AQUIFER EXEMPTION

Lower Tulare Formation: Elk Hills Oil Field, Phase 1 & 2

A presentation by the Division of Oil, Gas and Geothermal Resources with preliminary concurrence by the State Water Resources Control Board and Central Valley Regional Water Quality Control Board
The Elk Hills Oil Field, Aquifer Exemption can be accessed at: http://www.conservation.ca.gov/dog/Pages/Aquifer_Exemptions.aspx

Additional written comments may be submitted by
email to: comments@conservation.ca.gov
FAX to: (916) 324-0948,
or mail to: Department of Conservation
801 K Street, MS 24-02
Sacramento, CA 95814
ATTN: Aquifer Exemption
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**Agenda:**
Open Meeting – 4 pm
Introductory remarks – Bill Bartling
Discussion of Phase 1 and 2 Exemption Proposals – Emaad Abdullaay
Public Comments – facilitated by Bill Bartling
Final Remarks
Close Meeting

October 24, 2017
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Lower Tulare Formation: Elk Hills Oil Field, Phase 1 & 2

A presentation by the Division of Oil, Gas and Geothermal Resources with preliminary concurrence by the State Water Resources Control Board and Central Valley Regional Water Quality Control Board
1. Location

2. Stratigraphy

3. History
   a. Development
   b. Injection

4. Exemption Proposal

5. Meets Federal Exemption Criteria
   a. Not a current source of drinking water.
   b. Total Dissolved Solids more than 3,000 and less than 10,000 mg/l and not reasonably expected to supply a public water system.

6. Meets CA State Exemption Criteria
   a. The injection of fluids will not affect the quality of water that is, or may reasonably be, used for any beneficial use.
   b. The Injected fluid will remain in the aquifer or portion of the aquifer that would be exempted.
Approx. 27 Miles southwest of Central Bakersfield
1973 Productive Areas

Location

1973 Productive Area

Elk Hills Type Log

<table>
<thead>
<tr>
<th>FORMATION</th>
<th>COMPOSITE ELECTRIC LOG</th>
</tr>
</thead>
<tbody>
<tr>
<td>TULARE</td>
<td></td>
</tr>
<tr>
<td>SAN JOAQUIN</td>
<td></td>
</tr>
<tr>
<td>ETCHEGOIN</td>
<td></td>
</tr>
<tr>
<td>MONTEREY</td>
<td></td>
</tr>
<tr>
<td>TEMBLOR</td>
<td></td>
</tr>
</tbody>
</table>

1973 Non-Hydrocarbon Producing Zone (Tulare) (Not Exempted)

1973 Hydrocarbon Producing Zones (Exempted)

California Oil and Gas Fields, 1973
• Map of the Elk Hills Administrative Boundary showing the Phase 1 and Phase 2 aquifer exemption proposal areas.

Phase 1 (Lower Tulare)

Phase 2 (Lower Tulare)

Well 36-30R

Well 57WD-18G
At the Elk Hills Oil Field, the Tulare Formation consists of fluvial channels, floodplain and lacustrine deposits of gravel, sand, silt, clay, and limestone.
Tulare Stratigraphy - Phase 2

Phase 2 Tulare Formation
Type Log
Well 36-30R

Phase 2 Lower Tulare Proposal

Water and Oil bearing interval

Sand-rich layer

~75 feet of Claystone (Seal)

Air-water contact

Sand-rich layer

UPPER TULARE

PLEISTOCENE

TULARE FORMATION

AMNICOLA CLAYSTONE

LOWER TULARE

SATURATED INTERVAL

OIL SAND

UNSATURATED INTERVAL

SATURATED INTERVAL

UNSATURATED INTERVAL
1911
Production from the Etchegoin Formation occurred at Elk Hills Oil Field as early as 1911.

1957 - Present
Waterflooding was initiated in 1957 and has continued to the present for the Etchegoin and Monterey Formations.

1981
The Tulare Formation has been used since 1981 for injection and disposal of produced water.

1998
The Elk Hills Oil Field was formerly Naval Petroleum Reserve 1 and managed by the US Navy and the US Department of Energy before being sold in 1998 to Occidental Petroleum Corporation (OXY).

2014
In 2014 California Resources Elk Hills, LLC became the operator of Elk Hills Oil Field.
Exemption Proposal - Phase 1

- R-B to R-B’ cross-section
- Asphalto Exemption Area
- Tulare Clay
- San Joaquin Formation and older stratigraphic unit
- Amnicola Claystone
- Upper Tulare
- Lower Tulare
- Air Water Contact
- 5X vertical exaggeration

Legend:
- Exempted
- Phase 1 Lower Tulare Proposal
- Area outside and not included in Phase 1 Lower Tulare Proposal

Horizontal scale: 1 mile
Vertical scale: 1 mile
Exemption Proposal - Phase 1

- Buena Vista Exemption Area
- Air Water Contact
- Tulare Clay
- Amnicola Claystone
- San Joaquin Formation and older stratigraphic units

Legend:
- Green: Exempted
- Yellow: Phase 1 Lower Tulare Proposal
- Purple: Area outside and not included in Phase 1 Lower Tulare Proposal
Exemption Proposal - Phase 2

R-3 to R-3’ cross-section

- Asphalto Exemption Area
- Tulare Clay
- Air Water Contact
- Amnicola Claystone

Phase 2 Lower Tulare Proposal

Area outside and not included in Phase 2 Tulare Proposal

Horizontal scale: 4000 feet

5X vertical exaggeration

San Joaquin Formation and older stratigraphic unit

Exempted

Phase 2 Lower Tulare Proposal

Area outside and not included in Phase 2 Tulare Proposal
Exemption Proposal - Phase 2

Phase 2 Tulare Proposal: Exempted vs. Area outside and not included in Phase 2 Tulare Proposal.
Federal Exemption Criteria

Exemption criteria as specified in 40 CFR 146.4

a) The aquifer does not currently serve as a source of drinking water.

AND

c) The total dissolved solids (TDS) content of the ground water is more than 3,000 and less than 10,000 milligrams per liter (mg/L), and it is not reasonably expected to supply a public water system.
Exemption criteria as specified in 40 CFR 146.4

a) The aquifer does not currently serve as a source of drinking water.

AND

c) The total dissolved solids (TDS) content of the ground water is more than 3,000 and less than 10,000 mg/L, and it is not reasonably expected to supply a public water system.
Federal Exemption Criteria—Phase 1

Exemption criteria as specified in 40 CFR 146.4

✓ a) The aquifer does not currently serve as a source of drinking water

Public Water System Wells

• No water wells are currently used as a source of drinking water within Phase 1 Proposal Area, and the Elk Hills Oil Field administrative boundary.

• The closest Public Water Well is located about 8 miles from the proposed exemption area.

• The well draws water from zones above the proposed exemption area (Lower Tulare Formation).

Location of the Closest Public Water Well (GEOTRACKER GAMA)
Exemption criteria as specified in 40 CFR 146.4

✓ a) The aquifer does not currently serve as a source of drinking water.

Water Wells Locations in the Review Area

- 29 abandoned water wells were located within the water wells review area.
- All of the water wells were completed above the Amnicola Claystone.

Approximate Water Well Location (GEOTRACKER GAMA)
Exemption criteria as specified in 40 CFR 146.4,

a) The aquifer does not currently serve as a source of drinking water.

Water Wells Completion Zone in the Review Area

- Air Water Contact
- Tulare Clay
- E Clay
- Amnicola Claystone
- San Joaquin and Etchegoin Formations (Undiff.)
- Undifferentiated Alluvium/Tulare
- Upper Tulare Zone B
- Upper Tulare
- Lower Tulare
- 5,846 ppm TDS (KCWA, 1994)

Phase 1 Lower Tulare Proposal
Area outside and not included in Phase 1 Lower Tulare Proposal
Exemption criteria as specified in 40 CFR 146.4,

✓ a) The aquifer does not currently serve as a source of drinking water

Public Water System Wells

• No water wells currently used as source of drinking water within Phase 2 Proposal Area, and the Elk Hills Oil Field administrative boundary.

• The closest Public Water Well is located 5 miles from the proposed exemption area.
Exemption criteria as specified in 40 CFR 146.4

✓ a) The aquifer does not currently serve as a source of drinking water.

Water Wells Location in the Review Area

• 105 records of water supply wells found within the water wells review area.

• All water supply wells completed above the Amnicola Claystone.

• Water wells are vertically separated from the lower Tulare by approximately 1070 to 2410 feet.

• No water wells currently used as source of drinking water within Phase 2 Proposal Area, the water wells review area and Elk Hills Oil Field administrative boundary.
Exemption criteria as specified in 40 CFR 146.4

✓ a) The aquifer does not currently serve as a source of drinking water.

Water Wells Completion Zone in the Review Area

Cross section A-A’
Exemption criteria as specified in 40 CFR 146.4

a) The aquifer does not currently serve as a source of drinking water.

AND

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

- Lower Tulare Formation groundwater within the administrative boundary of Elk Hills Oil Field has TDS concentrations between 7,168 and 20,000 mg/L (Appendix 5).
- The West Kern Water District (WKWD), the local water district within the area of review, has declared that the Tulare Formation in the Elk Hills aquifer exemption area does not currently serve as a source of drinking water and will not reasonably be expected to supply a public water system (Appendix 7).
# Groundwater Constituents in Elk Hills Lower Tulare

## Drinking Water Standards – Maximum Contaminant Levels (MCLs)

<table>
<thead>
<tr>
<th>Constituent</th>
<th>Mean Concentration or Range mg/l</th>
<th>MCLs and Regulatory Thresholds mg/l</th>
<th>Threshold Exceeded?</th>
<th>% of Threshold</th>
</tr>
</thead>
<tbody>
<tr>
<td>Selenium (Lower Tulare)</td>
<td>0.720</td>
<td>0.05</td>
<td>Yes</td>
<td>1440%</td>
</tr>
<tr>
<td>TDS (Lower Tulare)</td>
<td>7,168 to 20,000</td>
<td>500</td>
<td>Yes</td>
<td>1434% to 4,000%</td>
</tr>
<tr>
<td>Chloride (Lower Tulare)</td>
<td>3,115 to 10,000</td>
<td>250 (recommended)</td>
<td>Yes</td>
<td>1,246% to 4,000%</td>
</tr>
<tr>
<td>Sulfate (Lower Tulare)</td>
<td>700 to 3,200</td>
<td>250 (recommended)</td>
<td>Yes</td>
<td>280% to 1,280%</td>
</tr>
</tbody>
</table>

MCLs: Maximum Contaminant Levels

**Exceeds Drinking Water Standards (Primary & Secondary MCL)**

(California State Water Resources Control Board)

3 Water samples collected from 3 wells (Appendix 5).
3 Water samples collected from 3 wells (Appendix 5).

### Environmental Protection Agency Drinking Water Health Advisory

<table>
<thead>
<tr>
<th>Constituent</th>
<th>Mean Concentration or Range mg/l</th>
<th>Regulatory Thresholds mg/l</th>
<th>Threshold Exceeded?</th>
<th>% of Threshold</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boron (Lower Tulare)</td>
<td>5.7 to 24</td>
<td>6.00</td>
<td>Yes</td>
<td>Up to 400%</td>
</tr>
<tr>
<td>Strontium (Lower Tulare)</td>
<td>4.8 to 17</td>
<td>4.00</td>
<td>Yes</td>
<td>120% to 425%</td>
</tr>
<tr>
<td>Sodium (Lower Tulare)</td>
<td>2,041 to 4,700</td>
<td>20.00</td>
<td>Yes</td>
<td>10,205% to 23,500%</td>
</tr>
</tbody>
</table>

Exceeds USEPA Drinking Water Health Advisory
* EPA Action Level
(US Environmental Protection Agency)
Exemption criteria as specified in PRC 3131(a),


2. The injection of fluids will not affect the quality of water that is, or may reasonably be, used for any beneficial use.

3. The injected fluid will remain in the aquifer or portion of the aquifer that would be exempted.
Exemption criteria as specified in PRC 3131(a),


2. The injection of fluids will not affect the quality of water that is, or may reasonably be, used for any beneficial use.

   • The Elk Hills Lower Tulare formation groundwater is not expected to be put to beneficial use as defined by the PRC 13050 (f), because of poor water quality in aquifer intervals located below the Amnicola Claystone.
Untreated Lower Tulare groundwater within the Elk Hills Oil Field is unfit for Agricultural use.

<table>
<thead>
<tr>
<th>Constituent</th>
<th>Mean Concentration or Range mg/l</th>
<th>Degree of Restriction on Use</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>None mg/l</td>
</tr>
<tr>
<td>TDS (Lower Tulare)</td>
<td>7,168 to 20,000</td>
<td>&lt; 450</td>
</tr>
<tr>
<td>Chloride (Lower Tulare)</td>
<td>3,115 to 10,000</td>
<td>&lt; 142</td>
</tr>
<tr>
<td>Boron (Lower Tulare)</td>
<td>5.7 to 24</td>
<td>&lt; 0.7</td>
</tr>
<tr>
<td>Sodium (Lower Tulare)</td>
<td>2,041 to 4,700</td>
<td>&lt; 69</td>
</tr>
</tbody>
</table>

Guidelines for Interpretation of Water Quality for Irrigation

Adapted from University of California Committee of Consultants, 1974
Meets State Exemption Criteria

Exemption criteria as specified in PRC 3131(a),


2. The injection of fluids will not affect the quality of water that is, or may reasonably be, used for any beneficial use.

3. The injected fluid will remain in the aquifer or portion of the aquifer that would be exempted.
   - Amnicola Claystone is the vertical confining layer for the Lower Tulare.
   - The injected water will remain within Elk Hills Phase 1 and 2 Tulare Formation Proposal Area.
Amnicola Claystone is a regionally extensive confining layer that provides vertical containment of injected water.

- Consists of silty claystone and has vertical permeability measuring less than 0.1 md from conventional core sample (Appendix 2).

- Evidence of confinement consists of the thickness, continuity, and low permeability of the Amnicola Claystone, and the offset of the Air – Water contact below and above the Amnicola Claystone, and is further supported by the numerous gas and oil shows seen in the lower Tulare.

Meet State Exemption Criteria

- Phase 1
- Phase 2
Exemption criteria as specified in PRC 3131(a),


✓ 2. The injection of fluids will not affect the quality of water that is, or may reasonably be, used for any beneficial use.

3. The injected fluid will remain in the aquifer or portion of the aquifer that would be exempted.

- Amnicola Claystone is the vertical confining layer for the Lower Tulare.
- Lateral containment is achieved through operational controls limiting the migration of injected fluids to the Phase 1 and 2 Lower Tulare Formation Proposal Area.
Exemption criteria as specified in 40 CFR 146.4,

✓ a) The aquifer does not currently serve as a source of drinking water.
✓ b) The total dissolved solids content of the ground water is more than 3,000 and less than 10,000 mg/l and it is not reasonably expected to supply a public water system.

Exemption criteria as specified in PRC 3131(a),

✓ 2. The injection of fluids will not affect the quality of water that is, or may reasonably be, used for any beneficial use.
✓ 3. The injected fluid will remain in the aquifer or portion of the aquifer that would be exempted.
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Please state your name and spell it for the record. Please speak clearly so that we may accurately record your comments.

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