LAKEWOOD VILLAGE TOWN HALL
100 HIGHRIDGE DRIVE
LAKEWOOD VILLAGE, TEXAS

TOWN COUNCIL MEETING
SEPTEMBER 22, 2016 7:00 P.M.

SPECIAL SESSION – AGENDA

Call to Order and Announce a Quorum is Present

A. PLEDGE TO THE FLAG:

B. PUBLIC HEARING: – A public hearing is scheduled to provide an opportunity for citizen comment on the Land Use Assumptions and Capital Improvements Plan for the Development of Water and Wastewater Impact Fees. The Town Council may adopt the Land Use Assumptions and Capital Improvements Plan with or without amendment following this public hearing.

C. VISITOR/CITIZENS FORUM: At this time, any person with business before the Council not scheduled on the agenda may speak to the Council. No formal action may be taken on these items at this meeting.

D. REGULAR AGENDA:

1. Consideration of Resolution Approving the Capital Improvements Plan and Land Use Assumptions for the Development of Water and Wastewater Impact Fees (Asbell)
2. Consideration of Resolution setting November 10, 2016 for a Public Hearing on Impact Fees for Water and Wastewater (Asbell)
3. Discussion of Well Feasibility Study (Asbell)

E. COUNCIL AND STAFF COMMENTS: Comments may be made by Council or Staff. No formal action may be taken on these items at this meeting.

F. ADJOURNMENT

I do hereby certify that the above notice of meeting was posted on the designated place for official notice at 5:15 p.m. on Monday, September 19, 2016.

Linda Asbell

Linda Asbell, TRMC, Town Secretary

TOWN OF LAKEWOOD VILLAGE 1977

The Town Council reserves the right to adjourn into closed session at any time during the course of this meeting to discuss any of the matters listed above, as authorized by Texas Government Code Section 551.071 (Consultation with Attorney), 551.072 (Deliberations about Real Property), 551.073 (Deliberations about Gifts and Donations), 551.074 (Personnel Matters), 551.076 (Deliberations about Security Devices) and 551.087 (Economic Development).

This facility is wheelchair accessible and accessible parking spaces are available. Requests for accommodations or interpretive services must be made 48 hours prior to this meeting. Please contact the Town Secretary's office at 972-294-5555 or FAX 972-292-0812 for further information.

One or more members of the LAKEWOOD VILLAGE MUNICIPAL DEVELOPMENT DISTRICT may attend this meeting. No action will be taken by the MDD Board during this meeting.

Kimley»Horn

Date: September 13, 2016
To: Town of Lakewood Village CIAC Committee
From: Kimley-Horn and Associates, Inc.

Subject: Capital Improvement Advisory Committee (CIAC) Meeting Notes from September 12th, 2016

The comments from the CIAC for Lakewood Village from the meeting that took place on September 12th, 2016 at 3:00 PM at the Lakewood Village Town Hall were as follows:

1. The Town of Little Elm has an existing well and ground storage tank located on the north side of the Little Elm ISD property along Eldorado Parkway. It is a possibility that Little Elm may lease the well and ground storage tank to the Town of Lakewood Village for water supply. The CIAC recommends that Town Council assess adding a water line to bring water from this well down to the Town's existing pump station to be pumped out to existing and future developments.

2. There is an existing well located on the west side of Eldorado Parkway that serves only a few homes. The CIAC recommends exploring pumping water from this well into the existing ground storage tanks to provide additional future water supply.

3. The CIAC recommends that Town Council evaluate not drilling another well at the existing pump station site, as it may induce too high of a drawdown on the existing aquifer. If a well is chosen to provide additional capacity to the Town, it is recommended that it be drilled at the Town property on Woodcrest Drive.

At the end of the meeting, Mr. Gary Newsome made a motion, Mr. Danny Cook seconded the motion, and the vote among the 5 members present was unanimous to adopt these comments as the official comments to be presented to the Town Council from the CIAC.

Name	Email.
Stuart Williams	Stuart.williams@kimley-horn.com
DANNY Cook	DRCCOOK@ATT.NET
Chip Hill	chip@riverrestproperty.com
Gary Newsome	garyenewsome@gmail.com
Darrell West	darrellwest2@sbcglobal.net
Chris FARAGE	CFARAGE@PARKER.COM
Todd Strouse	todd.strouse@kimley-horn.com

Town of Lakewood Village

Water and Wastewater Impact Fee Land Use Assumptions

Water Land Use Assumptions		
Year	Residential Population	Residential Connections
2016	657	219
2026	1,101	367

Wastewater Land Use Assumptions		
Year	Residential Population	Residential Connections
2016	657	219
2026	1,629	543

CIP PROJECT LIST

1. WESTERN DEVELOPMENT 8" WATER LINE #1 (4,450 LF)
2. WESTERN DEVELOPMENT 8" WATER LINE #2 (4,950 LF)
3. WESTERN DEVELOPMENT 8" WATER LINE #3 (1,860 LF)
4. WESTERN DEVELOPMENT 8" WATER LINE #4 (580 LF)
5. (2) 150,000 GALLON GROUND STORAGE TANKS
6. WATER WELL – 400 GPM CAPACITY AND 8" SUPPLY LINE TO PUMP STATION
7. PUMP STATION UPGRADE:
   (1) – 750 GPM PUMP
   12" DUCTILE IRON DISCHARGE HEADER FROM PUMP STATION TO EXISTING 8" MAIN IN HIGHRIDGE DRIVE

LEGEND

- EXISTING WATER LINE
- PROPOSED WATER LINE
- LAKEWOOD VILLAGE CITY LIMITS
- LAKEWOOD VILLAGE ETJ BOUNDARY
- LAKEWOOD VILLAGE WATER CCN BOUNDARY
- CIP PROJECT NUMBER
- PROPOSED GROUND STORAGE TANK
- PROPOSED PUMP
- PROPOSED WELL

Kimley-Horn

No.	Revision	By	Date

THIS DOCUMENT IS INCOMPLETE AND IS RELEASED TEMPORARILY FOR INTERIM REVIEW ONLY. IT IS NOT INTENDED FOR CONSTRUCTION, BIDDING, OR PERMIT PURPOSES.
STUART A. WILLIAMS P.E.
SERIAL NO. 121537
DATE: AUGUST 2016

Town of Lakewood Village Water Impact Fee Update

WATER IMPACT FEE UPDATE

DATE: AUGUST 2016
DESIGN: SAW
DRAWN: SAW
CHECKED: TLS
KHA NO.: 064487100

FIGURE
1.1

CIP PROJECT LIST

1. WESTERN DEVELOPMENT #1 – 8-INCH GRAVITY SEWER, LIFT STATION, AND 8-INCH FORCE MAIN
2. EXISTING WASTEWATER TREATMENT PLANT EXPANSION TO 0.2 MGD CAPACITY
3. LIFT STATION AT WASTEWATER TREATMENT PLANT UPGRADE TO 0.2 MGD CAPACITY
4. WESTERN DEVELOPMENT #2 – 8-INCH GRAVITY SEWER
5. WESTERN DEVELOPMENT #3 – 8-INCH GRAVITY SEWER, LIFT STATION, AND 4-INCH FORCE MAIN
6. LITTLE ELM ISD PROPERTY 8-INCH GRAVITY SEWER
7. STEVE HARVEY PROPERTY 8-INCH GRAVITY SEWER

LEGEND

- EXISTING FORCE MAIN
- EXISTING SEWER LINE
- PROPOSED SEWER LINE
- PROPOSED FORCE MAIN
- LAKEWOOD VILLAGE CITY LIMITS
- LAKEWOOD VILLAGE ETJ BOUNDARY
- LAKEWOOD VILLAGE SEWER CCN BOUNDARY
- PROPERTY OUTSIDE CITY LIMITS INCLUDED IN IMPACT FEE CALCULATION
- CIP PROJECT NUMBER
- EXISTING LIFT STATION
- PROPOSED LIFT STATION
- EXISTING TREATMENT PLANT
- EXISTING MANHOLE

Kimley»Horn

Texas Board Of Professional Engineers Firm Registration Number: F-928
12750 Merit Drive, Suite 1000, Dallas, TX 75251 972-770-1300

No.	Revision	By	Date

THIS DOCUMENT IS INCOMPLETE AND IS RELEASED TEMPORARILY FOR INTERIM REVIEW ONLY. IT IS NOT INTENDED FOR CONSTRUCTION, BIDDING, OR PERMIT PURPOSES.

STUART A. WILLIAMS P.E.
SERIAL NO. 121537
DATE: AUGUST 2016

Town of Lakewood Village Waste Water Impact Fee

EXISTING WASTE WATER

DATE: AUGUST 2016
DESIGN: SAW
DRAWN: DGD
CHECKED: TLS
KHA NO.: 064487100

FIGURE

2.1

TOWN OF LAKEWOOD VILLAGE, TEXAS

RESOLUTION NO. 16-XX

A RESOLUTION OF THE TOWN COUNCIL OF THE TOWN OF LAKEWOOD VILLAGE, TEXAS, ADOPTING THE TOWN'S CAPITAL IMPROVEMENTS PLAN AND LAND USE ASSUMPTIONS FOR WATER AND WASTEWATER IMPACT FEES.

WHEREAS, Chapter 395 of the Local Government Code has outlined the procedure for adopting impact fees; and

WHEREAS, it is desirable to adopt water and wastewater impact fees to be charged in the Town of Lakewood Village; and

WHEREAS, an engineering study has been completed on the proposed water and wastewater infrastructure to meet the needs of the town for future development.

NOW, THEREFORE, BE IT RESOLVED BY THE TOWN COUNCIL OF THE TOWN OF LAKEWOOD VILLAGE, TEXAS, THAT A CAPITAL IMPROVEMENTS PLAN AND LAND USE ASSUMPTIONS FOR WATER AND WASTEWATER IMPACT FEES, AS PROVIDED BY CHAPTER 395 OF THE TEXAS LOCAL GOVERNMENT CODE, AS DESCRIBED BELOW:

PASSED AND APPROVED BY THE TOWN COUNCIL OF THE TOWN OF LAKEWOOD VILLAGE, TEXAS, this 22nd day of SEPTEMBER, 2016.

APPROVED:

____
Dr. Mark E. Vargus,
Mayor

ATTEST:

____
Linda Asbell, TRMC
Town Secretary

TOWN OF LAKEWOOD VILLAGE, TEXAS

RESOLUTION NO. 16-XX

A RESOLUTION OF THE TOWN COUNCIL OF THE TOWN OF LAKEWOOD VILLAGE, TEXAS, ADOPTING THE TOWN'S CAPITAL IMPROVEMENTS PLAN AND LAND USE ASSUMPTIONS FOR WATER AND WASTEWATER IMPACT FEES.

WHEREAS, Chapter 395 of the Local Government Code has outlined the procedure for adopting impact fees; and

WHEREAS, it is desirable to adopt water and wastewater impact fees to be charged in the Town of Lakewood Village; and

WHEREAS, an engineering study has been completed on the proposed water and wastewater infrastructure to meet the needs of the town for future development.

NOW, THEREFORE, BE IT RESOLVED BY THE TOWN COUNCIL OF THE TOWN OF LAKEWOOD VILLAGE, TEXAS, THAT A PUBLIC HEARING SHALL BE HELD FOR POSSIBLE ADOPTION OF WATER AND WASTEWATER IMPACT FEES, AS PROVIDED BY CHAPTER 395 OF THE TEXAS LOCAL GOVERNMENT CODE, TO BE HELD AS DESCRIBED BELOW:

SECTION 1. This public hearing will be held on **November 10th , 2016 at 7:00 pm at Town Hall at 100 Highridge Drive, Lakewood Village, TX 75068.**

SECTION 2. Any member of the public has the right to appear at the public hearing and present evidence for or against the plan and assumptions.

SECTION 3. A public notice shall be posted for the public hearing meeting all the requirements of Chapter 395 of the Texas Local Government Code for the amendment of impact fees.

PASSED AND APPROVED BY THE TOWN COUNCIL OF THE TOWN OF LAKEWOOD VILLAGE, TEXAS, this 22nd day of SEPTEMBER, 2016.

APPROVED:

____

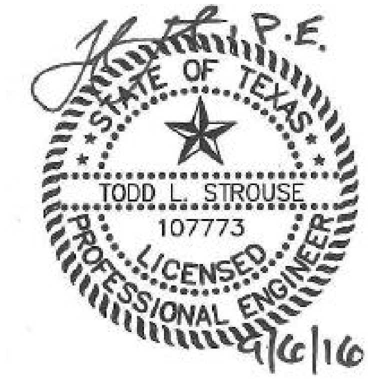
Dr. Mark E. Vargus,
Mayor

ATTEST:

____

Linda Asbell, TRMC
Town Secretary

Kimley»Horn



MEMORANDUM

To:	Town of Lakewood Village
From:	Todd Strouse, P.E.
	Kimley-Horn and Associates, Inc.
Date:	6 September 2016
Subject:	IPO 064487103 – Well Feasibility Study

INTRODUCTION

The Town of Lakewood Village (Town) currently operates 3 groundwater wells; two in the Paluxy aquifer and one in the shallower, less productive Woodbine aquifer. These existing wells have a total combined capacity of 190 gallons per minute (gpm) or 273,600 gallons per day. As the area within current Town limits continues to develop, water demands will grow larger than current production capacity. The Town hired Kimley-Horn to complete a well feasibility study to evaluate proposed well locations and aquifers to supply the Town with enough water to meet its future demand. This study includes data analysis of surrounding well sites and an opinion of probable construction cost for the proposed well and associated infrastructure.

FUTURE WATER DEMAND

The Town of Lakewood Village currently has 219 existing single family water connections. Historic well production log data for 2014 and 2015 provided by the Town indicates a maximum day current water demand of 162 gpm. Since actual pumping records from the pump station and historic tank level records are not available, the actual demand may be slightly different than what was calculated due to storage in the existing ground tanks. There are currently 75 lots that are platted but undeveloped in the Town limits. It was assumed that 13 acres of undeveloped land located at Green Meadow Drive and Shoreline Drive will be subdivided into 20 lots. In addition, using an expected density of 1 lot/acre and assuming that 20% of the undeveloped land would be used for public space, the 160 acres of undeveloped land in the northwest part of the Town will add a potential 128 connections. Table 1 below summarizes the current and future demands projected for Lakewood Village.

Table 1: Demand Summary

Year	Connections	Average Demand (gpm)	Maximum Day Demand (gpm)
2016	219	56	162
Buildout	442	113	327

The three current wells operated by the Town have a total combined capacity of 190 gpm. To meet the projected future maximum day buildout demand, the Town needs a new well that is able to produce approximately 137 gpm.

WELL OPTIONS

Kimley-Horn, with the assistance of our subconsultant R.W. Harden & Associates Inc. (RWH&A), compiled and reviewed available well records, reports, maps, databases, geophysical logs, and other applicable information for existing wells in the surrounding areas. See RWH&A's report in the Appendix for a more detailed explanation of the data to follow. Two aquifer zones, the Paluxy and the deeper Twin Mountains, were identified with the potential to sustain long-term production of the Town's fourth water well. RWH&A modeled both aquifer's potential production rates and concluded that the Paluxy and Twin Mountain Aquifers have a maximum continuous production rate of 125 gpm and 800 gpm respectively. It should be noted that peak pumping rates of an additional 25% to 75% of this long-term capacity can likely be sustained for short periods of time from a proposed well in either aquifer. However, the water production can also be limited by the capacity of the aquifer.

The 3 existing wells for the town (2 Paluxy and 1 Woodbine) are located at the pump station and ground storage tank facility (Location "A"). The Town has directed Kimley-Horn to explore locating the new well either at Location "A" or at a lot located on Woodcrest Drive (Location "B"). Exhibit 1 shows the current well locations and the proposed well site on Woodcrest Drive. It should be noted that the Woodcrest Drive location, Location "B", will have to include an 8" water supply line to bring the produced water to the pump station and ground storage tanks. Location "A" has the advantage of being located on the lot with the Town's pump station and ground storage tanks so a lengthy supply water line will not be needed. Proposed water piping placement is shown in Exhibit 1.

Modeling, conducted by RWH&A, suggests that multiple producing wells in the same aquifer will have an impact on one another and this induced interference drawdown is greater the closer the wells are to each other. Constructing another Paluxy well at Location "A" could require deeper pump settings and possibly reduce maximum production rates for all Paluxy wells. Constructing a Twin Mountain well at Location "A", will not interfere with the existing wells but is recommended to be located at least 50 feet away from the other wells. Exhibit 2 shows the existing well sites and potential proposed well location. Constructing a Paluxy well on the southern, Woodcrest Drive location, Location "B", will interfere less with existing wells but will need additional infrastructure to deliver the water to the pump and ground storage tank site.

WATER QUALITY

Water quality data was obtained from the Texas Water Development Board on wells in the surrounding areas. Water quality of both aquifers, on average, have reported TDS levels below secondary contaminate levels. They are not considered a public health hazard and do not exceed levels for aesthetic considerations. Some water tested from the Twin Mountain aquifer wells exceeded the aesthetic considerations but still is not considered a public health hazard. Blending or treatment of water from a Twin Mountain well may be required to ensure drinking water standards are met if this well is chosen. See Table 4 of RWH&A's report in the Appendix for a complete listing of available water quality test results in the surrounding area.

NORTH TEXAS GROUNDWATER CONSERVATION DISTRICT & TCEQ

North Texas Groundwater Conservation District (NTGCD) regulates groundwater production in Denton County. NTGCD is currently operating under temporary rules with plans to adopt permanent rules within a year. Temporary rules require a $100 registration fee for a new well and a fee of $0.10 / 1,000 gallons produced to be paid to NTGCD. Approval of new wells is typically granted within a few days of submittal of the registration forms. The adoption of permanent rules may make the well approval process more difficult with the possibility of increased hindrances such as mandatory well setbacks from property boundaries and regulated groundwater production based on acreage owned.

Approval by Texas Commission on Environmental Quality (TCEQ) is also necessary before constructing a well. Typically, approval of initial plans and specifications takes approximately 90 days to obtain. Once the well is constructed, various submittals are required to be sent to TCEQ in order to receive approval to use the well as a public water supply.

CONCLUSIONS

Analysis of hydrogeologic data indicates that Paluxy and Twin Mountain aquifers are the best candidates for groundwater production. Modeling by RWH&A estimated a maximum continuous production rate of 125 gpm for a Paluxy well and 800 gpm for a deeper Twin Mountain well. Construction costs will be less with the Paluxy well since the aquifer is shallower. Two locations were identified as possible well sites, Location “A”, the existing pump station, or Location “B”, a lot off Woodcrest Drive. The 8” diameter water line needed for Location “B” will be approximately 2,600 linear feet and have a capital cost approximately $219,000. The existing pump station location has added convenience of being positioned near existing water infrastructure but well placement may be difficult if NTGCD adopts stricter rules in the next year.

Production rate and water levels of existing Paluxy wells could be reduced with the addition of a new Paluxy well. The interference between the potential new Paluxy well and existing Paluxy wells will be greatly increased if the new well is placed on Location “A”. If a Paluxy well is chosen, it should be constructed on the Woodcrest Drive lot, Location “B”, based on drawdown and increased pumping costs. The opinion of probable construction cost for a 125 gpm Paluxy well at Location “B” is $1,225,000 including the 8” waterline needed to deliver water to the pump station.

A well in the Twin Mountain aquifer may be placed at either location with little to no interference on existing wells. The opinion of probable construction cost for a 350 gpm Twin Mountain well is $1,544,000 if placed in Location “B” and $1,292,000 if placed at Location “A”. If a Twin Mountain well is chosen, water produced may require blending or treatment to keep water quality constituents below maximum drinking water standards.

Table 2: Opinion of Probable Construction Cost

Paluxy		
Well Construction Cost	$	740,000
Additional Water Line	$	219,000
15% Contingency	$	144,000
Engineering Costs	$	94,000
Well Testing (per existing well)	$	14,000
Location "B" Total	$	1,225,000
Twin Mountain		
Well Construction Cost	$	1,030,000
Additional Water Line	$	219,000
15% Contingency (Location "A")	$	155,000
15% Contingency (Location "B")	$	188,000
Engineering Costs	$	107,000
Location "A" Total	$	1,292,000
Location "B" Total	$	1,544,000

As mentioned previously, the projected maximum day buildout demand based on projected densities for new development is approximately 327 gpm for the Town, and an additional 137 gpm production capacity will be necessary to provide maximum day demands in the future. Initial modeling indicates only 125 gpm as a maximum sustained production value for a new Paluxy well. If a Paluxy well is chosen to meet the future needs of Lakewood Village, it is recommended that aquifer testing be completed by RWH&A on the two existing Paluxy wells. Conducting aquifer tests will allow for more accurate estimates of long-term production, water quality, and interference drawdown in a relatively inexpensive way for a proposed new well. Aquifer testing of the 2 existing wells is expected to cost $14,000 for each well and will also verify reported production capacities of the existing wells.

Thank you for the opportunity to provide the Town of Lakewood Village with this information. If you have any questions regarding this memo, please feel free to contact us.

, P.E.

Todd Strouse, P.E.

Kimley-Horn & Associates, Inc.
106 West Louisiana Street
McKinney, Texas 75069
(469) 301-2592

Attachments

R.W. Harden & Associates, Inc. Report

Exhibit 1 – Potential Well Sites

Exhibit 2 – Existing Well Site (Location “A”)

Groundwater Availability Evaluation

Prepared for:

The Town of Lakewood Village

Prepared By:

R W HARDEN & ASSOCIATES INC

HYDROLOGISTS GEOLOGISTS ENGINEERS

August 2016

STATE OF TEXAS
MICHAEL RUBINOV
GEOLOGY
11429
LICENSED
PROFESSIONAL GEOSCIENTIST

The seal appearing on this document was authorized by
Michael Rubinov, P.G. 11429 on August 24th, 2016.
TBPG Firm Registration Number: 50033

Table of Contents

Tables

Plates

Evaluation of Potential Groundwater Supplies Town of Lakewood Village, Denton County, Texas

Introduction

The Town of Lakewood Village (Town) wishes to investigate new water sources to augment existing supplies in order to accommodate expected growth. One potential solution is to construct a new groundwater well at a Town-owned location that will be connected to the existing transmission infrastructure. The Town estimates that the proposed well will need to provide approximately 120 to 330 gallons per minute (gpm) in order to satisfy average and peak daily water demands within the foreseeable future. The Town wishes to determine the feasibility of developing additional groundwater supplies from hydrogeological, regulatory, scheduling, and cost standpoints.

To this end, R.W. Harden & Associates, Inc. (RWH&A) has performed an initial evaluation of the available groundwater resources in the Lakewood Village area. For this evaluation, RWH&A compiled and reviewed available geologic and hydrologic data including published and unpublished groundwater and geologic maps and reports, well completion records, well testing records, water quality analyses, and other applicable information from various public entities and RWH&A files. Using this data, each aquifer was assessed for production potential, water quality, and future impacts from other users. In addition, groundwater modeling was performed to estimate potential maximum well yields and pumping levels. Costs associated with aquifer testing, permitting, construction, and operation of a new public supply well in each aquifer were compiled. RWH&A has reviewed the regulatory requirements associated with construction and use of a potential new well for public supplies.

The Town has indicated two potential sites for well construction. Plate 1 shows the location of these proposed well sites and the Town's existing wells. The existing pump station (North Location) provides a convenient well location because of the existing storage facilities and water transmission infrastructure at the site. The area next to the original Town Well #2, now unused, is the second potential site (South Location) that may also provide a convenient, suitable well site.

Local Geology

Three regionally productive aquifers exist beneath the Town; the Woodbine Formation, Paluxy Formation, and the lower member of the Trinity Group of formations. Plate 2 is a map of regional surface geology and the location of the geologic cross section (Plate 3) that depicts the generalized structure of the aquifers beneath the Town. The Eagle Ford Formation is the surface geologic unit throughout the Town. The Woodbine Group, directly underlying the Eagle Ford, is the uppermost aquifer within the Town and consists of sand, sandstone, and clay and outcrops in a northwest to southeast trending band immediately west of the Town. The underlying Washita and Fredericks Groups, consisting of relatively-impermeable interbedded limestone, shale, marl, clay, and shale, act as an aquiclude in the region. The Trinity Group below consists of the Paluxy Formation, the Glen Rose limestone and the Twin Mountains Formation. The Twin Mountains Formation is further subdivided into the uppermost Hensell sand and lowermost Hosston sand members separated by limestone and shale formations. It should be noted that, because of the long history of well drilling in the Trinity Group and the regional variations in its structure and composition, the names assigned to the formations in this group vary throughout Texas. The most commonly used alternative names for the Trinity Group or its subdivisions include the Travis Peak, Antlers, Hosston, and Hensell. In this report, the Paluxy is considered the uppermost formation of the Trinity Group, while the label Twin Mountains is applied the sand-rich, productive layers of the lower Trinity.

Existing Infrastructure

As shown in Plate 1, the Town currently operates three groundwater wells. Two wells are completed in the Paluxy aquifer and one is completed in the Woodbine aquifer. Table 1 summarizes available information on the existing wells. It should be noted that there is a discrepancy between Well #1 as reported by the TWDB, and Town records. According to TWDB records, Old Well #1 is mapped at the North Location and Well #1 (Old Well #2) is mapped at the South Location, whereas Town records show Well # 1 (Old Well #2) in the North Location. Plate 1 shows the well locations as interpreted predominantly from Town records.

Table 1. Existing Well Information

Town Well Number	State Well Number	Status	Aquifer	Well Depth (ft bgl)	Casing Diameter (in)	Top of Screened Interval (ft bgl)	Bottom of Screened Interval (ft bgl)	Screen Diameter (in)	Most Recent Water Level (ft bgl)	Water Level Date
Well #1 (Old Well #2)	1849704	Active	Woodbine	365	5.25	316	365	Unknown	94.8	1/22/1976
Old Well #1	1849703	Inactive	Woodbine	372	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown
Well #2	1849707	Active	Paluxy	1082	7	922	1082	3	360	8/12/1979
Well #3	1849713	Active	Paluxy	1223	10	894	1215	6	598	7/24/2003

bgl - below ground level

Aquifer Evaluation

While some groundwater can be produced from many of the geologic formations underlying the Town, the Paluxy and the Twin Mountain Formations provide the most likely sources for long-term groundwater development. Although the Woodbine aquifer is a major source of groundwater locally and regionally, the aquifer is relatively shallow within the Town. Preliminary calculations and modeling indicate this aquifer will not be able to sustain the desired production rates over the long-term, with current water levels already at approximately 150 feet bgl and levels continuing to decline due to heavy usage in the region. Consequently, this report will focus on the Paluxy and the Twin Mountain aquifers.

Aquifer Characteristics

The Paluxy and Twin Mountains aquifers are primarily composed of layers of sand, silt, and clay that underlie much of Central Texas. These aquifer layers outcrop to the west of the Town (Plates 2 and 3) and dip toward the Gulf of Mexico at about 60 feet per mile. Infiltration of precipitation in outcrop zones provides groundwater recharge, which then travels downdip in the pore spaces between the sand grains that comprise the more productive zones of these aquifers.

Table 2 summarizes the general aquifer characteristics of the Paluxy and the Twin Mountains aquifers in the study area. The term "transmissivity" is often used as a measure of the productivity of an aquifer. All other aspects of the groundwater system being equal, an aquifer with twice the transmissivity of another aquifer can sustain about twice as much production. As shown in Table 2, the Paluxy is likely about half as transmissive as the Twin Mountain aquifer within the Town. Please note that no aquifer test data is publically available within the Town boundaries, the data in Table 2 reflects approximations made from Texas Water Development Board (TWDB) well records, the regional groundwater availability model (GAM) of the Trinity aquifer, and interpolations from well tests in the region.

Table 2. Estimated Aquifer Characteristics

	Paluxy Aquifer	Twin Mountains Aquifer
Depth to Top of Aquifer (ft)	910	1,350
Depth to Bottom of Aquifer (ft)	1,200	1,850
Aqufier Transmissivity (gpd/ft)	5,000	10,000
Static Water Level (ft)	620	590
Average TDS Concentration (mg/L)	640	940
Projected Water Level Decline (ft)	98	197

The Town operates two wells in the Paluxy aquifer. Properly conducted pump tests of these wells would give a much clearer picture of the hydraulic characteristics of the Paluxy aquifer within the Town and, additionally, provide hydraulic information on the existing wells. It is recommended that testing of an existing well be performed prior to constructing a new well in the Paluxy. Completing a testing program in the Twin Mountains aquifer is also recommended to provide surety of aquifer characteristics and water quality prior to full-scale well construction. Testing options and procedures are discussed below.

Water Levels

As listed in Table 2, water levels are similar in the Twin Mountains and Paluxy aquifers in the region. These water levels are an average of measurements recorded since the year 2000 in wells within five miles of the Town for the Paluxy and wells seven miles of the Town for the Twin Mountains (Plates 4 and 5). Due to a lack of data closer to the Town, the Twin Mountains aquifer data was collected from more distant well locations. Artesian pressure levels are approximately 300 feet above the top of the aquifer in the Paluxy and 750 feet above the top of the Twin Mountains.

Future well production rates are largely dependent on aquifer water levels. Because both target aquifers are a major source of groundwater, significant declines in artesian pressure levels are likely in the future, which will affect the availability of groundwater. In order to estimate future declines, RWH&A reviewed models and reports generated by Groundwater Management Area No. 8 (GMA-8), which is a regulatory body tasked with future planning of groundwater in northern Central Texas. GMA-8 has adopted "desired future conditions" (DFCs) for the aquifers in its borders. Specifically, the DFCs define acceptable future water level declines in the Paluxy and Twin

Mountains. According to modeling conducted by GMA-8 and the TWDB, the Paluxy aquifer is predicted to see an average of 98 feet of water level decline, while the Twin Mountains aquifer may experience about 197 feet of decline in Denton County over the next 50 years (Table 2). It is important to note that these predicted declines are derived from regional-scale planning models and DFCs, and that water level declines in the Lakewood area will be heavily dependent on the impacts associated with local users. Consequently, the estimates of decline should be considered approximations based on available information.

Site Specific Aquifer Productivity

An analytical groundwater model developed by RWH&A was used to estimate maximum potential future productivity and water level declines in the aquifers. The maximum well productivity is a function of transmissivity, well efficiency, and available drawdown. Well efficiency defines how efficiently a well transmits water from an aquifer to the surface. The model for this study assumes a 70% well efficiency, which is considered to be the minimum acceptable limit for a properly constructed public supply well. Available drawdown is the vertical distance between the static (non-pumping) water level and the deepest pumping water level desired in the well. The maximum pumping level is often limited to the top of the uppermost aquifer production zone that is screened by a well.

The Paluxy well was modeled at the South Location (Plate 1) to maximize distance from the existing Paluxy wells at the pump station. Typically, the closer a well is to another well producing from the same aquifer, the more each well induces "interference drawdown" on the other. Modeling suggests that about 60 feet of water level decline will be imposed on the existing Paluxy wells by a new well at the South Location. For comparison, if a new Paluxy well was constructed at the North Location, within 50 feet of the existing wells, the interference effects from the new well would equate to about 100 feet of water level decline in both existing wells, possibly requiring deeper pump settings and significantly reducing the maximum production rates of the wells.

A Twin Mountain well can be located at the North Location (Plate 1) without interfering with the existing wells. However, because boreholes can deviate from the original center in the subsurface during drilling, this well should be spaced at least 50 feet from the other wells. Typically, a maximum of 1.5 feet of deviation from center per 100 foot of hole drilled is allowable, however, without drilling records it is not possible to know how far an existing well bore may have diverged from center in the subsurface.

Table 3. Modeling Parameters and Results

	Paluxy Aquifer	Twin Mountains Aquifer
Aqufier Transmissivity (gal/day/ft)	5,000	10,000
Well Efficiency	70%	70%
Pumping Duration (yr)	50	50
Depth to Static Water Level (ft)	620	590
Assumed Regional Decline (ft)	98	197
Depth to Top of Aquifer (ft bgl)	910	1,350
Available Drawdown (ft)	192	563
Maximum Continous Production Rate (gpm)	125	800
Depth to Pumping Level (ft at 50 years)	814	1,080

Table 3 shows parameters applied to the model and estimates of short and long-term maximum production from a well completed in each aquifer. Production from the Paluxy is limited by the relatively small amount of available drawdown. The future average water level declines in the region, as reported by the DFCs, further reduce the available drawdown. Declines from usage of the existing wells, extrapolated using 2015 production data provided by the Town, were also included in the model to assess impacts from those wells on a new Paluxy well. Using the parameters in the Table 3, modeling suggests a new Paluxy well could sustain a long-term rate of production of approximately 125 gpm over a period of 50 years. Peak pumping rates of an additional 25% to 75% of the long-term capacity can likely be sustained for short periods of time, depending on drawdown from the other Town owned Paluxy wells and other users in the region. It should be noted that a safety factor using a maximum of 50% of the available drawdown was applied to this model. This factor is typically included to account for unforeseen hydraulic boundary conditions and/or increased drawdown due to other users in the region.

The Twin Mountains is several hundred feet deeper than the Paluxy, but groundwater levels are similar. Consequently, the amount of available drawdown is much greater in a Twin Mountains well. This larger amount of available drawdown in combination with the Twin Mountains' greater transmissivity allows for much larger sustained pumpage rates for wells completed in this aquifer as compared to the Paluxy, regardless of the larger predicted regional water level declines. Using 50% of the available drawdown, modeling suggests a Twin Mountains well could sustain a long-term rate of 800 gpm.

It should be noted that the reported maximum production rates are highly dependent on site-specific transmissivity and future water level declines. A change to either assumption will decrease or increase possible maximum production rates accordingly.

Water Quality

Table 4 lists the concentrations for some of the commonly reported chemical constituents and parameters from both aquifers in wells within the region. Total dissolved solid (TDS) is commonly used to delineate fresh, brackish, and saline waters; water with TDS concentration below 1,000 milligrams per liter (mg/L) is considered fresh. The Texas Commission of Environmental Quality (TCEQ) regulates public supply water quality using a defined set of primary and secondary maximum contaminant limits (MCLs) for certain water quality constituents. Water with constituent concentrations above primary MCLs is considered a hazard and must be treated to bring the levels below MCLs prior to distribution. Secondary contaminant limits are not considered a public hazard but represent aesthetic considerations. If not treated, approval from TCEQ must be granted before water with elevated secondary MCL's can be used for public supplies. As discussed below, some wells in the Lakewood area produce groundwater that exceeds secondary MCLs for TDS, sulfate, chloride, and fluoride.

Plates 4 and 5 depict Paluxy and Twin Mountains well locations in the region with measured TDS concentrations, where available. Water quality in the Paluxy is fresh throughout the region, with other reported major constituents below secondary MCLs. On average, water in the Twin Mountains is just below allowed TDS limits (Table 4) and is therefore considered fresh. However, of the 15 wells sampled, 5 wells reported TDS concentrations above secondary MCL's. Although average values for other reported constitutes are below secondary MCL's, sulfate and chloride concentrations were greater than the standard of 300 mg/L in several wells, while fluoride is slightly above the secondary limit of 2.0 mg/L in one well.

Although water from both aquifers is of acceptable quality for potable supply it may not be appropriate for irrigation use because of the relatively high concentrations of sodium and bicarbonate. Excess sodium can be toxic to many plant species, and both bicarbonate and sodium can negatively impact soil permeability over time. As shown in Table 4, the average values of the Sodium Adsorption Ratio (SAR) and the Residual Sodium Carbonate (RSC) are 46 and 7.5 milliequivalents per liter (meq/l), respectively in the Paluxy, and 45 and 6.4 meq/L in the Twin Mountains. While different species of plants can tolerate a wide range of sodium and bicarbonate, the SAR and RSC values shown here are generally considered high for sustained, long-term irrigation. If the Town intends to use unblended water from the well as a source of irrigation water, it is recommended that they consult with a qualified agronomist before doing so.

Table 4. Regional Water Quality

State Well Number	Calcium (mg/L)	Bicarbonate (mg/L)	Magnesium (mg/L)	Sodium (mg/L)	Sulfate (mg/L)	Chloride (mg/L)	Fluoride (mg/L)	Nitrate (mg/L)	pH	TDS (mg/L)	SAR	RSC (meq/L)
Paluxy Water Quality												
1849401	1.1	461	<0.5	259	95	17	1.2	<0.44	9.0	650	51	6.4
1849705	1	510	1	258	81	18	1.2	3	8.9	653	44	7.5
1849712	1.06	497	0.32	249	93.8	14.8	1.2	<0.02	9.0	653	54	7.0
1857306	1.6	566	0.4	271.5	100.9	19.2	1.3	0	8.7	673	50	9.3
1956502	0.8	494	0.37	249	91	18	0.8	2.4	8.7	633	42	7.7
1956601	1.4	531	0.25	269	84	19	1.4	2	8.9	677	46	7.9
1956901	1.4	466	0.5	250	92	17	0.9	2.3	9.0	634	42	6.7
1956903	1	526	0.5	266	83	17	1.2	<0.4	8.9	661	45	8.0
1964207	1	425	1	240	90	16	0.7	<0.4	9.1	589	41	5.9
1964301	1	456	0	240	83	15	0.6	0.8	8.5	602	66	6.7
1964304	1	497	2	235	79	15	0.9	<0.4	9.0	591	31	7.6
1964307	1.6	604	0.75	280	77	15	1.9	<0.04	8.6	701	46	9.4
Average	1.2	503	0.6	250	88	17	1.04	1.11	8.9	643	46	7.5
Maximum	1.6	604	2.0	280	101	19	1.90	3.00	9.1	701	66	9.4
Twin Mountains Water Quality												
State Well Number	**Calcium (mg/L)**	**Bicarbonate (mg/L)**	**Magnesium (mg/L)**	**Sodium (mg/L)**	**Sulfate (mg/L)**	**Chloride (mg/L)**	**Fluoride (mg/L)**	**Nitrate (mg/L)**	**pH**	**TDS (mg/L)**	**SAR**	**RSC (meq/L)**
1857305	3.4	381	0.85	344	98	247	0.6	1.02	8.5	908	44	6.3
1857401	6	388	1	405	125	325	0.8	2.7	8.3	1056	40	6.0
1857403	4	367	1	361	93	300	0.5	2.9	8.3	943	42	5.7
1857404	4	358	1	390	95	346	0.7	3.3	8.3	1015	45	5.6
1857602	4	351	0.7	398	89	343	0.5	0.22	8.5	1031	48	5.7
1858103	3.5	358	0.89	374	96	267	0.6	<0.04	8.5	947	46	6.0
1956802	4.1	337	1	484	80	532	0.32	0.08	8.4	1291	56	5.5
1964201	2	395	0.5	311	93	169	0.5	<0.04	8.7	800	45	6.9
1964211	1.5	355	0.36	283	81.8	174	0.37	0.56	8.9	755	54	6.5
1964305	1.4	537	<0.2	277	92	24	1.7	<0.4	8.9	700	47	9.6
1964308	2	337	1	308	91	170	0.3	0	8.7	778	44	6.7
1964316	10	552	3.3	336	326	25	2.2	0.04	8.0	990	24	8.3
1964505	2.04	348	0.57	337	88	201	0.6	0.04	8.6	833	54	6.1
1964506	2.76	361	0.87	320	79.1	255	0.53	<0.2	8.6	866	43	6.2
1964903	5	347	1	466	93	469	0.8	3.7	8.3	1208	50	5.4
Average	3.7	385	0.9	360	108	256	0.73	1.00	8.5	941	45	6.4
Maximum	10.0	552	3.3	484	326	532	2.20	3.70	8.9	1291	56	9.6
TCEQ Secondary Maximum Contaminant Limits (mg/L)	*NA*	*N/A*	*N/A*	*N/A*	*300*	*300*	*4*/2*	*10*	*>7.0*	*1,000*	*N/A*	*N/A*

meq/L - milliequivalents per liter
**** - Indicates Primary Contaminant Limits***

Groundwater District Regulation and Permitting

Groundwater production in Denton County is regulated by the North Texas Groundwater Conservation District (District or NTGCD). Created in 2009, the NTGCD is a relatively new entity and does not have complex permitting requirements as is the case with many other groundwater conservation districts in Texas. The District requires the submittal of a registration form for each new boring or production well. A $100 fee is imposed by the district for the registration, and an additional $100 driller's log deposit is required, which is refunded if the drillers log is submitted to the District within 60 days of well or boring completion. After a well is put into service, produced water is to be metered and a fee of $0.10 per 1,000 gallons is required to be paid to the District, per the 2016 fee schedule. A registration form with basic information and signatures of associated parties is required to be submitted before drilling begins and is typically approved with a few days of submittal.

Presently, the District is operating under temporary rules which will remain in effect until permanent rules are enacted. From conversations with the District it is likely that permanent rules will be adopted within the next 12 months. GMA-8 is presently reviewing the rules of the districts within its jurisdiction and will be disseminating new guidelines within the next year. As is the case in other Districts, these new rules may require mandatory well setbacks from property boundaries and regulate groundwater production based on acreage owned. The process for borehole drilling and well construction approval may also become longer and more complex. It is difficult to predict what changes will take effect, however, it may be worth-while to construct a well before new rules requiring more testing, longer approval wait times, or well setbacks are in effect.

TCEQ Approvals for Public Supply Wells

It is necessary to obtain TCEQ approval to construct and use public supply wells. Prior to well construction, a packet containing technical specifications detailing the construction of the proposed well and potential pollution hazards near the well site is submitted. Typically, about 90 days is needed for TCEQ review and approval of the submittals. Once the well is constructed, various documents are submitted in order to obtain "interim approval" to use the well as a public supply. These submittals include: 1) an executed deed and/or sanitary control easement for the area around the well, 2) a map of the final well site, 3) documentation of the methods and materials used to construct the well, 4) pump test results, 5) water chemistry analyses, and 6) bacteriological sampling results. Once submitted, a TCEQ review period of approximately 60 days is required to receive approval to use the well.

Aquifer Testing

As noted above, there is some regional variability in the hydraulic properties and chemical constituents associated with the target aquifers in the Lakewood area. Consequently, there is some uncertainty regarding the maximum yield and quality of the water produced by a well constructed in the future. Aquifer testing and sampling may be performed if the Town requires greater surety in the characteristics of a new well than can be provided by the available data. Construction and testing of relatively-inexpensive temporary wells can be performed to document aquifer properties prior to construction of a full-scale production well. In general, there are two approaches to implementing a testing program:

1) ***Stand-Alone Test Drilling and Aquifer Testing Program*** – A relatively small drilling rig is used to complete a test hole through the target aquifer(s). During test drilling, drill cuttings samples are collected and geophysical logging of the borehole is performed to assess sand thickness and character. Subsequently, a desired test zone depth is chosen and temporary casing and screen is installed in the well. The well is then tested using temporarily installed pumping equipment, stressing the aquifer to evaluate aquifer properties, and water quality samples are collected for laboratory analysis. Multiple zones can be tested by plugging off the deepest zone and installing the casing and screen in successively shallower zones. At the conclusion of the testing program, the temporary pumping equipment and well materials are removed and the borehole is plugged.
2) ***Conduct Aquifer Testing with Production Well Rig*** – In this approach, test drilling and aquifer testing using a temporary well are performed as described above, but by larger drilling equipment capable of constructing a production well. If the testing indicates acceptable aquifer properties, the test well equipment is removed and a permanent well is immediately constructed in the borehole.

The stand-alone test drilling and aquifer testing approach is generally preferred where significant variations in site-specific aquifer properties exist. In general, testing is performed at two or more locations being considered for permanent well location. The testing results are then evaluated and modeled to identify optimal well sites. Using this approach, productive capability and water quality are fully documented prior to well construction, and the Town is assured that the best well site was selected.

The second approach allows for a continuous process from well testing to well construction, and is likely the less expensive of the two approaches. However, there are limitations/drawbacks associated with it. First, because the drilling rig is on standby once testing is complete, the time available for data analysis and subsequent decision-making regarding whether to construct a permanent well is very limited. In addition, this approach does not allow for comparison of the hydraulic properties at various sites before well construction begins. Consequently, the primary benefit to this approach is to identify "fatal flaws" in the aquifer (insufficient saturated thickness, poor water quality) immediately prior to construction of a relatively-expensive permanent well.

If the Town wishes to construct a new Paluxy well, testing of the existing Paluxy wells is highly recommended as a relatively inexpensive way to document local aquifer characteristics and to determine the production potential of the existing wells. Using this information, more accurate estimates of the long-term productivity and interference drawdown resulting from a new well can be generated without incurring the cost of a full temporary well testing program.

Project Costs

General estimates of potential project costs are outlined in Tables 5 and 6. These tables show testing and well construction in the Paluxy and Twin Mountains aquifers. On the lower end of possible production, the total capital cost for constructing a new Paluxy well yielding a long-term rate of 125 gpm is approximately $740,000 and the estimated annual operations and maintenance cost is $61,000 for continuous operation at 125 gpm. Engineering, permitting, and well construction observation for a Paluxy production well is approximately $94,000. On the high end of the production scale desired by the Town, the total capital cost for constructing a new Twin Mountains well capable of producing a long-term rate of 350 gpm, is approximately $1,030,000 and the estimated annual operations and maintenance cost is $129,000. Engineering, permitting, and well construction observation for a Twin Mountains production well is approximately $107,000. Costs for pilot hole drilling, presented in Table 5, assume a 1,200 foot depth for the Paluxy and an 1,800 foot depth for the Twin Mountains, and include geophysical logging (natural gamma, spontaneous potential, resistivity, and caliper), sand sampling, and sieve analyses. Well construction costs assume a 14-inch diameter carbon steel casing and 8-inch diameter stainless steel screen assembly for the Paluxy well, and a 16-inch carbon steel casing and 10-inch screen assembly for the Twin Mountains well. Permanent pumping equipment costs include submersible pump and motor, concrete well foundation, well head infrastructure, and simple above ground electrical controls. It should be noted that these costs pertain to the underground portions of the well and for the pumping equipment and wellhead infrastructure up to the discharge flange. The values listed do not include costs associated with design and construction of above-ground infrastructure including electrical service, piping, roads, fencing, etc. that may be needed to integrate the well into the Town's water system.

Twin Mountains testing costs shown in Table 5 include costs for constructing a stand-alone test well, and constructing a test well immediately prior to permanent well construction. If conducting stand-alone aquifer testing, it is recommended that testing be conducted in least at two locations to determine the most beneficial site for a production well. The total cost of drilling a test hole and testing temporary wells at two sites for a stand-alone testing program is approximately 1,018,000 dollars, including engineering. Costs associated with constructing a stand-alone temporary well assume a test hole depth to 1,800 feet and include geophysical logging, sand sampling and sieve analyses, temporary well construction, 48 hours of well testing, water quality testing, and plugging of the test well upon completion. Engineering for the stand-alone testing includes specification preparation, contract management, test hole and test well construction observation, data collection, and reporting.

The cost for constructing a Twin Mountains temporary well immediately prior to permanent well construction is approximately 387,000 dollars, including engineering, and is an addition to the well construction costs. Costs associated with constructing a Twin Mountains temporary well during well construction includes the cost of installing and removal of temporary well materials, and aquifer testing. Engineering includes test hole and test well construction observation, data collection, and reporting.

Estimated costs for testing of one existing Paluxy well are presented in Table 5, and include disconnecting the well from permanent piping, installation of a temporary flowmeter, temporary discharge piping, temporary measuring tube installed to 900 feet, and 12 hours of pump testing. Engineering costs associated with the testing include planning, contractor management, data collection and reporting.

The potential electrical and maintenance costs associated with well operation were calculated using the following estimates and assumptions:

- Potential wellbore pumping levels were estimated through analytical flow modeling employing hydraulic parameters obtained from TWDB records and the regional groundwater availability model used by GMA-8.
- Future water level declines stemming from further development in the region were not included, but it should be noted that the cost to pump water from below ground to the surface will increase in the future as the aquifers are further developed.
- An assumed 41 feet of additional head for a Paluxy well constructed at the southern location and 69 feet for a Twin Mountains well constructed at the Pump Station were included to account for above-ground lift and pumping equipment friction losses.
- A raw power cost of $0.10 per kilowatt-hour.
- The Paluxy well was assumed to provide 125 gpm continuously, and the Twin Mountains well was assumed to provide 350 gpm, continuously.
- Pumping equipment must be replaced every 5 years.

The capital cost estimates herein are based on information provided by contractors and RWH&A experience; however, costs have recently begun to vary widely, with up to 30% variations in price from bidder to bidder. Therefore, these costs should be viewed as a general guideline and could change based on competitive projects in the area and economic conditions.

Table 5: Estimated Capital Costs

Capital Costs - Paluxy Aquifer		
Item	***Units***	***Cost***
Testing*		
Well Testing of Existing Well (One Well)	1	$14,000
Well Construction - 125 gpm Well		
Mobilization	1	$150,000
Pilot Hole - 1200 ft	1	$55,000
Well Construction - 8" Screen x 14" Casing	1	$400,000
Permanent Pumping Equipment - 125 gpm	1	$135,000
Total Capital Cost		**$740,000**
Capital Costs - Twin Mountains Aquifer		
Testing*		
Mobilization	1	$50,000
Stand Alone Test Well (One Well) - 1800 ft	1	$484,000
Well Construction - 350 gpm Well		
Mobilization	1	$250,000
Pilot Hole - 1800 ft	1	$70,000
Well Construction - 10" Screen x 16" Casing	1	$500,000
Permanent Pumping Equipment - 350 gpm	1	$210,000
Total Capital Cost		**$1,030,000**
Additional Items*		
Test Well (One Well) - 1800 feet	1	$387,000
Engineering Capital Costs		
Production Well Technical Specifications and Bidding	1	$20,000
TCEQ Submittal - Well Construction	1	$5,000
TCEQ Submittal - Interim Use	1	$5,000
Well Construction Observation - Paluxy Well	1	$64,000
Well Construction Observation - Twin Mountains Well	1	$77,000
Total Well Construction and Engineering Cost - Paluxy Well		**$834,000**
Total Well Construction and Engineering Cost - Twin Mountains Well		**$1,137,000**

*Includes engineering, construction observation, and testing oversight

Table 6: Estimated Operational Costs

Annual O&M Costs				
Item	***Quantity***	***Unit***	***Unit Price***	***Cost***
Well Energy Cost - 125 gpm - Paluxy Well	65,700	Thousand gallons per Yr	$0.39	$25,623
Groundwater District Water Use Fee* - Paluxy Well	65,700	Thousand gallons per Yr	$0.10	$6,570
Well Energy Cost - 350 - Twin Mountains Well	183,960	Thousand gallons per Yr	$0.43	$79,103
Groundwater District Water Use Fee* - Twin Mountains Well	183,960	Thousand gallons per Yr	$0.10	$18,396
Well Maintenance - Paluxy/Twin Mountains	1	Lump Sum	$10,000	$10,000
Well Pump Replacement (5 year life) - 125 gpm - Paluxy Well	1	Lump Sum	$25,000	$25,000
Well Pump Replacement (5 year life) - 350 gpm - Twin Mountains Well	1	Lump Sum	$40,000	$40,000
Total Annual Cost - 125 gpm - Paluxy Well				**$67,000**
Total Annual Cost - 350 gpm - Twin Mountains Well				**$147,000**

*Per North Texas Groundwater Conservation District 2017 Fee Schedule

Summary and Conclusions

The findings of this evaluation are as follows:

- The available hydrogeologic information suggests that the Paluxy and Twin Mountains aquifers are the best candidates for groundwater production within the Town. A Paluxy well is likely capable of yielding average, long term production rates of 125 gallons per minute with short term rates approximately 25% to 75% higher, while a Twin Mountains well may be capable of producing an average, long term production rate of up to 800 gallons per minute.

- There are relative advantages and disadvantages associated with developing the Paluxy or the Twin Mountains aquifers. The Paluxy is the shallower aquifer, which typically results in lower well construction costs. However, the Paluxy is thinner and less permeable than the Twin Mountains. Consequently, for a given rate of production, significantly greater well bore water level declines may be expected for a Paluxy well. In addition, interference effects from the existing Paluxy wells within and surrounding the Town will result in deeper pumping water levels (and increased electrical lift costs) for both a new and the existing wells.

- Although fresh in both aquifers, water of the Twin Mountains is more mineralized than the water of the Paluxy and regional averages indicate the Twin Mountains water quality is only slightly below maximum public supply standard limits. Water from the Twin Mountains may require blending or treatment if water quality constituents are locally found to be above drinking water standards. Common water quality indicators of both aquifers suggest the groundwater may not be appropriate for irrigation applications, however, the suitability of the water depends on the type of plant and soil being irrigated.

- The North Texas Groundwater Conservation District (NTGCD) presently requires a short registration form to be submitted before well construction begins. A $100 fee is required for well registration and an additional refundable $100 driller's log fee is required, refunded if a log is provided to the District within 60 days of well completion. Once water is produced from the well it is required to be metered and a fee of $0.10 per 1,000 gallons produced is to be paid to the District. Typical time required to obtain permission for drilling is one week. However, RWH&A communications with NTGCD staff indicates that more stringent rules on well placement, construction and water production may be implemented within the next year.

- Estimates of the general costs for engineering, permitting, aquifer testing, and well construction and operation were compiled for this study. Using various assumptions and limitations discussed herein, the total capital costs of a 125 gpm Paluxy well with 14-inch carbon steel casing and 8-inch stainless steel screen is approximately 834,000 dollars, including engineering. Annual operation and maintenance costs are projected to be approximately 61,000 dollars. The total capital cost of a 350 gpm Twin Mountains well with 16-inch carbon steel casing and 10-inch screen is approximately 1,137,000 dollars, including engineering. Annual operation and maintenance costs of a 350 gpm Twin Mountains well are projected to be approximately 129,000 dollars.

- According to regional data and modeling conducted by RWH&A, the Twin Mountains aquifer can sustain long term, continuous well rates of up to 800 gpm. If the Town anticipates greater demand in the future and prefers the option of producing up to 800 gpm without constructing additional wells, a larger diameter Twin Mountains well would allow for installation of larger pumping equipment as demand increases. A larger diameter Twin Mountains well, constructed of 18-inch carbon steel casing and 12-inch stainless steel screen, with 350 gpm pumping equipment will cost approximately 1,187,000 dollars, including engineering.

- There is some regional variability in the hydraulic properties and chemical constituents of the target aquifers in the Lakewood area. Consequently, there is some uncertainty regarding the maximum yield and quality of the water produced by a well constructed in the future. If the Town requires increased surety with regard to the productivity and/or chemical quality of groundwater within the target aquifers, test drilling and aquifer testing may be performed prior to production well construction. A stand-alone test drilling and aquifer testing program of the Twin Mountains aquifer is recommended in at least two sites to determine the most advantageous location for a production well. The cost for conducting this work is approximately 1,018,000 dollars, including engineering. If a less costly approach is desired, constructing and testing a temporary well immediately prior to permanent well construction will provide a simple "fatal flaws" analysis of the aquifer, identifying insufficient saturated thickness or poor water quality. If a fatal flaw is identified, the well construction process can be halted, ultimately saving the costs for installing the relatively-expensive permanent well materials. Testing immediately prior to permanent well material installation would cost approximately 387,000 dollars, including engineering, and would be an addition to the well construction cost. Testing of the existing Paluxy wells may be sufficient to prove up aquifer characteristics and would cost approximately 14,000 dollars for one well, including pump test oversight conducted by RWH&A.

Plates

Plate 1. Proposed Well Locations and Existing Town Wells

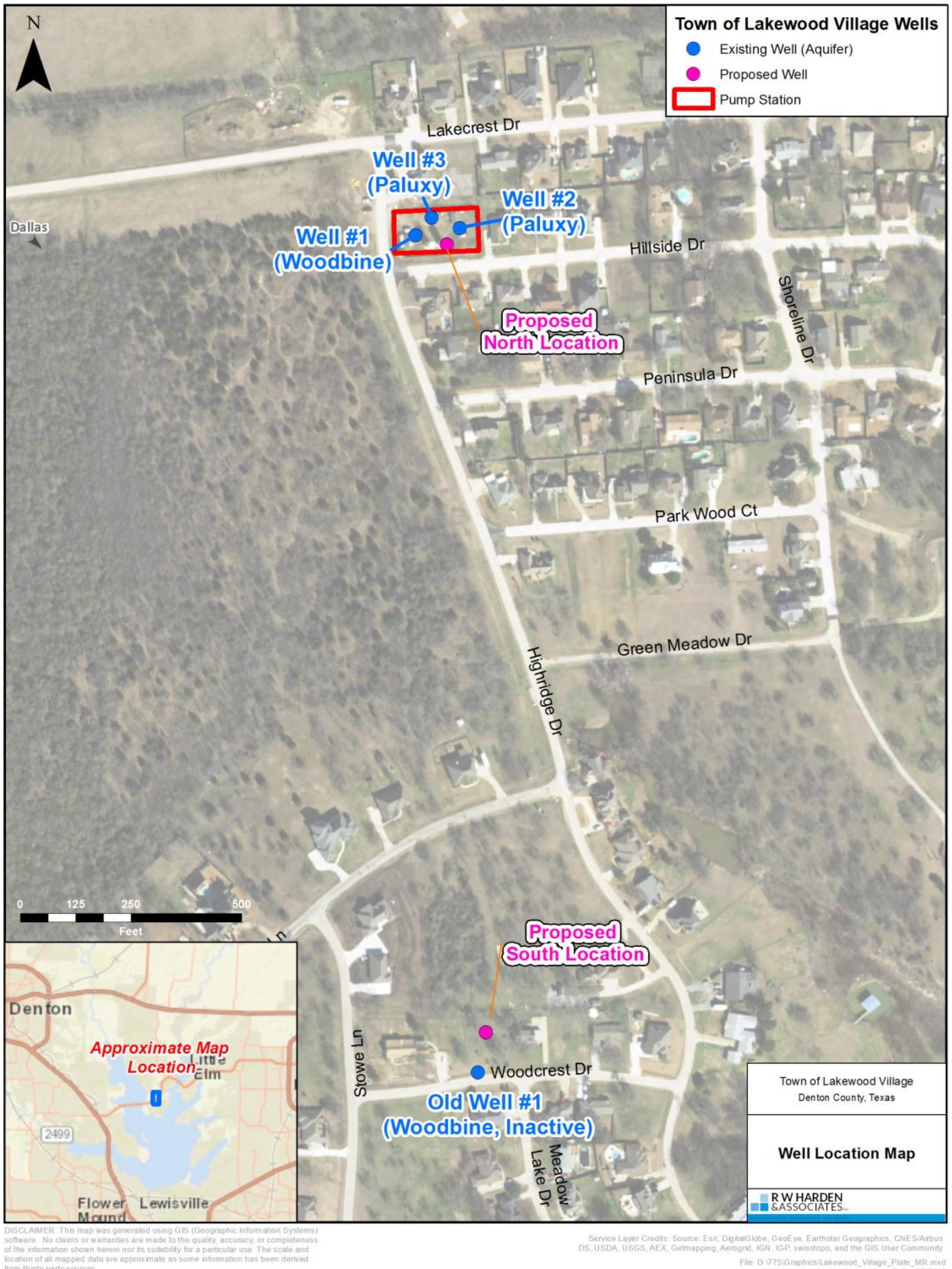
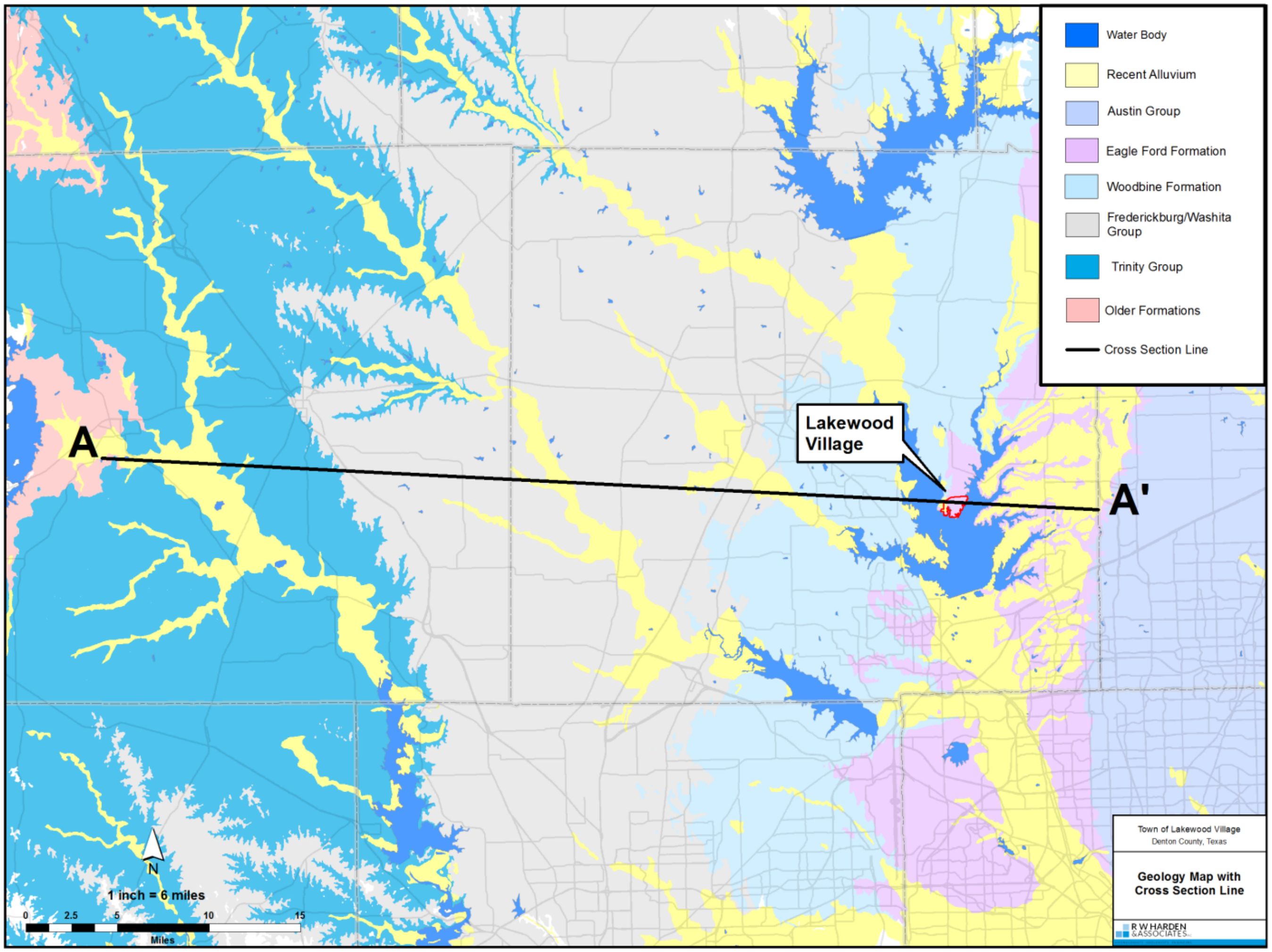


Plate 2. Surface Geology Map



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File: D:\775\Graphics\Geologic_Rock_Unit_Map_MR.mxd
Map Date: 8/2/2016

Plate 3. Geologic Cross Section

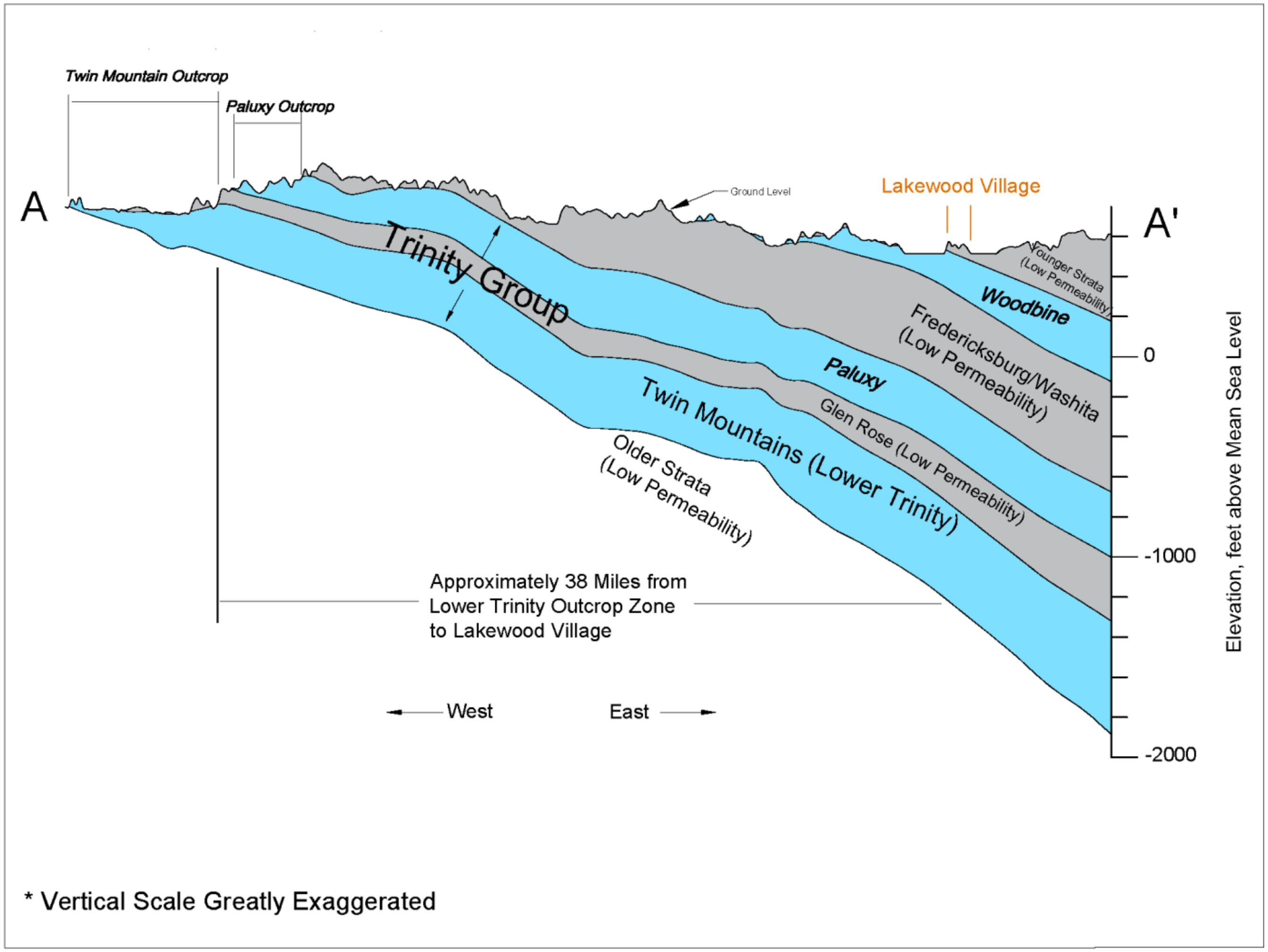
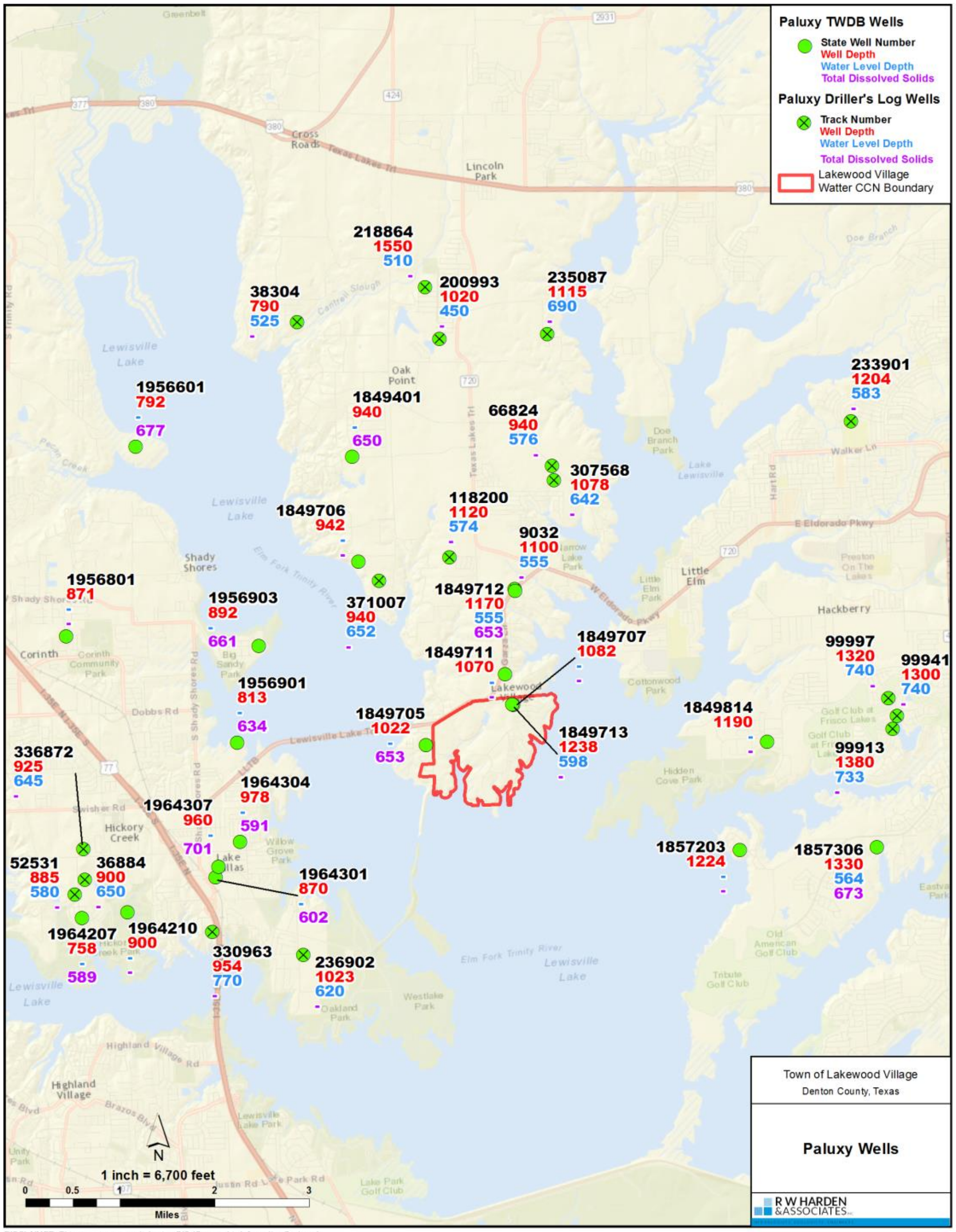


Plate 4. Paluxy Aquifer Wells



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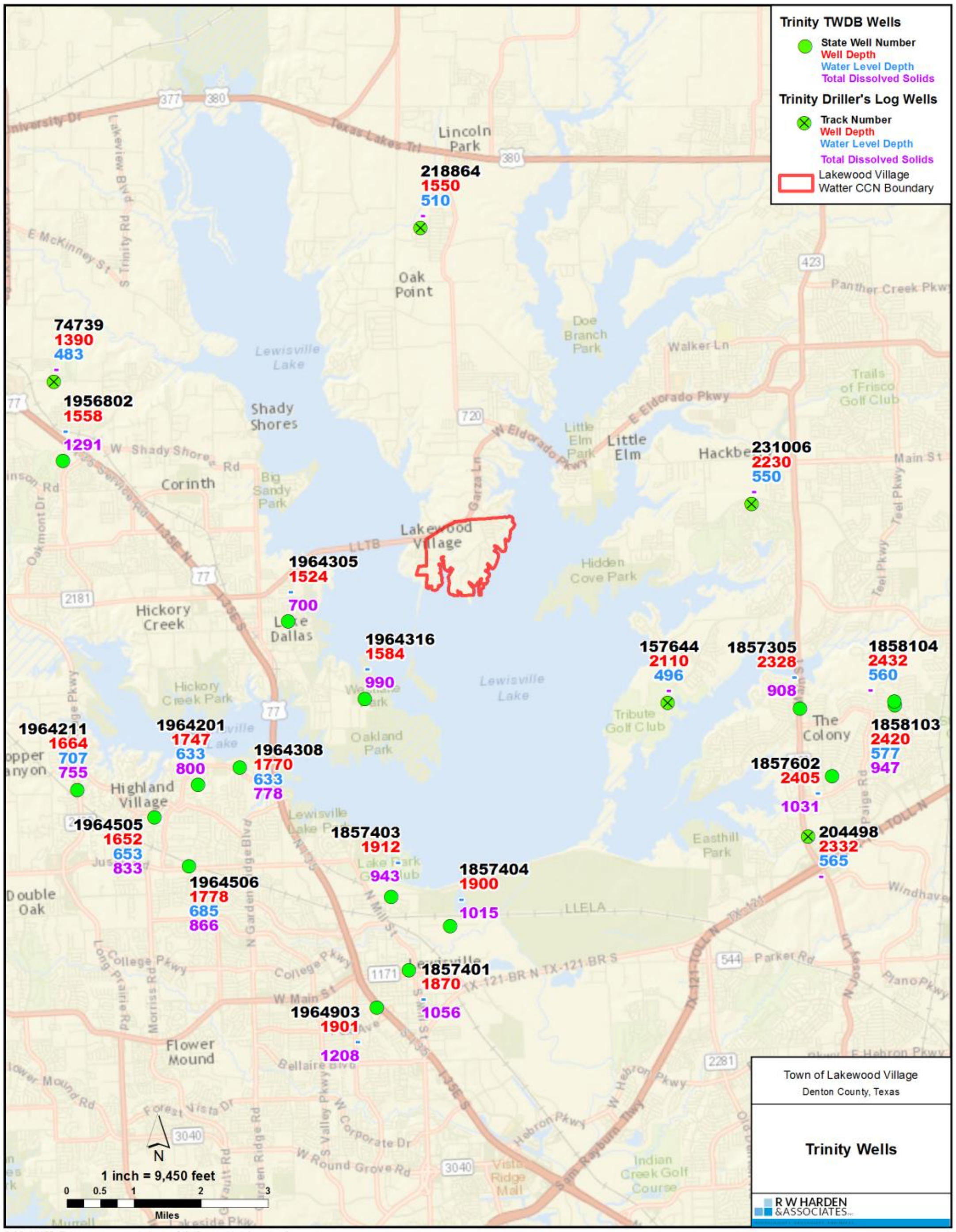
File: D:\775\Graphics\Paluxy_Plate.mxd
Map Date: 8/2/2016

Plate 5. Twin Mountains Aquifer Wells



DISCLAIMER: This map was generated using GIS (Geographic Information Systems) software. No claims or warranties are made to the quality, accuracy, or completeness of the information shown herein nor its suitability for a particular use. The scale and location of all mapped data are approximate as some information has been derived from thirdy party sources.

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File: D:\775\Graphics\Trinity_Plate_v2.mxd
Map Date: 8/2/2016

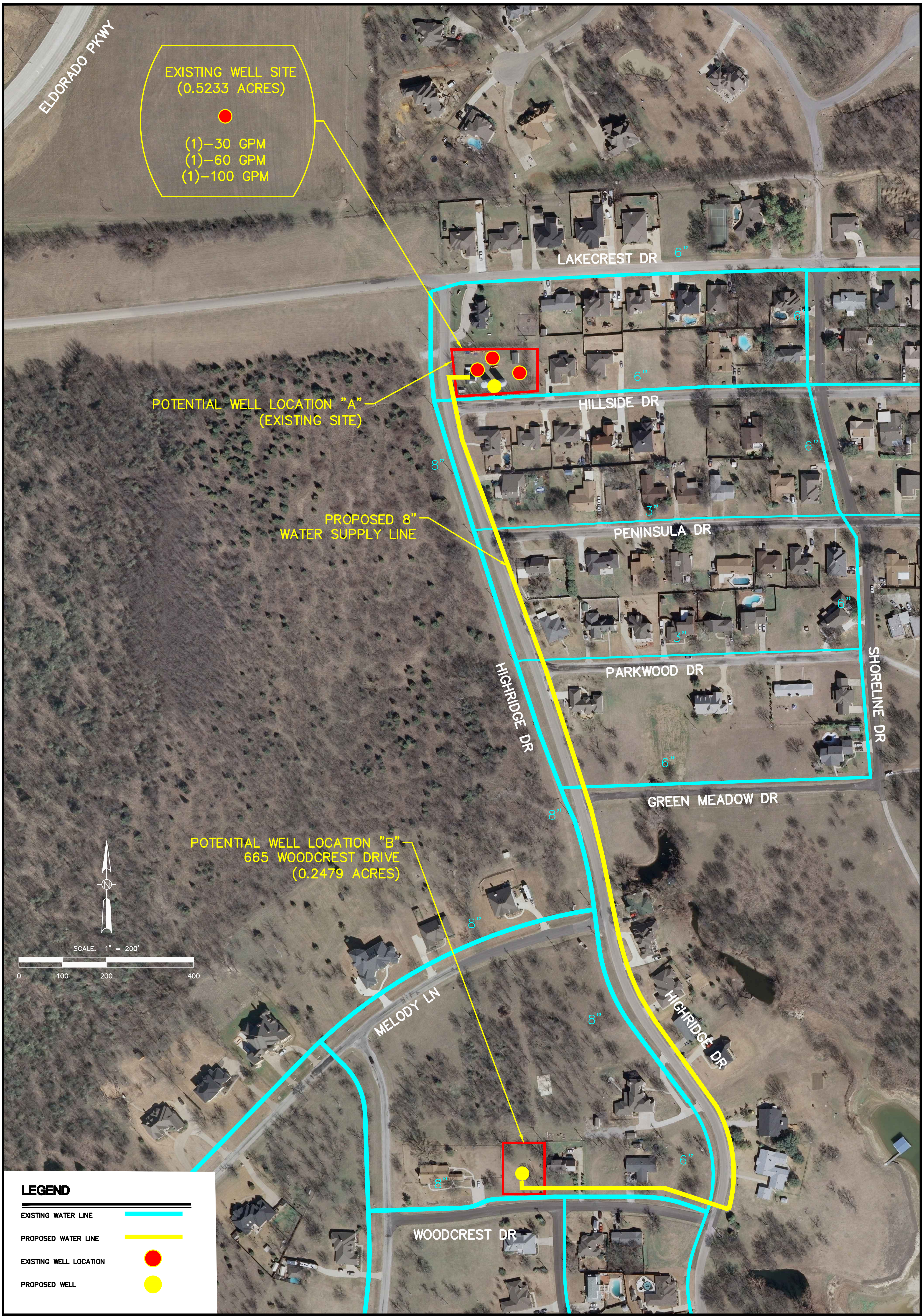
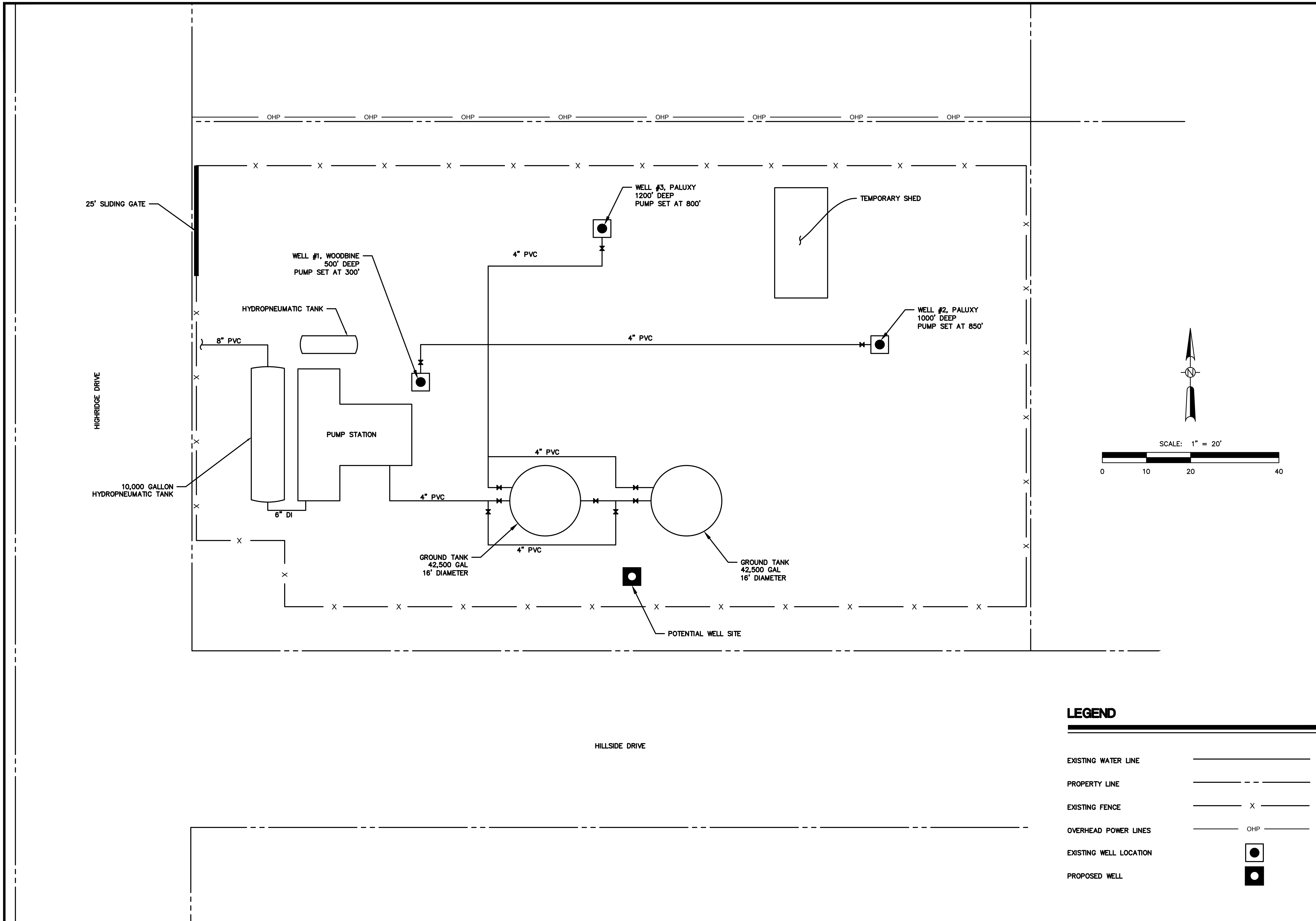


EXHIBIT	DATE: SEPTEMBER 2016	EXHIBIT 1 POTENTIAL WELL SITES	Town of Lakewood Village Well Feasibility Study	Kimley»Horn
1	DESIGN: SAW			Texas Board Of Professional Engineers Firm Registration Number: F-928 12750 Merit Drive, Suite 1000, Dallas, TX 75251 972-770-1300
	DRAWN: DGD			
	CHECKED: TLS			
	KHA NO.: 064487103			

No.	Revision	By	Date

K:\MKN_Civil\064487100 – Lakewood Village Water Impact Fees\Dwg\Exhibits\Memo_Exhibit 1 – Potential Well Locations.dwg



Kimley»Horn

No.	Revision	By	Date

Town of Lakewood Village
Well Feasibility Study

EXHIBIT 2 - EXISTING WELL SITE
(LOCATION "A")

DATE: SEPTEMBER 2016
DESIGN: SAW
DRAWN: DGD
CHECKED: TLS
KHA NO.: 064487103

EXHIBIT
2