



June 10, 2016

Job No. 8596.001

Anna Louzon c/o Yolo County CSA Administrative Support Team
625 Court Street, Room 202
Woodland, CA 95695

**Subject: Willowbank County Service Area – Proposed New Irrigation Supply Well –
Review and Assessment of Hydrogeologic Conditions and Recommendations**

Wood Rodgers, Inc. (Wood Rodgers) is pleased to provide the Water Subcommittee of the Willowbank County Service Area (CSA) with this review and assessment of the hydrogeologic conditions for the aquifer system underlying the CSA. The CSA is located near the southeastern city limits of Davis (City) in Yolo County, California. This report is a component of the feasibility study to determine if groundwater will be a suitable source for landscape irrigation for the CSA.

BACKGROUND

Currently, the CSA receives water from the City to meet its potable water and irrigation demands. Wood Rodgers has reviewed available water level and water quality data to determine the feasibility of constructing an irrigation well to meet irrigation demands, which will reduce the volume of the City's potable water needed to meet overall water demand in the CSA.

Wood Rodgers reviewed available water level and water quality data from the California Department of Water Resources (DWR) Water Data Library (WDL). Wood Rodgers also reviewed available water level, water quality, and well construction data from nearby City wells and University of California at Davis (UCD) wells. Below is a summary of the hydrogeologic conditions in the vicinity of the CSA and Wood Rodgers' recommendations for constructing an irrigation well.

Hydrogeology

Wood Rodgers conducted a review of available data for the geology and hydrogeology that exists in the vicinity of the CSA. The CSA is located within Yolo Groundwater Subbasin (5-21.67) (Subbasin) of the Sacramento Valley Groundwater Basin (DWR Bulletin 118). The Subbasin is bounded on the north by Cache Creek, on the east by the Sacramento River, on the south by Putah Creek, and on the west by the Coast Range Mountains. The main freshwater-bearing formations encountered within the Subbasin were derived from

sedimentary continental deposits of Late Tertiary (Pliocene) to Quaternary (Holocene) age. The formations from oldest (deeper) to youngest (shallower) include: the Tehama Formation, older alluvium, younger alluvium, and present-day stream channel and basin deposits.

Tehama Formation

The Tehama Formation is an important water-bearing unit and the majority of irrigation wells in the area are completed in this formation. The Tehama Formation is a non-marine deposit that originated from the Coast Range Mountains to the west and was deposited unconformably on top of older, east-dipping marine sediments (Pre-Tehama) that often contain groundwater with elevated concentrations of salts and methane gas. The Tehama Formation outcrops in the foothills of the Coast Ranges at the western edge of the Sacramento Valley and becomes thicker and deeper towards the center of the Sacramento Valley. Within the Tehama Formation, the gravel, sand, and silt materials are separated into distinct zones by impermeable and semi-permeable layers of clay and other fine-grained materials. The gravel and sand zones vary in thickness, from tens of feet up to 200 feet thick, but may lack lateral continuity. Wells completed in the coarse-grained layers of the Tehama Formation can yield up to several thousand gallons per minute (gpm) (DWR, Bulletin 118).

Wood Rodgers reviewed available well logs from the California Department of Conservation, Division of Oil, Gas, and Geothermal Resources (DOGGR) to assess the freshwater aquifers underneath the CSA (Figure 1). The base of the Tehama Formation is typically identified by a transition from coarse-grained aquifer material to fine-grained sediments containing brackish water. This indicates a transition into pre-Tehama marine-derived sediments. The DOGGR well logs indicate that the Tehama Formation extends to a depth of approximately 2,600 feet below ground surface (bgs) in the vicinity of the CSA.

Older and Younger Alluvium and Basin Deposits

The Quaternary alluvial deposits include (from oldest to youngest): Older Alluvium (Modesto and Riverbank Formations), and stream channel and basin deposits. The Quaternary alluvial deposits are generally less than 200 feet in thickness in this area.

Older alluvium consists of alluvial fan and terrace deposits containing silt, silty clay, sand and gravel. Wells completed in older alluvium can produce between 300 and 1,000 gpm (DWR, Bulletin 118).

Younger alluvium consists of recent stream channel and basin deposits that contain silt, sand, gravel and occasionally cobbles. Permeability in the younger alluvium ranges from moderate to high, which helps facilitate recharge into the Subbasin; however, these deposits are generally unsaturated and are not a viable source for water supply wells.

Groundwater Levels

Groundwater level data for local DWR monitored wells were obtained from the DWR WDL (<http://www.water.ca.gov/waterdatalibrary/>) and the California Statewide Groundwater Elevation Monitoring (CASGEM) database (<http://www.water.ca.gov/groundwater/casgem/>). Hydrographs of three DWR monitored wells (unknown depth) located in agricultural fields to the south of the CSA are illustrated in Figure 2. Historic water level data for nearby water supply wells were provided by the City and UCD. Based on the underlying hydrogeology, the wells were categorized based on well depth, with shallow wells less than 200 feet deep, intermediate wells constructed from approximately 200 to 600 feet deep, and deep wells constructed with total depths greater than 600 feet.

Historic water level data for shallow and intermediate wells indicate that groundwater levels respond to Subbasin conditions during wet and dry periods, as shown on Figure 2. Significant declines in groundwater elevations were recorded during drought (i.e. late 1970s and early 1990s), while during wet periods (i.e. mid-1980s and mid-1990s), groundwater levels quickly rebounded with groundwater recharge and with availability of surface water supplies and reductions in groundwater pumping throughout the Subbasin. Additionally, the hydrographs indicate that the intermediate wells have had approximately 60 feet of seasonal water level fluctuation over the past 25 years, with spring average water level elevations of approximately 10 feet above mean seal level (msl) and fall average water level elevations at approximately 50 feet below msl. The hydrographs indicate that groundwater elevations have decreased by approximately 2 to 3 feet per year over the last 5 years due to current drought; however, these trends are observed in intermediate wells throughout the Subbasin and the responses are similar to the drought of the early 1990s. Overall, the intermediate aquifer system appears sustainable with good recharge and is not in overdraft.

There are two nearby deep municipal City wells, one located less than one mile north of the CSA and the other located less than three miles northwest of the CSA, that have total well depths of 1,670 feet and 1,520 feet, respectively (refer to Figure 2). Wood Rodgers reviewed hydrographs for these two wells, in addition to hydrographs from all other deep City and UCD wells. The groundwater level data indicate that the deep aquifer system responds differently to Subbasin conditions than the shallow and intermediate aquifer system. The data indicate that groundwater levels have variable seasonal fluctuations of approximately 10 to 75 feet, with an average fluctuation of about 50 feet. Overall groundwater levels in the deep aquifer system have decreased by approximately 3 to 5 feet per year since 2000, and the groundwater level data indicate that the deep aquifer system is currently in overdraft.

Water Quality

Water produced from the shallow aquifers typically contains high concentrations of boron, selenium, nitrates, hexavalent chromium (Cr-6), and Total Dissolved Solids (TDS) and is generally poor for municipal and irrigation supply. As a result, the majority of municipal and irrigation supply wells in the area are not completed in shallow aquifers.

Fall 2014 water quality data were obtained from the State of California Division of Drinking Water (DDW) water quality database for nearby intermediate and deep City wells. The data indicated that water produced from intermediate aquifers had boron concentrations less than 1 milligram per liter (mg/L), EC concentrations of approximately 1,000 to 2,000 micro-Siemens per centimeter ($\mu\text{S}/\text{cm}$), and arsenic concentrations from 2.2 to 2.8 $\mu\text{g}/\text{L}$ (select wells with water quality are shown in Figure 3). Water produced from the intermediate aquifers has high “hardness,” but the intermediate aquifers are generally acceptable for irrigation water supply.

Water produced from deep aquifers had EC values that ranged from 440 to 640 $\mu\text{S}/\text{cm}$, and arsenic concentrations ranged from approximately 5 to 13 $\mu\text{g}/\text{L}$, and in certain areas, exceeded the DDW MCL of 10 $\mu\text{g}/\text{L}$. Data from City and UCD deep wells indicate that the deep aquifers are generally acceptable for municipal water supply in most areas; however, some areas may have unfavorable sodium-adsorption ratio (SAR) values for irrigation. Figure 3 shows two nearby deep City wells that have SAR values of 5.3 and 5.5, which are almost four times higher than SAR values for nearby intermediate wells.

Potential Impacts to nearby Wells

The City owns and operates four municipal water supply wells that are all located between approximately 0.5 and 1 mile north of the CSA (Figure 1). Three of the wells are completed in intermediate aquifers between 200 and 500 feet, and one well is completed in deep aquifers of the Tehama Formation between approximately 700 and 1,600 feet.

Land use to the south of the CSA is primarily agricultural. These agricultural areas are located within the Yolo County Flood Control and Water Conservation District (YCFCWCD) boundary; however, there is no current system in place to provide surface water supply or drainage to lands south of the CSA. As such, irrigation demands are provided via groundwater pumping from private agricultural wells.

It has been reported that several new wells were constructed recently south of the CSA; however, it is beyond this scope of work to assess what impacts these wells may have on a new well for the CSA due to the unknown pumping rate(s), well construction, and location.

Based on well capacity data from the City’s intermediate wells and overall groundwater level trends in the intermediate aquifer, it is likely that an intermediate-depth irrigation well

that is constructed within the CSA will have negligible pumping impacts to nearby City and private wells, and to the intermediate aquifer system as a whole.

SUMMARY & CONCLUSIONS

- Based on our analysis of historic groundwater data provided by DWR, the City, and UCD, groundwater levels in the intermediate aquifers decline during dry periods and recover during wet periods from recharge and reductions in groundwater pumping. Groundwater level data indicate that the intermediate aquifer system appears sustainable.
- Groundwater level data indicate that the deep aquifer system is currently in overdraft.
- The shallow aquifer system generally has poor water quality in regards to salinity, boron, nitrates, and selenium, and is likely not suitable for irrigation water supply.
- Water produced from the intermediate aquifers has high “hardness,” but is normally suitable for irrigation.
- Water produced from the deep aquifers is generally suitable for municipal water supply; however, water produced from the deep aquifers can contain high SAR values that may be undesirable for irrigation water supply.
- The intermediate aquifers (200 to 600 feet depth) will likely provide sufficient capacity to meet landscape irrigation demand in the CSA.

RECOMMENDATIONS

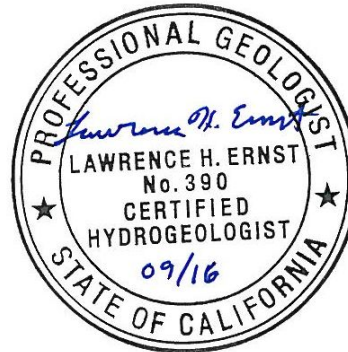
- Prior to the design and construction of an irrigation well, Wood Rodgers recommends conducting exploratory drilling to a depth of 600 feet at a site that is determined suitable for the irrigation well. Geophysical surveys conducted within the borehole will provide data that will be helpful in designing a well that has the best chance of meeting the water quality and capacity objectives.
- Wood Rodgers recommends completing the proposed irrigation well in intermediate aquifers between 200 and 600 feet to produce water of acceptable quality for irrigation purposes. The irrigation well should have a minimum of a 200 foot cement annular seal to reduce the potential for migration of water of poor quality from the shallower aquifers, and to comply with the City’s code for minimum seal depth for new wells.

We look forward to assisting the Water Subcommittee of the Willowbank County Service Area with groundwater development to meet irrigation needs. If you have any questions or if you need any additional information, please contact me at (916) 341-7447 (office) or (916) 417-7687 (cell).

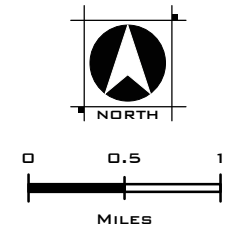
Sincerely,



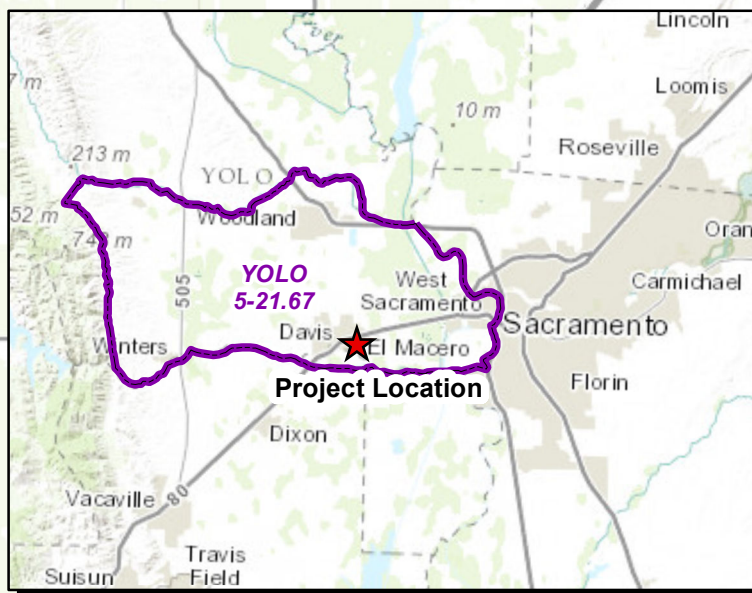
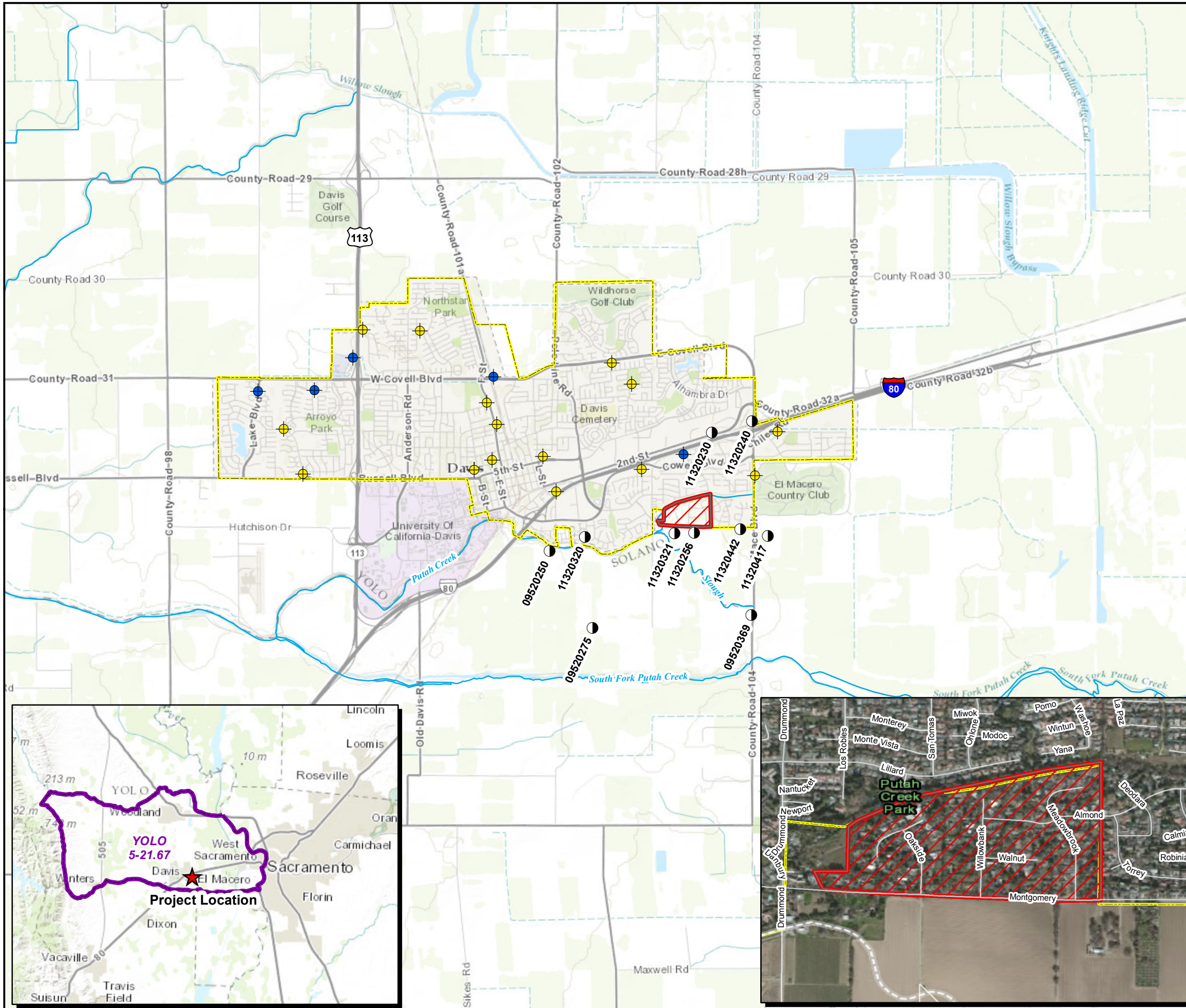
Lawrence H. Ernst, PG, CEG, CHG
Principal Hydrogeologist



PROJECT LOCATION MAP
WILLOWBANK COUNTY SERVICE AREA
YOLO COUNTY, CALIFORNIA
MAY, 2015



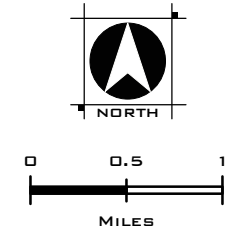
- Intermediate City Well
- Deep City Well
- DOGGR Well
- Willowbank CSA
- City of Davis
- Yolo Groundwater Subbasin (DWR)



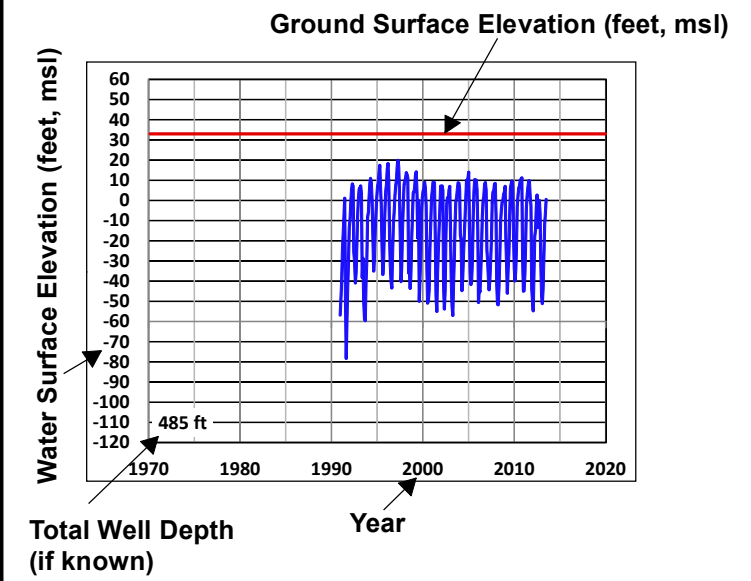
Sources:
Department of Conservation, Division of Oil, Gas and Geothermal Resources (DOGGR) online well log database.

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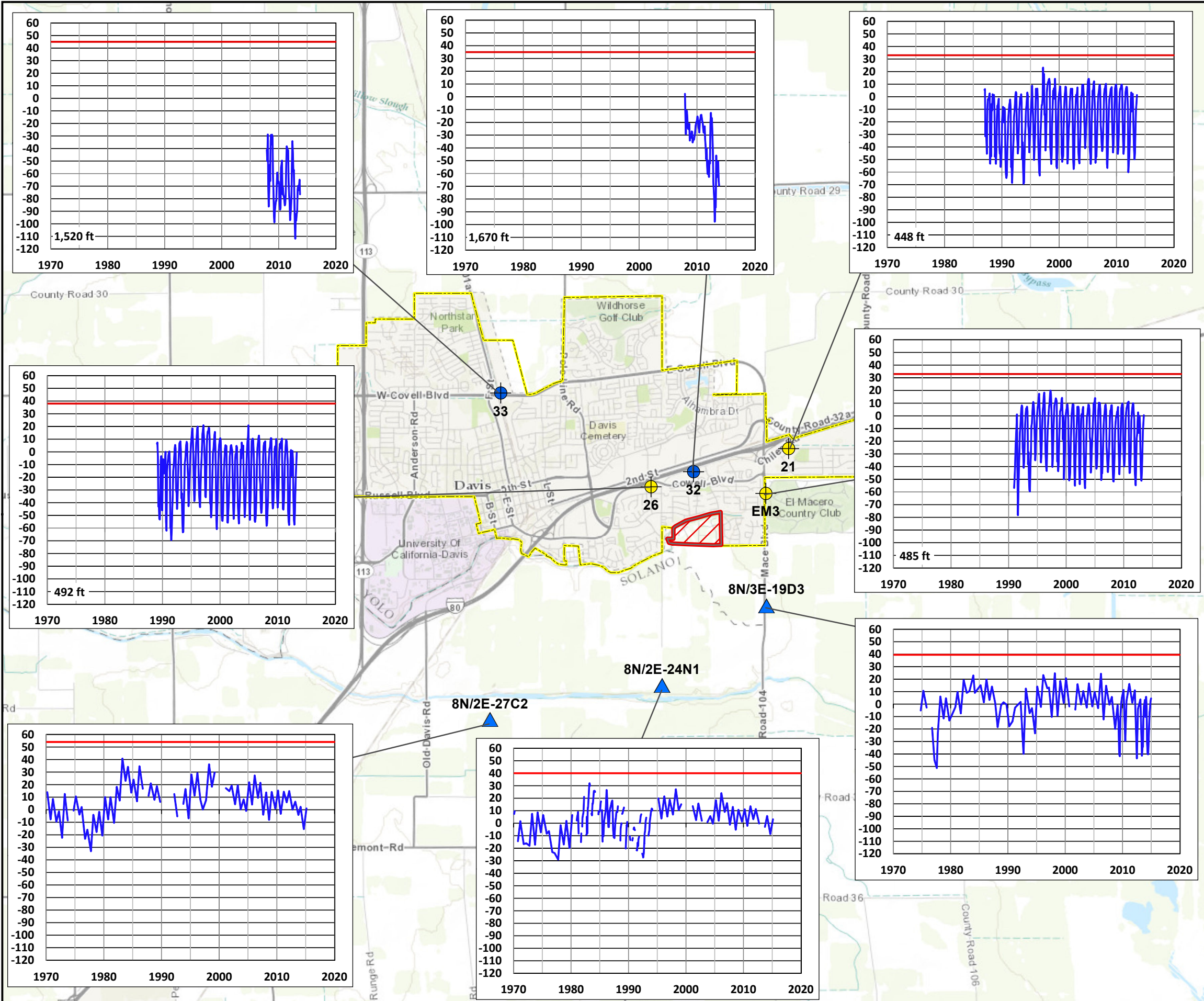
GROUNDWATER HYDROGRAPH MAP
WILLOWBANK COUNTY SERVICE AREA
YOLO COUNTY, CALIFORNIA
MAY, 2015



- ▲ Groundwater Monitored Well (DWR)
- Intermediate City Well
- Deep City Well
- Willowbank CSA
- City of Davis



Source:
Groundwater level data for the monitored wells were obtained from the California Department of Water Resources (DWR) Water Data Library online database.
Groundwater levels for the municipal wells were provided by the City of Davis.



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FIGURE 2

