



UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

REGION IX

75 Hawthorne Street
San Francisco, CA 94105-3901

March 29, 2018

Kenneth A. Harris Jr.
State Oil and Gas Supervisor
Division of Oil, Gas, and Geothermal Resources
California Department of Conservation
801 K Street, MS 18-05
Sacramento, CA 95814-3530

Re: Aquifer Exemption Request for the Elk Hills Oil Field, Phase 1 Area, Kern County, California

Dear Mr. Harris:

Based on a thorough review of the supporting documents submitted by the California Department of Conservation, Division of Oil, Gas, and Geothermal Resources and the State Water Resources Control Board, the U.S. Environmental Protection Agency (EPA) hereby approves the aquifer exemption request for the Lower Tulare Formation in the Elk Hills Oil Field, Phase 1 Area, in Kern County, California.

The approved aquifer exemption boundaries and depths, along with EPA's analyses and rationale in support of the approval, are detailed in the enclosed Record of Decision, also available at: <https://www.epa.gov/pacific-southwest-media-center/epas-oversight-californias-underground-injection-control-uic-program>. In accordance with applicable regulations at 40 C.F.R. Parts 144, 145, and 146, we find that this aquifer exemption request is a non-substantial program revision, and that the requested formation meets the following federal exemption criteria:

- The portion of the formation proposed for exemption in the field does not currently serve as a source of drinking water; and
- The portion of the formation proposed for exemption in the field has more than 3,000 milligrams per liter (mg/L) and less than 10,000 mg/L total dissolved solids content, and is not reasonably expected to supply a public water system.

If you have any questions, please contact David Albright, Manager, Drinking Water Protection Section, at (415) 972-3971.

Sincerely,

Tomás Torres *March 29, 2018*
Director, Water Division

Enclosure: Aquifer Exemption Record of Decision for Elk Hills Oil Field, Phase 1 Area

cc: Jonathan Bishop, Chief Deputy Director, State Water Resources Control Board

DESCRIPTION OF PROPOSED AQUIFER EXEMPTION

Aquifer to be Exempted: The Lower Tulare Formation below the Amnicola Claystone within the Elk Hills Oil Field, Phase 1 Area. The Phase 1 Area covers the southwest flank of the Elk Hills Oil Field.

Areal Extent of Aquifer Exemption: The areal extent of the proposed AE is approximately 9,079 acres. This includes the entire extent of the Lower Tulare Formation within the Phase 1 Area of the field. DOGGR has provided GIS shape files that delineate the AE boundary at the surface, which are included in the administrative record for this ROD. Refer to Figure 2 for a depiction of the proposed exempt formation.

Lithology, Total Dissolved Solids (TDS), Depth, Thickness, Porosity, and Permeability of the Aquifer: The following table presents the lithology, TDS levels, depth, thickness, and porosity and permeability information about the aquifer proposed for exemption.

<i>Aquifer</i>	Lower Tulare Formation
<i>Lithology</i>	Interbedded fluvial and lacustrine deposits of gravel, sand, silt, clay, and limestone.
<i>TDS (mg/L)</i>	7,168 to 20,000 mg/L.
<i>Depth to Top (feet)</i>	Approximately 400 to 2,300 feet below ground surface (BGS), or 950 to -1,800 feet mean sea level (MSL)
<i>Thickness (feet)</i>	Average of approximately 900 feet; ranges from 500 feet to 1,100 feet.
<i>Porosity and Permeability</i>	Porosity ranges from 24.2% to 40.8%. Permeability ranges from 7.7 to 7,446 millidarcies (mD).

Confining Zone(s): The Lower Tulare Formation within the Elk Hills Oil Field is confined above by the Amnicola Claystone and below by the shales and silts of the San Joaquin Formation. Lateral confinement is provided by pressure gradients and operational controls that contain the injected water within the exempted area. [Refer to Figures 3.1 through 3.4.]

BACKGROUND

On February 15, 2018, the EPA received a request from DOGGR for approval to exempt the Lower Tulare Formation within the Elk Hills Oil Field, Phase 1 Area in Kern County, California. DOGGR reviewed and concurred with the operator's request and proposed this AE based on the criteria at 40 CFR § 146.4(a): that it does not currently serve as a source of drinking water; and at 40 CFR § 146.4(c): that the TDS content of the aquifer is more than 3,000 milligrams per liter (mg/L) and less than 10,000 mg/L and it is not reasonably expected to supply a public water system. After the EPA's approval of the AE, the exempt formation would not be protected as an "underground source of drinking water" (USDW) under the Safe Drinking Water Act (SDWA) and DOGGR would be authorized, subject to state regulatory requirements, to approve Class II injection into the identified formation.

The Elk Hills Oil Field was discovered in 1975. Most of the oil and gas produced in the field is from the San Joaquin, Etchegoin, and Monterey Formations. Total field production through 2014 was approximately 1.4 billion barrels of oil and 3.0 trillion cubic feet of gas. In 2015, oil production at the Elk Hills Oil Field resulted in daily production of 472,918 barrels of water. Over 58 percent (276,222 barrels per day) of the produced water was used in enhanced oil recovery (EOR) projects in several Elk Hills reservoirs. EOR involves the re-injection of produced water to stimulate oil production. The remaining 42 percent (196,696 barrels per day) is injected into the Tulare Formation for disposal. In the Phase 1 Area, which includes only a portion of the Elk Hills Oil Field, 30,674 barrels of water per day are injected for disposal. A total of 11,196,042 barrels of water were injected into this area for disposal in 2015.

BASIS FOR DECISION

Regulatory Criteria under which the AE is Requested and Approved

40 CFR § 146.4(a) *It does not currently serve as a source of drinking water.*

In their concurrence on this AE package, the State Water Resources Control Board (State Water Board) determined that the Lower Tulare Formation does not currently serve as a source of drinking water and is not hydraulically connected to domestic or public water supply wells. This is based on an evaluation of information about water supply wells in the area, groundwater flow patterns, and confinement of the formation to groundwater flow. These reviews demonstrate that the aquifer identified for exemption does not currently serve as a source of drinking water because there are no existing drinking water supply wells, public or private, that currently or in the future would draw water from the Lower Tulare Formation; the formation is vertically and laterally confined (i.e., separated) from other USDWs; and no aquifers that serve as sources of drinking water are hydraulically connected to the aquifer. Further, within the State's water well search area (described more fully below), the Lower Tulare Formation is not currently a source of drinking water. The alluvium and undifferentiated Upper Tulare Formation (which serve as the shallow fresh water source in the area) are approximately 1,285 feet to 2,089 vertical feet above the top of the Lower Tulare Formation.

Water Supply Wells: DOGGR's AE request included information about water wells in the area proposed for exemption in order to establish that no drinking water wells or other water supply wells draw from the aquifer proposed for exemption. To identify potential water supply wells, the operator performed water well database searches, reviewing well records from the California Statewide Groundwater Elevation Monitoring (CASGEM) Program, the U.S. Geological Survey, the Kern County Water Agency (KCWA), the West Kern Water District (WKWD), the Department of Water Resources (DWR), and the GeoTracker Groundwater Ambient Monitoring and Assessment (GAMA) online database. In addition, a field survey of the CASGEM well locations was performed.

The water supply well search area ("study area") includes the sections entire extent of the formation proposed for exemption in the Phase 1 Area (described in Well/Project Location above), plus a buffer area beyond the proposed boundary of the proposed exemption area. The expanded area was selected for study (in consultation with the State Water Board) because the

area is known to have several old abandoned water wells and to account for uncertainties in the locations of water wells on well records.

The water well survey identified 30 well records; all for wells located outside the proposed exempt area (See Table 1). Of these 30 wells, six are irrigation wells, five are monitoring wells, two are identified as “DWR (Department of Water Resources) wells,” one is an oil well, and the well type of the other 16 wells is listed as unknown or no information was provided in the AE request. Based on a follow up site survey, only a few of the 30 wells identified in the survey are present today, and none show evidence of recent water production. The wells identified in the well search for which completion depths were reported are completed between 328 feet and 660 feet below ground surface and do not penetrate the first upper confining zone, the Tulare Clay, with one exception being an abandoned oil well with a total depth of 5,842 feet. The base of the water wells are separated from the base of the second confining zone, the Amnicola Claystone, by between approximately 1,285 feet to 2,089 feet of claystone (refer to Figure 3.1). Therefore, it is reasonable to conclude that the water wells do not draw from formations in hydraulic connection with the formation proposed for exemption. According to the AE request, no active water supply wells are present in the Phase 1 Area. The closest municipal water supply wells are operated by the WKWD at their South Wellfield; these wells are 8 miles northeast of the Phase 1 Area on the opposite side of the Elk Hills anticline (the domed rock structure that forms the Elk Hills Oil Field). As a result, the municipal drinking water supply wells are not in hydraulic connection with the formation proposed for exemption.

DOGGR’s well search investigation confirmed there are no domestic or public drinking water supply wells that draw from the Lower Tulare Formation, and that the formation proposed for exemption is not currently a source of drinking water and is not hydraulically connected to domestic or public water supply wells.

Groundwater Flow Patterns: DOGGR evaluated available hydrogeologic and other information on the aquifer proposed for exemption and the overlying formations, including local groundwater flow observations, injection volumes, and a groundwater flow model constructed for the Upper Tulare Formation in the Elk Hills Oil Field by the operator. The operator predicted that flow in the Lower Tulare Formation is negligible due to its depth, confined aquifer condition, lack of natural recharge, and absence of use as a drinking water supply. This is corroborated by the results of groundwater flow modeling performed by the operator and evaluated by the State Water Board as part of its concurrence on the AE. Within the proposed AE area, groundwater elevation is generally higher to the west and lower to the east, which is the direction of groundwater flow.

Confinement of the Formation to Groundwater Flow: DOGGR’s AE request included information about the vertical and lateral confinement of the Lower Tulare Formation, which is summarized below.

The Lower Tulare Formation is confined above by the Amnicola Claystone, a regionally extensive confining layer that separates the Upper and Lower Tulare Formations. The Amnicola Claystone consists of a silty claystone that averages approximately 75 to 100 feet thick.

Geophysical data logs demonstrate its presence throughout the Phase 1 Area, as well as across much of the rest of the Elk Hills Oil Field and neighboring oil fields. Lower confinement is provided by the low-permeability shales and siltstones of the San Joaquin Formation.

Lateral confinement from USDWs is achieved primarily through pressure containment (i.e., flow from high-pressure areas to low-pressure areas as supported by results from the groundwater flow model. The modeling results, which were reviewed by the State Water Board and DOGGR, show that movement of injected fluid in the field is driven by the presence of pressure sinks at production wells, and the presence of low-pressure areas at the air-water contact. Based on the simulation results, injected fluids are expected to flow toward these low-pressure areas and into the currently unsaturated zones in both the Upper and Lower Tulare Formations, and will not affect any USDWs.

After reviewing information regarding the location and depth of the existing drinking water supply wells, groundwater flow within the Lower Tulare Formation, and the lateral and vertical confinement of the formation as described in the AE request, the EPA concludes that the Lower Tulare Formation is not currently a source of drinking water and is not hydraulically connected to any domestic or public drinking water supply wells. Therefore, the EPA has determined that the aquifer proposed for exemption meets the criteria at 40 CFR § 146.4(a).

40 CFR § 146.4(c) *The total dissolved solids content of the groundwater is more than 3,000 and less than 10,000 mg/L and it is not reasonably expected to supply a public water system.*

DOGGR provided information on the TDS content of the Lower Tulare Formation, including supporting information such as analytical sampling data performed by certified laboratories and log-derived TDS data to support a demonstration that the TDS content of the Lower Tulare Formation is between 3,000 and 10,000 mg/L.

The TDS content of the Lower Tulare Formation in the vicinity of the area proposed for exemption ranges from 7,168 mg/L to 20,000 mg/L. Calculated salinity values from logs from four wells within the Phase 1 Area demonstrate TDS values of less than 10,000 mg/L. One sample result from the Lower Tulare Formation immediately adjacent to the Phase 1 Area (east) included a measured TDS value of 7,168 mg/L. There is also one well immediately east of the Phase 1 Area with a well-derived value for TDS below 10,000 mg/L.

On the south flank of the anticline, TDS levels transition to greater than 10,000 mg/L in the stratigraphically lowest part of the formation (approximately the lowermost 150 to 300 feet). While identifying the exact area of transition to greater than 10,000 mg/L TDS is complicated by the presence of erosive channels and variable-thickness mudstone layers, the trend of increasing TDS with depth is corroborated by the results of geophysical logs, and with the measured 20,000 mg/L TDS in the groundwater sample from Well 82-2B, which is an oil and gas production well within the area proposed for exemption. The portions of the Lower Tulare Formation where the TDS levels are greater than 10,000 mg/L do not meet the definition of a USDW and therefore are not addressed by this action.

The State's submittal notes that water quality within the Upper and Lower Tulare varies stratigraphically, but not laterally, and as a result the water quality will be consistent across the Phase 1 Area. Thus, EPA concurs that the data provided in the application and reviewed by both DOGGR and the State Board demonstrates that the portion of the Lower Tulare Formation proposed for exemption is more than 3,000 and less than 10,000 mg/L TDS.

Based on the results of chemical analyses presented in the AE package, the aquifer contains contaminants at levels that make it unlikely that it would supply a public water system. Chemical analysis of groundwater sampled from Well 48-9G (a water flood source well located immediately east of the Phase 1 Area) in the Lower Tulare Formation shows that the groundwater exceeds the maximum contaminant level for selenium, the secondary maximum contaminant levels for chloride and sulfate, and the EPA lifetime health advisory levels/drinking water equivalent levels for boron and strontium. Iron levels exceed secondary maximum contaminant levels in some portions of the formation. The application also states that, based on the results of volatile organic analysis of water sampled in Well 82-2B, hydrocarbons are present in the Lower Tulare Formation at levels that, while not commercially producible, represent an additional constituent that would require treatment. The presence of these constituents renders the groundwater in the Lower Tulare Formation unsuitable for domestic drinking water use.

DOGGR and the operator compared potential water treatment costs to local utility data to demonstrate that treating the water to remove these contaminants would be economically infeasible. The operator estimated the cost of treating Lower Tulare Formation groundwater (based on the concentrations reported in samples taken from Well 48-9G) so that it would meet drinking water standards.

The AE request includes treatment cost estimates to pump groundwater, treat the water with reverse osmosis and mechanical vapor compression, deliver the water, and properly manage treatment residuals. The study, "Evaluation of Economic Feasibility of Treating McKittrick Area Groundwater for Use as Drinking Water," was performed based on similar concentrations of contaminants (i.e., of TDS, chloride, sulfate, boron, and sodium) that are found in Lower Tulare Formation groundwater and in groundwater of the nearby McKittrick Oil Field. The study concluded that treating this groundwater to meet federal standards could result in an annual water charge per household of \$3,269. This would result in a nearly six-fold increase in the current average annual household water cost, in Kern County (of \$560). Further, because the Lower Tulare Formation in the proposed aquifer exemption area also contains hydrocarbons and lead, which would require additional treatment to remove, the costs for treatment could be even higher.

DOGGR also evaluated existing drinking water sources in the vicinity of the Elk Hills Oil Field and, determined that current sources can meet local demands. Based on a review of the WKWD's Urban Water Management Plan (UWMP), which evaluated the water supply's reliability and its ability to meet future water needs through the year 2040, DOGGR concluded that the District has adequate supplies from currently developed groundwater-bearing zones to meet expected population growth.

The primary source of water for the WKWD is groundwater, sourced from water wells in two areas to the east and northeast of the Elk Hills Oil Field. The WKWD recently added five new water wells, which improve the District's ability to meet future water needs. Additional measures to address water supply over the next 25 years include water banking and exchange programs with other agencies to bank surplus water to meet dry year water demands, and water recycling to reduce groundwater needs.

The application includes a statement from WKWD that the Lower Tulare Formation does not currently serve as a source of drinking water and would not reasonably be expected to be used in the future in the area proposed for exemption. As noted above, the water supply wells are completed in the alluvium and undifferentiated Upper Tulare Formation and are stratigraphically separated from the Lower Tulare Formation. The application also notes that good quality, low cost water is available from the Kern Delta area, and existing infrastructure exists to deliver this water to customers.

Based on our review of this information, the EPA concludes that the Lower Tulare Formation in the Elk Hills Oil Field, Phase 1 Area contains between 3,000 mg/L and 10,000 mg/L TDS and is not reasonably expected to supply a public water system. As such, the EPA has determined that the aquifer proposed for exemption meets the criteria at 40 CFR § 146.4(c).

PUBLIC NOTICE AND COMMENT

DOGGR provided public notice of this proposed AE on September 11, 2017 and held a public hearing on October 24, 2017 in Bakersfield, CA. The public comment period closed on October 24, 2017. DOGGR provided the EPA a summary of the public comments, copies of the public comments submitted, a transcript of the public hearing, and their responses to the written and oral comments.

In making this decision, the EPA considered all of the information submitted by the State, including all of the written and oral comments submitted to the State during its public comment process. Most of the issues raised in the comments to the State were addressed by DOGGR in its responses; supplemental responses are provided below.

One commenter who wrote to DOGGR requested that the EPA reject the exemption request before environmental review has occurred under the National Environmental Policy Act (NEPA). The EPA believes that the public comment and hearing procedures afforded by DOGGR and the in-depth technical analysis to protect USDWs required in the aquifer exemption proposal process under the EPA's UIC regulations and the enabling legislation in the SDWA provide a functionally equivalent environmental review for this action.

The commenter also raised concerns regarding protection of species under the federal Endangered Species Act (ESA). This issue is outside the scope of EPA's AE decision, as this action does not authorize future injection activities at the surface. Approval of this aquifer exemption pertains to groundwater that is hundreds to thousands of feet below the surface, and a review of materials submitted by the commenter indicates that there are no subsurface listed

threatened or endangered species that would be affected by the EPA's approval of the AE request.

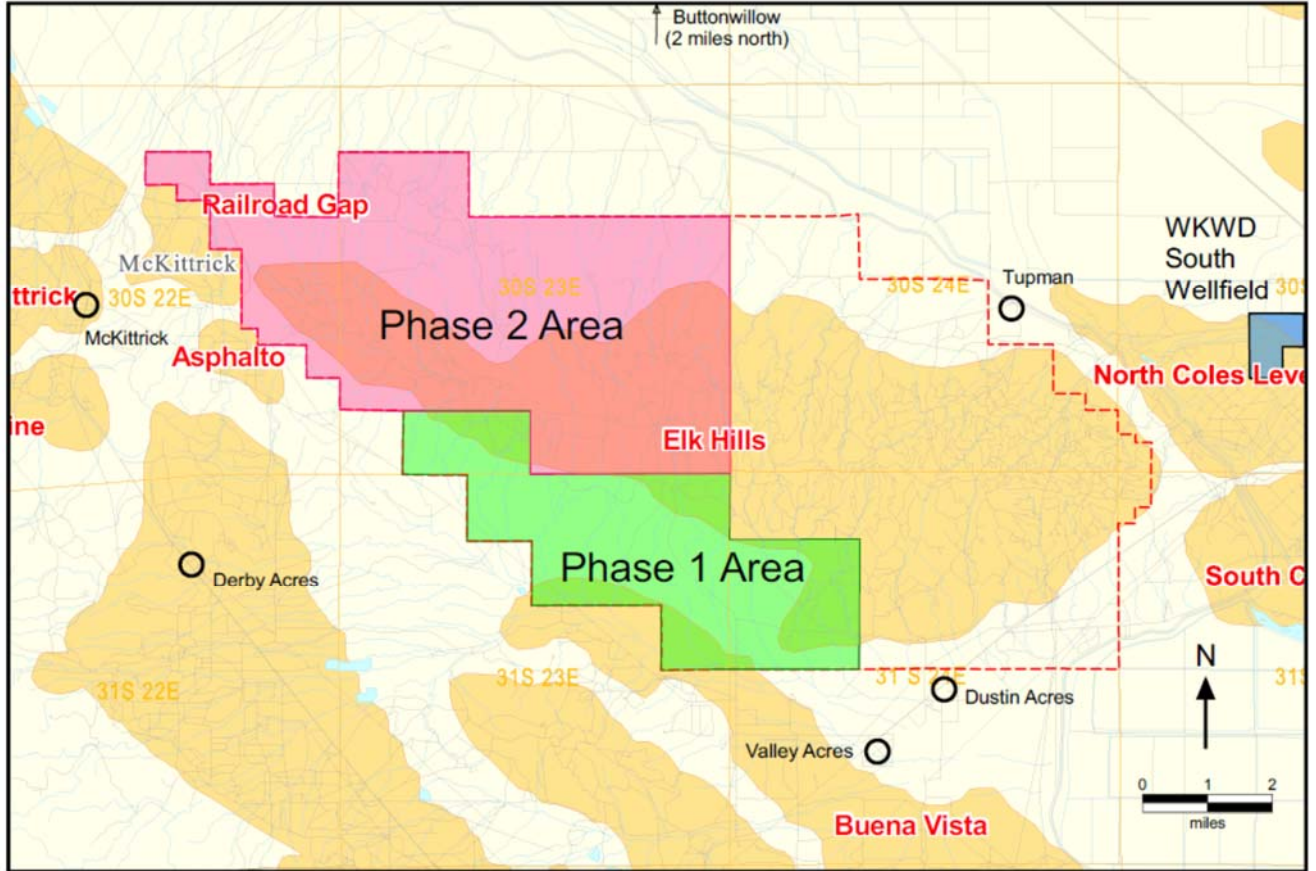
The commenter also questioned whether the current technical criteria to consider future drinking water uses are adequate given changing climate conditions and new technology available for water treatment. In considering whether the aquifer proposed for exemption cannot now and will not in the future serve as a source of drinking water, the EPA reviewed data regarding the level of contaminants in the groundwater and information on the feasibility of treatment of this water for human consumption. Even with the potential for improved treatment technology and higher demand for drinking water due to drought or scarcity, shallower aquifers than the Lower Tulare Formation would continue to provide an adequate supply of higher quality water for public water systems. As a result, the EPA concluded the aquifer is not reasonably expected to supply a public water system.

CONCLUSION AND DECISION

Based on a review of the entire record, including all the written and oral comments submitted to DOGGR during its public comment process, the EPA finds that the exemption criteria at 40 CFR § 146.4(a) and § 146.4(c) have been met and the EPA approves the aquifer exemption request as a non-substantial program revision.

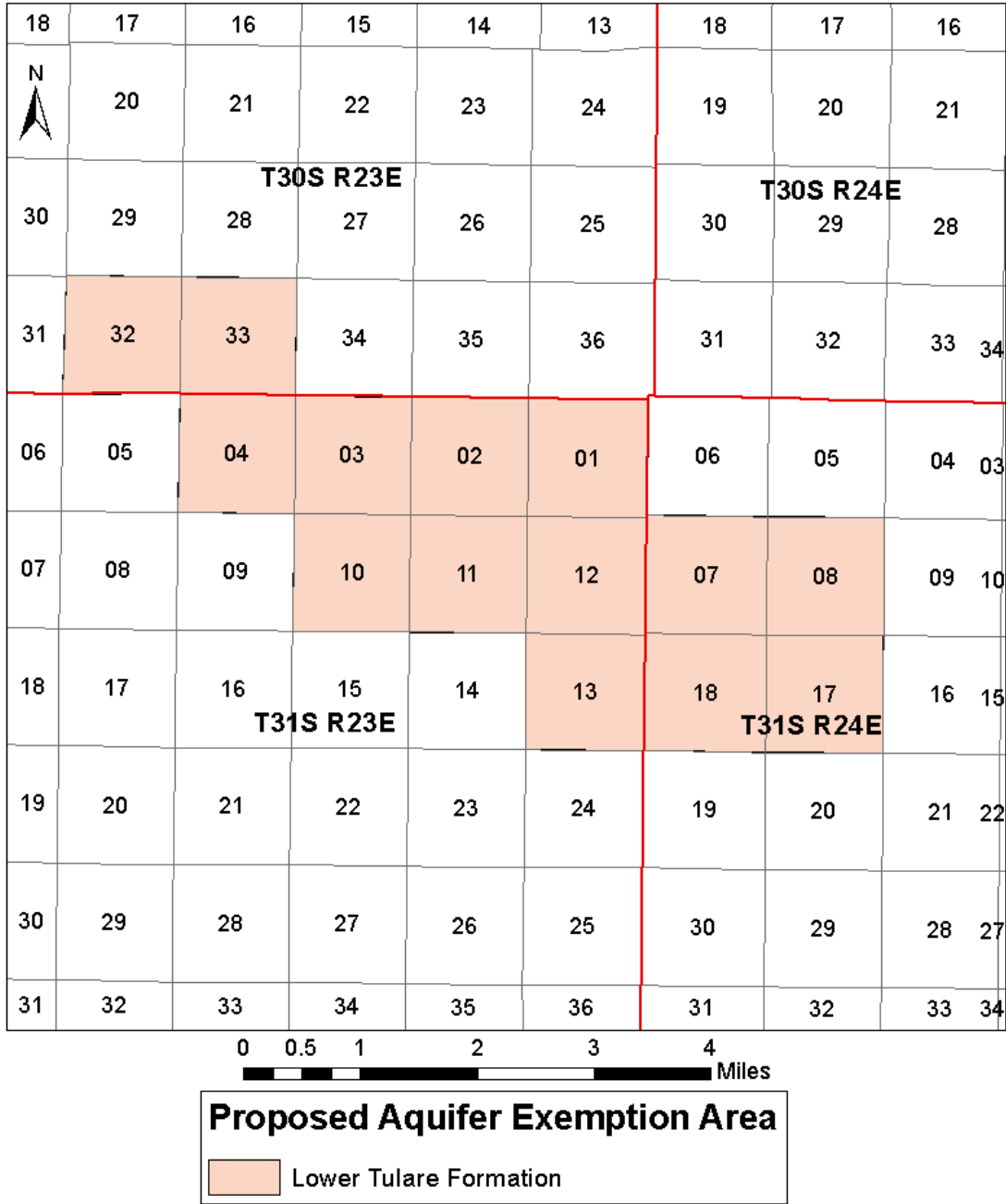
Effective Date: March 29, 2018

Figure 1: Location of the Elk Hills Oil Field - Phase 1 Area, Kern County, California



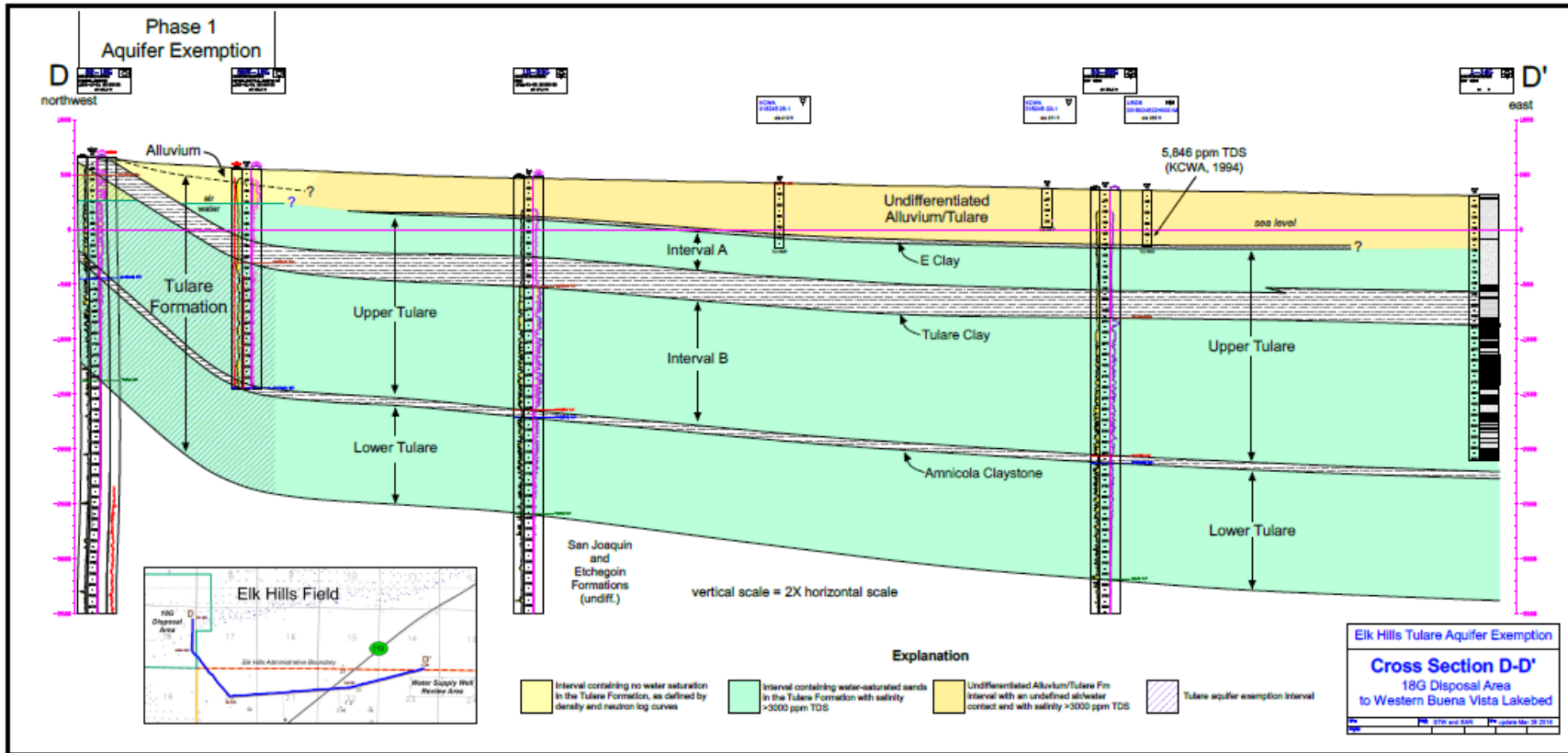
Source: Figure 2, DOGGR's Aquifer Exemption Application for the Elk Hills Oil Field - Phase 1 Area

Figure 2: Lower Tulare Formation Aquifer Exemption Location Map, Elk Hills Oil Field - Phase 1 Area, Kern County, California



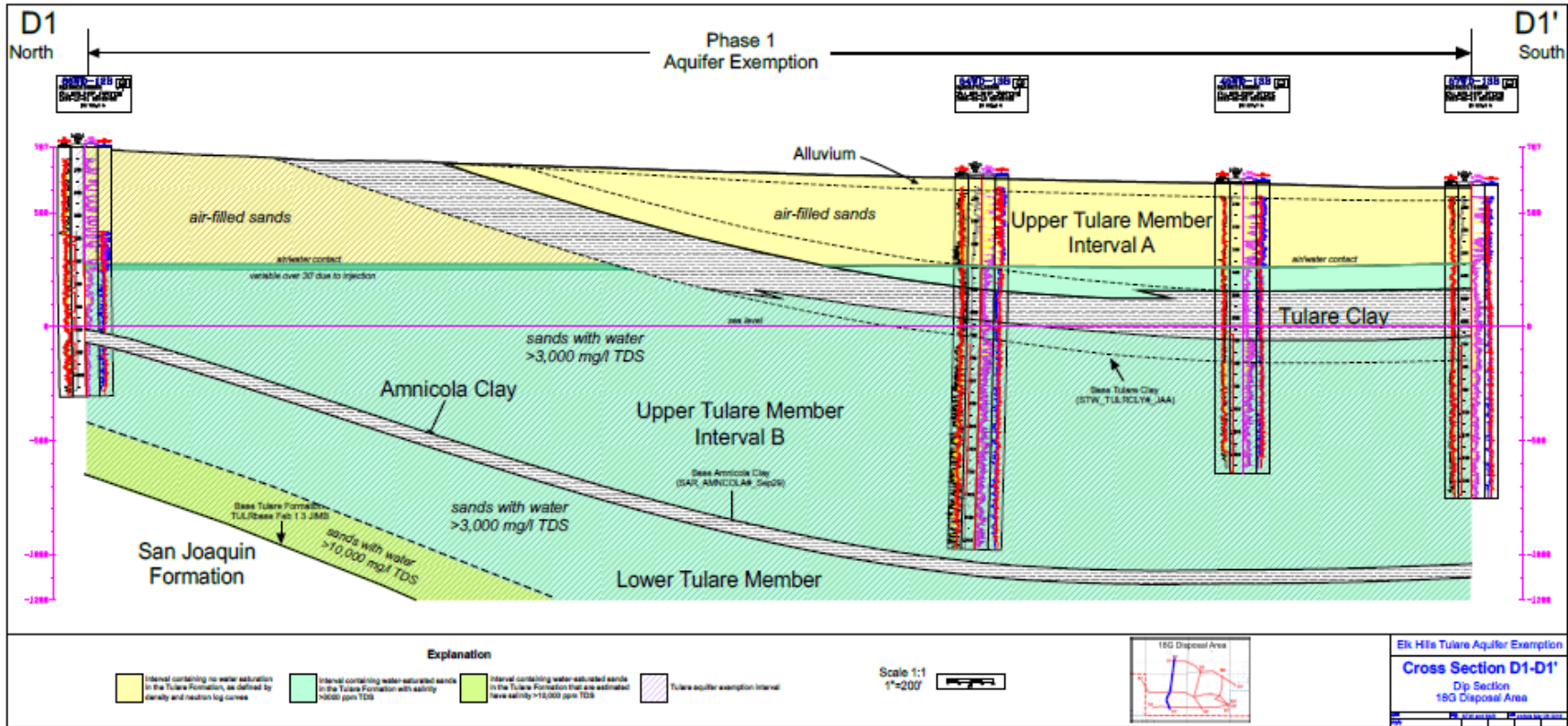
Source: DOGGR's Aquifer Exemption Application for the Elk Hills Oil Field - Phase 1 Area

**Figure 3.1: Cross Section D-D' across the Lower Tulare Formation Aquifer Exemption Area
Elk Hills Oil Field - Phase 1 Area, Kern County, California**



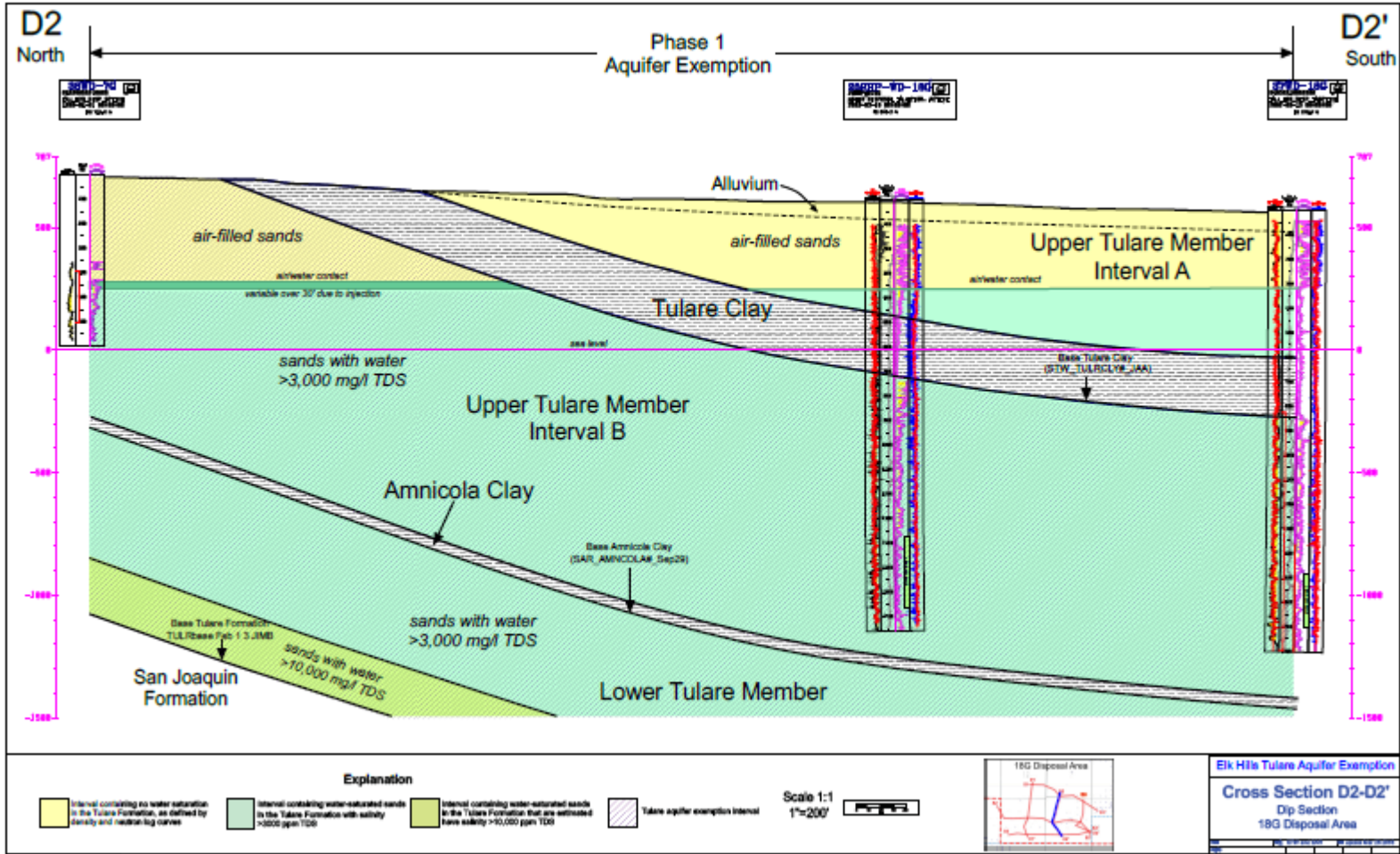
Source: Figure 13, DOGGR's Aquifer Exemption Application for the Elk Hills Oil Field - Phase 1 Area

**Figure 3.2: Cross Section D1-D1' across the Lower Tulare Formation Aquifer Exemption Area
Elk Hills Oil Field - Phase 1 Area, Kern County, California**



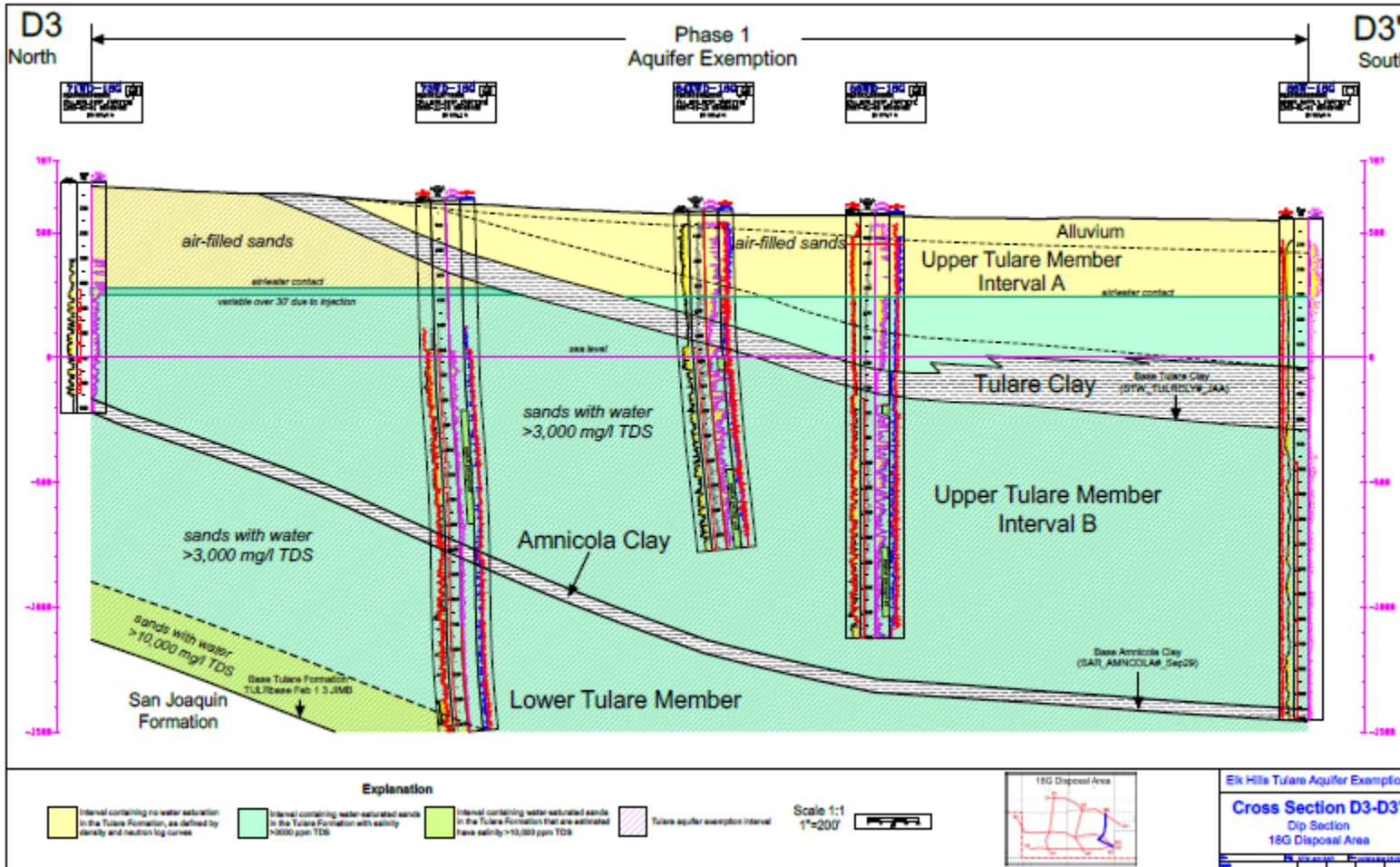
Source: Figure 13, DOGGR's Aquifer Exemption Application for the Elk Hills Oil Field - Phase 1 Area

**Figure 3.3: Cross Section D2-D2' across the Lower Tulare Formation Aquifer Exemption Area
Elk Hills Oil Field - Phase 1 Area, Kern County, California**



Source: Figure 13, DOGGR's Aquifer Exemption Application for the Elk Hills Oil Field - Phase 1 Area

**Figure 3.4: Cross Section D3-D3' across the Lower Tulare Formation Aquifer Exemption Area
Elk Hills Oil Field - Phase 1 Area, Kern County, California**



Source: Figure 13, DOGGR's Aquifer Exemption Application for the Elk Hills Oil Field - Phase 1 Area

Table 1: List of Water Supply Wells

WELL	Number Key to Maps	TOTAL DEPTH (MEASURED)	SURFACE ELEVATION	TOTAL DEPTH (SUBSEA)	FORMATION AT TOTAL DEPTH	BASE E CLAY	INTERVAL THICKNESS TD TO BASE E CLAY	BASE TULARE CLAY	INTERVAL THICKNESS TD TO BASE TULARE CLAY	BASE AMNICOLA CLAYSTONE	INTERVAL THICKNESS TD to BASE AMNICOLA CLAYSTONE
Part A: Water Wells in the 11-Section Review Area											
KCWA31S24E-22-1	1	504	362	-142	Undiff Alluvium/Tulare	-220	78	-850	708	-2000	1858
KCWA31S24E-22-2	2	510	361	-149	Undiff Alluvium/Tulare	-220	71	-850	701	-2000	1851
KCWA31S24E-22L1	3	347	371	24	Undiff Alluvium/Tulare	-220	244	-850	874	-1980	2004
KCWA31S24E-25E	4	560	298	-262	Undiff Alluvium/Tulare	-380	118	-1010	748	-2240	1978
KCWA31S24E-26D1	5	328	327	-1	Undiff Alluvium/Tulare	-285	284	-915	914	-2090	2089
KCWA31S24E-26N	6	5842	321	-5521	LOWER TULARE	-180	-5341	-810	-4711	-1920	-3601
KCWA31S24E-27B	7	417	352	-65	Undiff Alluvium/Tulare	-195	130	-825	760	-1920	1855
KCWA31S24E-27Q	8	428	346	-82	Upper Tulare Interval A	15	-97	-615	533	-1725	1643
KCWA31S24E-28-1	9	595	410	-185	Upper Tulare Interval A	-65	-120	-695	510	-1710	1525
KCWA31S24E-28B1	10	402	397	-5	Undiff Alluvium/Tulare	-120	115	-750	745	-1800	1795
KCWA31S24E-28L	11	660	410	-250	Upper Tulare Interval A	60	-310	-570	320	-1540	1290
KCWA31S24E-28L1	12	338	420	82	E Clay	110	-28	-520	602	-1490	1572
KCWA31S24E-28Q1	13	348	421	73	Upper Tulare Interval A	230	-157	-400	473	-1360	1433
CASGEM31S24E20J001M	14	Confidential	443		UNKNOWN	20		-610		-1610	
CASGEM31S24E22J001M	15	Confidential	341		UNKNOWN	-265		-895		-2090	
CASGEM31S24E22L001M	16	Confidential	369		UNKNOWN	-220		-850		-1980	
CASGEM31S24E25M061M	17	Confidential	298		UNKNOWN	-370		-1000		-2220	
CASGEM31S24E26D001M	18	Confidential	341		UNKNOWN	-275		-905		-2050	
CASGEM31S24E26M001M	19	Confidential	324		UNKNOWN	-230		-860		-2000	
CASGEM31S24E28B001M	20	402	407	5	Undiff Alluvium/Tulare	-75	80	-705	710	-1720	1725
CASGEM31S24E28Q001M	21	348	420	72	Upper Tulare Interval A	135	-63	-495	567	-1425	1497
CASGEM31S24E28Q002M	22	598	408	-190	Upper Tulare Interval A	130	-320	-500	310	-1475	1285
CASGEM31S24E36D065M	23	Confidential	296		UNKNOWN	-240		-870		-2210	
CASGEM31S24E36D066M	24	Confidential	296		UNKNOWN	-240		-870		-2210	
CASGEM31S24E36D067M	25	Confidential	295		UNKNOWN	-240		-870		-2210	
CASGEM31S24E36D068M	26	Confidential	295		UNKNOWN	-240		-870		-2210	
USGS031S024E22B001M	27	500	389	-111	Upper Tulare Interval A	-75	-36	-705	594	-1900	1789
USGS031S024E22H001M	28	500	355	-145	Undiff Alluvium/Tulare	-200	55	-830	685	-2020	1875
USGS031S024E24P001M	29	Not determined	291		UNKNOWN	-395		-1025		-2275	
USGS031S024E28L001M	30	402	410	8	E Clay	30	-22	-600	608	-1590	1598

Source: Table 4, DOGGR’s Aquifer Exemption Application for the Elk Hills Oil Field - Phase 1 Area