RICHARD C. SLADE & ASSOCIATES LLC
CONSULTING GROUNDWATER GEOLOGISTS

PRELIMINARY WELL DESIGN REPORT
PROPOSED WELL NO. 28

CITY OF ORANGE
ORANGE COUNTY, CALIFORNIA

PREPARED FOR:
TETRA TECH INC
AND
THE CITY OF ORANGE

PREPARED BY:

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JOB NO. 106-OGE18

OCTOBER 2019

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LIST OF ABBREVIATIONS/ACRONYMS USED IN REPORT

The following provides a list of abbreviations that may be used more than once throughout this report and is provided for the convenience of the reader.

Abbreviation	Full Description
APN	Assessor's Parcel Number (Orange County)
Al	aluminum
AL	action Level
B	boron
Ba	barium
bgs	below ground surface
BMP	Best Management Practice
Cu	copper
DDW	Division of Drinking Water
DTSC	Department of Toxic Substances Control
DWR	California Department of Water Resources
Fe	iron
HSLA	high strength low alloy
ID	inside diameter
LCS	low carbon steel
LUPs	linear underground/overhead projects
LUST	leaking underground storage tank
MCL	Maximum Contaminant Level
NL	Notification Limit
NPDES	National Pollutant Discharge Elimination System
OD	outside diameter
PCA	Potentially Contaminating Activity
PDR	Preliminary Well Design Report
PWL	pumping water level
RCS	Richard C. Slade & Associates LLC
RWQCB	California Regional Water Quality Control Board
Se	selenium
SP	spontaneous potential
SWPP	storm water prevention plan
SWL	static water level
SWRCB	State Water Resources Control Board
TDS	total dissolved solids
TH	total hardness
UST	underground storage tank
VOC	volatile organic compound
Zn	zinc
gpm	gallons per minute
gpm/ft ddn	gpm per foot of drawdown
mg/L	milligrams per Liter
µg/L	micrograms per Liter
µS/cm	microSiemens per centimeter

EXECUTIVE SUMMARY

Hydrogeologic conditions beneath a potential water well site in the City of Orange (City) for proposed Well No. 28 have been evaluated for this Preliminary Well Design Report (PDR). This proposed well site is on a City-owned property located at the address of 235 W Maple Avenue; at the northeast corner of the intersection of W Maple Avenue and N Lemon Street, as shown on Figure 1, “Well Location Map.”

The basic purposes of this hydrogeologic evaluation were to: assess local groundwater conditions; review and evaluate available water quality data from nearby City-owned wells; review nearby potential contaminating activities; provide a preliminary well design for the proposed new municipal-supply water well; evaluate the effect of pumping of the well on existing nearby wells; and evaluate a likely future pumping rate and depth setting for a permanent pump in the proposed well.

Available data for nearby existing wells within the City were obtained and reviewed for this project. These records included: driller’s logs; available static water level data, pumping rate data and specific capacity data; data on pumping water levels; groundwater quality data; and environmental data in the vicinity of the subject well site.

Review of the available data revealed that recent sediments (which form the Shallow Groundwater Unit), the slightly older sediments of the Lakewood Formation (which contains the lower Shallow Groundwater Unit and upper Principal Aquifer System) and the underlying San Pedro Formation (which contains the lower Principal Aquifer System), are generally present beneath the proposed well site. These aquifers currently provide groundwater to existing City-owned wells in the area.

Based on the available long-term water level data from nearby City Well No. 18, static water level (SWL) depths in the area have historically ranged from 103 ft to 218 ft below ground surface (bgs). Current SWLs, based on relatively recent SWL measurements from nearby City Well No. 18, are at depths on the order of 130 ft to 150 ft bgs. Based on limited pumping data available from nearby City Well Nos. 18, 25, and 27, current pumping water level (PWL) depths have ranged from 159 ft to 337 ft bgs, depending on the pumping rate in each respective well. Those pumping rates have ranged from 991 to 3,212 gallons per minute (gpm), and created water level drawdowns of 35 ft to 96 ft. Thus, current specific capacity values for these proximal City wells have ranged from approximately 28 to 45 gallons per minute per foot of drawdown (gpm/ft ddn).

Available historic groundwater quality data from existing onsite wells indicate that groundwater from the proposed new well will likely produce potable water similar to that from Well No. 18, if designed such that the new well contains perforations in the same aquifer systems that are perforated in this nearby well.

The results of this hydrogeologic evaluation indicate reveal that the a proposed new well at the City-selected site could have a pumping capacity of 2,500 to perhaps 3,000 gpm. General conditions and the basic <u>preliminary</u> design for the proposed new well include:

- An anticipated pilot hole drilling depth of 1,000 ft bgs.
- Construct the well to a cased depth of 960 ft bgs, using 20-inch diameter steel casing to a depth of 435 ft bgs, followed by 16-inch diameter steel casing (blank and interspersed Ful-flo louvers) to a depth of 940 ft bgs. A 20-foot long cellar pipe will be installed at the bottom of the casing from 940 to 960 ft bgs. Final depth and design of

the blank and perforated sections of the well casing will based on the geophysical electric logs and on the results of the geologic log of drill cuttings from the pilot hole.

- The estimated current SWL is on the order of 130 ft to 150 ft bgs.
- At an estimated pumping rate of 3,000 gpm and using an anticipated current specific capacity for the proposed new well of 40 gpm/ft ddn, the current PWL could be at a depth on the order of 205 to 225 ft bgs. Therefore, a permanent, pump depth setting of approximately 400 is preliminarily estimated at this time; this preliminary pump depth setting also factors in potential water level declines due to decline in specific capacity in the well over time and water level declines due to potential long-term drought.
- Preliminary costs for the drilling, construction, development, and testing of the proposed new well could be approximately $1,110,000 to $1,460,000, depending on the type of steel well casing to be used. In addition, the selected well site will have additional costs for well equipping activities to be performed after the well is constructed.

Recently, the constituents perfluorooctanesulfonic acid (PFOS) and perfluorooctanoic acid (PFOA) have become constituents of concern and have reportedly been detected in other City water-supply wells in the region. Thus, following completion of drilling of the pilot hole, it will be necessary to test for perfluoroakyl substances (PFAS), in addition to other COCs (such as perchlorate) by conducting isolated aquifer zone testing at specific depth intervals to be determined after review of the electric log.

INTRODUCTION

This Preliminary Well Design Report (PDR) presents the hydrogeologic findings and analyses of available data and provides preliminary design recommendations for a new municipal-supply water well (to be known as Well No. 28) for the City of Orange (City). Well No. 28 is proposed to be constructed at a City-selected site that is located at the northeast corner of W Maple Avenue and N Lemon Street in the City of Orange, California. Figure 1 shows the regional location of this site and the locations of other nearby City-owned municipal-supply water wells within the City. The subject property:

- is located at the address of 435 W Maple Avenue;
- has an Orange County assessor's parcel number (APN) of 039-162-23;
- is a single 0.36-acre land parcel; and
- has GPS coordinates of 33.789870°, -117.854924°

A production rate of 3,000 gallons per minute (gpm), if available from the aquifer systems beneath the well site, is desired by the City for the new City well.

The key purposes of this PDR are to: provide a hydrogeologic assessment of subsurface conditions in the vicinity of the proposed well site; and prepare a preliminary design for the proposed well. Data and recommendations presented in this report will be used by RCS geologists to subsequently prepare the Technical Specifications and Line Item Bid Sheets for the future bidding, construction and testing of this proposed new well.

Available data with regard to well construction, water levels, and water quality for the existing and former City wells in the vicinity of the proposed well site have been evaluated for this project and the various tables in this report summarize key information obtained from available data on subsurface geologic conditions, water levels, pumping data, and water quality data from those nearby wells. Further, driller's logs and available geologic logs from other nearby City wells (namely Well Nos. 4, 5, 18, 25, and 27) were also utilized to help define subsurface geologic conditions beneath the proposed well site in order to help identify the approximate depths and thicknesses of the underlying aquifer systems.

FINDINGS

Local Well Construction Parameters

The nearest existing City-owned wells to the subject well site are Well Nos. 4, 5, 18, 25, and 27 (see Figure 1); data from these wells are considered to be representative of conditions in the area of the proposed well site. Table 1, "Summary of Available Water Well Construction Data," summarizes the available basic construction data for these five wells. Key well information summarized thereon includes:

- Well Nos. 4, 5 and 18 were drilled utilizing the archaic cable tool drilling method, whereas Well Nos. 25 and 27 were drilled using the reverse circulation drilling method. The latter method is currently the principal method used to construct municipal-supply water wells in southern California.
- Pilot hole drilling depths ranged from 714 ft bgs in Well No. 18, to 993 ft bgs for Well No. 25.
- Well casing depths range from 714 ft bgs in Well No. 18 to 910 ft bgs in Well No. 27.
- Casings in Well Nos. 4, 5, 18, and 25 were constructed with low carbon steel (LCS) well casing and are generally 20 inches in diameter; casing in Well No. 27 is made of Type 304L stainless steel and has a casing diameter of 20 inches. Casing diameters in Well Nos. 4 and 25 were reduced to 12 inches and 16 inches, respectively, at depth. Note, that Well No. 4 has an upper casing liner of 14 inches in diameter to a depth of 202 ft bgs within its original 20-inch diameter casing.
- Sanitary seal information for Well Nos. 18, 25, and 27 shows seal installation depths ranging between 50 ft and 60 ft bgs. According the California Department of Water Resources (DWR) guidelines, a minimum 50-foot deep sanitary seal is required to use the groundwater pumped from a well for public supply.
- Annular cement seal information was only available for Well Nos. 25 and 27 where an annular cement seal was placed to depths of 390 ft and 400 ft bgs for Well Nos. 27 and 25, respectively. The annular seals are installed as a precautionary measure to act as physical barrier to inhibit poor quality shallower groundwater from migrating downward into the lower aquifer systems.
- Perforation intervals begin at depths as shallow as 195 ft bgs (in Well No. 5) to as deep as 430 ft bgs (in Well No. 25). The deepest perforations in these nearby wells range from 688 ft bgs (in Well No. 18) to 890 ft bgs (Well No. 27). Further, each well has multiple depth-discrete perforation intervals, reflecting the interlayered sand/silt/clay nature of the local earth materials. The total lengths of the perforated intervals in these five wells range from 112 ft in Well No. 18, to 220 ft in Well No. 25.
- The types of perforations are Roscoe Moss Company (RMC) Ful-flo louvers in Well Nos. 25 and 27. Slot openings range in size from 0.050-inch (50 slot) in the louvers in Well No. 27 to 0.085-inch (85 slot) in the louvers in Well No. 25. Well Nos. 4 and 5,

which were cable tool-constructed wells, were perforated with a Mills knife down-hole perforating tool. Specifications for the Well No. 4 Mills knife perforations are not available. Additionally, perforation type and depth for the casing liner installed in Well No. 4 are not available. Well No. 5 has perforations with a 5/8-inch wide slot opening. Well No. 18 was perforated with Roscoe Moss louvers having a slot opening width of ¼-inch.

0 Gravel packs used in the Well Nos. 25 and 27 were California Silica Sand Inc (CSSI) 6 X 9 and Tacna Sand and Gravel (Tacna) 8 X 20 gradation, respectively. Well Nos. 4, 5, and 18 were cable-tool drilled and such construction does not allow for gravel pack to be emplaced around the well casing.

Local Hydrogeologic Conditions

The proposed new well site is located near the east-central edge of the Orange County Groundwater Basin (OCGWB) within the Coastal Plain of Orange County. Figure 2, “Location of Proposed Well No. 28 Site within OCGWB,” shows the proposed new well site relative to the boundaries of the OCGWB. This basin is generally bordered on the north by Coyote Creek, on the west by the Pacific Ocean, and on the east and south by the Peninsular Ranges and the San Joaquin Hills, respectively. In the OCGWB, potentially water-bearing sediments of the aquifer systems tend to be thickest near the center of the basin (in the general Anaheim area), and they thin towards the margins of the basin along the fronts of the adjoining highland areas.

There are a number of discrete aquifer systems that occur throughout the OCGWB and understanding the lateral and vertical extent of these systems is useful for targeting potential aquifer zones from which groundwater could be obtained for water-supply purposes by the proposed well. The nomenclature used herein for these aquifer systems is based on work performed in the Orange County region by the DWR, the results of which were originally documented in a DWR reported titled “Progress Report on Groundwater Geology of the Coastal Plain of Orange County” (DWR, 1967); similar nomenclature was utilized in a report published by Orange County Water District (OCWD, 2006), titled “Hydrogeology of the Orange County Groundwater Basin – An Updated Review.”

Table 2, “Estimate of Depths and Approximate Thicknesses of Aquifer Systems,” has been prepared to show our interpretation of the approximate depths and thicknesses of the aquifer systems which might occur in the subsurface beneath the general area of the proposed well site. The nomenclature for these aquifer systems is based on the reports by the DWR (1967) and Orange County Water District (2006).

Based on those reports, the Shallow Groundwater Unit aquifer system in OCGWB is comprised of the water-bearing sediments of recent alluvium and the upper Lakewood Formation, and include the Talbert and Alpha aquifers. The Principal Aquifer System consists of the Beta, Lambda, Omicron, Rho, and Upper Main aquifers of the lower Lakewood Formation and San Pedro Formation. The Deeper Aquifer System represents the essentially nonwater-bearing deposits of the Pico Formation as identified by DWR using oil well electric logs (E-logs); those E-logs show that those deeper deposits are of low permeability. For the purposes of this report, the individually-named aquifer systems presented in the above table will be used to help delineate the separate aquifer systems in the water-bearing section in the vicinity of the proposed new well.

The estimated maximum combined thickness of these aquifer systems beneath the site of at least 740 ft. Underlying all of the above potentially water-bearing formations is the Pico Formation of upper Pliocene age. This marine-deposited formation consists largely of relatively fined-grained sediments of lower permeability. Hence, these underlying, and geologically older deposits of the Pico Formation are considered to be non-water bearing for municipal water-supply purposes.

The existing nearby City wells constitute the most local source of data for the anticipated subsurface geologic conditions for the proposed new well. Consequently, a review of the drillers' logs of these wells was performed by RCS geologists. Well No. 18 serves as the "type log" for the site since it is the most proximal existing well to the proposed well site. RCS also correlated the electric log of Well No. 27 with electric logs available for other wells in the region. The results of our review revealed that the lithology generally consists of interbedded layers and lenses of clay, silt, sand and gravel to a depth of at least 960 ft.

Based on our electric log correlations, perforations in the nearby City wells generally extend from the lower portion of the Shallow Groundwater Unit through the Principal Aquifer System. The more recently-drilled Well Nos. 25 and 27 have perforations that extend primarily within the Principal Aquifer System (from the Lambda to the Upper Main aquifers).

Water Level Data

The use of available historic static water level (SWL) data is one tool that can be used to detect possible long-term changes in water levels over time in a well. By reviewing such data, it is possible to determine the maximum amount of water level fluctuation that has occurred in an area over time. However, the period of record for such SWL data is dependent upon the period of available water level data which may, in many cases, be limited. Nonetheless, water level data are very useful as a predictive tool because they define not only the historically highest and lowest SWLs over time, but also the changes and responses in these SWLs to rainfall and recharge over time.

Historic SWL data for nearby City Well No. 18 were obtained in electronic format from the DWR water data library website; the period of data record for this well was 1969 to 1978. More recent SWL data were also available via measurements obtained by the City for Well No. 18 between 1996 and June 2019. Perforation intervals for Well No. 18 are generally from 372 ft to 688 ft bgs (with interspersed sections of blank casing). Figure 3, "Water Level Hydrograph of Nearby City Well No. 18," illustrates the pattern of the available SWL data for the above-listed time period for Well No. 18. Review of these data reveals the following:

- SWLs in Well No. 18 have ranged from 103 ft (in January 2006) to 218 ft (in July 2001). Based on relatively recent SWL measurements from nearby City Well No. 18, current SWL depths are on the order of 130 ft to 150 ft bgs.
- SWL measurements from Well No. 18 do not show any signs of a progressive or continuous increase or decline trend over time.
- The water level data shown on the hydrograph appear to respond to changes in rainfall throughout the period of available data (i.e., they tend to decline during drought and tend to rise during above-average rainfall conditions).

Also shown on Figure 3 is a solid, black line that represents the accumulated rainfall departure curve for annual rainfall data obtained from the "Santa Ana Fire Station" rain gage (Gage No. 047888); data for this rain gage are available from Western Regional Climate Center (WRCC) website. The accumulative rainfall departure algebraically compares the percentage of each rainfall year total to the long-term average annual rainfall calculated for the period of available record. Thus, as shown on Figure 3, SWL trends in Well No. 18 tend to correlate with trends in the accumulated rainfall departure over time. That is, increases in SWLs monitored by the transducers over time tend to occur during periods of above-average rainfall, when the accumulated departure curve is seen to be ascending to the right on that figure. Conversely, the decreases in static water levels over time tend to correspond to periods of below-average rainfall (which is shown by the declining trend in the accumulated rainfall departure curve). This indicates that rainfall recharge (or lack thereof) directly influences SWLs in the well.

Pumping Rate Data

Available data on SWLs, pumping rates, and pumping water levels (PWLs), water level drawdown, and specific capacities were obtained from driller's logs and data provided to RCS geologists by the City. Table 3, "Comparison of Available Pumping Data," provides a summary and comparison between data from the original constant rate pumping tests conducted at the date of well construction, and the recent pumping data provided to RCS geologists by the City. Key pumping test data for the City wells include:

- The initial SWLs following completion of well construction for City Well Nos. 4, 5, 18, 25, and 27 were reported at the following depths: no data (ND) for Well Nos. 4 and 5 in 1999; 183 ft bgs for Well No. 18 in December 1977; 204 ft bgs for Well No. 25 in June 1998; and 252 ft bgs for Well No. 27 in September 2014.
- The reported average pumping rates during the initial, post-construction constant rate pumping tests ranged between 1,150 gpm for Well No. 4 in 1999, and 3,153 gpm for Well No. 25 in June 1998. The PWLs ranged from 235 ft to 321 ft bgs, and that resultant water level drawdowns ranged between 21 ft in Well No. 4, and 101 ft in Well No. 5. Reported and/or calculated specific capacities for the five nearby City wells were as follows: 54.8 gpm per foot of drawdown (gpm/ft ddn) in Well No. 4; 17.1 gpm/ft ddn in Well No. 5; 45.2 gpm/ft ddn in Well No. 18; 42.8 gpm/ft ddn in Well No. 25; and 43.5 gpm/ft ddn in Well No. 27.
- The yield factor (YF), which is a ratio of the pumping rate to the total length of casing perforations in a well, as expressed in gpm per foot of perforations (gpm/ft perfs), has historically ranged from 10 to 21 gpm/ft perfs in the five nearby existing City wells.
- More recent pumping data for City Well Nos. 18, 25, and 27 show that SWLs were reported at the following depths: 168 ft bgs for Well No. 18 in February 2016; 228 ft bgs for Well No. 25 in March 2016; and 214 ft bgs for Well No. 27 in May 2019. Pumping rates ranged from 991 gpm in Well No. 18, to 3,212 gpm in Well No. 27.
- Calculated percent changes between the initial, post-construction specific capacity and those values calculated from more recent available pumping data show a decline in specific capacity values in Well Nos. 4, 18, and 27; these declines range between 23% to 54% over time (see Table 3). Specific capacities appear to have increased between 4% and 127% in Well Nos. 25 and 5, respectively.
- Recent data show YF values of 7 to 17 gpm/ft perfs. Thus, there appears to be a decline in YF over time in all the wells, indicating a possible loss in the production capacities of each well, with the exception of Well No. 27, in which this factor has actually increased slightly since it was constructed in 2014. It is difficult to compare yield factors in a specific well over time, because the original or early pumping rates (and hence the original yield factor values) are often higher when a well is new; in addition, the design rates of the permanent pump are often less than the rates used for the constant rate pumping tests at the date of well construction.
- A dynamic (spinner) flowmeter survey was performed in City Well No. 27 following its construction in September 2014. The results of this spinner survey revealed that that

majority of the groundwater flow into the well, approximately 84%, originated from the perforated intervals between 495 ft and 790 ft bgs; the pumping rate during this spinner survey was approximately 3,000 gpm. Based on electric log correlation, these perforated depths intervals correlate to the Principal Aquifer System in the local groundwater basin.

General Water Quality Conditions

Table 4, "Summary of Available Groundwater Quality Data (1987 to 2019)" summarizes the water quality data available directly from the online water quality database of the State Water Resources Control Board (SWRCB), Division of Drinking Water (DDW) for City-owned Well Nos. 4, 5, 18, 25, and 27. Data presented on Table 4 have been compared to current California State Primary and Secondary Maximum Contamination Levels (MCLs) and reveal the following with regard to key water quality constituents.

Selected Key General Mineral and Physical Constituents

a. The groundwater character of the local aquifer systems beneath the study area appears primarily to be a mixed cation, sodium-calcium-bicarbonate ($Ca\text{-}HCO_3$) type.

b. Total dissolved solids (TDS) concentrations have ranged from 290 milligrams per Liter (mg/L) to 634 mg/L. The current State Secondary (recommended) MCL for TDS for public-supply are: 500 mg/L (lower); 1,000 mg/L (upper); and 1,500 mg/L (short-term). Thus, the detected concentrations are generally below or just above the recommended DDW Secondary MCL for TDS.

c. Total hardness (TH) concentrations have ranged from 128 mg/L to 374 mg/L. These values place the water in the hard to very hard range (120 mg/L to above 180 mg/L) according to the U.S. Geological Survey (USGS) classification system (Durfor & Becker 1962).

d. The reported pH of groundwater has ranged from 7.5 to 8.4, indicating that the water is slightly alkaline (greater than 7.0). The State Secondary MCL for pH ranges between 6.5 and 8.5.

e. Specific conductance values were reported to range from 487 microSiemens per centimeter (µS/cm) to 987 µS/cm, the maximum values were obtained from Well Nos. 4 and 5. The State Recommended Secondary MCL for this constituent is 900 µS/cm, indicating groundwater from Well Nos. 4 and 5 has occasionally exceeded this current Recommended MCL.

f. Turbidity values have ranged from 0.1 nephelometric turbidity units (NTU) to 1.8 NTU and have been consistently below the Secondary MCL of 5 NTU for the data record for the listed wells.

g. Sulfate (SO_4) was detected at values ranging from 55 mg/L to 174 mg/L in the five nearby City-owned wells. The State Secondary MCL for sulfate is 250 mg/L; thus, the reported concentrations of SO_4 for all five nearby City wells are below this MCL.

h. Chloride (Cl) was reported at valued ranging from 27 mg/L to 105 mg/L in groundwater samples from these five wells. The State Recommended Secondary MCL for this constituent is also 250 mg/L; thus, the detected concentrations of this constituent are below the MCL for Cl in all five wells.

i. Fluoride (F) was reported to be present in relatively low concentrations, ranging from 0.16 mg/L to 0.41 mg/L in these five wells. These values are well below the State Primary MCL of 2 mg/L for this constituent.

j. Nitrate (as NO_3) concentrations ranged from 1.0 mg/L to 37 mg/L were reported in groundwater samples collected from the five wells listed in Table 4. The current Primary MCL for nitrate as NO_3 is 45 mg/L and, hence, the reported results are well below this MCL value.

Detected Inorganic Constituents (Trace Element)

The trace metals detected in groundwater samples from the five wells listed in Table 4 are summarized below:

a. Aluminum (Al) concentrations ranged between ND and 25 micrograms per Liter (µg/L). The Secondary MCL for Al is 200 µg/L and its Primary MCL is 1,000 µg/L. Hence, the reported concentrations of this constituent are well below the Primary or Secondary MCLs.

b. Detected arsenic (As) concentrations ranged from ND to 3.4 µg/L (the latter value was from Well No. 4). The current Primary MCL for As is 10 µg/L. The reported maximum detected As concentrations in Well Nos. 4, 5, 18, 25, and 27 were 3.4 µg/L, 2.7 µg/L, ND, ND, and ND, respectively. Hence, all reported maximum As concentrations were below this MCL.

c. Barium (Ba) concentrations ranged from ND to 130 µg/L. The Secondary MCL for this constituent is 1,000 µg/L. Thus, reported Ba concentrations were below MCL in the five list City wells.

d. Boron (B) was detected concentrations ranging from ND to 990 µg/L. The DDW has established a Notification Level (NL) of 1,000 µg/L for this constituent; the reported concentrations do not exceed this NL.

e. Copper (Cu) was reported at concentrations ranging from ND to 2.4 µg/L and are below the Action Level (AL) of 1,300 µg/L for this constituent.

f. Iron (Fe) concentrations were reported to range from ND to 300 µg/L (the latter value was from Well No. 5). The Secondary MCL for Fe is 300 µg/L indicating the maximum reported Fe value for Well No. 5 equaled the MCL. Fe has not been detected in the other four City wells listed on Table 4.

g. Nickel (Ni) was reported at concentrations ranging from ND to 2.8 µg/L; all values are below the Secondary MCL of 100 µg/L for Ni.

h. Selenium (Se) was reported at concentrations ranging from ND to 82 µg/L. Only Well No. 4 reported a Se concentration (82 µg/L) that exceeded the Primary MCL of 50 µg/L.

i. Vanadium (V) concentrations were reported to range from ND to 3.7 μg/L; all detected values are below the DDW Notification Level (NL) of 50 μg/L for V.

j. Zinc (Zn) concentrations were reported from ND to 4.3 μg/L. These concentrations are well below the Primary MCL for Zn of 5,000 μg/L.

Detected Volatile Organic Compounds (VOCs)

A total of two VOCs were detected in samples collected from Well No. 25. The VOCs were bromodichloromethane and chloroform, both of which are chemical compounds of trihalomethanes (THM) and occur as disinfection byproducts. The concentrations of these two VOCs were reported to be 0.7 μg/L and 2.3 μg/L, respectively. These concentrations are well below the Primary MCL of 80 μg/L for total trihalomethanes.

Radiological Constituents

The DDW database revealed that a few radiological constituents have previous been detected in Well Nos. 4, 5, 18, 25, and 27. Table 4 shows that gross alpha, radium-226, radium-228, and uranium have historically been detected in some of the five wells listed on Table 4. Only gross alpha appears to have been detected above its respective MCL of 5 picocuries per Liter (pCi/L), and this occurred in Well Nos. 4, 5, and 18.

LOCAL CONDITIONS

Site Conditions

This City-selected well site is a relatively small, 0.36-acre, rectangular-shaped property located on the northeast corner of the intersection of W Maple Avenue and N Lemon Street in the City of Orange. Figure 4, “Site Location Map,” illustrates a more detailed view of the site and surrounding physical features on an aerial photograph base map. At the time of RCS’s site visit on July 31, 2019, the site was observed to be a vacant lot that was relatively flat, with chain-link fencing surrounding the perimeter of the property.

Preliminary Hydrogeologic Considerations

The proposed well site is plotted on Figure 4 and is seen to lie approximately 1,850 ft northeast of City Well No. 18. Based on a data review, the following hydrogeologic conditions are anticipated beneath the proposed new well site:

- Based on the driller’s logs and available E-logs, the estimated depth to the base of the Lakewood Formation (lower Shallow Groundwater Unit and upper Principal Aquifer System) is approximately 520 ft bgs. The San Pedro Formation (lower Principal Aquifer System) may extend from that depth to approximately 960 ft bgs or deeper. Directly beneath the San Pedro Formation, the nonwater-bearing Pico Formation is expected. Thus, a pilot hole at the site may need to be drilled to a maximum depth of 1,000 ft bgs in order to verify the entire Lakewood and San Pedro Formations have been penetrated.
- The estimated current SWL is on the order of 130 to 150 ft bgs.
- A potential pumping rate of 2,000 gpm to perhaps 3,000 gpm could be possible.
- An estimated current specific capacity value on the order of 40 gpm/ft ddn may be attainable for a proposed new well at the site. This is dependent upon the depths of the perforated intervals, and the character of the aquifer systems perforated in the proposed new well (e.g., the grain size distribution, aquifer thicknesses, hydraulic conductivity, etc.).
- Water quality data from nearby City-owned Well Nos. 4, 5, 18, 25, and 27 indicate that general mineral and physical constituents, inorganic constituents (trace metals), VOCs, and radiological constituents have generally been detected in the local groundwater at concentrations below their respective State Primary and/or Secondary MCLs, with the exception of only a few constituents at specific periods in time.

Site Logistics

Based on our site visit on July 31, 2019, conditions at and adjacent to the subject property appear moderately favorable with regard to logistical constraints for well construction.

- The site has adequate space for drilling and requisite equipment; it measures 130 ft by 115 ft in size and is graded and generally flat.
- The site lies within a mixed commercial and residential area. Single-family homes were observed on adjacent properties to the east of the proposed new well site and across W Maple Avenue to the south. Thus, noise control barriers (i.e., sound walls) along the entire perimeter of the property will be needed to reduce construction noise. Other sound reduction methods may be implemented such as muffler controls and silencers on the equipment, air compressors, etc.
- There appear to be two secured and gated entrances on the west (N Lemon Street) and south (W Maple Avenue) sides of the subject property.
- Overhead utilities (power lines, telephone lines, etc.) were not observed along any boundary of the property. Thus, ingress/egress to and into the site should not be hampered by overhead utility lines.
- Traffic control will be needed when the drill rig and other equipment are entering and/or exiting the proposed well site from the street.
- The Contractor will need to provide the entire site with security when drilling crews are not onsite.
- There is a nearby storm drain located along the southern boundary of the property on W Maple Avenue; this storm drain can be used for discharge of well development and well testing fluids. Stormwater effluent is then eventually discharged into the Santa Ana River. Well development and testing fluids could be discharged into this storm drain but will first require treatment and monitoring because of potential elevated metal and radiological concentrations that may be present in groundwater pumped from the well during this work.
- Drilling water or “make-up” water needed for drilling purposes is typically sourced from municipal water sources such as fire hydrants and water mains. Fire hydrants and water mains were not observed in proximity to the proposed new well site. However, the City will install a hydrant (water source) to the site prior to well construction.

<u>Discussion of Drill Site Layout</u>

Because the site is located within a commercial/residential area, then all well drilling equipment and materials will need to be kept onsite. Consequently, this will require sufficient area be available around the drill rig to provide adequate space for all required equipment and storage areas for construction of the proposed new well. Figure 5, “Preliminary Site Layout Diagram for Well Construction,” shows a possible layout of the required well construction equipment at the subject property. This equipment would consist of, but not necessarily be limited to, the following:

- The drill rig and accompanying above-ground fluid holding tank (i.e., “mud” tank) to temporarily store the drilling fluids and the fluids generated during all well development operations.

- The pipe trailer for the drill pipe.
- The driller's trailer (aka, the "doghouse") to house job tools and provide shelter for the drillers.
- Areas to temporarily store drill cuttings, well drilling supplies and construction materials (i.e., casing, gravel pack, etc.).
- Settling tanks (i.e., Baker or Rain-for-Rent tanks) to clarify/treat well development and testing fluids prior to discharge to the local storm drain system.
- The sound walls around the property.

It should be noted that Figure 5 shows one potential layout for the drill rig and equipment at the proposed new well site. Because the footprint of each major piece of drilling equipment is drawn to approximate scale on the figure, it appears there is adequate space at the site in which to place a drill rig and associated equipment.

The final placement of the rig and equipment will be determined by the drilling company selected by the City to conduct the well construction operations. In addition, the well site location may need adjustment to better accommodate the final placement of the drill rig and associated equipment, as desired by the Contractor; the final well site can be defined at the pre-construction meeting following the award of the bid by the City.

General Considerations for the Site

Construction and testing of the proposed new well will require a multitude of tasks to be completed in accordance with State and Federal laws. For these construction and testing tasks several necessary permits will need to be obtained prior to commencement of construction operations at the proposed well site. Such key permits would include:

- A well drilling permit to start construction on the well. This permit is obtained by the selected drilling contractor from the Orange County Health Care Agency (OCHCA) Environmental Health Division and is needed prior to the construction of the proposed well. Specifically, a permit application is filed by the driller a few weeks in advance of commencement of his drilling operations at the site.
- The SWRCB general construction permit does require the development of a stormwater pollution prevention plan (SWPPP) for this drill project, as per the SWRCB Order No. 2009-0009–DWQ, as Amended by 2010-0014–DWQ and 2012-0006–DWQ; Construction General Permit (CGP) No. CAS000002. The SWRCB construction general permit states that a SWPPP is required for:

  "any construction or demolition activity, including, but not limited to, clearing, grading, grubbing, or excavation, or any other activity that results in a land disturbance of equal to or greater than one acre and any Construction activity associated with linear underground/overhead projects (LUPs) including, but not limited to, those activities necessary for the installation of underground and overhead linear facilities (e.g., conduits, substructures, pipelines, towers, poles, cables, wires, connectors, switching, regulating and transforming equipment and associated ancillary facilities) and include, but are not limited to, underground utility mark-out, potholing, concrete and asphalt cutting and removal, trenching, excavation, boring and drilling, access road and pole/tower pad and cable/wire pull station, substation construction, substructure installation, construction of tower footings and/or foundations, pole and tower installations, pipeline installations, welding, concrete and/or pavement repair and/or stockpile/borrow locations."

Because the entire footprint of "disturbed" land at the subject site (including the areas to spread drill cuttings and to temporarily store drill/testing fluids) is estimated to be 0.36 acres (or less), a SWPPP will not be needed. It should also be noted that no aboveground or underground additional pipeline work is anticipated in conjunction with this drill project.

- Because discharge of well development and testing fluids will be performed near the Santa Ana River (via the Santiago Creek Channel) then the City may need to obtain an encroachment permit from the Orange County Flood Control District (OCFCD).
- Discharges to the nearby storm drain will likely need to be regulated under a recently adopted SWRCB state-wide permit in 2014 for discharges from public water under Order No. WQ 2014-0194-DWQ. Page 6, Item 1b of that order states that authorized discharges include planned discharges due to "Groundwater well development, rehabilitation and testing."
- The contractor will be required to ensure that the current industry-standardized best-management practices (BMPs) be implemented at the subject drill site to properly minimize the impacts on the Santa Ana River or associated tributaries, by reducing the volume of and improving the quality of surface water runoff from the subject drill site that would normally drain into the Santa Ana River and/or its tributaries. At a minimum, the contractor will be responsible for the installation of a rumble rack BMP at the entrance to the drill site, and also the installation of sandbags and straw wattle around the perimeter of any stockpiled soils, i.e., drill cuttings piles.
- Other required permits are not associated with the actual construction of the well. For example, a permit to operate the well will need to be eventually obtained from the DDW during the equipping phase of the proposed new well. No other permits are required from any other local agency.

POTENTIALLY CONTAMINATING ACTIVITIES

Inventory of Potentially Contaminating Activities

A preliminary inventory of past and current potentially contaminating activities (PCAs) was compiled using readily available data for the proposed well site. An initial assessment was performed using the Regional Water Quality Control Board (RWQCB) GeoTracker website, as it provides a compilation of environmentally impacted sites, and is also linked to the Department of Toxic Substances Control (DTSC) EnviroStor website which shows cleanup sites, land disposal sites, waste permit sites, permitted underground storage tank (UST) sites, and leaking underground storage tank (LUST) sites.

For the proposed new well, certain PCAs of concern in the area occur within a 2,000 ft radius of the proposed new well site. According to the GeoTracker website, six active remediation sites exist within a 2,000-foot radius. Figure 6, "GeoTracker Map of Proposed Well Site and Vicinity," shows the locations of PCAs in the vicinity of the proposed well site. A summary of these PCAs and their current cleanup status, as based on the information provided on the GeoTracker and EnviroStor websites, are discussed below:

- The light blue triangles, of which there are 2 within 2,000 ft and downgradient of the proposed well site, indicate sites where the DTSC is lead agency for regulating site activities. One DTSC site listed as "So Cal Gas/Orange MGP" (ID No. 30490106) and located approximately 1,400 ft southwest of the proposed well site, is currently being used by SoCal Gas as a metering and regulating facility for a city-wide natural gas distribution system. The site contains underground distribution pipelines and aboveground controls. Near surface soils were impacted with polycyclic aromatic hydrocarbons (PAHs) and total petroleum hydrocarbons (TPHs). Contaminated soils were excavated from the site, but some impacted soils still remain onsite in unreachable areas. Currently, the property is only appropriate for commercial/industrial use. DTSC is currently working with the property owner on a Voluntary Cleanup Agreement (VCA) and the site was considered to be active as of November 16, 2017.

  The other DTSC shown on Figure 6 is listed as "AMF VOIT INC" (ID No. 8001403), and is located 1,900 ft southwest of the proposed well site. This site is described as a sporting goods manufacturing facility. Very limited information is provided on the EnviroStor website, but the current cleanup status is listed as "no action required" as of October 5, 2018.
- The several red squares with an "X" through them delineate those LUST site where the RWQCB is the lead agency. These symbols show those sites where cleanup actions have been completed and the case has been closed by that lead agency.

- The open red squares indicate those LUST site where the current cleanup/remediation is occurring but are currently eligible for closure. There are only two of these open LUST sites within 2,000 ft of the proposed well site and they are both located to the west and downgradient from the proposed well site.
- The open green square that is located approximately 1,100 ft the northwest of the proposed well site and is slightly upgradient is a cleanup site listed as "Chapman University, Former Anaconda West/Anaconda Wire and Cable" (ID No. T100000045009). This site was formerly occupied by Anaconda Wire and Cable Company, and subsequently successor companies, commercial, and other industrial tenants. The potential contaminants of concern are listed as tetrachloroethylene (PCE) and trichloroethylene (TCE) and the potential media of concern is listed as "indoor air, other groundwater uses (uses other than drinking water), soil, and soil vapor". Extensive subsurface investigations have been performed onsite and a soil contingency plan, which consists of demolition and soil excavation and removal, was submitted and approved by OCHCA and RWQCB staff. Impacted soil with VOCs will be targeted during soil excavation and removal.

Overall, the majority of nearby PCAs appear to consist of predominantly permitted UST sites (dark red squares).

POTENTIAL PUMPING INTERFERENCE WITH OTHER CITY WELLS

The proposed new well site is located in an area that has several other existing wells currently pumping at rates ranging from 1,000 to 3,200 gpm. Because the proposed new well is to be located in this area, then there is the potential for water level drawdown interference to occur between nearby pumping wells. To evaluate this potential, RCS calculated the theoretical water level drawdown interference that the proposed new well could induce in wells proximal to the new well site.

City Well Nos. 18 and 27 are the closest wells, being located approximately 1,850 ft southwest and 5,280 ft east of the proposed well site, respectively. Thus, to determine if there is a potential impact to water levels, a calculation of the theoretical drawdown was performed on these two closest wells. In the calculation of potential drawdown interference impacts on nearby wells, the computer program PUMPIT, which uses the Theis equilibrium equation to calculate drawdown, was used with the following assumed basic aquifer conditions input into that program:

1) The aquifer system(s) is homogeneous, isotropic, and of infinite areal extent and there are no nearby flow boundaries.
2) All wells being evaluated fully penetrate the <u>same</u> aquifer system.
3) Groundwater in the area was assumed to have no gradient or flow direction, and the groundwater occurs under semi-confined to confined conditions.
4) Constant pumping rates of 2,500 and 3,000 gpm were assigned to the new well. The duration of pumping of a new well was based on a continuous, 24-hours per day basis; hence, there were <u>no</u> pump shutdowns for the entire pumping periods assumed for the calculations.
5) Time periods of 1, 30, 60, 90, and 120 days of <u>continuous</u> pumping were assumed for the proposed well. That is, flow to the well was in a continuous dynamic state for these entire pumping durations.
6) A transmissivity (T) of approximately 150,000 gallons per day per foot of saturated aquifer thickness (gpd/ft) and a storativity (S) value of 0.00069, with an effective porosity of 0.2 (dimensionless) were assigned to the local aquifer systems. For modeling purposes, the S value was estimated as being representative for the aquifer system(s) penetrated by City wells. These parameters were used so that the resultant water level drawdown interference values in nearby wells would be representative of pumping of the new well under the above-listed conditions.

Table 5, "Preliminary Calculation of Theoretical Water Level Drawdown in Nearby City Wells," shows the potential theoretical water level drawdown that may be induced in nearby City Well

Nos. 18 and 27 by the future pumping of proposed new City Well No. 28 at each of the two pumping rates of 2,500 and 3,000 gpm for the time periods shown. The results reveal that at a pumping rate of 2,500 gpm in the proposed new well, water level drawdown in the other two nearby City wells could range from as low as 2 ft in Well No. 27, after one day of continuous pumping, to as much as 15 ft in City Well No. 18, after 120 days of continuous pumping. When the pumping rate is set at 3,000 gpm, then the calculated water level drawdown may range from as little as 2.4 ft in Well No. 27 after only one day of pumping, to as much as 18 ft of drawdown in City Well No. 18 after 120 days of continuous pumping.

The calculations for the theoretical drawdown interference using PUMPIT presented herein indicates only what the induced theoretical water level drawdown could be in these two wells, based on the above assumptions (ideal aquifer conditions) and parameters (estimated values of T and S). However, in our experience, water level drawdown induced by pumping of wells under actual conditions may be significantly less than that which has been theoretically calculated using the modeling software and it is possible that nearby City wells will not exhibit the water level drawdowns calculated above. It is recommended that during the constant rate pumping test of the proposed well, the water levels in the other wells be monitored and checked for possible water level changes induced by the pumping of the new well.

CONCLUSIONS

Well Site Feasibility

Based on our review and interpretation of available data, it appears hydrogeologically feasible for the City to drill and construct new municipal-supply Water Well No. 28 at the selected well site on the subject property (APN 039-162-23). The pilot hole for the proposed new well will likely need to be drilled to a maximum depth of 1,000 ft bgs; this should enable the borehole to fully penetrate the potential aquifer systems within the Lakewood and San Pedro Formations beneath the property.

Key logistical issues that might impact the construction of a well at the selected site include the presence of residential properties to the east and south, which will require noise control measures to be implemented on all sides of the property during all drilling and construction activities at the site.

Anticipated Groundwater Parameters/Conditions

Based on the available data and information, the following outlines the anticipated groundwater conditions for the proposed new well:

- It is anticipated that the aquifer systems in the lower portion of the Lakewood Formation (i.e., Lambda aquifer) and the San Pedro Formation (i.e., the Omicron, Rho, and Main aquifers) will provide the groundwater supply to the proposed new well.
- Final values for wellblend water quality, pumping rates, and specific capacity of the proposed new well cannot be determined until the proposed new well is constructed and subjected to final pumping tests and groundwater sampling for laboratory testing.
- An initial SWL depth estimated to be in the range of 130 ft to perhaps 150 ft bgs. However, shallower SWLs may be possible, especially if somewhat shallower aquifer systems are perforated.
- An operational pumping rate in the range of 2,500 gpm to perhaps 3,000 gpm could be achieved, if particularly favorable hydrogeologic conditions are encountered in the pilot hole. However, it is possible that production rates could be somewhat lower, if unfavorable hydrogeologic conditions are encountered during drilling at the site, based on the geologic log and on review of the new E-logs.
- Based on available data, a specific capacity on the order of 40 gpm/ft ddn is anticipated from the proposed new well.
- Should the well be perforated similar to existing Well Nos. 25 and 27, then the final water quality sample from the proposed new well is anticipated to have the following: a Na-Ca-HCO_3 water character; TDS concentrations on the order of 500 to 600 mg/L;

and total hardness concentration on the order of 130 to 210 mg/L (very hard water). It is possible that the concentrations of certain radiologicals might be elevated and above their respective MCL.

PRELIMINARY WELL DESIGN CRITERIA

Based on our hydrogeologic evaluation, the Principal Aquifer System (which includes the Beta, Lambda, Omicron, Rho, and Upper Main aquifer systems) will represent the main sources of groundwater for the proposed new well. However, it is possible that some of the overlying (slightly shallower) aquifer systems could also be perforated in the proposed new well, and the suitability of these aquifer systems will need to be further assessed during drilling in the open pilot hole.

Below is a summary of our preliminary design criteria for the proposed new well at the proposed well site. Figure 7, "Preliminary Well Design Diagram," provides a schematic diagram of this preliminary design. The depths listed for drilling and construction details are considered preliminary at this time, but they will be used during the RCS-preparation of the Technical Specifications for the proposed new well. The final well construction design will be determined only after pilot borehole drilling data are acquired and will be based on the results of the geologic logging of the drill cuttings, grain size analysis of drill cuttings, and downhole geophysical surveying (electric logs and caliper).

Pilot Borehole Drilling and Reaming

- The reverse circulation drilling method is recommended. Drill cuttings generated during drilling will need to be removed from the proposed well site.
- Drill a borehole for the conductor casing to a minimum depth of 50 ft bgs and to a minimum diameter of 44 inches (minimum). Install approximately 50 ft of 38-inch outside diameter (OD) by 3/8-inch (minimum) wall thickness mild steel conductor casing. Grout the annular space between this casing and the walls of the borehole from the bottom of the conductor to ground surface. The grouting of the annular space between the conductor borehole and conductor casing may also help serve as a cement sanitary seal for the proposed new well.
- Drill a 17½-inch nominal diameter pilot hole to a depth of approximately 1,000 ft bgs in order to fully penetrate the Lakewood and San Pedro formations and to extend slightly into the upper portion of the underlying Pico Formation. An Eastman Drift survey should be conducted at 100-foot depth intervals to help maintain a straight and vertical borehole during pilot hole drilling and during subsequent reaming of the borehole.
- Collect and log the drill cuttings and submit representative drill samples for grain size distribution testing, the results from which will allow the filter pack gradation and perforation slot sizes to be determined.
- Conduct downhole geophysical surveys within the open pilot hole using a spontaneous potential (SP) survey, short-normal (16-inch) and long-normal (64-inch) resistivity

surveys, a laterolog 3 or a focused resistivity (guard) survey, a sonic variable density survey, gamma-ray survey and a magnetic deviation survey using a magnetometer tool.

- o Conduct isolated aquifer zone testing in at least four depth-discrete, potential aquifer zones that are to be selected by RCS geologists after reviewing the geophysical logs. Based on the electric log correlations performed by RCS, zone testing could be performed in the proposed pilot hole between the depths of 400 ft to 1,000 ft bgs. This testing will be performed to check groundwater quality conditions in the borehole and under low-flow and short-term conditions, with regard to concentrations of selected constituents, including: general minerals and inorganic chemicals, VOCs; and other constituents such as perchlorate and PFAS constituents, such as perfluorooctanesulfonic acid (PFOS) and perfluorooctanoic acid (PFOA). PFOS and PFOA have reportedly been recently detected in municipal-supply wells in the region.
- o Provided the new in-situ pilot hole data indicate it is feasible to construct a well at the site, the upper portion of the pilot hole can be reamed to a diameter of 36 inches and to a depth of 445 ft bgs; following this, the lower portion of the borehole below 445 ft bgs can be reamed to a diameter of 26 inches and to a maximum depth of 980 ft bgs.
- o Following completion of reaming activities, perform caliper and magnetic deviation surveys to help verify the final borehole diameters and possible borehole deviation. If the final borehole ream is found to deviate from the recommendations for plumbness and alignment stipulated in the Technical Specifications, the Contractor will need to remediate/repair the problem(s) <u>before</u> installing the casing.

<u>Well Casing and Gravel Pack</u>

- o Install a 20-inch inside diameter (ID) by 3/8-inch wall thickness steel blank pump house casing from ground surface to a depth of 435 ft bgs. This well casing will also extend two feet above ground surface.
- o Install a five-foot long, 20-inch x 16-inch ID cone reducer between the depths of 435 ft and 440 ft bgs.
- o From 440 to 940 ft bgs, install 350 feet of 16-inch ID by 5/16-inch wall thickness steel Roscoe Moss Ful-flo louvered well casing, interspersed with approximately 150 feet of steel blank casing. The final placement of the steel blank and perforated casings will depend on the results of the E-logs and the geologic logs. A slot size of 0.050 inches is preliminarily recommended at this time for the louver openings.
- o At the bottom of the casing, install a 20-foot long section of 16-inch ID by 5/16-inch wall thickness steel cellar pipe with an end cap; hence, the bottom of the well casing could be set to a depth of approximately 960 ft bgs.
- o Provide a 4-inch ID camera tube; a 3-inch ID gravel feed tube, a 3-inch ID vent tube and a 2-inch ID sounding tube. The camera tube and sounding tube shall enter the blank well casing at depths as shown on Figure 7, whereas the bottom of the vent tube will be placed to a depth of 2 ft bgs. The tops of these tubes shall also extend 2 ft above ground surface.

- A 6 x 12 gradation to the gravel pack is anticipated at this time. This gravel pack can extend from a depth of approximately 390 ft to a depth of 980 ft bgs (590 feet in length). The upper 5 feet of the gravel pack can be a fine-grained sand.
- A deep annular grout seal consisting of a 10.3-sack cement emplaced in the annual space to a depth of approximately 390 ft bgs is recommended to help prevent the downward migration of possible contaminants from the upper, shallow aquifer systems at the drill site. A plaster sand can be installed on top of the gravel pack (i.e., from 300 to 305 bgs), to prevent cement filtrate from entering the gravel pack. The final depth of this seal, plaster sand, and gravel pack are to be determined by the results and analysis of the E-logs generated after completion of the pilot hole.

Well Development

- The well shall be initially developed by mechanical methods, by simultaneously airlifting and swabbing in each 20-foot long section of louvered well casing. The use of development chemicals (chlorination and/or dispersants) may also be required. Mechanical and chemical development should be conducted for an approximate period of 100 hours in the proposed new well or until no further significant removal of sand or drilling fluids and cuttings are observed.
- A temporary test pump shall be installed in the proposed new well to conduct well development by pumping methods. The test pump should have a capacity of approximately 1.5 times the target well production rate (± 4,500 gpm), and the pump intake can be set to a depth of approximately 400 ft. A period of approximately 100 hours of pumping development is estimated to be conducted in the well.
- An In-Situ Aqua Troll® Flow Cell Probe (or similar device) and digital flowmeter shall be installed to permit the automatic measurement and recording of selected water quality parameters and instantaneous flow rates throughout pumping development and testing.
- A video survey to check the condition of the openings for the casing louvers and determine if additional well development is needed.

Downwell Testing

- Final pumping tests shall be performed on the proposed new well and will consist of a 12-hour long, four-point, 4-step drawdown test, followed by a recommended 24- to 48-hour constant rate pumping test to help identify the future operational pumping rate of the proposed new well. A target pumping rate of 2,500 to perhaps 3,000 gpm is desired by the City.
- Near the end of the constant rate pumping test, conduct a flowmeter (spinner) survey under dynamic (pumping) conditions to establish the baseline flow regime within the well. These data can be compared to future spinner data in the well in order to determine the differential change in flow rates in each section of perforations.
- A gyroscopic alignment and plumbness survey will be performed following removal of the test pump from the well. At this time, a spinner survey under static (non-pumping) conditions is recommended to establish baseline static flow conditions in the well.

Such information may useful in assessing the downwell flow regime of the well under non-pumping conditions.

- A final video survey to help document as-built well conditions and a final well disinfection (via chlorination) will be conducted in the well.

Preliminary Evaluation of Well Construction Costs

For City preliminary budgetary considerations, we estimate the preliminary current cost of drilling, constructing, developing and aquifer testing of the proposed well, using the well design illustrated in Figure 7, could be approximately between $1,100,000 and $1,460,000, depending on the type of steel selected by the City for the blank and perforated casing. There are four alternative types of steel that can conceivably be used for well construction, as shown on Table 6, "Preliminary Comparison of Well Construction Costs." These four steel types are: low carbon steel (LCS), sometimes referred to as "mild steel" (ASTM A139); copper-bearing steel with carbon steel and not greater than 0.2% copper (ASTM A139); high strength, low alloy (HSLA or Corten) steel (ASTM A606); and Type 304L stainless steel (ASTM A778). Each of these steel types provide a different amount of corrosion protection, from the least protective (low carbon steel) to the most protective (Type 304L stainless steel). However, there is a considerable cost differential between each grade of steel.

Table 6 provides an estimated range of costs for the proposed new well (i.e., and "engineer's estimate") using the four alternative options for the casing material. The approximate costs for drilling and constructing the new well for each casing material option listed are as follows:

- Low Carbon Steel: $1,100,000
- Copper-Bearing Steel: $1,165,000
- High Strength, Low Alloy Steel: $1,209,000
- Type 304L Stainless Steel: $1,464,00

In determination of the type of casing to use, it is generally understood that low carbon steel has the least amount of corrosion protection and should generally not be used in corrosive environments or where there is the potential for hydrogen sulfide (H_2S) to occur in the groundwater. Thus, the groundwater environment will dictate the life of the well casing. For LCS, a typical lifetime may be on the order of 20 to 30 years. Copper-bearing steel casing affords a greater degree of corrosion protection but can also become impacted in corrosive and/or H_2S environments; its typical lifetime may be on the order of 40 to 50 years. High strength, low alloy (or Corten) steel casing may last up to 65 to 75 years. On the other hand, Type 304L stainless steel provides the greatest degree of protection and can potentially last much for as long as 100 years. The chromium in stainless steel helps the steel to rapidly develop an oxide layer (passivation), which tends to inhibit any corrosion of the metal in groundwater of good quality. However, high chloride groundwater could significantly reduce the corrosion resistance of even stainless steel casing. City Well No. 27 was drilled in 2014 and was constructed using Type 304L stainless steel.

After the new well has been placed into service, then regular maintenance of it should be performed in order to help maintain its efficiency. Such maintenance is independent of the type of material used in the well. Rather, such maintenance is actually due to the aggressiveness of bacteria in the well, which eventually leads to plugging of the perforations and gravel pack, via biofouling. Generally, it is recommended that a video survey of the well be conducted when the specific capacity of the well has declined by 15 to 20%. Depending on the degree of biofouling present, declines in specific capacities between wells vary in time and thus, no pre-set period for maintenance can be established.

PRELIMINARY ASSESSMENT OF FUTURE PUMPING RATE

Potential Pumping Rate and Specific Capacities

Table 7, "Preliminary Assessment of Pump Rates and Pump Depth Settings", presents a preliminary evaluation of the final pumping rates and depth settings for a permanent pump in proposed new City Well No. 28. This preliminary information is based upon available water level and pumping rate data from the other City-owned water wells. Thus, Table 7 represents our preliminary opinion of potential pumping rates and resulting PWLs that may occur in the proposed new well, based on the available data from other existing City water wells in the area. It is possible that this preliminary estimate could differ significantly from actual pumping conditions at the time the proposed new well is constructed and tested.

Using estimated current SWL conditions (at a depth of 150 ft bgs), along with pumping rates of 2,000 to 3,500 gpm, and using an estimated specific capacity value of 50 to 35 gpm/ft ddn (depending on the pumping rate), the resulting PWLs from these parameters could occur at depths of approximately 190 to 250 ft bgs, respectively. Factoring in an anticipated 15% decrease in the specific capacity over time and an additional 50-foot SWL decline over time (due to long-term drought conditions), would tend to create a future pumping level at depths ranging from 267 to 338 ft bgs (at pumping rates of 2,500 to 3,500 gpm, respectively). Thus, the intake for a future permanent pump could be placed at a depth ranging from 300 to 400 ft bgs. It is possible that actual values of any of these elements could differ significantly from those listed in Table 7 and any final evaluation of the pumping parameters and characteristics of the new well shall be based on the results of production testing performed on the proposed well. The final depth setting for the permanent pump will need to be determined by a pump engineer, based on that engineer's analysis of the final pumping test data and calculated backpressures and frictional losses in the pumping system and water-supply lines.

CLOSURE

Disclaimer

This Preliminary Well Design Report has been prepared for by RCS for Tetra Tech Inc, and the City of Orange and applies only to evaluating the hydrogeologic conditions regarding the preliminary design of new, municipal-supply City Well No. 28 at the City-selected well site. This Preliminary Well Design Report has been prepared in accordance with the care and skill generally exercised by reputable professionals, under similar circumstances in this or similar localities. No other warranty, either express or implied, is made to the professional advice presented herein.

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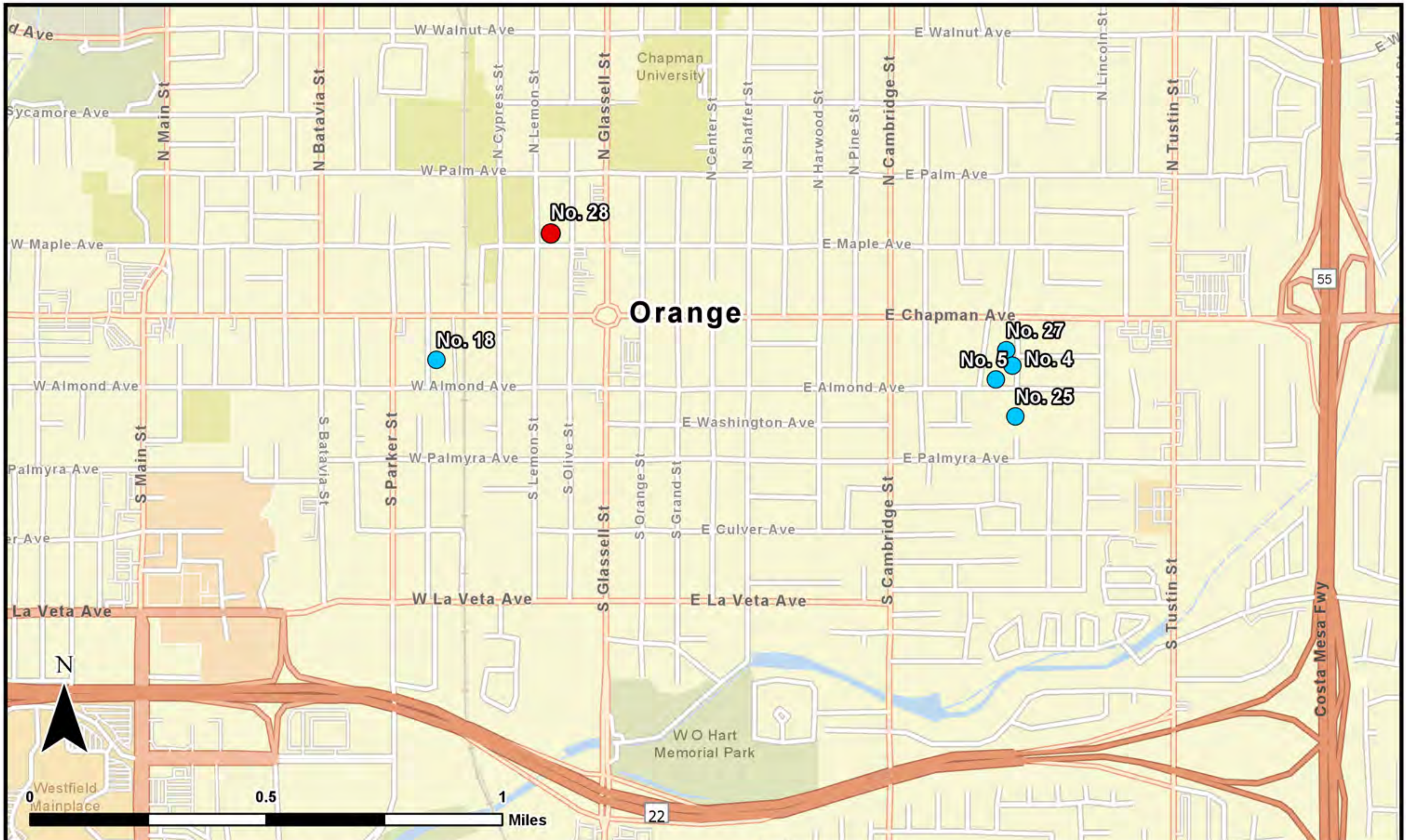


LEGEND

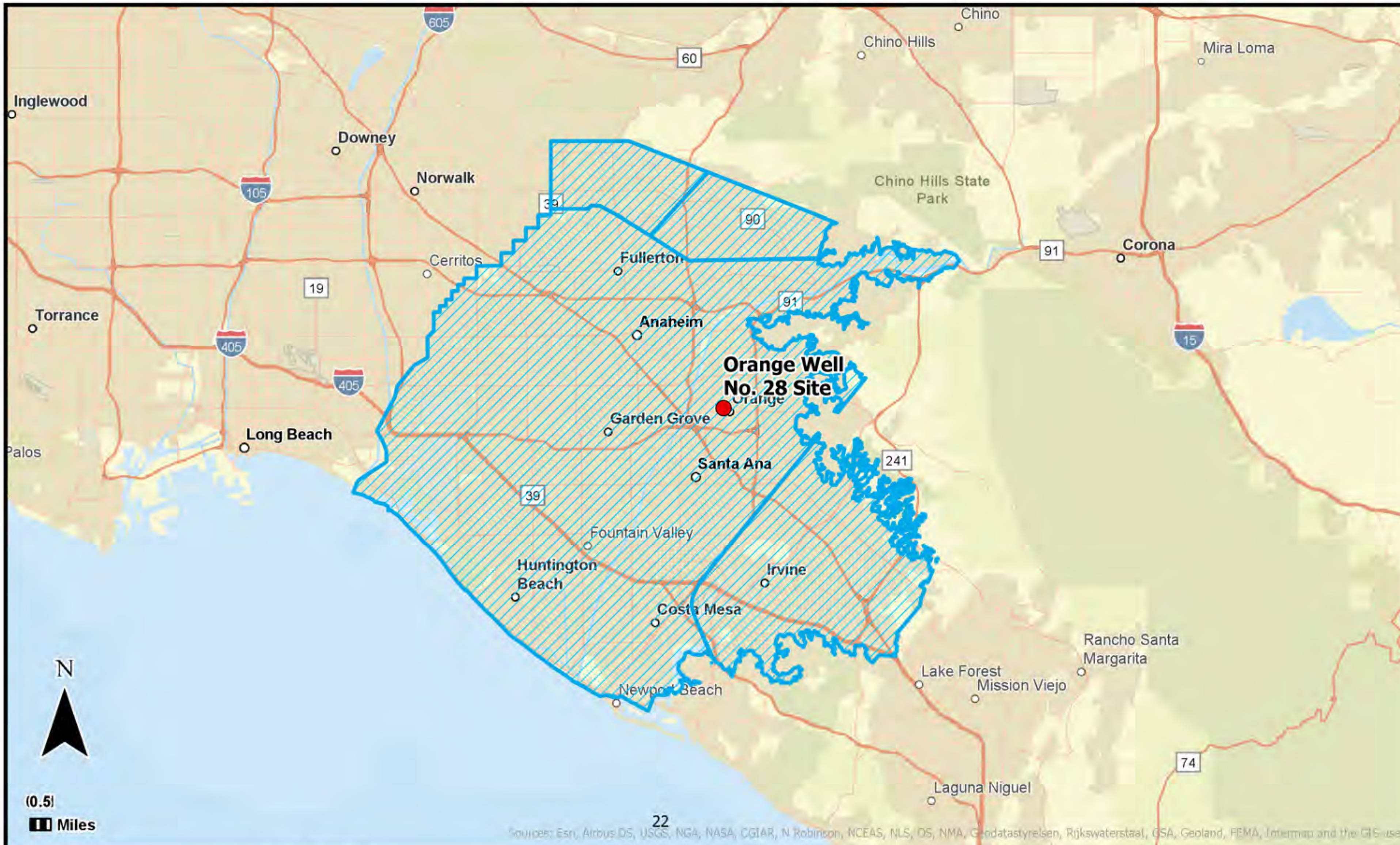
- City Well
- Proposed Well

RCS

FIGURE 1
WELL LOCATION MAP

Job No. 106-OGE18

October 2019



LEGEND

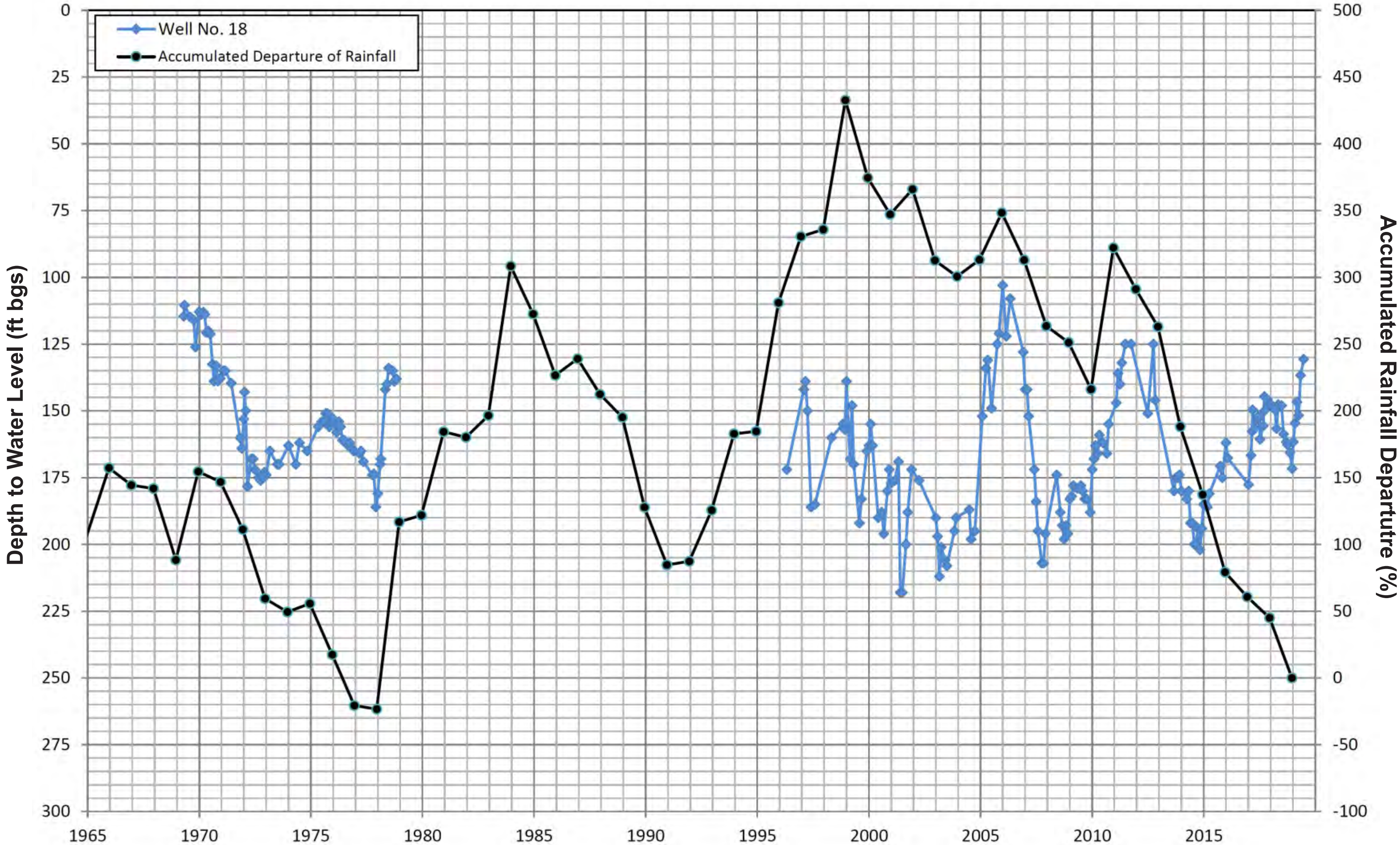
- Proposed Well 28 Site
- Orange County Groundwater Basin

RCS

FIGURE 2
LOCATION OF PROPOSED WELL NO. 28 SITE

Job No. 106-OGE18

October 2019



Ground Surface Elevation: 180.7 ft amsl

RICHARD C. SLADE & ASSOCIATES LLC
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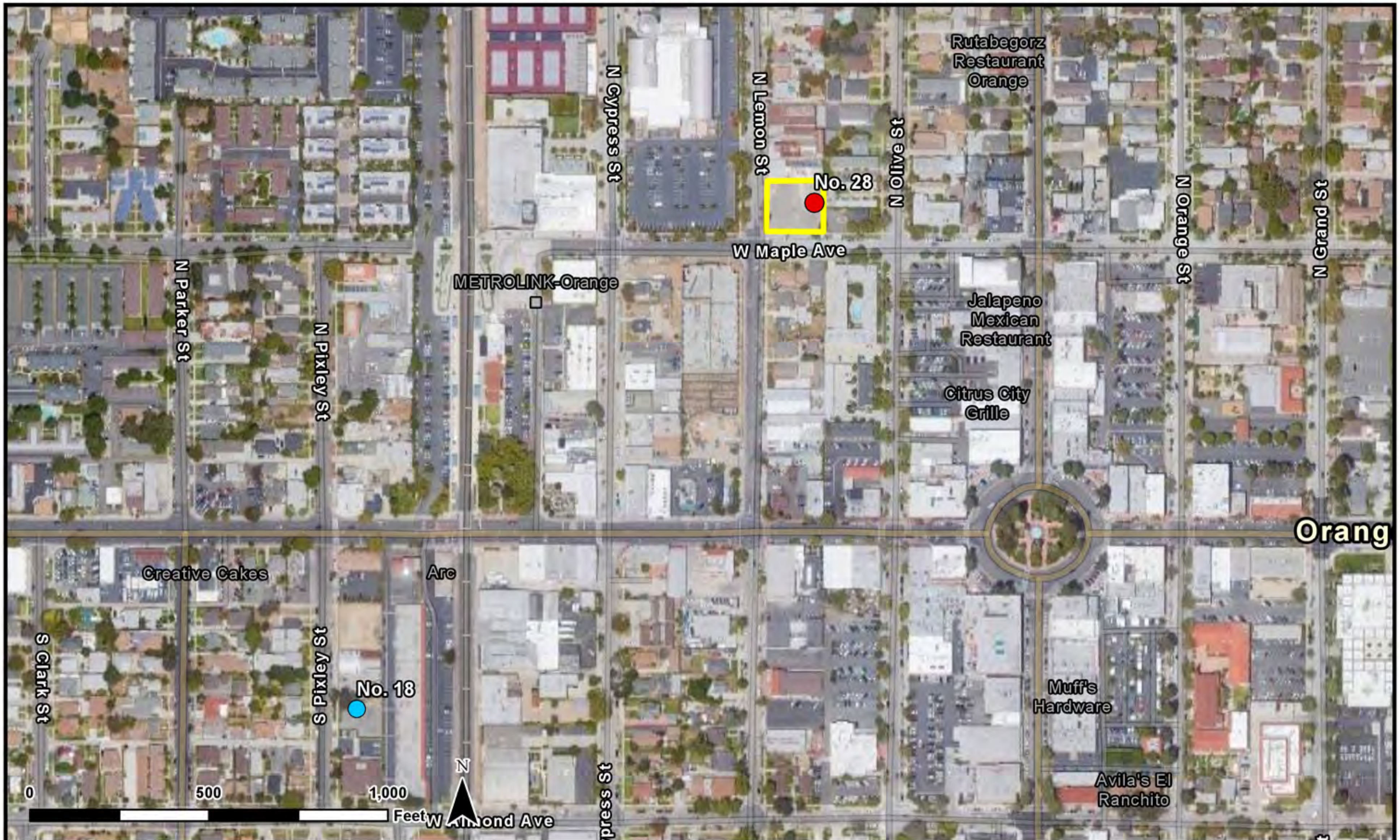
Sherman Oaks, CA 91401
Southern California (818) 506-0418
Northern California (707) 963-3914
www.rcslade.com

FIGURE 3
WATER LEVEL HYDROGRAPH
OF NEARBY CITY WELL NO. 18

Job No. 106-OGE18

October 2019



LEGEND

City Well

Proposed Well

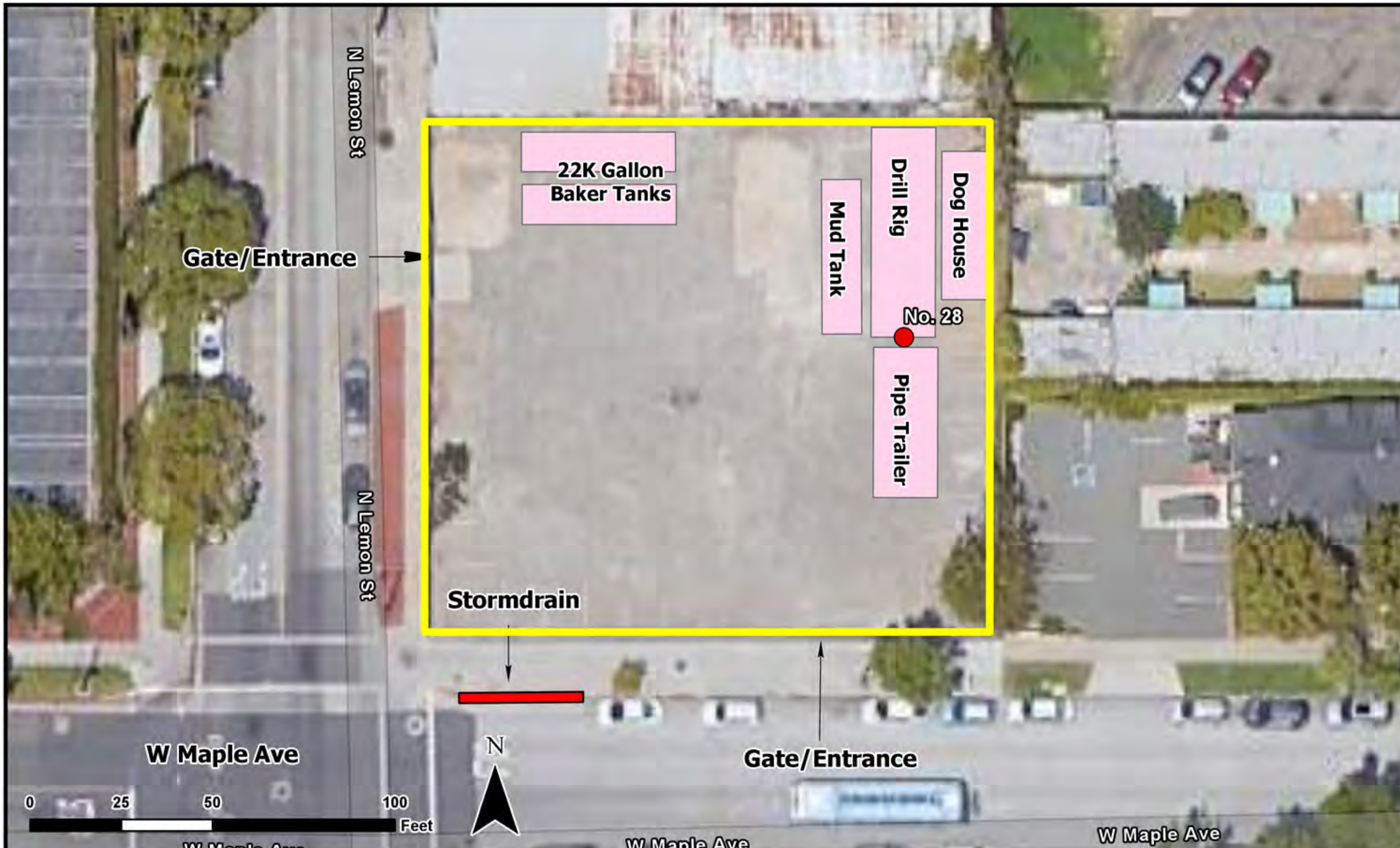
Subject Property

RCS

FIGURE 4
SITE LOCATION MAP

Job No. 106-OGE18

October 2019



LEGEND

Proposed Well

RCS

FIGURE 5
PRELIMINARY SITE LAYOUT DIAGRAM FOR WELL CONSTRUCTION

Job No. 106-OGE18

October 2019

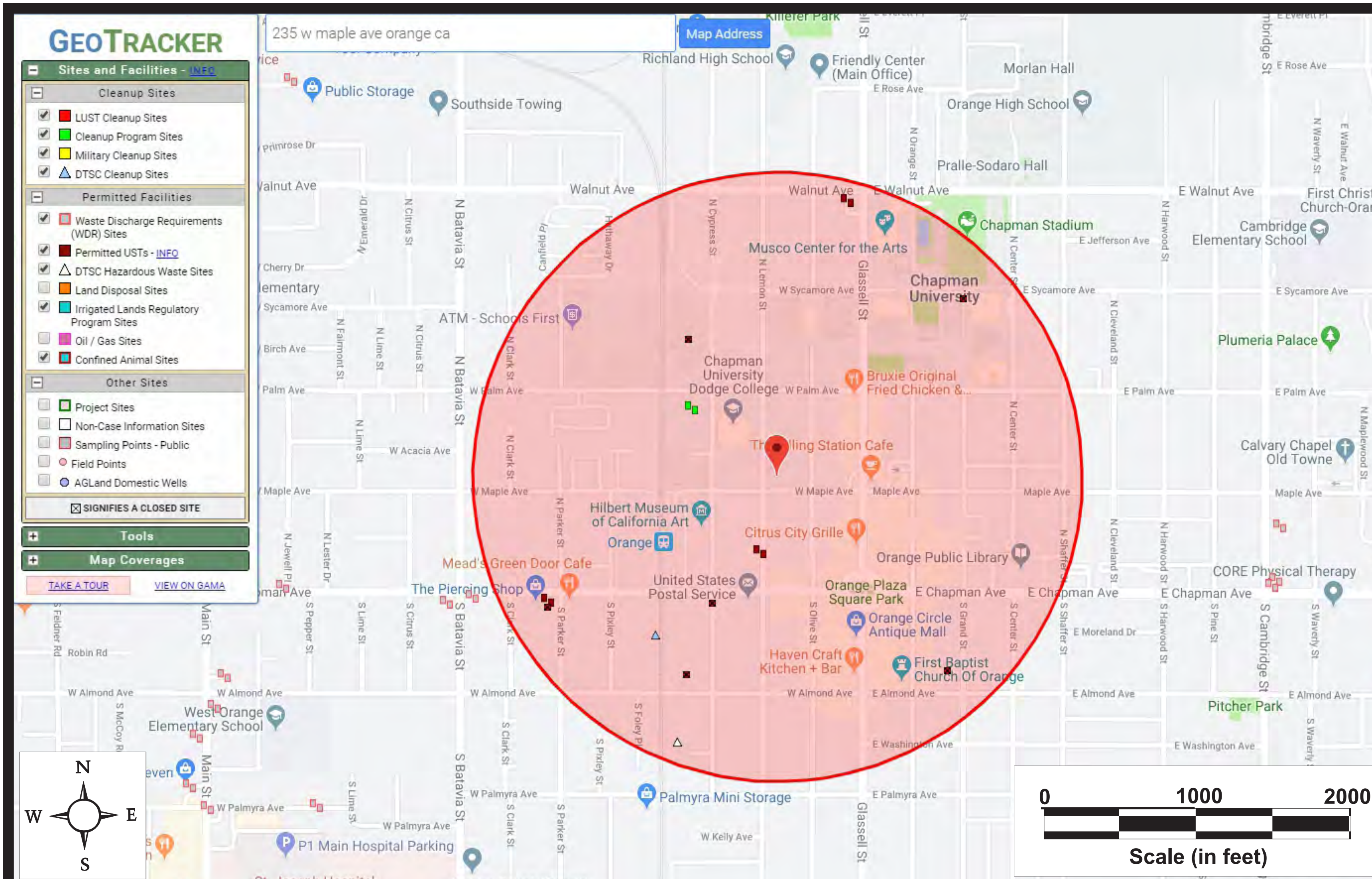


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FIGURE 6
GEOTRACKER MAP
OF PROPOSED WELL SITE AND VICINITY

Job No. 106-OGE18 **October 2019**

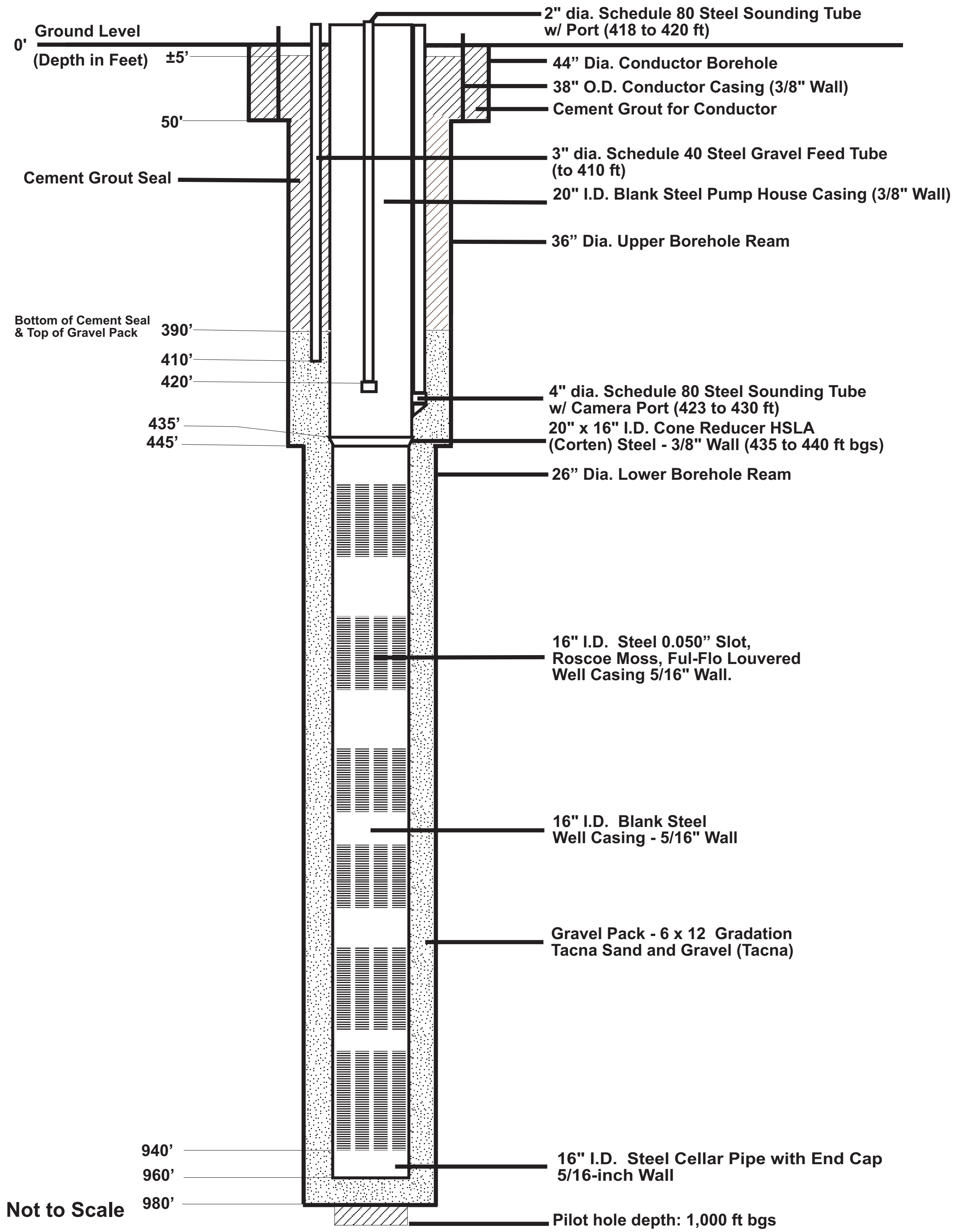

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FIGURE 7
PRELIMINARY WELL DESIGN DIAGRAM
CITY OF ORANGE WELL NO. 28

Job No. 106-OGE18 October 2019

TABLE 1
SUMMARY OF AVAILABLE WELL CONSTRUCTION DATA
CITY OF ORANGE WELLS IN VICINITY OF PROPOSED WELL SITE

City Well No.	Driller's Log No.	Date Drilled	Drilling Method	Depth of Pilot Hole (ft bgs)	Sanitary Seal Depth (ft bgs)	Casing Diameter (inches) & Steel Type	Total Casing Depth (ft bgs)	Reported Perforation Interval (ft bgs)		Perforation Type & Size	Total Length of Perforations (ft)	Gravel Pack Gradation & Depth Interval (ft bgs)
4	3010027004	November 1920	Cable Tool	726	None*	20" to 12" at depth; later, 14" liner to 202' and 12" below LCS	726	280-320 436-450 492-514	550-565 688-711	Mills Knife No data on size	114	None
5	3010027005	December 1927	Cable Tool	751	None*	20" LCS	751	195-201 231-239 251-255 258-265 277-297 301-323 441-459	501-502 520-527 579-583 619-627 652-675 698-723	Mills Knife ⅝" X 5"	153	None
18	78989	December 1977	Cable Tool	714	54	20" LCS	714	372-388 430-451 532-552 563-574	588-598 636-653 671-688	Moss Hydraulic Louvers ¼" X 2¼"	112	None
25	3010027025	July 1998	Reverse Circulation	993	to 60 ft around 36" conductor; to 400 ft in annulus	20" to 400'; 16" 400-905 LCS	905	430-450 470-480 500-510 560-590 640-670	690-710 730-740 750-760 780-840 865-885	Ful-flo Louvers 0.085" (85 slot)	220	6 X 9 CSSI 400 to 905
27	e0221380	September 2014	Reverse Circulation	960	to 50 ft around 42" conductor; to 390 ft in annulus	20" Type 304L Stainless Steel	910	425-455 495-520 645-665 690-715 740-790	825-840 870-890	Ful-flo Louvers 0.050" (50 slot)	185	8 X 20 Tacna 390 to 930

Notes:

ft bgs = feet below ground surface

LCS = Low carbon steel

*Well Nos. 4 and 5 do not have a standard sanitary seal because due to cable tool drilling method. Well No. 14, which was also drilled using the cable tool method, and was initially drilled within a conductor casing and, thus, has a cement sanitary seal.

TABLE 2
ESTIMATE OF DEPTHS AND APPROXIMATE THICKNESSES OF AQUIFER SYSTEMS NEAR PROPOSED WELL NO. 28 SITE

Formation (age)	Name of Aquifer System		Potential Depth Interval (ft bgs)	Thickness (ft)
	DWR (1967)	OCWD (2006)		
Alluvium (Recent)	Talbert	Shallow Groundwater Unit	? to 95	?
Lakewood (Upper Pleistocene)	Alpha		110 to 235	125
	Beta	Principal Aquifer System	250 to 400	150
	Lambda		430 to 520	90
San Pedro (Lower Pleistocene)	Omicron		555 to 670	115
	Rho		690 to 790	100
	Main (Upper)		800 to 960	160
Pico Formation (Pliocene)	Pico	Deeper Aquifer System	960 to ?	?

Notes:

ft bgs = feet below ground surface

TABLE 3
COMPARISON OF AVAILABLE PUMPING DATA
CITY OF ORANGE WELLS IN VICINITY OF PROPOSED WELL SITE

City Well No.	General Perforation Depth Interval (ft bgs) & Total Length of Perforations (ft)	INITIAL POST-CONSTRUCTION WELL YIELD DATA							RECENT WELL YIELD DATA						
		Date	Reported Pumping Rate (gpm)	Reported Static Water Level ft bgs)	Reported Pumping Water Level (ft bgs)	Reported Drawdown (ft)	Specific Capacity (Q/s, in gpm/ft of drawdown)	Yield Factor (gpm/ft perfs)	Date	Reported Pumping Rate (gpm)	Reported Static Water Level ft bgs)	Reported Pumping Water Level (ft bgs)	Reported Drawdown (ft)	Specific Capacity (Q/s, in gpm/ft of drawdown)	Yield Factor (gpm/ft perfs)
4	280-711 (114 ft)	1999	1,150	ND	ND	21	54.8	10	6/2008	884	159	194	35	25.3	8
5	195-723 (153 ft)	1999	1,725	ND	ND	101	17.1	11	11/2007	1,049	173	200	27	38.9	7
18	372-688 (112 ft)	12/1977	2,350	183	235	52	45.2	21	2/2016	991	168	203	35	28.3	9
25	430-885 (220 ft)	6/1998	3,153	204	278	73.6	42.8	14	3/2016	2,453	228	283	55	44.6	11
27	425-890 (185 ft)	9/2014	3,000	252	321	69.0	43.5	16	5/2019	3,212	214	310	96	33.5	17

Notes:
ND = no data
ft bgs = feet below ground surface
gpm = gallons per minute
gpm/ft ddn = gallons per minute per foot of drawdown
gpm/ft perfs = gallons per minute per foot of perforations

TABLE 4
SUMMARY OF AVAILABLE GROUNDWATER QUALITY DATA (1987 to 2019)
CITY OF ORANGE WELLS IN VICINITY OF PROPOSED WELL SITE

Constituent Analyzed	Units	Maximum Contaminant Level	Well No. 4	Well No. 5	Well No. 18	Well No. 25	Well No. 27
General Physical Constituents							
Turbidity	NTU	5	0.2 to 1	0.1 to 1.8	0.1 to 0.8	0.1 to 0.2	0.1 to 0.2
Specific Conductance	µS/cm	900; 1,600; 2,200(1)	830 to 987	580 to 974	551 to 794	487 to 572	495 to 597
pH	units	6.5 to 8.5	7.6 to 8.2	7.5 to 8.3	7.7 to 8.4	7.5 to 8.2	7.8 to 8.0
Color	CU	15	ND	ND	ND	ND	ND
Odor	TON	3	ND	1.5	ND	ND	ND
General Mineral Constituents							
Total Dissolved Solids	mg/L	500; 1,000; 1,500(1)	524 to 614	356 to 634	338 to 488	303 to 368	290 to 358
Total Hardness		None	296 to 374	195 to 348	151 to 311	128 to 174	149 to 205
Bromide		None	0.18 to 0.2	0.13 to 0.27	0.10 to 0.19	0.1 to 0.12	ND
Calcium		None	89 to 115	61 to 103	60 to 94	41 to 55	47 to 62
Magnesium		None	18 to 24	10.6 to 23	11 to 19	6.1 to 9.1	7.9 to 13
Sodium		None	49 to 72	38 to 65	36 to 45.8	46 to 55	45 to 50
Potassium		None	1.9 to 3.2	1.3 to 3.5	1.8 to 2.7	1.7 to 2.0	1.8 to 2.0
Bicarbonate (HCO_3)		None	158 to 243	194 to 233	176 to 196	176 to 185	174 to 255
Sulfate		250, 500, 600(1)	114 to 174	70 to 140	73 to 116	55.9 to 71.6	55.3 to 74.8
Chloride		250, 500, 600(1)	75 to 105	36 to 101	34 to 72.2	27 to 45	31 to 45
Fluoride(1)		2	0.2 to 0.37	0.16 to 0.31	0.25 to 0.41	0.17 to 0.24	0.22 to 0.25
Nitrate as NO_3		45	6.6 to 31	4.7 to 37	2.6 to 2.8	4.0 to 7.9	1.0 to 1.1
Foaming Agents (MBAS)		0.5	ND	0.02	0.05	ND	ND
Detected Inorganic Constituents (Trace Elements)							
Aluminum	µg/L	200	1.9 to 25	12	3	2.6 to 3.8	ND
Arsenic		10 (EPA)	1.1 to 3.4	2.7	ND	ND	ND
Barium		1000	60.6 to 102	100 to 130	111 to 130	68.5 to 82.1	ND
Boron		1,000 NL	140 to 170	110 to 150	990	120	ND
Copper		1,300 AL	1.1 to 2.4	ND	1.2	1.6 to 2.4	ND
Iron		300	ND	300	ND	ND	ND
Nickel		100	1.7 to 2.8	1.8	1.2	1.1 to 1.2	ND
Selenium		50	2.2 to 82	1.3	2.2	1.2	ND
Vanadium		50 NL	ND	1.3	1.5	3 to 3.7	ND
Zinc		5,000	1.7 to 2.8	ND	2.6	2.5 to 4.3	ND
Radiological Constituents							
Gross Alpha	pCi/L	5	1.9 to 5.26	0.4 to 7.53	0.5 to 5.96	2.06 to 2.9	1.76 to 2.84
Radium-226		5	ND	ND	0.06	ND	0.027 to 1
Radium-228			ND	ND	ND	ND	1
Uranium		20	0.875 to 6	2.14 to 3.76	3.74 to 5.45	1.75 to 3.15	0.73 to 2.30
Other Detected Constituents							
Bromodichloromethane (THM)	µg/L	--	ND	ND	ND	0.7	ND
Chloroform (THM)		--	ND	ND	ND	2.3	ND
Total Trihalomethanes (THM)		80	ND	ND	ND	ND	ND

Units:

NTU = nephelometric turbdity unit; µS/cm = microsiemens per centimeter; CU = color units; TON = threshold odor number; mg/L = milligrams per liter; µg/L = micrograms per liter; pCi/L = picocuries per Liter

Notes:

(1) The three listed numbers represent the recommended, upper and short-term State Maximum Contaminant Levels for the constituent.

Units: NTU = nephelometric turbdity unit; µS/cm = microsiemens per centimeter; CU = color units; TON = threshold odor number; mg/L = milligrams per liter; µg/L = micrograms per liter; pCi/L = picocuries per Liter

ND = Not Detected

NL = State Notification Level

AL=Action Level for Copper

EPA= U.S. Environmental Protection Agency MCL

TABLE 5
PRELIMINARY CALCULATION OF THEORETICAL WATER LEVEL DRAWDOWN IN NEARBY CITY WELLS

WELL NO.	APPROXIMATE RADIAL DISTANCE FROM PROPOSED WELL NO. 28 SITE (ft)	ASSUMED WELL NO. 28 PUMPING RATE (gpm)	CALCULATED RANGE OF DRAWDOWN INTERFERENCE VALUES (ft)				
		PUMPING PERIOD (days):	1	30	60	90	120
18	1,850	2,500	6	12	13	14	15
		3,000	7	15	16	17	18
27	5,280	2,500	2	8	9	10	11
		3,000	2.4	10	11	12	13

Notes:
1. Water level drawdown interference calcuations based on the following values:
2. Aquifer saturated thickness (b): 200 ft
3. Transmissivity (T): 150,000 gpd/ft
4. Storativity (S) value used: 0.00069
5. Effective porosity used: 0.02
6. T and S values based on and calibrated to actual 24-hour test performed in 2014 on Well No. 27
7. All water level drawdown values rounded to nearest foot

TABLE 6
PRELIMINARY COMPARISON OF WELL CONSTRUCTION COSTS
FOR CITY OF ORANGE WELL NO. 28

ITEM NO.	ITEM DESCRIPTION	DESIGN QUANTITY	UNIT	LOW CARBON STEEL		COPPER-BEARING STEEL		HIGH STRENGTH, LOW ALLOY STEEL		TYPE 304 STAINLESS STEEL	
				ESTIMATED UNIT PRICE	TOTAL	ESTIMATED UNIT PRICE	TOTAL	ESTIMATED UNIT PRICE	TOTAL	ESTIMATED UNIT PRICE	TOTAL
PILOT HOLE DRILLING, DOWNHOLE TESTING AND REAMING											
1	Mobilize/demobilize reverse circulation drill rig and equipment	1	LS	$ 105,000.00	$ 105,000.00	$ 105,000.00	$ 105,000.00	$ 105,000.00	$ 105,000.00	$ 105,000.00	$ 105,000.00
2	Furnish, install, & maintain noise control walls	500	LF	$ 250.00	$ 125,000.00	$ 250.00	$ 125,000.00	$ 250.00	$ 125,000.00	$ 250.00	$ 125,000.00
3	NPDES Permit Compliance	1	LS	$ 75,000.00	$ 75,000.00	$ 75,000.00	$ 75,000.00	$ 75,000.00	$ 75,000.00	$ 75,000.00	$ 75,000.00
4	38-inch O.D. steel conductor casing in 44-inch borehole to 50 ft bgs	50	LF	$ 850.00	$ 42,500.00	$ 850.00	$ 42,500.00	$ 850.00	$ 42,500.00	$ 850.00	$ 42,500.00
5	Pilot hole drilling (50 ft to 1000 ft bgs)	950	LF	$ 105.00	$ 99,750.00	$ 105.00	$ 99,750.00	$ 105.00	$ 99,750.00	$ 105.00	$ 99,750.00
6	Downhole geophysical surveys	1	LS	$ 10,000.00	$ 10,000.00	$ 10,000.00	$ 10,000.00	$ 10,000.00	$ 10,000.00	$ 10,000.00	$ 10,000.00
7	Isolated Aquifer Zone Testing	4	Per Zone	$ 20,000.00	$ 80,000.00	$ 20,000.00	$ 80,000.00	$ 20,000.00	$ 80,000.00	$ 20,000.00	$ 80,000.00
8	Aquifer zone seal	25	LF	$ 130.00	$ 3,250.00	$ 130.00	$ 3,250.00	$ 130.00	$ 3,250.00	$ 130.00	$ 3,250.00
9	36-in dia. pilot hole ream (50 to 445 ft)	395	LF	$ 115.00	$ 45,425.00	$ 115.00	$ 45,425.00	$ 115.00	$ 45,425.00	$ 115.00	$ 45,425.00
10	26-in dia. pilot hole ream reverse circulation (445 to 980 ft)	535	LF	$ 100.00	$ 53,500.00	$ 100.00	$ 53,500.00	$ 100.00	$ 53,500.00	$ 100.00	$ 53,500.00
11	Downhole caliper survey	1	LS	$ 3,500.00	$ 3,500.00	$ 3,500.00	$ 3,500.00	$ 3,500.00	$ 3,500.00	$ 3,500.00	$ 3,500.00
12	Deviation survey of reamed borehole	1	LS	$ 3,500.00	$ 3,500.00	$ 3,500.00	$ 3,500.00	$ 3,500.00	$ 3,500.00	$ 3,500.00	$ 3,500.00
13	Destruction (per linear foot basis) *	1000	LF	$ 50.00	$ 50,000.00	$ 50.00	$ 50,000.00	$ 50.00	$ 50,000.00	$ 50.00	$ 50,000.00
WELL CASING AND TUBES											
14	20-in I.D. steel blank pump house casing (3/8-in wall)	437	LF	$ 95.00	$ 41,515.00	$ 180.00	$ 78,660.00	$ 235.00	$ 102,695.00	$ 550.00	$ 240,350.00
15	16-in I.D. to 20-inch I.D. casing reducer (3/8-in wall)	1	LS	$ 2,540.00	$ 2,540.00	$ 2,540.00	$ 2,540.00	$ 2,540.00	$ 2,540.00	$ 6,630.00	$ 6,630.00
16	16-in I.D. steel blank well casing (5/16-in wall)	150	LF	$ 65.00	$ 9,750.00	$ 120.00	$ 18,000.00	$ 155.00	$ 23,250.00	$ 380.00	$ 57,000.00
17	16-in I.D. steel louvered well casing (50-slot, 5/16-in wall)	350	LF	$ 130.00	$ 45,500.00	$ 185.00	$ 64,750.00	$ 225.00	$ 78,750.00	$ 355.00	$ 124,250.00
18	16-in I.D. steel cellar pipe (5/16-in wall) with end cap	20	LF	$ 25.00	$ 500.00	$ 30.00	$ 600.00	$ 35.00	$ 700.00	$ 45.00	$ 900.00
19	4-inch I.D. steel camera port	1	LS	$ 8,700.00	$ 8,700.00	$ 9,100.00	$ 9,100.00	$ 9,500.00	$ 9,500.00	$ 12,000.00	$ 12,000.00
20	4-in I.D. steel sounding tube with camera port (to 430 ft)	432	LF	$ 10.00	$ 4,320.00	$ 10.00	$ 4,320.00	$ 10.00	$ 4,320.00	$ 55.00	$ 23,760.00
21	2-in I.D. steel pressure transducer tube (to 420 ft)	422	LF	$ 5.00	$ 2,110.00	$ 5.00	$ 2,110.00	$ 5.00	$ 2,110.00	$ 15.00	$ 6,330.00
22	3-in I.D. steel gravel feed tube (to 410 ft)	412	LF	$ 10.00	$ 4,120.00	$ 10.00	$ 4,120.00	$ 10.00	$ 4,120.00	$ 30.00	$ 12,360.00
23	Gravel pack: Tacna 6 X 12 (390 ft to 980 ft)	590	LF	$ 75.00	$ 44,250.00	$ 75.00	$ 44,250.00	$ 75.00	$ 44,250.00	$ 75.00	$ 44,250.00
24	Annular grout seal (5 ft to 390 ft bgs)	385	LF	$ 70.00	$ 26,950.00	$ 70.00	$ 26,950.00	$ 70.00	$ 26,950.00	$ 70.00	$ 26,950.00
25	Downwell gyroscopic alignment survey	1	LS	$ 4,500.00	$ 4,500.00	$ 4,500.00	$ 4,500.00	$ 4,500.00	$ 4,500.00	$ 4,500.00	$ 4,500.00
26	Standby time	24	HR	$ 475.00	$ 11,400.00	$ 475.00	$ 11,400.00	$ 475.00	$ 11,400.00	$ 475.00	$ 11,400.00
WELL DEVELOPMENT											
27	Mechanical well development	100	Hr	$ 600.00	$ 60,000.00	$ 600.00	$ 60,000.00	$ 600.00	$ 60,000.00	$ 600.00	$ 60,000.00
28	Chemical development (10% chlorine solution)	200	GAL	$ 20.00	$ 4,000.00	$ 20.00	$ 4,000.00	$ 20.00	$ 4,000.00	$ 20.00	$ 4,000.00
29	Chemical development (polymer dispersant)	20	GAL	$ 250.00	$ 5,000.00	$ 250.00	$ 5,000.00	$ 250.00	$ 5,000.00	$ 250.00	$ 5,000.00
30	Mobilization and demobilization of test pump & appurtenances	1	LS	$ 45,000.00	$ 45,000.00	$ 45,000.00	$ 45,000.00	$ 45,000.00	$ 45,000.00	$ 45,000.00	$ 45,000.00
31	Pumping development	100	HR	$ 400.00	$ 40,000.00	$ 400.00	$ 40,000.00	$ 400.00	$ 40,000.00	$ 400.00	$ 40,000.00
WELL TESTING											
32	Step-drawdown testing	12	HR	$ 400.00	$ 4,800.00	$ 400.00	$ 4,800.00	$ 400.00	$ 4,800.00	$ 400.00	$ 4,800.00
33	Constant-rate discharge testing	48	HR	$ 400.00	$ 19,200.00	$ 400.00	$ 19,200.00	$ 400.00	$ 19,200.00	$ 400.00	$ 19,200.00
34	Flow meter (spinner) survey	1	LS	$ 6,000.00	$ 6,000.00	$ 6,000.00	$ 6,000.00	$ 6,000.00	$ 6,000.00	$ 6,000.00	$ 6,000.00
35	Color video camera survey	3	LS	$ 2,500.00	$ 7,500.00	$ 2,500.00	$ 7,500.00	$ 2,500.00	$ 7,500.00	$ 2,500.00	$ 7,500.00
36	Disinfection of well and capping	1	LS	$ 5,500.00	$ 5,500.00	$ 5,500.00	$ 5,500.00	$ 5,500.00	$ 5,500.00	$ 5,500.00	$ 5,500.00
ESTIMATED WELL CONSTRUCTION COSTS SUBTOTALS:											
	PILOT HOLE DRILLING, DOWNHOLE TESTING AND REAMING:			**$ 696,425.00**			**$ 696,425.00**		**$ 696,425.00**		**$ 696,425.00**
	WELL CASING AND TUBES:			**$ 206,155.00**			**$ 271,300.00**		**$ 315,085.00**		**$ 570,680.00**
	WELL DEVELOPMENT:			**$ 154,000.00**			**$ 154,000.00**		**$ 154,000.00**		**$ 154,000.00**
	WELL TESTING:			**$ 43,000.00**			**$ 43,000.00**		**$ 43,000.00**		**$ 43,000.00**
	TOTAL ESTIMATED COST (Items 1- 35):			**$ 1,099,580.00**			**$ 1,164,725.00**		**$ 1,208,510.00**		**$ 1,464,105.00**

TABLE 7
PRELIMINARY ASSESSMENT OF PUMPING RATES AND PUMP DEPTH SETTINGS FOR PERMANENT PUMP IN PROPOSED CITY OF ORANGE WELL NO. 28

Item	Parameter	Potential Values			
A.	Estimated Static Water Level Depth at Site, for June 2019 (ft bgs).	150			
B.	Estimated Specific Capacity (gpm/ft ddn).	50	45	40	35
C.	Possible Maximum Pumping Rate (gpm).	2,000	2,500	3,000	3,500
D.	Resulting Drawdown (in ft)=(C/B).	40	56	75	100
E.	Initial Pumping Water Level Depth (ft bgs)=(A+D).	190	206	225	250
F.	Additional Water Level Decline (in ft) Due to Estimated 15% Decline in Specific Capacity of Well.	7	10	13	18
G.	Estimated Water Level Decline (in ft) Due to Long Term Drought.	50	50	50	50
H.	Estimated Water Level Drawdown Interference Due to Pumping of Existing Wells	20	20	20	20
I.	Estimated Future Pumping Water Level Depth (in ft bgs) with Declines Due to Above Listed Factors=(E+F+G).	267	285	308	338
J.	Recommended Maximum Depth (ft bgs) for Pump Intake.	300	320	340	360

Notes:
ft bgs = feet below ground surface
gpm = gallons per minute
*Values listed above are considered to be approximate