen can result in well yield declines and increased turbidity and corrosiveness. Given that several of the City's wells have problems with excessive sediments in the wellbore, it is possible that the pumping water level in some of the City's wells have fallen below the screened interval, the screen and gravel pack were not appropriate for the aquifer materials, the well screens have developed holes, and/or encrustations on the well screen are being eroded due to water level lowering and increased turbulence. Well testing and access to the wells with down hole video equipment may provide the necessary information to properly recommend a course of action. The City should be aware that well replacement may be recommended in some instances. Although aeration and sanding may occur when wells in unconfined aquifers are pumped at rates that cause turbulent flow, development of water table aquifers is a common practice and turbidity, sanding, and corrosion can usually be avoided through proper well design, appropriate production rates, and maintenance to remove encrustations.

Regulatory Considerations

Wichita County is currently not under the jurisdiction of a groundwater conservation district so there are no regulatory issues beyond the state requirements for a public water supply well. The Texas Commission on Environmental Quality (TCEQ) regulates the approval of groundwater wells for use in public water supplies through design, construction and testing standards, as well as and procedures for approval. In recent years the TCEQ has shown a greater interest in shallow unconfined aquifer wells than in the past. Of interest to the City, TCEQ has a program to determine if a groundwater well produces water under the influence of surface water (called GUI). If the City constructs a GUI well that delivers water to the public water supply system, additional monitoring and treatment may be required. Selecting well field locations and well designs carefully may reduce the possibility of constructing a GUI well, thus avoiding the cost of additional monitoring and treatment.

Shallow Alluvial Aquifer

The uppermost formations in the area are the shallow Quaternary age alluvium, terrace deposits, sheet and dune sand deposits located within 2 to 4 miles of the Red River (Figure 1) composed primarily of sand, silt and clay. Some of the driller's reports and well records identify this alluvial material as the Seymour Aquifer. However, for the sake of simplicity, these Quaternary sediments will be collectively referred to as the Shallow Alluvial aquifer in this report.

The majority of wells in the Burkburnett area listed in the TWDB and TDLR databases are currently operating or abandoned/plugged City wells that are completed in the Shallow Alluvium. The Shallow Alluvial Aquifer is relatively thin, typically ranging from approximately forty to seventy feet in depth, and is limited in areal extent. Because the Alluvium is relatively thin and shallow, it is likely more susceptible to drought conditions than deeper aquifer zones. Therefore this aquifer may be susceptible to drought conditions that may result in degradation of both water quantity and quality.

As shown on the attached geology map, the majority of City wells are probably completed in either the Dune Sand or Terrace deposits of the Shallow Alluvial Aquifer (Figure 1). Based on the limited information available, RWH&A estimates that new wells completed in these portions of the aquifer may produce 35-70 gallons per minute. By securing a sufficient number of well sites or rehabilitating/replacing existing well over productive portions of the aquifer, it is likely this aquifer has the potential to supply the City up to two million gallons per day.

In general, the water quality from the Sallow Alluvial aquifer is good, with the exception of nitrate (>10 mg/L) and hardness (>350 mg/L) which are in excess of secondary drinking water standards. The presence of elevated nitrate levels (>10 mg/L) suggests that the aquifer is being directly recharged from surface infiltration, although the elevated levels could be due to surface leakage around inadequately sealed well bores. Because the existing water treatment facility is designed to treat water produced from the Shallow Alluvial Aquifer, it is the most logical target for development and can likely meet the desired two million gallon per day demand. This can possibly be accomplished through: 1) rehabilitation of existing wells, 2) replacement of existing, damaged or inefficient wells, or 3) acquisition of new well sites and well construction.

Deep Aquifer (Petrolia Formation)

The Permian age Petrolia Formation underlies the Shallow Alluvial aquifer at a depth of about 800 to 1,000 feet below ground level. The Petrolia is exposed at the surface from the south end of the City past the Wichita River and dips to the north-northwest at a rate of approximately 30 feet per mile (Figure 1). This formation is comprised of mudstone and shale with interbedded sandstone layers and lenses. Although TWDB records indicate there are only a few wells completed in the Petrolia, analysis of the available information suggests that the deeper sand layers in this formation may provide a potential option for water development.

Examination of a representative sample of geophysical logs near Burkburnett show sand zones in the Petrolia Formation having sufficient thickness (greater than 40 feet) and depth (800-1000 feet below ground level) to permit construction of a well that may be capable of producing 200-300 gallons per minute. Test hole drilling and test well construction will be required to confirm these initial estimates.

Chemistry data from wells completed in this formation indicate a different water quality as compared to the Shallow Alluvial aquifer. Based on the electrical conductivity reported on these geophysical logs, and tests from other wells reportedly completed in the Petrolia Formation within Wichita, Clay and Archer counties, we estimate these layers will have a total dissolved solids (TDS) concentration ranging from fresh water (<1,000 mg/L) to very saline (>8,000 mg/L). A listing of TWB water chemistry records from Wichita, Clay and Archer counties with minimum, maximum and average values for each constituent is presented in Table 1. Deeper wells (>100 feet deep) and wells low in nitrate (<mg/L), indicating water that has not been recently recharged from the surface, may be an indicator of the chemistry expected from the Petrolia in the Burkburnett area. A listing of TWDB low-nitrate (<10 mg/L) chemistry data from deep (>100 ft depth) wells with minimum, maximum and average values for each constituent are shown in Table 2. Although the existing treatment facility probably is not capable of removing dissolved solids, the formation may be a reasonable target for future expansion of the City's water system. It may be possible to incorporate a preliminary evaluation of this resource within the scope of the proposed exploration program. However, a complete evaluation of this potential resource will require a separate exploration and evaluation program. It should also be noted that the potential exists for utilizing desalination technologies to remove dissolved minerals from produced groundwater so that it can be used as a public supply. Desalination was relatively expensive and rare in the past, but is now becoming more common and, subsequently, costs of treatment have declined in recent years.

Current Condition of Existing Facilities

In January 2012, RWH&A personnel conducted a site visit to assess the external condition of the existing well heads and to determine what work might be needed to conduct an aquifer test on selected wells or otherwise gain access to the well casing and screen. It appears that the existing well fields, which consist of a total of 72 wells (not all are active), are regularly monitored and maintained. All of the wellheads have been updated to the same configuration with a sample port, water level measurement port and a flow meter. However, the sites are not equipped with all of the surface completions that would typically be present at public supply wells such as fencing around the well head, electrical connections in appropriate fixtures and well heads protected by proper enclosing structures. Because the City's water demand exceeds the capacity of the existing well fields, each well is monitored on a regular basis to collect flow data and to verify continuous operation.

The current well field was installed over a period of many years and drilling and construction information is not available for most wells. Additionally, no records of well tests were available, preventing an in-depth evaluation of aquifer characteristics and well efficiencies at this time. Therefore, in order to evaluate the performance of the well field, aquifer tests would need to be performed on select wells to estimate well efficiency and the general production characteristics of the wells and the aquifer. Based on these results, RWH&A can perform a more comprehensive evaluation of the existing well field. It may be possible to rehabilitate some of the existing wells through re-lining, mechanical or chemical cleaning of the well and/or more aggressive development to obtain adequate production.

Preliminary Well Tests

In April 2012, RWH&A personnel conducted a second site visit to perform two preliminary well tests. One well was selected to evaluate the characteristics of the Quaternary Dune Sands and one well was selected to evaluate the characteristics of the Quaternary Terrace deposits. Neither of these tests provided a complete evaluation of the shallow alluvial aquifer because of time and equipment limitations. However, these tests were sufficient to document the productivity of the aquifers zones near the wells and to provide examples of the typical well production characteristics. The information collected pertaining to pumping equipment, water production rates and maintenance procedures is key to effective planning of more detailed investigations and for improving and expanding the City's well fields.

The Slama-Green #3 well was tested to evaluate the characteristics of the Quaternary Terrace deposits. Shortly after the first test started, the water level in the well declined to the level of the pump, producing a gurgling noise from the outflow pipe. City personnel stated that this was normal behavior for this and several other City wells. The outflow of the pump was decreased using a gate valve installed on the test assembly and the test was restarted. Once again, the water level declined to the level of the pump (Figure 2), albeit over a slightly longer period of time. At this point testing on this well was discontinued because of time constraints. The transmissivity (a measure of the general productivity of an aquifer) of the Terrace Deposits calculated from the results of the second aquifer test is approximately 176 gallons per day per foot of drawdown. This is a relatively low value for fluvial terrace deposits and may not be an accurate indicator of the hydraulic characteristics of these sediments.

The Cooper #3 well was selected to evaluate the characteristics of the Quaternary Dune Sands. The pumping portion of this test ran for a little more than twenty hours and produced an unexpected result that has proved to be very informative. After approximately five hours the output of the pump output began to decrease slightly. After just over seven hours the water level in the well began to oscillate (Figure 3), suggesting that the pump output began to fluctuate. Flow measurements taken towards the end of the pumping portion of the test support this hypothesis. Because this portion of the test ran overnight the measurements are not detailed enough to confirm the hypothesis. The transmissivity of the Terrace Deposits calculated from the results of the second aquifer test is approximately 7,000 gallons per day per foot of drawdown. This is within the range of transmissivity values one might expect from these deposits but, similar to the Slama-Green #3 well, the value is on the middle to lower end of the range of typical values and may not be an accurate indicator of the hydraulic characteristics of these sediments.

During the course of these pump tests, RWH&A personnel also observed the operation (flow) of well in the Hurd-H, Hurd-T, and Ellis well fields over a short period of time. In each of these well fields, a similar pattern was observed, with one or more wells running slowly (<~8 GPM), one or more wells were running at a moderate speed (>~8 and <~12 GPM) and one well was running fast (>~20 GPM). City personnel indicated that the exact configuration of the pipes connecting each well to the main pipeline (collector systems) running to the transfer station on the Prescott lease is not known. Although it is not possible to make a determination from these observations, it is possible that the collector systems are configured in such a way that the output of one well interferes with the output of another well in the same well field. Another possibility is that the collector systems have become at least partially blocked with sand or other material over time.

Conclusions

Based on the preliminary data obtained from the background research and initial well tests, the City should be able to obtain up to two million gallons of water per day from the Shallow Alluvial Aquifer. This best approach to develop this supply in an economic manner will be to combine modifications to the operations and maintenance program with additional wells in new well fields and a rehabilitation program for existing wells. A more comprehensive testing program should be conducted to determine the most favorable location and configuration of the new additions to the City's well field and to evaluate the effectiveness of rehabilitating existing wells.

During the testing of the Slama-Green #2 well, well bore pumping levels declined to the pump intakes. Submersible pumps require that the pump be submerged under a minimum (manufacturer-specified) depth of water to function properly. One of the primary reasons for this submergence is to provide adequate cooling for the pump motor. In order to keep these wells from "tripping off" every few days, their outflow should be restricted to maintain this minimum submergence. Even though a well may not produce as many gallons per minute as possible at a given moment, continuous operation of lower-yield wells will increase the average productivity and reliability of the wells, while decreasing wear on pumping equipment.

While setting up the testing equipment on the Cooper #3 well, City personnel indicated that the pump was believed to be (at least partially) covered in sand or "sanded-in". If this is the case, the yield fluctuations observed during the test may be due to motor malfunction due to improper cooling. As discussed above, submersible pumps require not only a depth of water above them; they also require free-flowing water to cool themselves effectively. The depth of infilling sediments in the City's wells should be measured periodically to determine when a well needs to be cleaned in order to prevent damaging the pumps. Conducting these tests on other wells will help City personnel maintain and operate the well field. In order to minimize the labor cost of conducting these tests, a pump/aquifer testing rig with automatic data collection capabilities should be acquired by the City.

Currently, the records of the City's well fields are kept in a variety of formats (i.e. paper records and excel files). Information pertaining to the configuration of the well field piping systems (routing, pipe sizes, connection points, etc.) is also limited. Whenever practical, this information should be compiled and organized into consistent, digital formats to facilitate easier access by City personnel. On a regular basis during the recommended well field assessment and possible well drilling and installation, data will be recorded in electronic databases and preserved for future use. Finally, any other gaps in data coverage will be identified to be addressed in future work.

Recommendations

RWH&A has prepared the following recommendations to describe the general process of obtaining additional supplies that meet the treatment plant capacity. In general, and because of the large number of wells, RWH&A recommends that a phased approach is taken so that the extent of problems can be identified and the solutions implemented at a reasonable cost. Therefore, we recommend conducting the following phases of work in the order described below and as needed. The following points summarize the findings of this evaluation and RWH&A's recommendations on how the project should move forward:

1) **Map the Well Collector Piping Layout** – The configuration of the well field transmission pipelines in conjunction with cycling of individual wells may result in excessive back-pressure at some points in the system which can limit well production rates. In order to determine whether this is the case, the configuration of the piping system connecting each well to the twelve-inch water main feeding into the storage tank on the Prescott lease should be mapped. This task can be accomplished by City personnel using readily available rental equipment. The results of this work can be included in the recommended database/GIS mapping system. This work can be expanded to include mapping the collector systems from all of City's wells, if desired.
2) **Additional Testing of the Existing Well Field** – To assess operation of individual wells in addition to investigating the hydrologic characteristics of the Shallow Alluvial aquifer, RWH&A recommends acquiring an automatic data recording system for City personnel to conduct aquifer/pump tests on existing City wells. The baseline information compiled during these tests will be used to focus efforts in later tasks and to gage the effectiveness of changes to the system.
3) **Compile Existing City Data into a Database System** – We recommend that a database be constructed to facilitate the management of the City's wells. The data will be analyzed to determine the actual cost of producing water from each of the City's wells as accurately as possible. Several of our existing clients have found GIS systems useful for tracking their wells and collection/distribution infrastructure. Working with City personnel, RWH&A can generate graphic user interfaces necessary to create a tool that will be useful in managing the City's well fields and distribution system.

4) **Improvements to Existing Well Field** – The City currently expends a great deal of effort to maintain the current well field. The preliminary well/aquifer testing suggests that poor well efficiency, over-pumping of wells, and sanding problems may be limiting the productivity of the City's well fields. This phase of the project will investigate improvements that can be made to the existing well field to improve production and/or reduce the effort required to maintain well field production levels. There are three types of improvements to the existing well field that may be recommended, depending on the results of the testing. Because RWH&A is uncertain of the effectiveness of these solutions, a pilot program is recommended to evaluate a small set of wells, perhaps five or ten, and select one well to be re-lined to gage the success of the available well rehabilitation techniques on the City's wells.

   i. *Rehabilitation* - Testing on the selected sample of wells has indicated possible problems with poor well efficiency, over-pumping of wells and sanding problems that have caused pumping issues. Down-hole video surveys will be recorded to identify issues impacting well productivity such as details of the screen configuration and indications of problems like screen and gravel pack fouling. If the well conditions are favorable RWH&A will conduct and oversee a pilot project to install a new liner and gravel pack in an existing well. This work would only be conducted on a well that has the potential for additional production and screens and casing that are suitably constructed and in reasonably good condition.

   ii. *Replacement* - Well replacement will be recommended at sites where the aquifer is productive, but the screen and/or casing are deteriorated beyond the ability to rehabilitate. This would allow the City to keep a productive site and utilize existing infrastructure.

   iii. *Abandonment* - Some wells, no matter the amount of rehabilitation, were probably completed in unproductive portions of the aquifer. The cost of the rehabilitation or replacement must be weighed against anticipated improvement and the cost for evaluating, acquiring, and providing infrastructure to a new site. If enough wells are located at productive sites, the poor productivity sites can be abandoned or used as back-up capacity. At this time, it is impossible to recommend rehabilitation, replacement, or abandonment without testing. However, RWH&A recommends that testing, replacement and rehabilitation proceed in a phased manner so that increases in capacity can be obtained in a cost-effective manner.

5) **Improvements to Operations of Existing Well Field** – As mentioned previously, preliminary well/aquifer testing has indicated possible problems with poor well efficiency, over-pumping of wells, and sand infiltration may have reduced individual well yields in some cases. While many of these problems are likely due to the physical condition of the wells, operational procedures may also affect overall productivity of the City's well fields. This phase of the project will continue the

assessment of current procedures and identify potential improvements that can be made to the existing well field operations to improve production, reliability, and reduce the effort required to maintain production levels. The following are examples of the types of procedures that may be implemented to increase productivity while decreasing O&M costs:

i. *Restrict Individual Well Production* – During the testing of the Slama-Green #2 well, the water level decreased until it neared the pump, which resulted in air-ingestion and/or cavitation and subsequent fluctuation in well yield and increased wear on the pump and motor. Where testing indicates, the outflow from a well should be restricted to ensure that pumping levels do not drop below the level necessary for proper pump submergence.

ii. *Perform Regular Monitoring and Maintenance on Wells* – There is no regularly scheduled maintenance program for the City's wells at this time. It is recommended that regular measurements of pertinent information such as operating water levels and well depth (to determine how much sand has accumulated in a particular well) be conducted. It is also recommended that this information be incorporated into a database to aid in tracking maintenance needs and costs. By performing regular monitoring and maintenance the City should be able to reduce or at least schedule the amount of maintenance required by an individual well. Additionally, the information will also be useful in future well rehabilitation, replacement and/or abandonment determinations.

iii. *Switch from Rigid PVC Drop Pipe to Flexible Drop Pipe* – Switching to flexible drop pipe should reduce the time required to remove and re-install a pump in an existing City well. This system does not require that City personnel stop every twenty feet to make a pipe connection when installing or removing a pump. This should make well maintenance and pump replacement less time-consuming thereby reducing the City's maintenance costs.

6) **Exploration of New Well Field Areas** – Based on the results of the preliminary well/aquifer tests, RWH&A recommends that an exploration program be conducted to determine the likeliest areas to develop a new well field in the Shallow Alluvial Aquifer. The initial areas recommended for investigation are located between the Prescott and Cooper leases near the existing twelve-inch water main running along Farm to Market Road 1177. A second area of investigation along Ashton Road, between Gilbert creek and the City Water Treatment Facility can be added to this investigation if desired.

Inquiries should be made to determine the possibility of accessing and possibly acquiring properties in the preferred area(s) to conduct an initial investigation to determine the feasibility of constructing new well fields. Once land availability appears feasible, then a geophysical investigation and test hole drilling program may be performed to evaluate the identified properties for suitability as a well/well field site:

i. *Surface Geophysical Investigation* – An initial surface geophysical investigation will cover a larger area with less surface impact compared to traditional test hole drilling. This investigation will use one or more electrical and/or electromagnetic techniques to determine the subsurface characteristics of existing and potential Shallow Alluvial well fields. This method has proven to be a comparatively inexpensive way to locate production wells over portions of the aquifer that have thicker sands and will therefore be more productive, reducing the capital cost per gpm of capacity.

ii. *Test Hole/Pilot Well Drilling* – After the geophysical investigation identifies a suitable area, specific sites will be selected for test hole drilling. This will require a traditional test hole program where a small diameter hole is drilled, the sediments are logged, and down-hole geophysical data are collected at a given location. When the test hole indicates conditions are favorable, a pilot well will be installed to determine actual aquifer characteristics of production and water quality. It should be noted that the geophysical program described above significantly reduces the number of test holes need to locate productive sites.

7) **Well Field Design and Installation** – It is likely that additional wells/well fields are needed to obtain 2 MGD of capacity. In order to reduce the number of wells needed for the desired production capacity, wells should be tailored to the unique conditions at each well site. As opposed to a "cookie cutter" approach, well designs will focus on utilizing the methods and materials suited to increasing well productivity and reliability, while reducing the rate at which sediments infiltrate and accumulate in the well bore. Preliminary estimates obtained from contractors suggest that each additional well will cost $25,000 to $35,000 each. This cost includes the well construction, pumping equipment, and water quality testing necessary for TCEQ interim approval for a public water supply well. It does not include exploration, transmission piping, property acquisition, easements, electrical infrastructure (possibly including some SCADA controls), roads, fencing or engineering costs.

8) **Exploration of the Deeper Aquifer (Petrolia Formation)** – Based on the results of the preliminary investigation by RWH&A, the potential exists for utilizing deeper aquifer zones in the Petrolia Formation as a future water source. If this option is pursued, it is recommended that a geophysical investigation and test hole drilling program be conducted to verify the long-term availability and chemical quality of Petrolia groundwater. Because of the costs involved with this work, RWH&A recommends that this program be considered as an option to be conducted if

sufficient funds are available after all other exploration, well design and production well installation work is complete. The following provides brief descriptions of the investigative methods:

i. *Surface Geophysical Investigation* – An initial surface geophysical investigation will cover the target areas with less surface impact compared to traditional test hole drilling. This investigation will use one or more electrical and/or electromagnetic techniques to determine the subsurface characteristics of the deeper Petrolia Formation. This method is a relatively inexpensive way to locate deeper, potentially productive areas aquifer zones, reducing the cost of exploration drilling.

ii. *Test Hole Drilling* – After the geophysical investigation identifies a suitable area, a specific test hole site will be selected. A small diameter hole will be drilled, the sediments are logged, and down-hole geophysical data will be collected at that location. When the test hole indicates conditions are favorable, a temporary well will be constructed to conduct short-term aquifer testing and sampling.

Table 1: All Petrolia and Wichita Formation Wells in Wichita, Clay and Archer Counties

State Well Number	County	Aquifer	Well Depth	Silica	Calcium	Magnesium	Sodium	Potassium	Strontium	Carbonate	Bicarbonate	Sulfate	Chloride	Fluoride	Nitrate	p.H	Total Hardness	TDS
2006203	Clay	PETROLIA	100		2.6	0.58	411	2.2	0.2	12	468.61	113	268	0.57	0.04	8.55	9	1041
2006202	Clay	PETROLIA	80	12	29	5.5	177			15.6	339.26	34	96	0.9	4.92	8.5	94	541
2036101	Archer	WICHITA	80	10	25	15	596			0	516.21	266	502	1.7	1	7.9	124	1670
2034101	Archer	WICHITA	20	14	160	58	560			0	352.68	185	835	1.2	178	7.4	637	2164
2035701	Archer	WICHITA	28	14	178	103	671			0	424.68	279	1016	2.4	225	7.7	867	2697
2035701	Archer	WICHITA	28	20	332	139	549			0	412.48	266	1364	0.9	116	7.4	1400	2989
2016601	Clay	WICHITA	500	12	2	0.3	331			16	532	72	132		1.2	8.5	6	828
2035402	Archer	WICHITA	200	4	96	47	2760			0	246.51	1343	3393	2.2	0.4	7.2	432	7766
2035401	Archer	WICHITA	100	5	222	53	379			0	375.11	196	790	0.4	0.4	7.3	771	1830
2034104	Archer	WICHITA		17	266	51	745			0	272.14	36	1532	0.9	5.5	7.6	873	2787
2034104	Archer	WICHITA		19	132	19	197			0	319.73	39	356	0.8	29.8	8.1	407	949
2034104	Archer	WICHITA		16	412	80	702			0	286.78	88	1721	0.7	72	7.7	1357	3232
2034104	Archer	WICHITA			215	36	394	3.6	1.7	0	312.41	57	872	0.7	57.29	7.08	686	1791
2034102	Archer	WICHITA	20	15	45	24	252			0	600.41	27	177	0.9	0.4	7.5	211	836
2033606	Archer	WICHITA	28	12	82	20	35			0	273.08	33	32	0.8	65	7.3	286	414
2033605	Archer	WICHITA	30		129	32	169	1.8	0.9	0	290.44	59	354	0.44	65.21	7.11	454	954
2033605	Archer	WICHITA	30	14	282	70	469			0	281.9	71	1154	0.5	58	7.2	991	2257
2033604	Archer	WICHITA	80	13	88	82	346			0	488.14	234	372	4.1	112	7.6	556	1491
2033603	Archer	WICHITA	18	14	113	27	240			0	399.05	189	274	0.9	10	7.4	393	1064
2033602	Archer	WICHITA	70	9	46	12	221			0	389.29	72	177	0.7	4	7.7	164	733
2033601	Archer	WICHITA	20	13	63	30	174	2		0	471.05	63	149	0.6	23	7.9	280	749
2033601	Archer	WICHITA	20	13	95	75	293			0	429.56	147	440	2.8	70.97	8.3	545	1347
2033601	Archer	WICHITA	20	12	67	50	201			0	522.31	71	206	1.5	10	7.6	372	875
2033508	Archer	WICHITA	50		181	133	599	9.2	1.83	0	493.02	837	796	0.64	58.26	7.15	1000	2858
2033508	Archer	WICHITA	50	14	107	67	318	4		0	572.34	331	309	0.7	23.2	8.2	542	1455
2033508	Archer	WICHITA	50	14	110	61	268			0	584.55	276	242	0.9	3	7.3	525	1262
1462502	Clay	WICHITA	50		55	9.6	61	1.8	0.2	0	290.44	19	8	0.65	48.34	7.19	176	346
1462502	Clay	WICHITA	50	25	56	8	73			0	328.27	21	9	0.6	44	7.9	172	398
2033505	Archer	WICHITA	65	11	46	11	193			0	368.54	29	163	0.6	13	7.4	160	647
2023201	Clay	WICHITA	182	9	12	4	1120			7.2	505.22	529	1108	2.5	1.5	8.4	46	3041
2012601	Archer	WICHITA	80	9	25	23	2185			0	781.02	612	2588	2.1	0.4	7.8	157	5828
1464701	Clay	WICHITA	190	13	32	30	325			2.4	699.26	92	174	1.2	0.4	8.3	203	1013
2015801	Clay	WICHITA	60	38	87	27	212			8.4	711.46	65	89	0.6	0.9	8.4	328	877
2005601	Clay	WICHITA	90	14	14	8.2	302			0	505	37	192	0.5	0	7	68	816
2005601	Clay	WICHITA	90	13	16	14	280			0	533.29	37	175	0.5	0.4	8.3	97	798
2006201	Clay	WICHITA	102	12	56	9	120			1.2	351.46	21	96	0.8	3.8	8.3	176	492
2007501	Clay	WICHITA	180	13	175	53	217			0	328.27	171	273	0.7	392.9	8.3	654	1457
2007501	Clay	WICHITA	180	12	110	40	96			0	314.85	53	143	0.6	167	8	439	776
2008301	Clay	WICHITA	155	11	27	14	636			0	485.7	436	466	1.9	3.2	8.1	124	1833

State Well Number	County	Aquifer	Well Depth	Silica	Calcium	Magnesium	Sodium	Potassium	Strontium	Carbonate	Bicarbonate	Sulfate	Chloride	Fluoride	Nitrate	p.H	Total Hardness	TDS
2008301	Clay	WICHITA	155	14	62	32	34	6		0	308.75	43	25	0.8	36.86	8.3	286	405
2014103	Clay	WICHITA	110	12	93	74	1182			0	496.68	439	1640	2.2	16	7.8	536	3702
2015501	Clay	WICHITA	106	16	87	20	153			0	467.39	53	104	0.5	80	8	299	743
2015501	Clay	WICHITA	106	17	82	29	204			0	506.44	78	160	0.5	55.73	7.9	323	875
2015501	Clay	WICHITA	106		107	29	135	3.6	0.78	0	517.43	83	102	0.58	61.31	7.03	387	777
1463701	Clay	WICHITA	20	12	33	20	302			0	610.17	99	147	1.6	14	8.1	164	928
2021707	Archer	WICHITA	90	8	11	8.4	825			0	602.85	227	803	0.8	0.4	8.1	62	2180
2021401	Archer	WICHITA	90	17	56	9.85	16			0	197.7	21	21	0.4	3.5	7.5	180	241
2021402	Archer	WICHITA	90	8	19	6	336			0	495.46	6.2	283	0.7	0.4	7.6	72	902
2021403	Archer	WICHITA	90	9	8.6	3.55	468			0	322.17	24	550	0.7	0.4	7.7	36	1222
2021404	Archer	WICHITA	80	24	80	16	44			0	405.15	13	10	0.5	2	7.6	265	388
2021405	Archer	WICHITA	80	11	86	18	233			0	351.46	142	263	0.3	11	7.8	288	937
2021406	Archer	WICHITA	80	11	40	26	226			0	412.48	55	230	0.6	0.4	8	206	791
2021407	Archer	WICHITA	50	16	115	30	124			0	427.12	64	180	1	9	7.5	410	749
2021703	Archer	WICHITA	70	10	44	15	152			0	375.87	54	97	1	4	7.5	171	561
2021704	Archer	WICHITA	57	15	92	20	170			0	395.39	225	105	0.6	0.4	7.6	311	822
2021803	Archer	WICHITA	36	11	92	33	208			0	375.87	124	222	0.7	76	7.4	365	951
2021706	Archer	WICHITA	80	8	18	19	894			0	658.99	245	904	1.1	0.4	8.3	123	2413
2021202	Archer	WICHITA	79	9	124	51	971			0	646.78	471	1089	1.2	3	7.9	519	3037
2021708	Archer	WICHITA	84	9	34	26	647			0	534.51	223	679	0.7	0.4	7.4	191	1881
2021709	Archer	WICHITA	60	8	109	84	432			0	439.32	184	630	0.8	112	7.8	617	1775
2021710	Archer	WICHITA	75	12	48	16	291			0	483.26	109	224	0.6	27	7.7	185	965
2021711	Archer	WICHITA	90	12	31	15	213			0	453.97	43	138	1.6	2	7.6	139	678
2021712	Archer	WICHITA	82	12	244	148	633			0	488.14	605	855	1.8	336	7.5	1217	3074
2021713	Archer	WICHITA	90	10	5.8	3.75	328			0	529.63	46	202	0.9	0.4	8.1	29	857
2021714	Archer	WICHITA	70	14	79	8.9	57			0	400.27	11	12	0.6	7	7.8	233	386
2021715	Archer	WICHITA	59	8	6.6	3.75	386			14.4	739.53	30	153	0.8	0.4	8.6	31	966
2021801	Archer	WICHITA	110	12	42	11	83			0	312.41	24	38	0.5	3	7.6	150	367
2033507	Archer	WICHITA	30	12	102	43	223			0	251.39	129	372	1.3	64	7.4	431	1069
2021705	Archer	WICHITA	54	11	20	11	184			0	429.56	41	77	1	0.4	7.9	95	556
2020504	Archer	WICHITA	100	8	4.4	1.95	548			0	488.14	25	514	1	0.4	8.3	19	1342
2020504	Archer	WICHITA	100	8	12	3	260			0	267.26	43	236	0.8	16	8.3	42	710
2012901	Archer	WICHITA	30		102	74	824	5.3	1.32	0	540.61	300	999	0.62	213.7	7.38	560	2786
2012901	Archer	WICHITA	30	9	87	57	734			0	536.95	234	871	0.6	148	8	451	2404
2012901	Archer	WICHITA	30	13	176	145	1047			0	447.87	370	1551	0.7	503	8	1035	4025
2012901	Archer	WICHITA	30	9	81	57	768			0	534.51	217	947	0.9	105	7.7	436	2447
2013701	Archer	WICHITA	50	14	51	7.9	106			0	408.82	8.2	31	0.6	0.4	8.1	159	420
2013701	Archer	WICHITA	50	16	49	13	151			0	500.34	15	43	0.6	0.4	7.7	175	534
2013702	Archer	WICHITA	65	6	46	15	158			0	388.07	33	119	0.6	0.4	7.9	176	568
2013702	Archer	WICHITA	65	7	54	12	189			0	345.36	18	218	0.4	0.44	8.2	184	668
2013702	Archer	WICHITA	65		142	89	931	2.5	2.08	0	381.97	324	1462	1.12	33.91	7.31	722	3175

State Well Number	County	Aquifer	Well Depth	Silica	Calcium	Magnesium	Sodium	Potassium	Strontium	Carbonate	Bicarbonate	Sulfate	Chloride	Fluoride	Nitrate	p.H	Total Hardness	TDS
2013801	Archer	WICHITA	60	13	69	31	181			0	483.26	46	169	1.2	8	7.7	299	755
2013802	Archer	WICHITA	35	14	75	14	28			0	319.73	12	18	0.4	1.5	7.7	244	320
2013803	Archer	WICHITA	70	11	32	13	359			0	461.29	58	333	1.3	0.4	7.9	133	1034
2013804	Archer	WICHITA	80	12	44	17	174			0	427.12	44	93	0.7	29	7.9	179	623
2019701	Archer	WICHITA	25	13	121	29	81			0	248.95	114	130	0.6	111	7.7	421	722
2019801	Archer	WICHITA	21	15	129	39	142			0	291.66	163	121	0.6	272.84	8	482	1025
2019801	Archer	WICHITA	21	12	158	55	175			0	273.36	192	176	0.6	390	8	620	1293
2019801	Archer	WICHITA	21	13	181	55	157			0	274.58	177	174	0.5	464	7.6	677	1356
2020501	Archer	WICHITA	90	9	36	15	570			0	319.73	217	650	1.5	2	7.7	151	1657
2020501	Archer	WICHITA	90	8	67	23	248			0	325.83	149	259	0.9	14	8.3	261	929
2021204	Archer	WICHITA	42	10	54	13	97			0	283.12	21	49	0.3	82	7.7	188	465
2020503	Archer	WICHITA	100	8	7.6	2.9	699			0	541.83	39	755	0.8	0.4	8.2	30	1779
2021203	Archer	WICHITA	85	8	37	19	2254			0	530.15	411	3058	1.8	0.4	7.9	170	6049
2020505	Archer	WICHITA	88	8	4.6	3.53	729			0	568.68	43	772	0.8	0.4	8.1	26	1840
2020506	Archer	WICHITA	100	10	15.4	3.5	746			6	606.51	47	793	1.5	0.8	8.4	52	1921
2020601	Archer	WICHITA	40	17	84	24	121			0	478.38	45	81	0.8	4	7.3	308	612
2020602	Archer	WICHITA	75	16	35	16	160			0	419.8	30	93	0.3	0.4	7.6	153	557
2021101	Archer	WICHITA	42	14	116	28	74			0	151.32	69	140	0.6	204	7.4	404	720
2021201	Archer	WICHITA	80	8	12	11	362			12	568.68	100	189	0.7	0.4	8.4	75	974
2021804	Archer	WICHITA	50	14	57	22	95			0	410.04	30	31	1.3	34	7.5	232	485
2020502	Archer	WICHITA	125	14	246	96	1142			0	446.65	398	1954	0.7	36.9	8.1	1008	4107
2020502	Archer	WICHITA	125	12	20	10	287			0	414.92	17	268	0.5	0.4	7.8	91	818
2029203	Archer	WICHITA	80	10	44	22	515			0	449.09	148	558	0.6	17	7.7	200	1535
2028501	Archer	WICHITA	76	10	44	13	97			0	273.36	32	77	0.9	19	7.8	163	427
2028501	Archer	WICHITA	76	12	65	19	136			0	262.37	45	143	0.7	92.28	8.3	240	641
2028501	Archer	WICHITA	76	12	68	19	113			0	264.82	43	113	0.8	81	8	247	580
2028701	Archer	WICHITA	25	14	68	19	97			0	302.65	51	81	1.2	33	7.1	247	513
2028901	Archer	WICHITA	30	14	84	29	75			0	319.73	55	82	0.9	55	7.6	328	552
2028902	Archer	WICHITA	80	12	47	15	66			0	317.29	22	23	0.6	0.4	7.3	178	342
2029102	Archer	WICHITA	140		6.5	4	347	4.1	0.27	4.8	453.97	61	243	0.75	2.21	8.09	32	897
2029102	Archer	WICHITA	140	7	6.4	4.75	335			0	468.61	57	237	0.8	0.4	8	35	878
2029102	Archer	WICHITA	140	9	8	23	328	3		0	450.31	63	238	0.7	0.4	8.2	114	894
2029102	Archer	WICHITA	140	8	9	5	356			15.6	483.26	41	251	0.7	0.18	8.6	43	924
2029103	Archer	WICHITA	90	7	13.8	5.2	691			0	754.17	194	520	3.1	28	8.2	55	1832
2029103	Archer	WICHITA	90	7	12	6	710			0	781.02	211	540	3.5	16	8.2	54	1889
2029104	Archer	WICHITA	26	14	234	59	177			0	256.27	117	346	0.6	480	7.3	826	1553
2029105	Archer	WICHITA	23	12	100	32	147			0	297.76	74	197	0.8	120	7.4	381	829
2021802	Archer	WICHITA	56	15	41	6.6	103			6	286.78	19	55	0.5	6.91	8.4	129	394
2021802	Archer	WICHITA	56	12	46	11	94			0	322.17	21	55	0.8	0.4	7.5	160	398
2021802	Archer	WICHITA	56	10	33	5.6	101			0	281.9	18	48	0.5	3.8	8.3	105	358
2029202	Archer	WICHITA	120	9	16	9.5	734			0	732.21	219	587	1.2	0.5	7.8	79	1936

State Well Number	County	Aquifer	Well Depth	Silica	Calcium	Magnesium	Sodium	Potassium	Strontium	Carbonate	Bicarbonate	Sulfate	Chloride	Fluoride	Nitrate	p.H	Total Hardness	TDS
2028203	Archer	WICHITA	30	14	86	28	222			0	323.39	117	287	1	53	7.8	329	967
2028203	Archer	WICHITA	30	16	91	36	273			0	344.14	139	325	1	73.67	8.1	375	1123
2028203	Archer	WICHITA	30	15	76	28	181			0	314.85	89	184	1.2	98	7.6	304	827
2029208	Archer	WICHITA	58	12	53	35	186			0	497.9	57	157	0.4	0.4	7.9	276	745
2029210	Archer	WICHITA	90	9	1.6	0.3	209			18	392.95	28	56	0.9	2	8.9	5	518
2029210	Archer	WICHITA	90	11	3	0.4	227			0	481	27	55	0.9	0.4	8.2	9	561
2033201	Archer	WICHITA	90	8	35	38	1056			0	485.7	491	1159	2	0.4	8.1	243	3028
2033301	Archer	WICHITA	45	12	354	115	248			0	367.32	934	390	0.8	64	7.2	1356	2298
2033302	Archer	WICHITA	50	10	75	34	83			0	366.1	59	70	0.9	68	7.7	327	579
2033501	Archer	WICHITA	90	14	47	30	298			0	430.78	96	307	0.7	0.4	8	240	1004
2033501	Archer	WICHITA	90	14	32	24	258			0	502.78	88	160	0.9	0.4	7.7	178	824
2033502	Archer	WICHITA	52	14	185	101	440			0	544.27	542	508	1.4	104	7.4	877	2163
2033503	Archer	WICHITA	70	2	38	6	8.8			0	58.58	36	35	0.2	0.4	7	119	155
2033504	Archer	WICHITA	65	13	18	18	165			0	451.53	32	53	0.7	0.4	8.2	118	522
2033504	Archer	WICHITA	65	16	21	14	168			14.4	423.46	22	60	0.6	1.06	8.6	109	525
2033504	Archer	WICHITA	65	14	19	15	162			8.4	417.36	33	59	0.6	1.2	8.5	109	517
1463403	Clay	WICHITA		10	54	34	253			0	464.95	63	271	0.5	4.8	8	274	918
2029106	Archer	WICHITA	11	14	62	16	59			0	344.14	16	18	0.7	13	7.7	220	367
2021805	Archer	WICHITA	28	17	21	5.2	22			0	102.51	9.6	13	0.4	11	7.3	73	149
2021806	Archer	WICHITA	35	10	22.4	10.8	166			0	366.1	65	71	0.6	4	8.1	100	529
2021807	Archer	WICHITA	65	12	35	16	183			16.8	402.71	100	73	0.5	1.5	8.9	153	635
2021808	Archer	WICHITA	25	14	125	26	190			0	358.78	84	296	0.9	30	7.8	418	942
2021809	Archer	WICHITA	25	17	64	13	57			0	161.09	35	71	0.4	84	7.7	213	420
2021810	Archer	WICHITA	36	13	31	23	329			0	536.95	93	262	1.1	0.4	8.1	171	1016
2021812	Archer	WICHITA	75	7	44	15	116			0	290.44	47	90	0.3	22	7.9	171	484
2021813	Archer	WICHITA	20	17	206	84	153			0	444.21	138	416	0.9	121	7.8	859	1354
2026401	Archer	WICHITA	32	13	74	17	22			0	324.61	10	14	0.7	5.5	7.6	254	315
2026401	Archer	WICHITA	32	13	84	15	22			0	353.9	9	12	0.4	3.1	7.9	271	332
2028404	Archer	WICHITA	45	10	59	35	271			0	414.92	102	311	0.7	5	7.9	291	997
2028404	Archer	WICHITA	45	13	160	158	594			0	397.83	508	1015	1.2	67	8.2	1049	2711
2028404	Archer	WICHITA	45	10	60	39	266			0	402.71	105	310	0.8	7	8.2	310	995
2026702	Archer	WICHITA	110	9	11.6	6.1	967			0	671.19	211	962	2.8	1.1	8	54	2500
2026702	Archer	WICHITA	110	10	1.6	12.6	886			7.2	648	179	893	2.6	0.93	8.4	55	2311
2026702	Archer	WICHITA	110	7	9.4	7.5	659			0	507.66	148	667	2.5	0.4	7.9	54	1750
2028403	Archer	WICHITA	20	16	135	45	119			0	346.58	26	335	0.6	16	7.5	521	863
2027301	Archer	WICHITA	25	6	40	18	68			0	224.54	54	43	1.1	15	8.1	173	355
2027301	Archer	WICHITA	25	15	86	23	55			0	252.61	47	48	1	126	8	309	525
2027301	Archer	WICHITA	25	6	84	23	45			0	191.59	79	50	0.9	115.58	8.2	304	497
2027303	Archer	WICHITA	93	10	87	42	753			0	536.95	227	994	0.7	20	7.7	389	2397
2028101	Archer	WICHITA	40	12	59	48	170			0	373.43	69	198	0.5	45	7.6	344	785
2028103	Archer	WICHITA	82	12	186	132	1311			0	517.43	1319	1319	2.4	267	7.8	1007	4802

State Well Number	County	Aquifer	Well Depth	Silica	Calcium	Magnesium	Sodium	Potassium	Strontium	Carbonate	Bicarbonate	Sulfate	Chloride	Fluoride	Nitrate	p.H	Total Hardness	TDS
2028104	Archer	WICHITA	30	11	59	34	411			0	417.36	122	479	1	68	7.6	287	1390
2028201	Archer	WICHITA	30	5	48	10	75			0	131.8	73	96	0.4	7	7.7	160	379
2028201	Archer	WICHITA	30	15	65	17	55			0	256.27	38	34	0.7	60	7.4	232	410
2028202	Archer	WICHITA	35	14	143	46	445			0	358.78	248	479	1	260	7.2	546	1812
2033506	Archer	WICHITA	65	14	115	28	127			0	295.32	84	158	1.2	128	7.6	402	800
2026701	Archer	WICHITA	100	9	10.2	10.2	889			0	695.6	196	883	4.4	0.4	8	67	2344
1460701	Wichita	WICHITA	62	10	100	30	96			0	245.29	102	136	0.4	110.88	8.3	372	705
1460701	Wichita	WICHITA	62	10	110	30	85			7.2	209.9	86	127	0.4	154	8.5	397	712
2013101	Wichita	WICHITA	47	10	130	82	1102			7.2	386.85	316	1729	0.5	1.6	8.4	661	3568
2013101	Wichita	WICHITA	47	10	108	107	1091			18	373.43	332	1759	0.5	1.3	8.6	709	3610
		Minimum	11	2	1.6	0.3	8.8	1.8	0.2	0	58.58	6.2	8	0.2	0	7	5	**149**
		Maximum	500	38	412	158	2760	9.2	2.08	18	781.02	1343	3393	4.4	503	8.9	1400	**7766**
		Average	70.4	12.0	77.5	31.8	372.9	3.8	1.0	1.3	414.8	145.6	427.6	1.0	50.5	7.8	324.0	**1323.4**

Table 2: Deep (>=100 ft), Low-Nitrate (<10 mg/L) Wells in the Petrolia and Wichita Formation Wells in Wichita, Clay and Archer Counties

State Well Number	County	Aquifer	Well Depth	Silica	Calcium	Magnesium	Sodium	Potassium	Strontium	Carbonate	Bicarbonate	Sulfate	Chloride	Fluoride	Nitrate	p.H	Total Hardness	TDS
2006203	Clay	PETROLIA	100		2.6	0.58	411	2.2	0.2	12	468.61	113	268	0.57	0.04	8.55	9	1041
2035401	Archer	WICHITA	100	5	222	53	379			0	375.11	196	790	0.4	0.4	7.3	771	1830
2020504	Archer	WICHITA	100	8	4.4	1.95	548			0	488.14	25	514	1	0.4	8.3	19	1342
2020503	Archer	WICHITA	100	8	7.6	2.9	699			0	541.83	39	755	0.8	0.4	8.2	30	1779
2026701	Archer	WICHITA	100	9	10.2	10.2	889			0	695.6	196	883	4.4	0.4	8	67	2344
2020506	Archer	WICHITA	100	10	15.4	3.5	746			6	606.51	47	793	1.5	0.8	8.4	52	1921
2006201	Clay	WICHITA	102	12	56	9	120			1.2	351.46	21	96	0.8	3.8	8.3	176	492
2026702	Archer	WICHITA	110	7	9.4	7.5	659			0	507.66	148	667	2.5	0.4	7.9	54	1750
2026702	Archer	WICHITA	110	10	1.6	12.6	886			7.2	648	179	893	2.6	0.93	8.4	55	2311
2026702	Archer	WICHITA	110	9	11.6	6.1	967			0	671.19	211	962	2.8	1.1	8	54	2500
2021801	Archer	WICHITA	110	12	42	11	83			0	312.41	24	38	0.5	3	7.6	150	367
2029202	Archer	WICHITA	120	9	16	9.5	734			0	732.21	219	587	1.2	0.5	7.8	79	1936
2020502	Archer	WICHITA	125	12	20	10	287			0	414.92	17	268	0.5	0.4	7.8	91	818
2029102	Archer	WICHITA	140	8	9	5	356			15.6	483.26	41	251	0.7	0.18	8.6	43	924
2029102	Archer	WICHITA	140	7	6.4	4.75	335			0	468.61	57	237	0.8	0.4	8	35	878
2029102	Archer	WICHITA	140	9	8	23	328	3		0	450.31	63	238	0.7	0.4	8.2	114	894
2029102	Archer	WICHITA	140		6.5	4	347	4.1	0.27	4.8	453.97	61	243	0.75	2.21	8.09	32	897
2008301	Clay	WICHITA	155	11	27	14	636			0	485.7	436	466	1.9	3.2	8.1	124	1833
2023201	Clay	WICHITA	182	9	12	4	1120			7.2	505.22	529	1108	2.5	1.5	8.4	46	3041
1464701	Clay	WICHITA	190	13	32	30	325			2.4	699.26	92	174	1.2	0.4	8.3	203	1013
2035402	Archer	WICHITA	200	4	96	47	2760			0	246.51	1343	3393	2.2	0.4	7.2	432	7766
2016601	Clay	WICHITA	500	12	2	0.3	331			16	532	72	132		1.2	8.5	6	828
1463403	Clay	WICHITA		10	54	34	253			0	464.95	63	271	0.5	4.8	8	274	918
2034104	Archer	WICHITA		17	266	51	745			0	272.14	36	1532	0.9	5.5	7.6	873	2787
		Minimum	100	4	1.6	0.3	83	2.2	0.2	0	246.51	17	38	0.4	0.04	**7.2**	**6**	**367**
		Maximum	500	17	266	53	2760	4.1	0.27	16	732.21	1343	3393	4.4	5.5	**8.6**	**873**	**7766**
		Average	144.3	9.6	39.1	14.8	622.7	3.1	0.2	3.0	494.8	176.2	648.3	1.4	1.4	**8.1**	**157.9**	**1758.8**

Figure 2: Water Level Over Time; Slama-Green #3 Well

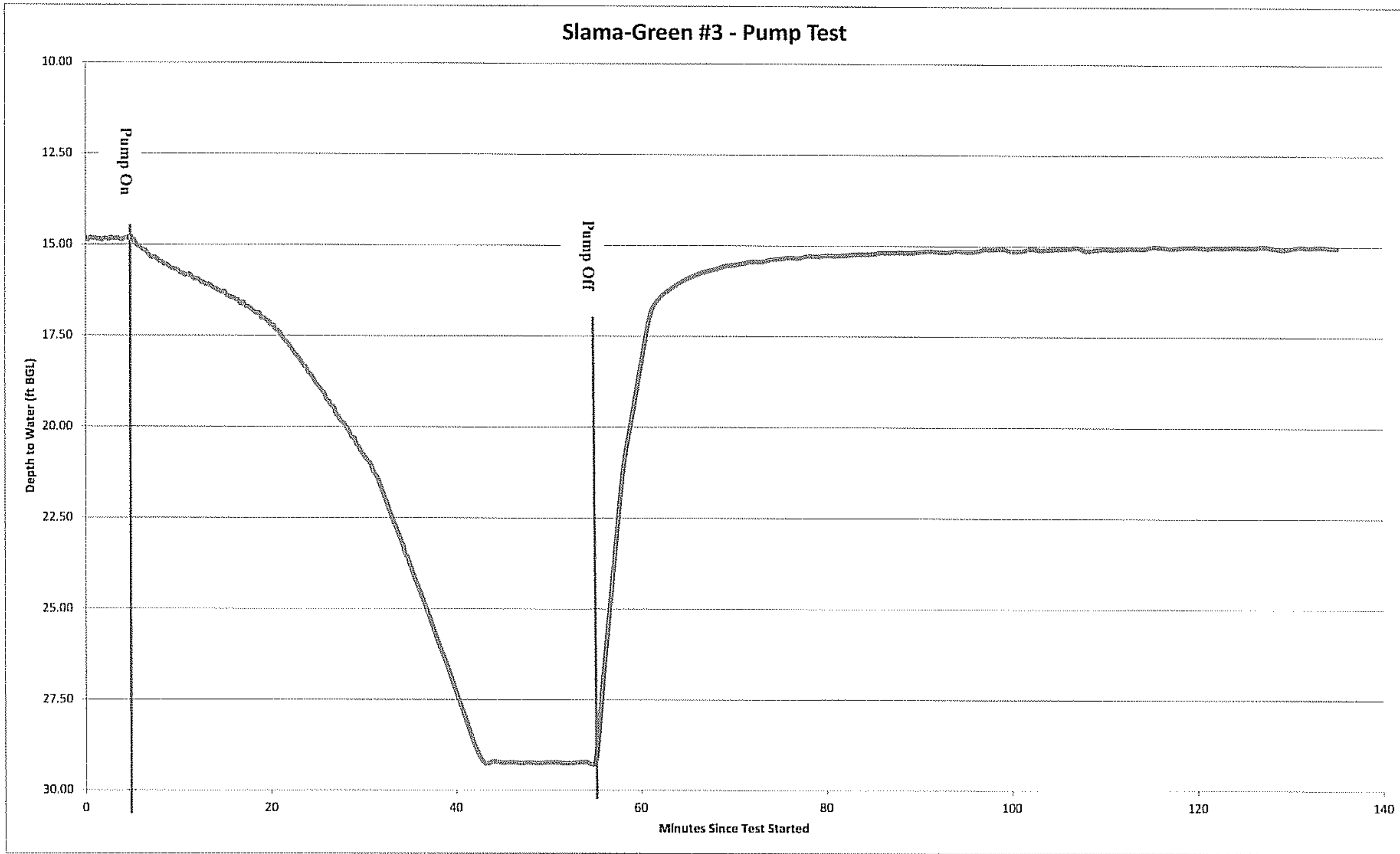


Figure 3: Water Level over Time; Cooper #3 Well