Comprehensive Hydraulic Fracturing Study
Los Angeles, California

Dan Tormey, Ph.D., P.G.
Cardno ENTRIX
Los Angeles, California
Monterey Formation projected to be the richest shale oil in North America, but how to tap it?
Environmental Baseline:

Los Angeles Oil Basin is the richest in the world by size

Urban growth overlain on the many producing fields
Hydraulic Fracturing Study

• Settlement agreement condition

• Independent Consultant to prepare study of feasibility and potential impacts of hydraulic fracturing and gravel packing

• Peer-reviewed factual information on the effects of hydraulic fracturing

First Comprehensive Study to Measure All Effects of Specific Hydraulic Fracturing Events
How does hydraulic fracturing work?

Fluids Used in Inglewood Hydraulic Fracturing

Water and Sand 99.51%

Oil Field consists of shales and sandstones, folded and faulted.
Nodular Surface on Top

Frac Study Wells

Looking North

1 Mile
Newport-Inglewood Fault

Bradna Surface with Faults

Frac Study Wells

Sentous Thrusts

Looking North

1 Mile
Rubel Surface with Faults

Frac Study Wells

Sentous Thrusts

Newport-inglewood Fault

Looking North

1 Mile
Rindge Surface with Faults

Frac Study Wells

Sentous Thrusts

Newport-Inglewood Fault

Looking North

1 Mile
H-Sand Surface with Faults

Frac Study Wells

Newport-Inglewood Fault

Sentous Thrusts

Looking North

1 Mile
UIHZ Surface with Faults

Newport-Inglewood Fault

Sentous Thrusts

Looking North

1 Mile
PICO Surface with Faults

Newport-Inglewood Fault

Sentous Thrusts

1 Mile

Looking North
PICO Surface w/ Discontinuous Water Bodies & Faults

Discontinuous Water Bodies

Newport-Inglewood Fault

Sentous Thrusts

Looking North

1 Mile
Vickers Reservoir Hydrocarbon Seal with Faults

Discontinuous Water Bodies

Newport-Inglewood Fault

Sentous Thrusts

Hydrocarbon Seal

Looking North

1 Mile
The zone affected by hydraulic fracturing is approximately 7,700 feet beneath fresh water (1 ½ miles).
Discontinuous Water Bodies
Newport Inglewood Fault
Pico Surface (Freshwater Base)
Vickers "H" Sand
Rindge Surface
Rubel Surface
Sentous Surface
Well 2 Microseismic Events & Frac Model
Well 1 Microseismic Events & Frac Model
1 Mile ~ 7,700 ft.
Impermeable Hydrocarbon Seal
Well 2 Microseismic Events & Frac Model
Sentous Surface
"... the Baldwin Hills are modeled as a no-flow cell." (USGS 2003)

"The Baldwin Hills form a complete barrier to groundwater movement where the essentially nonwater-bearing Pico formation crops out." (DWR 1961)
Discontinuous Water Bodies

Well 2 Microseismic

Well 1 Microseismic

Hydraulic Fracturing
~7,700 ft below Base of Fresh Water

Impermeable Hydrocarbon Seal

Pico Surface (Freshwater Base)

1 Mile
Water Quality

• 2/3 of water for the vicinity of Oil Field comes from the Colorado River or Northern California
  – Not affected by hydraulic fracturing
• Remainder is from surface water or groundwater sources greater than 1.5 miles away
• All public water is:
  – Tested quarterly and reported
  – Must meet drinking standards

Further Information: http://www.westbasin.org/water-reliability2020/groundwater/overview
Groundwater quality consistently meets drinking water standards, before and after hydraulic fracturing.
I. Microseismic Monitoring

- Hydraulic fracturing produces microseismic effects: Richter magnitude of -2 to -3
- Tectonic quakes are larger and deeper
- Hydraulic fracturing is insufficient to induce tectonic earthquakes

II. Vibration Monitoring

- Induced seismicity in Ohio and elsewhere is linked to wastewater injection

III. CalTech Accelerometer

- Field has operated a water flood since 1971 without seismicity
- Ongoing monitoring
Methane Migration

• Oil Field is adjacent to City of LA “Methane Zone”

• May be included in a County-wide program

• Methane in shallow soil gas from Inglewood, if detected, has been biogenic

• Methane detected in groundwater has been thermogenic
Study Findings: monitoring before, during, and after hydraulic fracturing did not detect effects to:

- Hydrogeology
- Water Use
- Water Quality
- Containment of Fractures
- Well Integrity
- Slope Stability
- Subsidence
- Ground Movement
- Induced Seismicity
- Methane (soil gas and groundwater*)
- Air Emissions
- Noise
- Vibration
- Community Health*

Oil Field has ongoing monitoring for most of these resource categories.
Questions and Discussion

Dan Tormey, Ph.D., P.G.
daniel.tormey@cardno.com
(424) 832-1303
Cardno ENTRIX
Los Angeles, California