To: Hearing Officer 9-10-2015

Periodic Review of Baldwin Hills Community Standard Districts

1) How is the ground water quality monitored?

2) What enforcement procedures are in place if the ground water is found to be contaminated?

Mark Walker
Resident
View Park

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SEP 10 2015
REGIONAL PLANNING COMMISSION

Stapleton / RPC

R 2015-02225-2

REQUEST TO ADDRESS
THE HEARING OFFICER
OF LOS ANGELES COUNTY

DATE 9 / 10 / 12

AGENDA ITEM No. ____

FAVOR ☐ OPPOSE/CONCERN ☐

☐ APPLICANT

PUBLIC COMMENT AGENDA ITEM ☐ OTHER ☐

THE INFORMATION BELOW IS REQUIRED. ALL FUTURE CORRESPONDENCE WILL BE SENT USING THE INFORMATION YOU PROVIDE HERE.
---PLEASE PRINT CLEARLY---

LAST NAME:

FIRST NAME: CHARLES

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SEP 10 2015
PLANNING COMMISSION
Stapleton/ Pfey

ORGANIZATION (IF APPLICABLE):

STREET ADDRESS:

CITY: WINDSOR HILLS ZIP CODE: 90043

EMAIL ADDRESS:

TELEPHONE NUMBER: - -

Summary of your position on this matter (optional)

HI, I AN A CONCERN RESIDENT OF WINDSOR HILLS, I LIVE JUST EAST OF LA BREA, NORTH OF SLAUSON, IN THE IMEDIATE NEIGHBORHOOD. I TOO HAVE EXEPINCED LATE NIGHT, WHEN THE WIND HAS DISAPATED (DIED DOWN), BAD ODORS FROM THE OIL FIELD, I WAS BORN AND RAISED IN THIS AREA, THEN MOVED AWAY. I HAVE RECENTLY MOVED BACK, AN HAVE NEVER SMELLED

☐ **Check here if you would like to receive notification of future actions on this item.**

☐ **Check here if you DO NOT intend to testify today, but would like to receive notice of future actions on this item.**

SUCH ~~[illegible]~~ BAD SMELLING ODOR. THE ODOR IS
BAD ENOUGH TO MAKE ME GO BACK INSIDE
THIS SHOULD BE. ~~THERE SHOULD BE~~ LATE
NIGHT, THERE IS
~~[illegible] AN INDEPENDANT MODERATOR~~
NO TRAFFIC, SO WHAT IS
THE SOURCE! YOU TELL
ME. ASK DOOR TO DOOR
IF PEOPLE SMELL ODORS
PLEASE HELP OUR COMMUNITY
MONNITOR IN THE NEIGHBORS
NOT IN THE FIELD, GAS
CAN COME UP IN OTHER PLACES!

THANK YOU

REQUEST TO ADDRESS
THE HEARING OFFICER
OF LOS ANGELES COUNTY

DATE__/__/__

AGENDA ITEM No. ____

FAVOR ☐ OPPOSE/CONCERN ☐

☐ APPLICANT

PUBLIC COMMENT AGENDA ITEM ☐ OTHER ☐

THE INFORMATION BELOW IS REQUIRED. ALL FUTURE CORRESPONDENCE WILL BE SENT USING THE INFORMATION YOU PROVIDE HERE.
---PLEASE PRINT CLEARLY---

LAST NAME

FIRST NAME

RECEIVED
SEP 10 2015
REGIONAL PLANNING COMMISSION

ORGANIZATION (IF APPLICABLE)

Stapleton / RPR12
R2015-02225-2

STREET ADDRESS

CITY

ZIP CODE

EMAIL ADDRESS

TELEPHONE NUMBER

Summary of your position on this matter (optional)

I have personally observed discrepencies which demonstrate that this process does Not Reflect that the health and safety of the people in ths community are being left out against Big oil who is paying the Countics Bills. Please explain what the benefit is to the County?

☐ **Check here if you would like to receive notification of future actions on this item.**

☐ **Check here if you DO NOT intend to testify today, but would like to receive notice of future actions on this item.**

The chemical Water that
has been used & Stored

Is it beening sold to
farmers for irrigation
Of fruits & Vegetables
in Caly?

Dolly Harris

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SEP 10 2015
REGIONAL PLANNING COMMISSION
Stapleton / R Ruiz
R2015-02225-2

REQUEST TO ADDRESS
THE HEARING OFFICER
OF LOS ANGELES COUNTY

DATE 9/11/15 **AGENDA ITEM No.** ____

FAVOR ☐ OPPOSE/CONCERN ☐

☐ APPLICANT

PUBLIC COMMENT AGENDA ITEM ☐ OTHER ☐

THE INFORMATION BELOW IS REQUIRED. ALL FUTURE CORRESPONDENCE WILL BE SENT USING THE INFORMATION YOU PROVIDE HERE.
---PLEASE PRINT CLEARLY---

FERRAZZI
LAST NAME

PAUL
FIRST NAME

CCSC
ORGANIZATION (IF APPLICABLE)

4209 JACKSON AVE
STREET ADDRESS

CULVER CITY
CITY ZIP CODE

EMAIL ADDRESS

- -
TELEPHONE NUMBER

Summary of your position on this matter (optional)
REVIEW NEEDS LANGUAGE CHANGES

did NOT speak

☐ **Check here if you would like to receive notification of future actions on this item.**

☐ **Check here if you DO NOT intend to testify today, but would like to receive notice of future actions on this item.**

R2015-02225-2

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SEP 10 2015
REGIONAL PLANNING COMMISSION

Stapleton / R Ruiz

Attention; Hearing Officer

September 10, 2015

Periodic review of the Baldwin Hills Community Standards District Project No.
R2015-02225 RADV No. T201500005
Public Meeting: September 10, 2015

Periodic review comments

Ground movement
Injection program has caused uplift and subsidence
Activating a Grabin to move and correlating earthquakes have happened along this fault.
Community has seen significant property damage since ramp up production.

Request: The annual ground movement survey be performed twice a year and that the trigger point for further analysis be revised to 0.3 inches of ground movement.
This must be put in as an amendment to the CSD to protect against any future damages associated with the injection program.
Waiting a year as shown that the oil operator is not been able to hits it's mark of .6 inches as certain areas have seen uplift as much 3 inches in other areas shown subsidence 3 inches

County Response: Note that the ground movement issue is under review by DOGGR. At this point, experts have not determined that increasing the frequency of data collection would contribute in any significant way to the ground movement study analysis.

DOGGR was not and it is not part of the CSD therefor

The CSD must be amended to protect us

Request: That all rigs at the oil field use same noise mitigation as drill rigs.

County Response: Request that all drill rig types at the oil field be required to have the same noise requirements as the main drill rig is acknowledged, however, are not required by the CSD.

Disruptive pipe banging during drilling maintenance and work over not addressed because peak levels our average out overtime
Therefore it didn't happen
Peak level noises are disruptive and inconsistent with quality-of-life and should NOT be dismissed.

County Response: Request that the noise monitoring program include peak values is acknowledged, however, the Department of Public Health provided input during the preparation of the

Periodic Review and did not recommend any changes to the monitoring program. A noise "spike" such as an instantaneous banging of pipe may not be captured by the hourly averaged noise monitoring program, however, a persistent nuisance type noise would be indicated in the monitoring. In addition, the complaint process under Provision F.7 provides for public input and documentation of noise issues.

CSD must be amended to protect us

Dust mitigation insufficient

Vegetation has been removed for roadways and platforms
Plus drought has caused dust bowl
Daily nuisance creating higher maintenance costs to the public and negative health impacts to Nearby schools and residents

Request: Fugitive dust testing.

County Response:The Inglewood Oil Field operates with an active dust control plan pursuant to CSD Provision E.2.p; plan requirements include the use of water trucks and other dust control methods. Regarding air quality testing, the Baldwin Hills Air Quality Study provides air toxic monitoring data for the Inglewood Oil Field. The Air Quality Study considered the 37 air toxics emitted from the Oil Field and performed a hazard identification to prioritize the air toxics of greatest concern. The Air Quality Study was completed during early 2015.

MRT's Assertion that a Community health assessment had been done about living next to the nation's largest oil field is false

The Baldwin Hills Air study is a whitewash. Carefully crafted to confuse with hundreds of irrelevant pieces of data.

Note that they did the V O C study starting on July 4,2013 and stopped 2 weeks later. The well records that they supplied indicate almost no well work over (1), well maintenance (3) and one new well drilled.

Black carbon (BC) is not the main toxic issue from an oilfield and that is over 95% of the data. As anyone will tell you the Black Carbon is from diesel trucks, buses and planes. Not the correct element to study.

It is cheap and point the reader away form the main chemicals of concern.

I suggest that constant monitoring include the main chemical that we know is from oil fields and does make people sick, hydrogen sulfide and the other reduced sulfurs, sulfur dioxide and many more that we're not Studied.

a constant 24 hour monitor at the school and do a study of the health of the student and teachers.

The study had nothing to do with any health Issues related to the oil field.

The CCST report verifies it's an inherent danger and therefore

The CSD must be revised to protect us.

The AQMD's amendments to Rule 1148.1 – Oil and Gas Production Wells must be adopted...
No future, Gravel packing acidizing or Fracking should be allowed.

The CSD must be amended to protect us

Oder complaints

A personal complaint to the AQMD resulted in a notice of violation that caught the oil operator of Not properly treating V O C contaminated soil.
They engaged in on site spreading and grading of V O C contaminated soil resulting in an uncontrolled evaporation of V O Cs
There should be no future treatment of on-site contaminated soil and
The CSD must be amended to protect us.

No V O C's monitoring on work over maintenance and drilling rigs is required.
The citizens coalition for safe community has detected V O C readings as high as 1,744 ppm
There is only one MET station and it was over 1.7 miles away from the release of V O C's

County Response: Request for the need of additional meteorological stations to cover the entire oil field is acknowledged, however, additional stations are not required by the CSD and were not determined to be necessary by the CSD EIR

This is insufficient to accurately detect Wind flow patterns of potentially harmful releases into the community
A determination of a potential spill and the subsequent path of airborne pollutants would depend on a variety of variables including the meteorology at the time of the release.
The CSD must be amended to protect us

There has been numerous instances of Over proliferation of rigs in one area.
There are no guarantees that this won't happen future.

The CSD must be amended to protect us.

Request that the oil operator post Prop 65 signage along the parks pathways bordering the oil field.

Response: The oil field does have the referenced and requested Proposition 65 signage, the signs are posted on the oil field fence near the gated entrances.

This is insufficient to warn patrons of the park of potential risks to their health since it is located in the middle of an oil field.

The CSD must be amended to protect us

Request that all oil field monitoring records be maintained for the life of the project

Response: Request for monitoring data to be kept for the life of the project is acknowledged, however, it is not required by the CSD. Please note that it is the current practice at FM O&G to maintain and keep all monitoring records.

This is for only a few years and at their discretion.
Knowing what happened at the dog park from a poorly abandoned well.
As well as a noxious release of toxins into Culver City that Started this process.

The CSD must be amended to protect us.

As MRT says there's no Fracking, Gravel packing or acidizing going on so put in in writing
AMEND the CSD to protect us.

Mr. Richard Bruckner as director of regional planning the CSD must be amended to protect us
It's easier to do now than to litigate later

Thank you

Gary Gless
President C C S C
Citizens Coalition for Safe Community
800CCSC@gmail.com

Stapleton/RPly R2015-02225-2

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SEP 10 2015
REGIONAL PLANNING COMMISSION

Clyde T. Williams 323-528-9682
09 10 15
cdwilliams2012@yahoo.com
4117 Barrett Rd LA 90032

1) Need to install 6 additional water quality monitoring wells for water quality of at least 3 aquifers and deepest groundwater table, both upflow and down flow from field.

2) Require at least 3 unannounced safety, release, spill and fire drills per year

3) Provide delineations of CSD jurisdiction, subsurface, and surface boundaries of the Inglewood oil field.

4) E.2 Require all transport trucks to be covered permanently or water sprinkled twice per day whenever wind velocities exceed 25 mph in a day.

5) G.8 No meeting of CAP and/or MAC with operator present with meeting being open to stakeholders and public

6) E.26 Any consultant or reviewer must be selected only by LACo DRP and DPW

Dr. Clyde T. Williams (2) 091015

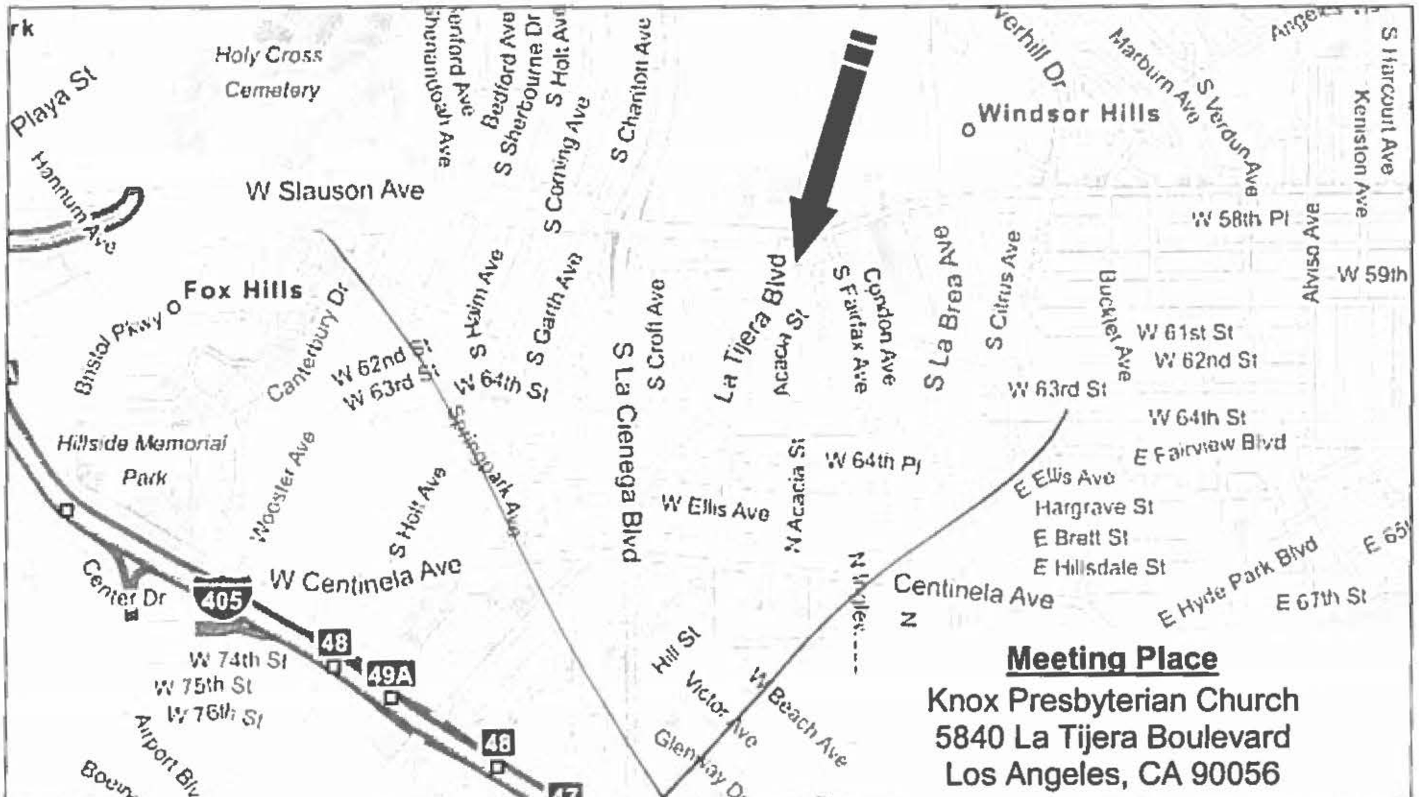
7) E 26 CSD must clearly compare all downhole activities with the related activities on the surface and CSD requirements for such surface activities

8) Any use of feasibility and effectiveness must be documented and quantitatively analyzed within the CSD or supporting documents;

9) CSD must clearly demarcate the current and prospective jurisdiction of the CSD with regard to those of the DOGGR, SCAQMD, LAWQCBrd, and Cal Dep. Tox. Subs. Controls.

PART IV - ADJOURNMENT

MAP



Off-street parking is available off of W. 59th Street.

TIME LIMITS: The Hearing Officer has established time limits with respect to receipt of testimony regarding matters on this Agenda. Applicants will be allowed fifteen (15) minutes to present testimony in support of their application, with an additional ten (10) minutes for responses to issues raised by other witnesses. Other proponents and opponents will be limited to a time determined by the Hearing Officer. Responses to questions from the Hearing Officer will not be included in these time limitations. All speakers are urged to refrain from repeating testimony presented by others. The Hearing Officer may impose different time limits, depending upon the length of the agenda, the number of speakers wishing to give testimony and/or the complexity of an agenda item.

WRITTEN TESTIMONY: Written testimony that is received prior to the public hearing will be made a part of the record and need not be read into the record.

PUBLIC HEARING CLOSING AND RE-OPENING: Public hearings that are closed during the course of the meeting may be re-opened by the Hearing Officer without notice at any time prior to adjournment of the meeting.

LOBBYIST REGISTRATION: Any person who seeks support or endorsement from the Hearing Officer on any official action may be subject to the provisions of Ordinance No. 93-0031, relating to lobbyists. Violation of the lobbyist ordinance may result in a fine and other penalties. FOR INFORMATION, CALL (213) 974-1093.

MEETING MATERIALS: The agenda package is available at the Department of Regional Planning ("Department"), 320 West Temple Street, 13th Floor, Los Angeles, California 90012, and may be accessible on the Department's website at http://planning.lacounty.gov/baldwinhills/review. Any meeting-related writings or documents provided to the Hearing Officer after distribution of the agenda package, unless exempt from disclosure pursuant to California law, are available at the Department and are also available in the hearing room on the day of the Hearing Officer meeting regarding that matter.

Regarding water usage:
Mayor Sahli-Wells of Culver city formally requested a statement of water usage.
Contrary to Mr. Martini's statement, the operator refused to comply.

Thank you.

R2015-02225-2

J E Beckman

CCSC

CITIZENS COALITION FOR A SAFE COMMUNITY

R2015-02225-2
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Stapleton/R.Ruiz

CCSC Comments to Baldwin Hills CSD Periodic Review Final Draft

The Citizens Coalition for a Safe Community submits the following comments and suggestions for requirements and language changes to the Baldwin Hills Community Standards District Periodic Review.

We first would suggest given the sloppy, inaccurate and heavily biased Periodic Review preparer's, Marine Research Specialists, responses that the Hearing Officer and Planning Director, Richard Bruckner consider redoing the Review with another consulting firm and include information being supplied in comments.

In the preparers executive summary they state ***"As detailed in the following pages of this report, the results of this Periodic Review document that the provisions of the CSD have been effective and adequate to protect the health, safety, and general welfare of the public."***

The report also determined that no recommendations to change the language of the CSD are necessary at this time. This statement is a lie and being such the credibility of this firm and their evaluation is suspect.

The following are a number of recommended changes and citations of CSD non-compliance for review.

E.

Oil Field Development Standards.

The following provisions shall apply throughout the oil field portion of the district:

1a.Community Alert Notification System ("CAN"). The operator shall maintain and **test on an annual basis a CAN for automatic notification of area residences and businesses** in the event of an emergency arising at the oil field that could require residents or inhabitants to take shelter, evacuate, or take other protective actions.

CSD NON-COMPLIANCE: CAN SYSTEM NEVER TESTED TO RESIDENT LEVEL OF EMERGENCY NOTIFICATION

2.

Air Quality and Public Health. The operator shall at all times conduct oil operations to prevent the unauthorized release, escape, or emission of dangerous, hazardous, harmful and/or noxious gases, vapors, odors, or substances, and shall comply with the following provisions:

CSD NON-COMPLIANCE:

SCAQMD VIOLATION P#56565 AND PROSECUTION OCTOBER 12, 2013
SOIL VOC EMISSIONS GREATER THAN 50 PPM
See attachment A.

j.

Meteorological Station. The operator shall maintain and operate a meteorological station at the oil field in good operating condition and in compliance with all applicable Environmental Protection Agency ("EPA") and SCAQMD rules, regulations, and guidelines, and to the satisfaction of the director. The operator shall conduct an audit of the meteorological station on an annual basis and submit the results of the audit to the SCAQMD and the director. The operator shall maintain the data files for the meteorological station for a period of not less than 10 years. All such data shall be available upon request to the SCAQMD and the director.

J.THIS SECTION OF THE CSD SHOULD REQUIRE ANOTHER METEOROLOGICAL STATION GIVEN THE IRREGULAR TERRAIN AND SIZE OF THE INGLEWOOD OIL FIELD SURFACE AREA

k.

Updated Health Risk Assessment. After every five years of operation of the meteorological station, the operator shall provide the previous five years of metrological data to the SCAQMD and the director. If the SCAQMD or the director determines that the previous five years of metrological data from the oil field could result in significant changes to the health risk assessment that was conducted as part of the Baldwin Hills Community Standards District Environmental Impact Report, then the county may elect to re-run the health risk assessment using the previous five years of metrological data from the metrological station.

CSD NON-COMPLIANCE: THE ORIGINAL HEALTH RISK ASSESSMENT WAS NOT PROPERLY DESIGNED AND CONDUCTED BY DPH
See attachments: B,C,D
B: CCST
C: LACO DPH LETTER
D: Peer Review LETTER

4.
Geotechnical.
The operator shall comply with the following provisions:
e.
Ground Movement Surveys. The operator shall conduct ground movement surveys once every 12 months, or more frequently if determined necessary by the director of public works, following all provisions of a ground movement monitoring plan that is acceptable to DOGGR and the director of public works, that calls for both vertical and horizontal ground movement surveys, at specified survey locations within, and in the vicinity of, the oil field, utilizing high precision Global Positioning System technology, in combination with a network of ground stations (or any alternative technology specified in the ground movement monitoring plan approved by the director of public works), and following other survey methods outlined in the plan.
The surveys shall be conducted by a California-licensed surveyor.

The survey results shall be analyzed in relation to oil field activities, such as production, steam injection, and water-flooding, taking into consideration individual oil producing zones, injection schedules, rates, volume, and pressure.

The analysis shall be completed in collaboration by a California-registered professional petroleum engineer, registered geotechnical engineer, and certified engineering geologist.

The results of the annual monitoring survey and analysis shall be forwarded to DOGGR and the director of public works. If requested by DOGGR or the director of public works, the operator shall make modifications to the ground movement monitoring plan.

In the event that survey indicates that on-going ground movement, equal to or greater than 0.6 inches at any given location, or a lesser value determined by the director of public works is occurring in an upward or downward direction in the vicinity of or in the oil field, the operator shall review and analyze all claims or complaints of subsidence damage that have been submitted to the operator or the county by the public or a public entity in the 12 months since the last ground movement survey.

Based thereon, the operator shall prepare a report that assesses whether any of the alleged subsidence damage was caused by oil operations and submit said report to DOGGR and the department of public works.

The department of public works shall review the report to determine if it concurs with its conclusions. If the report concludes that damage has not been caused by oil operations, and the department of public works does not concur in that conclusion, it shall forward its conclusions to DOGGR for its review and possible action.

If the report concludes that damage was caused by oil operations and the department of public works concurs with any such conclusion, the department of public works shall forward the department of public works' conclusions to DOGGR and ask DOGGR to evaluate the operator's fluid injection and withdrawal rates to determine whether adjustments to these rates may alleviate the ground movement, and if so, where in the oil field such adjustments should be made.

The operator shall implement whatever adjustments in the rates of fluid injection and/or withdrawal that DOGGR determines are necessary and appropriate to alleviate any ground movement damage. The county shall promptly notify the CAP of any such action that is taken pursuant to this subsection.

Injection pressures associated with secondary recovery operations (i.e., water flooding) or disposal of produced fluids shall not exceed reservoir fracture pressures as specified in Title 14 of the California Code of Regulations, section 1724.10, and as approved by the DOGGR.

CSD NON-COMPLIANCE: PUBLIC WORKS DID NOT CONCUR WITH FINDINGS OF OPERATOR'S SUBCONTRACTORS REPORT STATING THAT THE COUNTY IS NOT QUALIFIED TO MAKE A GEOLOGICAL ASSESSMENT

5.

Noise Attenuation. All oil operations on the oil field shall be conducted in a manner that minimizes noise and shall comply with the following provisions:

a.

Noise Limits. The operator shall comply with the following provisions:

i.

All oil operations on the oil field shall comply with the noise provisions of **Chapter 12.08 of Title 12 of the County Code, with the exception of drilling, redrilling, and reworking, which are exempt from the provisions of said chapter.**

ii.

Hourly, A-weighted equivalent noise levels associated with drilling, redrilling, and reworking shall not elevate existing baseline levels by more than five dBA at any developed area. For daytime activities (7:00 a.m. to 7:00 p.m.) existing baseline noise levels shall be defined as the maximum daytime equivalent noise level (Leq) at the closest monitoring site as shown in Table 4.9.3 of the 2008 Baldwin

Hills Community Standards District Environmental Impact Report. For nighttime activities (7:00 p.m. to 7:00 a.m.), existing baseline noise levels shall be defined as the minimum nighttime equivalent noise level (Leq) at the closest monitoring site as shown in Table 4.9.3 of the 2008 Baldwin Hills Community Standards District Environmental Impact Report. Updated baseline noise levels may be set and additional monitoring sites may be established, from time to time by the director. In no case shall baseline noise levels include any drilling, redrilling, or reworking operations.

iii.

Noise produced by oil operations shall include no pure tones when measured at a developed area.

The director and director of public health should establish a Sustained Peak Time Limit Threshold as opposed to the current use of a Weighted Average Threshold.

11.

Oil Field Waste Removal.

The operator shall comply with the following provisions:

b.

Waste Discharge. No oil field waste shall be discharged into any sewer, storm drain, irrigation systems, stream or creek, street, highway, or drainage canal. Nor shall any such wastes be discharged on the ground provided that the foregoing shall not prohibit the proper use of active drilling sumps and mud pits.

CSD NON-COMPLIANCE: FEDERAL EPA DISTRICT 9 HAS ISSUED CLEAN WATER ACT VIOLATION NOTICES FOR THE INGLEWOOD GAS PLANT IN 2009, 2013 AND 2015

26.

Drilling, Redrilling, and Reworking Operations.

b.

Number of Drilling and Redrilling Rigs. No more than three drilling or redrilling rigs shall be present within the oil field at any one time.

c.

Annual Drilling, Redrilling, Well Abandonment, and Well Pad Restoration Plan. Before the end of each calendar year, the operator shall develop and deliver to the director an annual drilling, redrilling, well abandonment, and well pad restoration plan, which shall describe all drilling, redrilling, well abandonment, and well pad restoration activities that may be conducted during the upcoming calendar year. Drilling and redrilling shall be scheduled to avoid over concentration of such activities in that year in any one area if located near a developed area. The operator may at any time submit to the director proposed amendments to the then current annual plan. No drilling, redrilling, or abandonment activity may be commenced unless it is described in a current annual plan (or an amendment thereto) which has been approved by the director.

The annual plan (and any amendments) shall be provided to the CAP for review and comment. All comments on the annual plan from the CAP shall be submitted to the director in writing, and, if timely submitted, will be considered as part of the director's review and approval. The director shall complete the review of the annual plan (and any amendments) within 45 days of receipt, and shall either approve the annual plan or provide the operator with a list of deficiencies. The annual plan shall comply with the provisions of this subsection, and shall include the following:

i.

The maximum number of wells proposed to be drilled or redrilled;

ii.

Approximate location of all wells proposed to be drilled or redrilled;

iii.

Approximate location of all proposed new well pads, including their size and dimensions;

iv.

Estimated target depth of all proposed wells and their estimated bottom hole locations;

v.

A discussion of the steps that have been taken to maximize use of existing well pads, maximize use of redrilled wells, and maximize the consolidation of wells;

vi.

Location of all proposed well abandonments, if known, in accordance with DOGGR integrity testing program of idle wells;

vii.

~~**x.**~~

~~**A topographic vertical profile showing proposed location of new wells that reflects local terrain conditions and that addresses the potential visibility of existing and proposed wells and other production facilities from residential and recreation areas.**~~

THIS SECTION OF CSD LANGUAGE SHOULD BE REMOVED IF DIRECTOR APPROVES OF CONSULTANT RECOMMENDATION

30.

Well and Production Reporting. The operator shall deliver annual production reports to the director and the fire chief. The reports shall provide the following information:

a.

A copy of all DOGGR Forms 110 and 110B submitted during the previous 12 months.

b.

Number and mapped location of wells drilled or redrilled, including well identification numbers.

c.

Number and mapped location of water injection wells, including well identification numbers.

d.

Number and mapped location of idled wells, including well identification numbers and the date each well was idled.

e.

Number and mapped location of abandoned wells, including date each well was abandoned and/or re-abandoned.

f.

Any additional information requested by the director or the fire chief.

B, C, D, E LANGUAGE SHOULD BE CHANGED TO INCLUDE REQUIREMENT OF ALL WELL BOTTOMHOLE LOCATIONS GIVEN THE POTENTIAL OF GAS MIGRATION ALONG FAULTS AND FRACTURES INTO SURFACE RESIDENTAL HOMES AND BUSINESSES

31.

Idle Well Testing and Maintenance. The operator shall comply with Title 14 of the California Code of Regulations section 1723.9 regarding testing and maintenance of idle wells, or subsequently enacted state regulations regarding testing and maintenance of idle wells. The operator shall carry out all additional tests, remedial operations, and mitigation measures required by DOGGR if any idle wells do not meet the test standards.

32.

Abandoned Well Testing. The operator shall conduct annual hydrocarbon vapor testing of areas within the oil field that contain abandoned wells. The testing shall be done using a soil gas vapor probe, or another method approved by the director. The results of the testing shall be submitted to the director and DOGGR on an annual basis. Abandoned wells that are found to be leaking hydrocarbons that could affect health and safety shall be reported to the director and DOGGR within 24 hours of the abandoned well test. If directed by DOGGR, the operator shall re-abandon the well in accordance with DOGGR rules and regulations. If the test results for an abandoned well area are at or below the background levels for two consecutive years that area shall thereafter be tested every five years.

LANGUAGE SHOULD BE CHANGED TO REQUIRE PROPER ADDITIONAL DEPTHS OF SOIL PROBE TESTING

33.

Well and Well Pad Abandonment.

c.

Contaminated Materials. All contaminated soils and materials within the well pad boundaries shall be removed and treated or disposed of in accordance with all local, county, State, and federal regulations.

CSD NON-COMPLIANCE:
SCAQMD VIOLATION P#56565 AND PROSECUTION
SOIL VOC EMISSIONS GREATER THAN 50 PPM
See attachment A.

CSD NON-COMPLIANCE: FEDERAL EPA DISTRICT 9 HAS ISSUED CLEAN WATER ACT VIOLATION NOTICES FOR THE INGLEWOOD GAS PLANT IN 2009, 2013 AND 2015

Monitoring and Compliance.

1.

Environmental Quality Assurance Program ("EQAP"). The operator shall comply with all provisions of an environmental quality assurance program that has been approved by the director. The following provisions relate to the EQAP:

a.

EQAP Requirements. The EQAP shall provide a detailed description of the steps the operator shall take to assure compliance with all provisions of this section, including but not limited to, all of the monitoring programs called for by this section.

b.

Annual EQAP Reports. Within 60 days following the end of each calendar year, the operator shall submit to the director an annual EQAP report that reviews the operator's compliance with the provisions of the EQAP over the previous year and addresses such other matters as may be requested by the director. The annual EQAP report shall include the following:

i.

A complete list and description of any and all instances where the provisions of the EQAP, or any of the monitoring programs referred to therein or in this section, were not fully and timely complied with, and an analysis how compliance with such provisions can be improved over the coming year.

ii.

Results and analyses of all data collection efforts conducted by the operator over the previous year pursuant to the provisions of this section.

c.

EQAP Updates. The EQAP shall be updated as necessary and submitted to the director for approval along with the annual EQAP report. The EQAP updates shall be provided to the CAP and MACC for review and comment. Comments from the CAP and MACC, if timely received, shall be considered by the director before making a decision to approve the same. The director shall complete the review of EQAP updates as soon as practicable, and shall either approve the updated EQAP or provide the operator with a list of specific items that must be included in the EQAP prior to approval. The operator shall respond to any request for additional information within 30 days of receiving such request from the director, unless extended by the director.

2.

Environmental Compliance Coordinator. The operator shall recommend and fund the environmental compliance coordinators. The number of environmental compliance coordinators shall be determined by the county and shall take into account the level of oil operations at the oil field. The environmental compliance coordinator(s) shall be approved by, and shall report to, the director. The responsibilities of the environmental compliance coordinator(s) shall be set forth in implementation guidelines that may be developed by the county for the oil field and shall generally include:

a.

On-site, day-to-day monitoring of construction or drilling and redrilling activities as determined by the director.

b.

Taking steps to ensure that the operator, and all employees, contractors, and other persons working in the oil field, have knowledge of, and are in compliance with all applicable provisions of this section.

c.

Evaluating the adequacy of drilling, redrilling, and construction impact mitigations, and proposing improvements to the operator or contractors and the county.

d.

Reporting responsibilities to the various county agencies with oversight responsibility at the oil field, as well as other agencies such as DOGGR, and SCAQMD.

CSD NON-COMPLIANCE: FEDERAL EPA DISTRICT 9 HAS ISSUED CLEAN WATER ACT VIOLATION NOTICES FOR THE INGLEWOOD GAS PLANT IN 2009, 2013 AND 2015
(IN CSD PERIODIC REVIEW RESPONSE PREPARERS CLAIM IGNORANCE ALTHOUGH THIS WAS DISCUSSED AT CAP MEETING WITH CANDANCE SALWAY, VP FREEPORT-MCMORAN AND LUIS PEREZ, MARINE RESEARCH SPECIALISTS, INGLEWOOD ENVIRONMENTAL COMPLIANCE COORDINATOR)

CSD NON-COMPLIANCE:
SCAQMD VIOLATION P#56565 AND PROSECUTION
SOIL VOC EMISSIONS GREATER THAN 50 PPM
See attachment A.
ENVIRONMENTAL COMPLIANCE COORDINATOR FAILED TO INDENTIFY VIOLATION IN DAY TO DAY INSPECTIONS OF OPERATIONS

3.
Safety Inspection, Maintenance, and Quality Assurance Program ("SIMQAP"). The operator shall comply with all provisions of a safety inspection, maintenance, and quality assurance program that has been approved by the director and the fire chief.
a.
SIMQAP Requirements. The SIMQAP shall, at a minimum provide for:
i.
Inspection of construction techniques;
ii.
Regular maintenance and safety inspections;
iii.
Periodic safety audits;
iv.
Corrosion monitoring and leak detection; and
v.
Inspections of all trucks carrying hazardous and/or flammable material prior to loading.

CSD NON-COMPLIANCE: LACO FIRE DEPARTMENT HAZ-MAT WAS UNAWARE OF TANKER TRUCKLOADS OF METHANOL BEING USED IN THE INGLEWOOD OIL FIELD INJECTION OPERATIONS

b.
SIMQAP Updates. The operator shall periodically review and revise the SIMAQP to incorporate changes in procedures, and new safety and maintenance technologies and procedures. The operator shall make such revisions at least every five years, or more frequently, if the operator determines changes are necessary or if requested by the director or the fire chief. The operator shall submit SIMQAP updates to the director and the fire chief for their review and approval. The director shall complete the review of SIMQAP updates as soon as practicable, and shall either approve the updated SIMQAP or provide the operator with a list of specific items that must be included in the SIMQAP prior to approval. The operator shall respond to any request for additional information within 30 days of receiving such request from the director, unless extended by the director.
c.
Worker Notification. The operator shall ensure that all persons working on the oil field comply with all provisions of the currently approved SIMQAP.
d.
Inspections. The SIMQAP shall provide for involvement of county staff or the environmental compliance coordinator in all inspections required by this section.

CSD NON-COMPLIANCE: LACO FIRE DEPARTMENT HAZ-MAT WAS UNAWARE OF TANKER TRUCKLOADS OF METHANOL BEING USED IN

THE INGLEWOOD OIL FIELD INJECTION OPERATIONS

CSD NON-COMPLIANCE: FEDERAL EPA DISTRICT 9 HAS ISSUED CLEAN WATER ACT VIOLATION NOTICES FOR THE INGLEWOOD GAS PLANT IN 2009, 2013 AND 2015
(IN CSD PERIODIC REVIEW RESPONSE PREPARERS CLAIM IGNORANCE ALTHOUGH THIS WAS DISCUSSED AT CAP MEETING WITH CANDANCE SALWAY, VP FREEPORT-MCMORAN AND LUIS PEREZ, MARINE RESEARCH SPECIALISTS, INGLEWOOD ENVIRONMENTAL COMPLIANCE COORDINATOR)

CSD NON-COMPLIANCE:
SCAQMD VIOLATION P#56565 AND PROSECUTION
SOIL VOC EMISSIONS GREATER THAN 50 PPM
See attachment A.
ENVIRONMENTAL COMPLIANCE COORDINATOR FAILED TO INDENTIFY VIOLATION IN DAY TO DAY INSPECTIONS OF OPERATIONS

5.
Noise Monitoring. The public health department shall retain an independent qualified acoustical engineer to monitor ambient noise levels in the areas surrounding the oil field as determined necessary by the director or the director of public health. The monitoring shall be conducted unannounced and within a time frame specified by the director or the director of public health. Should noise from the oil operations exceed the noise thresholds specified in this section, no new drilling or redrilling permits shall be issued by the county until the operator in consultation with the director and director of public health identifies the source of the noise and the operator takes the steps necessary **to assure compliance with thresholds specified in this section.** The results of all such monitoring shall be promptly posted on the oil field web site and provided to the CAP.

The director and director of public health should establish a Sustained Peak Time Limit Threshold as opposed to the current use of a Weighted Daily Average Threshold. Language should reflect change.

7.
Complaints. All complaints related to oil operations received by the operator shall be reported on the same business day to the environmental compliance coordinator and to the director. In addition, the operator shall maintain a written log of all complaints and provide that log to the director, the MACC, and CAP on a quarterly basis. Depending upon the nature of the complaint, the operator shall report the complaint to the SCAQMD, DOGGR, and any other appropriate agencies with oversight authority regarding the complaint at issue. If the complaint is received after normal business hours, it shall be reported to the

environmental compliance coordinator and the agencies at the opening of the next business day.
Language change should be made to require full reporting of complaint, agency response inspection and action taken, such as NOV and prosecution.

G.
Administrative Items.

2.
Draw-Down Account. The operator shall maintain a draw-down account with the department of regional planning from which actual costs will be billed and deducted for the purpose of defraying the expenses involved in the county's review and verification of the information contained in any required reports and any other activities of the county, including but not limited to, enforcement, permitting, inspection, coordination of compliance monitoring, administrative support, technical studies, and the hiring of independent consultants. The initial amount to be deposited by the operator shall be $500,000. In the first year, if withdrawals from the account have reduced its balance to less than 50 percent of the amount of the initial deposit ($250,000), the operator shall deposit $50,000 in supplemental funds within 30 business days of notification. After the first year, if the balance in the draw-down account is reduced at any time to $50,000, the operator shall deposit $50,000 in supplemental funds on each occasion that the account is reduced to $50,000 or less within 30 business days of notification. There is no limit to the number of supplemental deposits that may be required. At the discretion of the operator, the amount of an initial or supplemental deposit may exceed the minimum amounts specified in this subsection. The director may, from time to time, increase the minimum $50,000 figure to account for inflation or the county's experience in obtaining funds from the account.

INTERNAL LACO EMAILS REVEAL COUNTY FUNDS WERE USED BY PLANNING DIRECTOR, RICHARD BRUCKNER FOR MAILINGS TO ABOUT 24,000 INGLEWOOD AREA RESIDENTS DURING CALIFORNIA ASSEMBLY DISTRICT 54 CAMPAIGN OF SEBASTIAN RIDLEY-THOMAS.

Sincerely,

Paul V. Ferrazzi
Executive Director
Citizens Coalition for a Safe Community

ATTACHMENT #A

SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT
21865 COPLEY DRIVE - DIAMOND BAR, CA 91765-4178

NOTICE OF VIOLATION

DATE OF VIOLATION 10 / 16 / 2012

NAME: Plains Exploration & Production

MAILING ADDRESS: 5640 S. Fairfax Ave. CITY: Los Angeles

LOCATION-ADDRESS OF VIOLATION: 5640 S. Fairfax Ave. I.D. #: 133987

CITY: Los Angeles SECTOR: LF TELEPHONE #: (323) 298-2266

YOU ARE HEREBY NOTIFIED THAT A VIOLATION OF CALIFORNIA HEALTH AND SAFETY CODE SECTION(S)

AND/OR SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT RULE(S)
1166(c)(1)(A); 1166(c)(2); 1166(c)(4); 1166(c)(5)

HAS BEEN COMMITTED. SUCH VIOLATIONS MAY BE PUNISHED BY THE IMPOSITION OF THE CIVIL OR CRIMINAL PENALTIES PRESCRIBED BY ARTICLE 3, CHAPTER 4, PART 4, DIVISION 26 (BEGINNING WITH SECTION 42400) OF THE CALIFORNIA HEALTH AND SAFETY CODE. EACH DAY DURING WHICH THE VIOLATION OCCURS MAY BE PUNISHED AS A SEPARATE VIOLATION WHETHER OR NOT A NOTICE OF VIOLATION IS ISSUED ON EACH SUCH DAY.

Description of Violation:

- Not operating pursuant to a mitigation plan approved by the Executive Officer for VOC containing material.
- Not properly handling VOC-contaminated soil from excavation or grading
- Not properly treating VOC contaminated soil
- Engaging in on-site spreading & grading of VOC-contaminated soil resulting in uncontrolled evaporation of VOC.

BY: Christian Aviles, INSPECTOR TELEPHONE (909) 396-3147

SERVED TO: Pat Gorski TITLE: EH&S Advisor

SERVED BY: Christian Aviles DATE: 10 / 19 / 2012

No. P 56565

OFFICE OF STATIONARY SOURCE COMPLIANCE

ORIGINAL

South Coast Air Quality Management District
21865 Copley Drive, P.O. Box 4941, Diamond Bar, CA 91765-0941

NOTICE TO COMPLY

Date of Inspection: 10 / 16 / 12

Facility Name: Plains Exploration & Production			Facility ID#: 133987
Location Address: 5640 S. Faifax Ave.	City: Los Angeles		Zip: 90056
Telephone #: (323) 298-2266			Sector: LF
Mailing Address: 5640 S. Fairfax Ave.	City: Los Angeles		Zip: 90056

YOU ARE DIRECTED TO COMPLY WITH:

Item #	•AQMD Permit # or Equip Description •AQMD Rule # •California H&S Code §	A MEANS OF ACHIEVING COMPLIANCE IS:	DUE DATE (Date compliance is due)
1	CA H&S Code 42303	All records of excavation or handling of VOC Containing Soil Dating Back to 2009	10/26/12
2	CA H&S Code 42303	All contracts for excavation or handling of VOC Containing Soil Dating Back to 2009	10/26/12
3	CA H&S Code 42303	Any records of off-site soil brought on-site to be treated at bio-treatment site	10/26/12

REPLY REPORT BY CITED FACILITY
(attach additional pages as necessary)

DATE COMPLIANCE ACHIEVED	DESCRIPTION OF HOW COMPLIANCE WAS ACHIEVED

SIGNATURE OF OWNER/RESPONSIBLE OFFICIAL:

TITLE:

DATE:

SERVED TO: Pat Gorski

TITLE: EH&S Advisor

TELEPHONE: (323) 298-2441

BY INSPECTOR: Christian Aviles

DATE ISSUED: 10-19-12

Instruction/Information:

- For each minor violation cited compliance shall be achieved by the due date specified above for that particular violation.
- Within 5 working days of achieving compliance for each respective violation, the owner/responsible officer of the cited facility must complete and return a signed copy of this Notice to the South Coast Air Quality Management District at the address listed above. Please copy this Notice as many times as necessary to provide the required information. On each copy, include a written statement describing when and how compliance was achieved. Send all completed copies to the attention of the inspector named above.
- Failure to respond or a false statement that compliance has been achieved is a violation subject to further legal action pursuant to the California Health and Safety Code.
- **The facility cited in this Notice is subject to re-inspection at any time to ensure compliance.**

NOTICE # D 25810

SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT

FILE COPY (Blue) *FACILITY COPY (Gold)* *INSPECTOR COPY (White)*

South Coast Air Quality Management District
21865 COPLEY DR., P.O. Box 4941, DIAMOND BAR, CA 91765-0941

NOTICE TO COMPLY

10 / 16 / 12
DATE OF INSPECTION

Facility Name: Plains Exploration & Production **Facility ID#:** 133987 **Sector:** LF

This Notice to Comply is being issued to:

☒ Request additional information needed to determine compliance with clean air requirements.
☐ Correct a minor violation found during an inspection.

Failure to respond or take corrective action, or providing false statements in response to this Notice to Comply can lead to issuance of a Notice of Violation pursuant to the California Health and Safety Code. The facility cited above is subject to re-inspection at any time to ensure compliance.

YOU ARE HEREBY DIRECTED TO COMPLY WITH:

#	AQMD RULE/ CAL H&S CODE	REQUIREMENT	COMPLIANCE DUE DATE	COMPLIANCE ACHIEVED DATE
4	CA H&S Code 42303	Any Rule 1166 Plans used for handling material at PXP Inglewood dating back to 2009 to include Plans used by contractors	10/26/12	
5	CA H&S Code 42303	All monitoring records of handling of VOC containing soils at PXP dating back to 2009	10/26/12	
6	CA H&S Code 42303	All monitoring records of bio-farm sites at PXP dating back to 2009	10/26/12	
7	CA H&S Code 42303	Total volume of VOC Containing soil handled by PXP since 2009	10/26/12	
8	CA H&S Code 42303	Total surface area of PXP biofarms & locations of staging areas or stockpiles	10/26/12	

Served To: Pat Gorski		Served By: Christian Aviles	
Title: EH&S Advisor		Date Served: 10-19-12	Phone: (909)396-3147	Fax:
Email Address: PGorski@PXP.com	Phone: (323) 298-2441	Email Address: Caviles @aqmd.gov	Forms/Applications/Info available at: www.aqmd.gov

I hereby certify that the facility cited in this Notice to Comply has achieved compliance with the requirements listed above.

NAME OF OWNER/RESPONSIBLE OFFICIAL ______ TITLE ______ SIGNATURE ______ DATE ______

Instructions:

- For each minor violation cited above, compliance shall be achieved by the compliance deadline specified for that particular violation.
- Within 5 working days of achieving compliance for each respective violation, the owner/responsible officer of the cited facility must complete and return a signed copy of this Notice to Comply to the South Coast Air Quality Management District at the address listed above.
- Please copy and return this Notice to Comply as many times as necessary to provide the required information. On each copy, include the date on which compliance was achieved. Date, sign, and send all completed copies to the attention of the inspector named above.

NOTICE#: D25810 ***(continued)*** **Page** 2 **of** 2

FILE COPY (Blue) *FACILITY COPY (Gold)* *INSPECTOR COPY (White)*

ATTACHMENT #B

Chapter Four

A Case Study of the Petroleum Geological Potential and Potential Public Health Risks Associated with Hydraulic Fracturing and Oil and Gas Development in The Los Angeles Basin

Seth B. C. Shonkoff[1,2,3], Donald Gautier[4]

[1]PSE Healthy Energy, Oakland, CA
[2]Department of Environmental Science, Policy, and Management, University of California, Berkeley, CA
[3]Lawrence Berkeley National Laboratory, Berkeley, CA
[4]Dr. Donald Gautier, LLC, Palo Alto, CA

4.1. Introduction to the Los Angeles Basin Case Study

The Los Angeles Basin is unique in its exceptional natural concentration of oil directly beneath a dense urban population. In few other places in the world has simultaneous petroleum development and urbanization occurred to such an extent. Conflicts of oil and city life are not new to Los Angeles, but recent reports suggesting the possibility of additional large-scale oil production enabled by hydraulic fracturing, coupled with the ever increasing encroachment of urbanization on the existing oil fields, lends a particular urgency to the need to understand the public health implications of having millions of people who live, work, play, and learn in close proximity to billions of barrels of crude oil.

The Los Angeles Basin Case Study contains two components. In Section 4.2, Gautier reviews the history and current trends of oil production in the Los Angeles Basin combined with a geology-based analysis of the potential for additional petroleum development. We conclude in this section that oil production in the Los Angeles Basin has been in decline for years, and that continued oil development is likely to be within existing oil fields rather than widespread development of previously undeveloped source-rock (shale tight oil) resources outside of these boundaries. Based on this scenario of future oil development, in the second part of the Los Angeles Basin Case Study, Section 4.3, Shonkoff and colleagues review the numbers and demographics of residents, schools, daycare centers and other "sensitive receptors" in proximity to existing active oil and gas development operations. The authors then use criteria air pollutant and toxic air contaminant data from southern California and elsewhere to evaluate the potential implications of oil and gas activities for public health. Next, Shonkoff and colleagues assess the potential for protected groundwater contamination attributable to hydraulic fracturing-enabled oil and gas development and potential exposure pathways. Finally, conclusions, research needs, and recommendations are presented.

4.2. History, Distribution, and Potential for Additional Oil Production in the Los Angeles Basin

Donald L. Gautier[1]

[1]*Dr. Donald Gautier, LLC, Palo Alto, CA*

4.2.1. Abstract

Beneath the city of Los Angeles is a deep geological basin with all the components and timing of a nearly ideal petroleum system. As a consequence, the basin has one of the highest known natural concentrations of crude oil, located directly beneath a modern megacity. Petroleum has been exploited in Los Angeles since prehistoric times, but more than 90 percent of the known oil was found during a 15-year flurry of exploration in the first half of the twentieth century. Petroleum development and urbanization have gone hand in hand and been in conflict since the beginning. In spite of intense development, large quantities of recoverable oil probably remain. Besides known oil, the basin has resource potential in three categories: (1) Relatively small volumes of oil in undiscovered conventional oil fields, (2) Large volumes of additional recoverable oil in existing fields, and (3) The possibility of unconventional "shale oil" resources in Monterey-equivalent source rock systems near the center of the basin. Extensive development of any of these resources with existing technology would entail conflicts between oil production and the needs of the urban population. Therefore, technological innovations would probably be required for large-scale additional petroleum development in the Los Angeles Basin.

4.2.2. Introduction

The City of Los Angeles (L.A.) is unique in the large volumes of petroleum that underlie the city. Close proximity of a large urban population to intensive oil development poses potential hazards not necessarily present in areas of lower population density. Therefore, the possibility of extensive new development of additional petroleum resources raises concerns about potential consequences to human health. This part of the Los Angeles Basin Case Study discusses the petroleum resources of the basin and the potential for additional development.

4.2.3. Historical Summary of Petroleum Development

Native Americans used oil from natural seeps long before Europeans arrived in southern California (Merriam, 1914; Harris and Jefferson, 1985; Hodgson, 1987), and commercial production came in the mid-nineteenth century from hand-dug pits. In 1880 the Puente Oil Company drilled an exploratory well near the seeps in Brea Canyon and found Brea-Olinda oil field. At that time, Los Angeles had a growing population of about 11,000 people. In 1890, Edward Doheny and Charles Canfield started developing Los Angeles City Field; the ensuing oil boom made them rich, but also upset locals with its noise, smell, and mess. Only 50,000 people then lived in L.A., but conflicts between oil and the urban population had already begun (Rintoul, 1991).

Exploratory drilling was wildly successful in the second and third decades of the twentieth century. The biggest fields were found in a 15-year period beginning with Montebello in 1917 and ending with Wilmington-Belmont in 1932. In the frenzy of the early years of the petroleum boom, operators seemed to have little regard for efficiency, safety, human health, or environmental consequences. Wells interfered with one another and reservoirs were ruined; spills, well failures, fire, injury, and death were common.

With unrestricted production, output from each giant field spiked, flooding the market and collapsing prices. Wells on Signal Hill flowed 41,200 m^3 (259,000 barrels) per day in October of 1923 (Rintoul, 1991). That year, Long Beach field produced more than 11 million m^3 (68 million barrels) and Santa Fe Springs field more than 13 million m^3 (81 million barrels). Inglewood output exceeded 2.9 million m^3 (18 million barrels) in 1925, and Huntington Beach yielded more than 4.1 million m^3 (26 million barrels) in 1927. Wilmington-Belmont was the only giant field initially developed in a more orderly fashion, and as production from other fields declined, it provided an ever-greater share of L.A. production. In 1969 Wilmington gave up more than 14 million m^3 (89 million barrels) of oil, while all of California Division of Oil, Gas, and Geothermal Resources (DOGGR) District 1 (L.A., Orange and San Bernardino counties), including Wilmington, produced about 26.9 million m^3 (169 million barrels). By the late 1970s, with few new discoveries and increasing pressure from urbanization, wildcat drilling # had all but ceased in the Los Angeles Basin (Figure 4.2-1).

Greater L.A. is now home to more than 18 million people, many of who have a high demand for refined petroleum, but who struggle to reconcile oil production and city life. Field operations are increasingly constrained by federal, state, county, and local policies, and by competing commercial interests. Many small fields have been shut in with reservoirs still on primary production, and operations of most large fields have been contracting for years. In 2013, all onshore wells in District 1 produced just 2.2 million m^3 (14 million barrels) of oil, less than 10% of the 1969 output.

Inefficient development practices and highly restricted application of secondary and tertiary recovery technologies are the main reasons for the low recovery efficiencies (the portion of the original oil in place that has been produced or is in remaining proved reserves) now observed in the Los Angeles Basin oil fields (Gautier et al., 2013. Geologists and engineers who know the basin believe that large amounts of additional oil could be recovered with the systematic application of modern technology (Gautier et al., 2013). However, even when oil prices soared between 2007 and 2014, operator's efforts in Brea Olinda, Huntington Beach, Long Beach, Inglewood, Santa Fe Springs, Wilmington, and other fields only managed to flatten the decline (Figure 4.2-2), suggesting that without some sort of technological innovation, the petroleum era in southern California could end with billions of barrels of recoverable oil still in the ground.

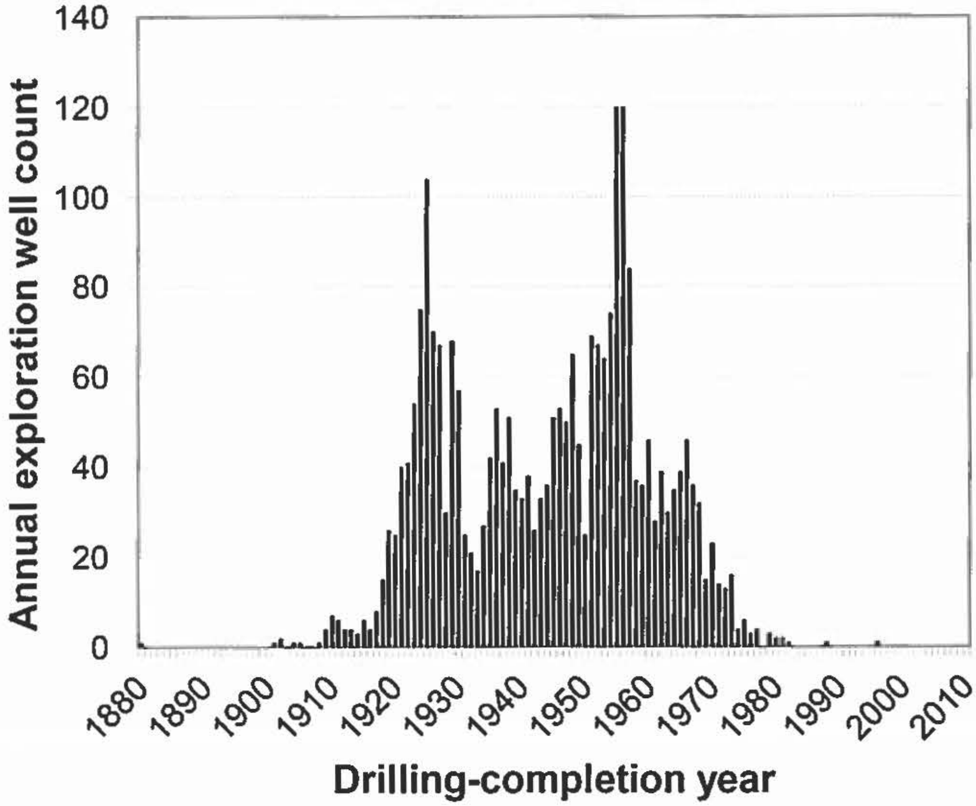

Figure 4.2-1. Numbers of wildcat exploration well drilled as a function of time in the Los Angeles Basin (Figure courtesy of T.R. Klett, U.S. Geological Survey).

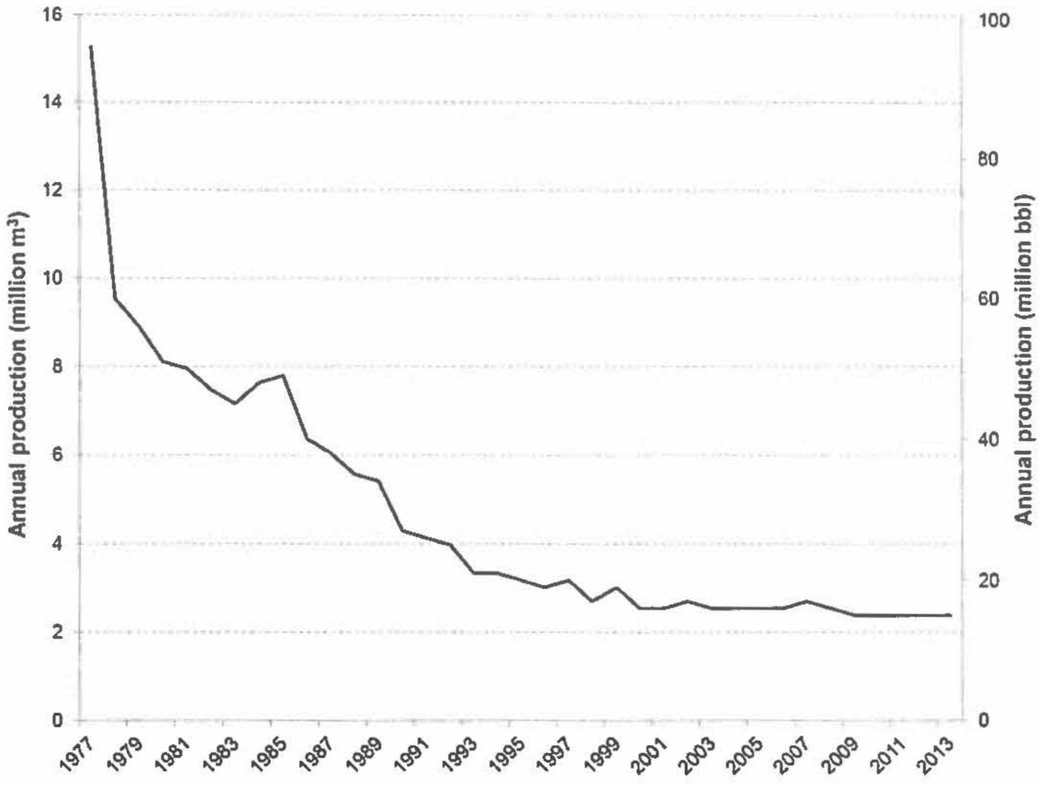

Figure 4.2-2. Graph showing onshore production of crude oil from reserves in the Los Angeles Basin between 1977 and 2015. Data from the Energy Information Administration (downloaded 2 May 2015).

4.2.4. Distribution of Known Petroleum

To geologists, the Los Angeles Basin is a small (5,700 km²; 2,200 mi²) but deep structural chasm filled with more than 8,000 meters (>26,000 feet) of sediments and sedimentary rock. A nearly ideal petroleum system and fortuitous timing of geological events have endowed the basin with what may be the world's highest concentration of crude oil (Barbat, 1958; Biddle, 1991; Gardett, 1971; Wright, 1987; Yerkes et al., 1965) (Figure 4.2-3). Petroleum is still forming in Los Angeles, as demonstrated by numerous oil and gas seeps such as those at Rancho La Brea (Hancock Park) and Brea Canyon. The fact that gas caps are almost nonexistent in the oil fields suggests that most gas-phase hydrocarbons have been naturally lost to the atmosphere, while much of the migrated oil has accumulated in conventional traps.

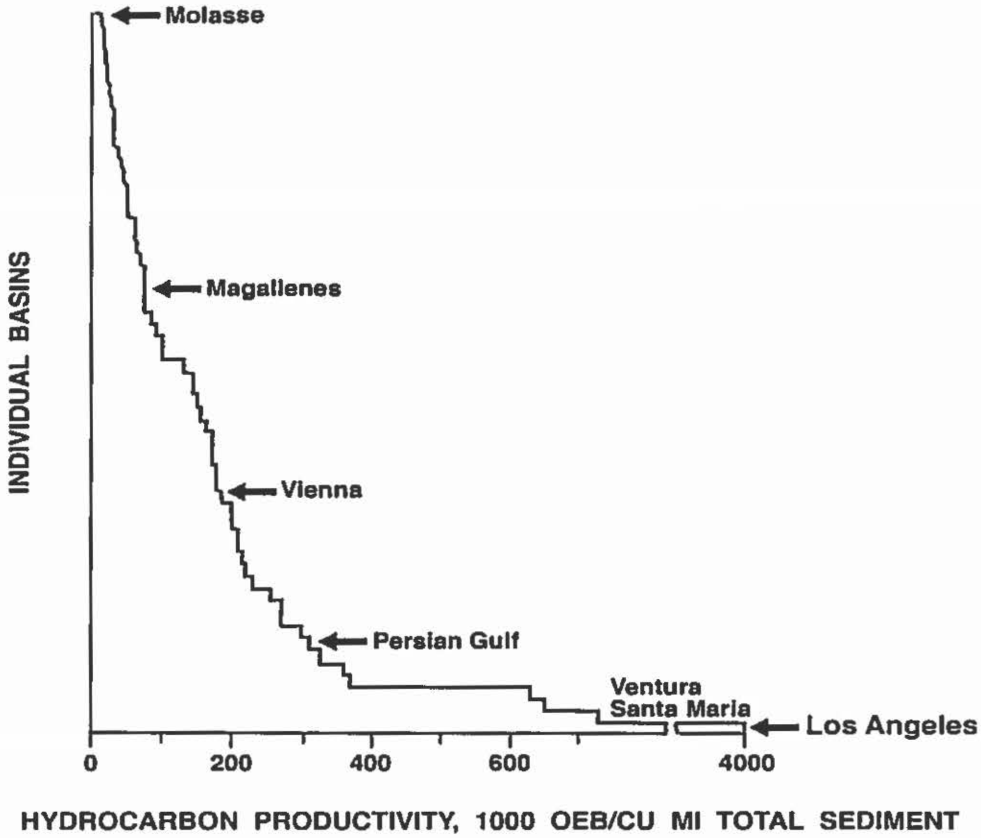

Figure 4.2-3. Relative hydrocarbon concentration by basin. Source: Kevin Biddle 1991: American Association of Petroleum Geologists Memoir 52 (OEB/CU MI = Oil equivalent barrels per cubic mile).

No petroleum province of comparable richness exists in the midst of a megacity. Petroleum has been produced from 68 named fields, most of which are closely related to the basin's principal structures (Wright, 1991). The largest oil accumulations, by known oil (cumulative production and reported remaining reserves), are: Wilmington-Belmont, Huntington Beach, Long Beach, Santa Fe Springs, Brea-Olinda, Inglewood, Dominguez, Coyote West, Torrance, Seal Beach, Richfield, Montebello, Beverly Hills East, Coyote East, Rosecrans, and Yorba Linda. These 15 accumulations, which account for more than 91 percent of recoverable oil in the basin, were all found before 1933. The most recent discoveries occurred during the early-to-mid 1960s when Beverly Hills East, Las Cienegas (Jefferson area), Riviera, and San Vicente were found. Another large field, Beta Offshore, was found in federal waters in 1976.

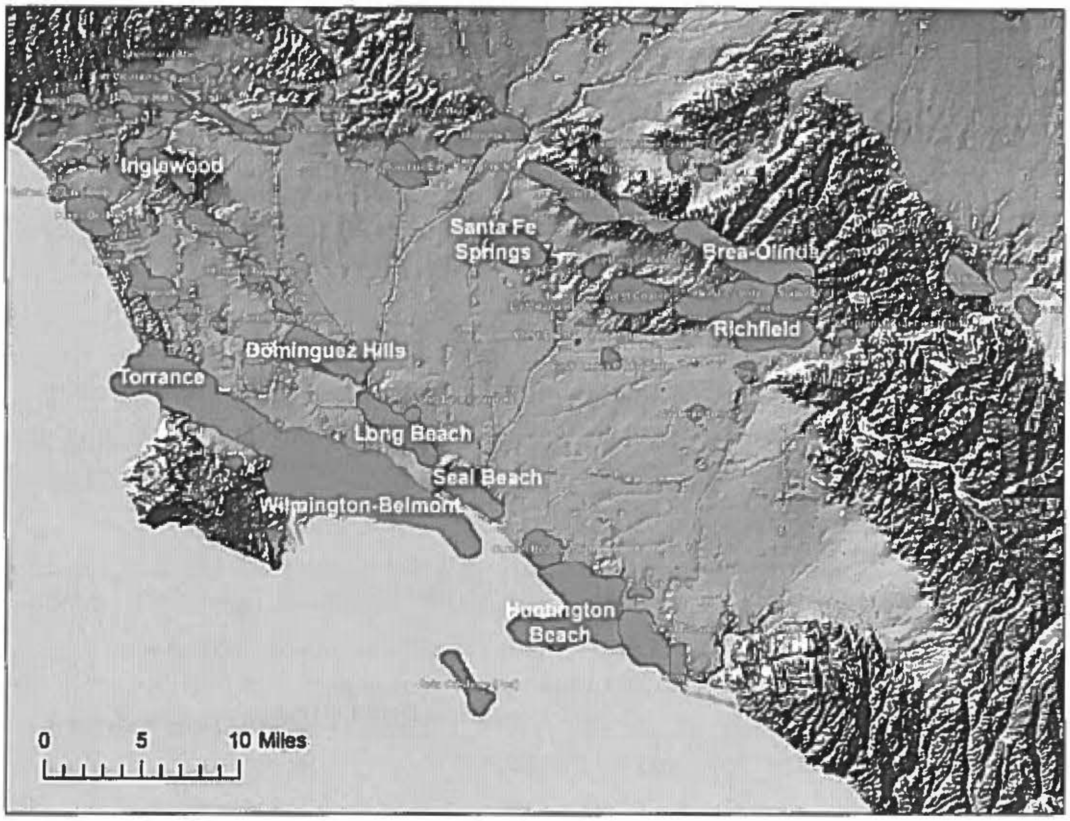

Figure 4.2-4. Map showing shaded relief topography and named oil fields of the Los Angeles Basin. The ten largest fields, studied by Gautier et al. (2013) are labeled in bold type.

4.2.5. Resource Potential of the Los Angeles Basin

In addition to its cumulative production and reported remaining reserves, the basin has resource potential in three categories: (1) Undiscovered conventional oil fields, (2) Growth of reserves in existing fields, and (3) Development of unconventional resources.

4.2.5.1. Undiscovered Conventional Oil Fields

The last systematic assessment of undiscovered conventional oil and gas resources in the Los Angeles Basin was conducted by the United States Geological Survey (USGS) and published in 1995 (Beyer, 1995; Gautier et al., 1995). At that time, the mean undiscovered conventional oil resource for the basin, including state waters but excluding federal waters, was estimated to be approximately 980 million barrels of technically recoverable oil (MMBO).

These estimated undiscovered resources were distributed among seven confirmed (meaning historically productive) USGS-defined plays (Volume I, Chapter 4,) having an aggregated mean estimated undiscovered conventional resource of 160 million m^3 (1 billion barrels) of oil (Gautier et al., 1995). A mean basin-level estimate of almost 0.16 billion m^3 of oil (1 billion barrels of oil (BBO)) would be considered quite significant in almost any untested petroleum basin. However, in Los Angeles, where the original oil in place probably exceeded 6.4 billion m^3 of oil (40 BBO), an undiscovered technically recoverable volume of less than 0.16 billion m^3 of oil (1 BBO) represents the aggregate recoverable resource remaining in many small and hard-to-find accumulations that may not warrant much expensive exploration effort. If found, these undiscovered accumulations would be expected to share many of the geological features of the known field population.

4.2.5.2. Growth of Reserves in Existing Fields

In order to evaluate the volumes of potentially recoverable oil remaining in existing fields of the Los Angeles Basin, the USGS recently assessed the 10 largest fields in the basin (Figure 4.2-4) (Gautier et al., 2013), using production, reserves, and well data published by the California Division of Oil, Gas, and Geothermal Resources. The geology of each field was analyzed, and the history of its engineering and development practices was reviewed. Probability distributions for original oil in place and maximum potential recovery efficiency were developed. The maximum recovery was evaluated on the basis of recovery efficiencies that have been modeled in engineering studies, achieved in similar reservoirs elsewhere, or indicated by laboratory results reported in technical literature. Probability distributions of original-oil-in-place and recovery efficiency were combined in a Monte Carlo simulation to estimate remaining recoverable oil in each field. The results were then probabilistically aggregated. Those aggregated results from the USGS study suggest that between 0.22 and 0.89 billion m^3 (1.4 and 5.6 billion barrels) of additional oil, recoverable with current technology, remain in the 10 analyzed fields, with a mean estimate is approximately 0.51 billion m^3 (3.2 billion barrels). In addition to the estimated remaining recoverable resources in the ten largest fields, recoverable oil likely also remains in the other 58 oil fields in the Los Angeles Basin. It is likely that some of these fields contain reservoirs that are of low permeability.

Recovery of these resources would probably require field-level redevelopment and unrestricted application of current technology, including use of improved imaging and widespread application of directional drilling, combined with extensive water, steam, and carbon dioxide flooding. Because the majority of petroleum reservoirs of the giant Los Angeles Basin fields are sandstones with high porosity and permeability, redevelopment of these fields would not generally require hydraulic fracturing as a common practice. However, certain lower permeability reservoirs are probably present in many of these large fields, the development and production of which could require the local and limited application of hydraulic fracturing in conjunction with other techniques.

4.2.5.3. Unconventional Resources

In principal, any petroleum source rock in the proper state of thermal maturation could be a reservoir for shale oil or shale gas production. Given the large concentrations of petroleum in the Los Angeles Basin, it is certain that prolific organic-rich source rocks are present in the basin, and that they are thermally mature for oil generation. Therefore, it is possible that thermally mature source rocks might be directly developed for oil in the Los Angeles Basin as they have been in Texas, North Dakota, and elsewhere.

During its 1995 National Assessment (Gautier et al., 1995), the USGS described a potential play involving technically recoverable resources in source rocks and adjacent strata in the Los Angeles Basin (Beyer, 1995). Although the play was not quantitatively assessed at the time, its resource potential and geological properties were described. The identification and descriptions of this postulated petroleum accumulation, named the "Deep Overpressured Fractured Rocks of Central Syncline Play", were based largely on the results of the American Petrofina Central Core Hole No. 1 (Redrill) well (APCCH). The APCCH, located in Sec. 4, T. 3 S., R. 13 W., is the deepest well yet drilled in the Los Angeles Basin (Wright 1991; Beyer 1995). It encountered abnormally high pore fluid pressures and tested moderately high-gravity oil below about 5,500 m (18,000 ft). The well bottomed in lowermost Delmontian (Late Miocene) rocks at a measured depth of 6,466.3 m (21,215 ft) and did not reach the presumed Mohnian (Late Middle Miocene) Monterey-equivalent source rock. The unconventional reservoir was postulated to consist of fractured strata within and immediately adjacent to the source rock interval.

The potentially productive area of the postulated source-rock play includes most of the Central Syncline and its deep flanks, at depths below which the source rock interval has been heated sufficiently for maximum petroleum generation and formation of an over-pressured condition (Figure 4.2-5). The deep southwestern flank of the Central Syncline was regarded by Beyer (1995) as the most favorable location for potentially productive continuous source-rock reservoirs.

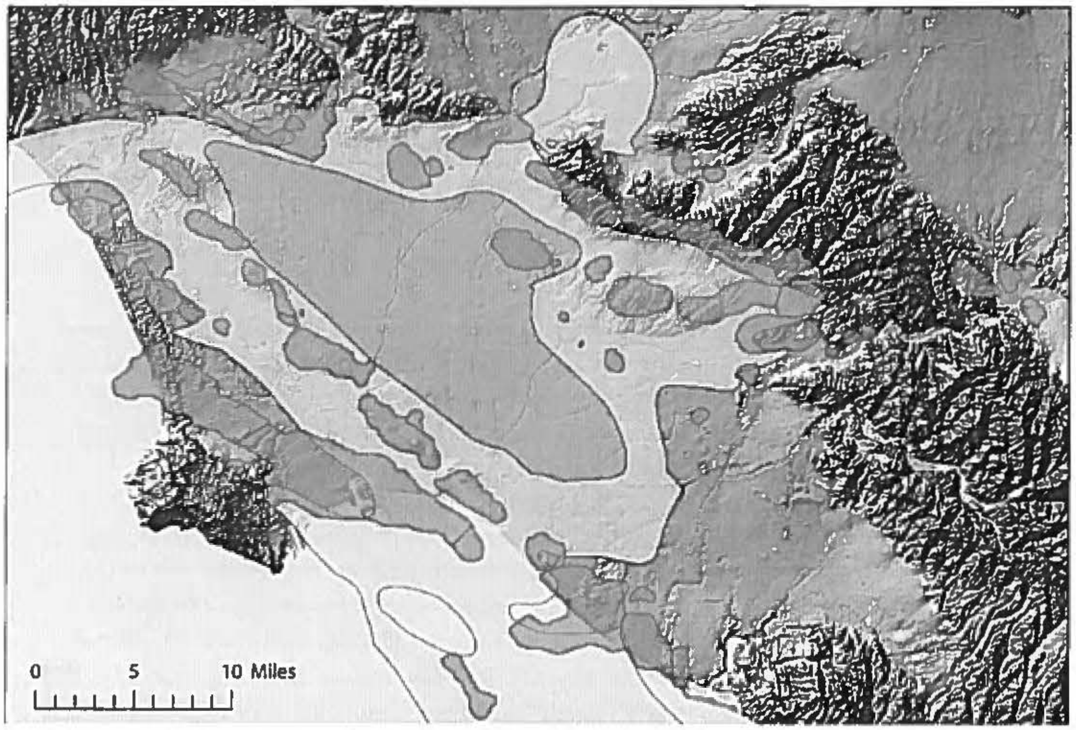

Figure 4.2-5. Map showing shaded relief topography of the Los Angeles Basin, with oil fields shown on Figure 4.2-4 in dark green and the areas where Monterey-equivalent (Mohnian-age) strata are at depths of 2,400 m (8,000 ft) or more and 14,000 feet (4,300 m) or more,shown in light green and red, respectively. Oil field outlines from DOGGR, and Monterey-equivalent depths from Wright (1991). There area in red approximately corresponds to the deepest part of the Central Syncline of the basin.

The postulated fracturing of potential reservoir rocks is inferred to result from extremely high pore fluid pressures formed during maturation of kerogen in organic-rich shales. Late Miocene and early Pliocene extensional faulting and more recent tectonic compression may also contribute to fracturing. Natural fractures are thought to provide efficient pathways for oil expulsion and migration away from source rocks. The likelihood of natural fracturing thus may constitute a technical risk to the potential shale oil play. However, the presence of overpressuring in the APCCH suggests that at least some seals remain intact and that at least some oil is retained. Several petroleum geochemists, including Price (1994), have suggested that large amounts of generated hydrocarbons may remain in or near source rocks in basins where expulsion routes have not been effectively provided by tectonics; an example of this phenomenon would be the large quantity of oil retained by the Bakken Formation in North Dakota.

The postulated continuous-type play is unexplored. The APCCH confirmed the presence of hydrocarbons and overpressuring, but did not directly demonstrate the play, as its total depth did not reach the reservoir level. Other, less deep, wells west of the Central Syncline on the east flank of the Newport-Inglewood Zone have penetrated interbedded sandstone and shale containing marine kerogen in lower Mohnian strata. Recently, hydraulic fracturing has been applied to a number of deep wells in the Inglewood oil field to enhance oil recovery (Cardno ENTRIX, 2012), and perhaps to test the concept of an unconventional source-rock system play in the Los Angeles Basin.

The geological evidence suggests that large volumes of hydrocarbons were generated from source rocks in the Central Syncline, and that at least some oil remains. However, the idea that large recoverable volumes of petroleum are present at great depth in suitable reservoir rocks is hypothetical. Moreover, because of the likely highly fractured condition of the potentially productive source rock intervals, the degree to which hydraulic fracturing would be needed for development of this hypothetical play is also a subject of speculation. The presence of at least some recoverable oil in fractured reservoirs closely associated with source rocks in the deep Central Syncline has been demonstrated by the APCCH. Burial history modeling and the occurrence of overpressured oil in the APCCH suggests that the potential shale play would be at depths of 4,270 m (14,000 ft) or more in the Central Syncline. These possible "shale oil" resources would be located beneath the central Los Angeles Basin, largely outside existing oil field boundaries (Figure 4.2-5). Testing their development potential would require drilling deep wells specifically targeting the shale oil potential.

4.2.5.4 Summary of Resource Potential

The available geological, drilling, and production data suggest that oil development in the Los Angeles Basin is likely to continue to focus on existing fields rather than on widespread development of previously undeveloped source-rock (shale tight oil) resources. Undiscovered conventional fields may contain hundreds of millions of barrels of oil, but they would probably be scattered around the basin in mostly small to medium-size accumulations. The largest remaining quantities of recoverable oil are believed to be in existing fields. The ten largest conventional fields are estimated to still contain in the range of 0.22 to 0.89 billion m^3 (1.4 billion to 5.6 billion barrels) of oil that could be recovered with today's technology, and large volumes of additional oil may be present in the other 58 named fields of the basin. This remaining oil would probably be easier and cheaper to develop on a large scale than would postulated unconventional resources in deeply buried source rocks outside of existing fields.

Production of the remaining recoverable oil in existing fields might be enhanced by hydraulic fracturing, such as has been used recently in Inglewood, Brea-Olinda and Wilmington-Belmont fields. As costs of hydraulic fracturing have come down, it is becoming a common practice, even in Los Angeles. Widespread massive hydraulic fracturing is probably not essential for additional oil production. Instead, water flooding, carbon dioxide injection, and thermally enhanced oil recovery methods such as steam injection, could probably be used to produce most of the remaining oil, with or without hydraulic fracturing. However, any large-scale new petroleum development in Los Angeles would probably require technological innovations to reduce potential conflicts with the urban population.

Assuming the recoverable source-rock resources exist, our analysis suggests that even with social acceptance by the local population, geological and petroleum engineering obstacles would need to be overcome prior to a full build-out of a source-rock play in the Los Angeles Basin. Moreover, the quantity of oil that could be recovered from such source rocks is highly uncertain.

4.2.6. Summary of Findings

- The Los Angeles Basin is extremely rich in petroleum.
- No petroleum province of comparable size underlies such a populated urban area.
- The largest onshore fields in the basin were discovered before 1933.
- Exploratory ("wildcat") drilling largely ceased by 1980.
- Oil production in most fields has been declining for years.
- Oil fields were developed inefficiently, and much recoverable oil remains in existing fields. Remaining undiscovered conventional oil fields are probably relatively small and scattered.
- A source-rock (shale oil) play is hypothetically possible in the deeper parts of the basin, largely outside of existing fields.
- Given the large quantities of recoverable petroleum remaining in conventional oil fields, large-scale development of continuous-type oil source rocks outside of existing fields is considered unlikely in the near future.
- Technological innovation is probably necessary for any widespread new petroleum development in the basin.

4.3. Public Health Risks Associated with Current Oil and Gas Development in The Los Angeles Basin

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4.3.1. Abstract

The Los Angeles Basin has among the highest concentrations of oil in the world, and simultaneously is home to a global megacity. Oil and gas development in Los Angeles occurs in close proximity to human populations. In this case study, we investigate locations of currently active oil and gas development, the proportion of these wells that have been enabled or supported by well stimulation treatments, the emissions of criteria air pollutants and toxic air contaminants from this development, and the numbers and demographics of residents and sensitive receptors (schools, daycare centers, residential elderly care facilities) in close proximity to these operations. We then assess potential risks to potable groundwater posed by hydraulic fracturing in the Los Angeles Basin.

The public health proximity analysis elucidates the location of populations that might be disproportionately exposed to emissions of criteria air pollutants and toxic air contaminants from the development of oil and gas. With few exceptions, most of the documented air pollutant emissions of concern from oil and gas development are associated with oil and gas development in general and are not unique to the well stimulation process. In the Los Angeles Basin, approximately 1.7 million people live, and large numbers of schools, elderly facilities, and daycare facilities are sited, within one mile of an active oil and gas well—and more than 32,000 people live within 100 meters (328 feet) of such wells. Even where the proportion of the total air pollutant emission inventory directly or indirectly attributable to well stimulation and oil and gas development in general is small, atmospheric concentrations of pollutants near oil and gas production sites can be much larger than basin or regional averages, and can present risks to human

health. Studies from outside of California indicate that community public health risks of exposures to toxic air contaminants (such as benzene and aliphatic hydrocarbons) are most significant within ½ mile (800 meters or 2,625 feet) from active oil and gas development. These risks will depend on local conditions and the types of gas and petroleum being produced. Actual exposures and subsequent health impacts in the Los Angeles Basin may be similar or different, but they have not been measured.

The results of our groundwater risk investigation, based upon available data, indicate that a small amount of hydraulic fracturing in the Los Angeles Basin has occurred within groundwater with <10,000 mg/L total dissolved solids (TDS) and in close proximity to groundwater with <3,000 mg/L TDS. This creates a risk of hydraulic fractures extending into or connecting with protected groundwater and creating a possible pathway for human exposures to chemicals in fracturing fluids for those that rely on these water resources.

4.3.2. Introduction

As described by Gautier in Section 4.2 above, the Los Angeles Basin is one of the most petroleum-rich basins on earth (Barbat, 1958; Biddle, 1991; Gardett, 1971; Wright, 1987; Yerkes et al., 1965). Oil development has occurred in this region since the 1800s and continues today. As reported in Volume I, well stimulation—hydraulic fracturing and acidizing—occurs in this basin, but the Los Angeles Basin is a distant second to the San Joaquin Valley in terms of total oil development and the fraction of oil and gas production enabled with stimulation treatments.

The Los Angeles Basin, in general, has relatively high population density and simultaneously hosts intensive oil and gas development. Given this high population density, the environmental public health dimensions of upstream oil and gas development in the Los Angeles Basin differ from those in other basins. For instance, while any industrial activities that emit criteria air pollutants and toxic air contaminants (TACs) in areas of low human population density create human health risks, conducting the same industrial processes in dense urban areas exposes a larger number of people to risks and as such, increases population health risks.

In this case study we examine the proximity of human populations—including vulnerable populations and sensitive receptors such as schools, daycare centers and residential elderly care facilities—to currently active oil and gas wells and those wells that have been stimulated. Many health hazards of well-stimulation-enabled oil and gas development that have been identified in the peer-reviewed literature and in Volume II, Chapter 6 of this report are indirect; that is, the hazards are not directly attributable to well stimulation. However, these hazards are an effect of potential exposures associated with enabled oil and gas development. The corollary to this is that many of the health impacts we discuss as due to proximity to stimulated wells will likely be the same for proximity to all oil and gas wells, whether they are stimulated or not. This is particularly relevant in California, where high-volume hydraulic fracturing—which, due to its large scale, is a far more industrially intensive process—is rarely conducted in California and only once in the Los Angeles Basin (Cardno ENTRIX, 2012) as a test well under likely non-generalizable conditions. In Volume II, Chapter 3 (Air Quality) the TACs that are known to be emitted from oil and gas development are not specific to stimulation fluids or stimulation processes (also see Volume II, Chapter 6 for a deeper explanation of this issue). Further, available data in California only allows for analyses of total air pollutant emissions from all oil and gas development, and the proportion from stimulation can only be estimated.

In light of the urban density of the Los Angeles Basin and findings from Volume II, Chapter 3 (Air Quality), this case study focuses primarily on potential public health hazards and risks associated with the development of oil and gas—in general and from wells that have been stimulated—from an air quality perspective. As such, this case study evaluates existing data about the public health implications of oil and gas development in a densely populated mega-city. In turn, it compensates for the lack of adverse health outcome data by investigating information on risk factors that suggest, but does not confirm with certainty, the risks to human health. The precepts of the field of public health include an emphasis on the anticipation of risk to human health even though the impact of these risks has not been proven. A primary goal of public health research is to anticipate and prevent harm rather than observe harm after if has occurred.

First, we examine the public health literature pertinent to the intersection of public health and oil and gas development. We then analyze available California state inventories on emissions of criteria air pollutants and TACs from upstream oil and gas development. From our assessment of air pollutant emissions, we distinguish which contaminants from oil and gas development in the Los Angeles Basin pose concerns, and we look more closely at the health risks of inhalation of benzene in particular. Given the fact that benzene levels may be elevated near active oil and gas production wells of all sorts, we examine the proximity of the population to active oil and gas wells, as well as the fraction of those active wells that were stimulated. With this approach, we assess human health risks in the context of all oil and gas development, rather than the smaller portion of the risks associated with only stimulation-enabled oil and gas development.

Finally, we examine the possibility that water supply in the Los Angeles Basin could become contaminated due to hydraulic fracturing and oil and gas development enabled by hydraulic fracturing.

Noise pollution, light pollution, industrial accidents, and truck traffic are also potentially important environmental stressors associated with well-stimulation-enabled and other types of upstream oil and gas development. These factors are covered in Volume II, Chapter 6, but are outside of the scope of this case study.

4.3.3. Air Pollution Attributable to Upstream Oil and Gas Development and Public Health Risks in the Los Angeles Basin

4.3.3.1. Background and Scientific Basis for Focus on Air Quality

There have been few epidemiological studies that measure health effects associated with oil and gas development enabled or supported by well stimulation, and there have been none in California. The studies that have been published are focused on exposures to toxic air contaminants or TACs (many TACs are referred to as "hazardous air pollutants" outside of California) while fewer studies have evaluated associations between oil and gas development and exposure to water contamination.

Each of the studies discussed in Volume II, Chapter 6 (Human Health), and again discussed below in this subsection has limitations in study design, geographic focus, and capacity to evaluate associations between cause and effect. These studies suggest that health concerns attributable to air pollution from oil and gas development are not specifically direct effects of the well stimulation process, but rather health damaging air pollutant emissions are associated with indirect effects of oil and gas development in general. For example, the studies in Colorado (McKenzie et al., 2012; McKenzie et al., 2014) found that the most likely driver of poor health outcomes were aliphatic hydrocarbons and benzene. These compounds are part of the hydrocarbons in the reservoir and so they are co-produced and co-emitted with oil and gas production and processing. It is important to note that available human health studies are insufficient to accurately understand the potential air impacts of direct well stimulation activities, which may expose both site workers and local communities to higher air concentrations of a different mixture of chemicals than would be experienced during enabled-production activities.

Finally, a broad conclusion in many of the studies discussed in Volume II, Chapter 6 (Human Health) and below is that distance from oil and gas development matters in terms of potential human health hazards, primarily associated with exposure to TACs.

4.3.3.2. Summary of Air Pollution and Public Health Study Findings

The environmental public health literature suggests that one of the primary toxic air contaminant (TAC) exposure risk factors associated with oil and gas development is geographic proximity to active oil development (see Volume II Chapter 6). This is further corroborated by atmospheric studies on dilution of conserved pollutants such as benzene once emitted to the atmosphere (United States Environmental Protection Agency (U.S. EPA), 1992). While oil and gas development throughout the U.S.—both enabled by hydraulic fracturing and in general—has been linked to regional air quality impacts (Pétron et al., 2012; Pétron et al., 2014; Thompson et al., 2014; Helmig et al., 2014; Roy et al., 2013), a number of TACs have been observed at even higher concentrations in close proximity to where active oil and gas development takes place (Macey et al. 2014;

Colborn et al., 2014; Brown et al., 2014; Brown et al., 2015). Additionally, an analysis by Brown et al. (2014) found that there might be intermittent spikes in emissions from activity and infrastructure during oil and gas development. A study on air pollutant emissions during hydraulic fracturing activities conducted by Allen et al. (2013) also found that spikes in emissions of methane and associated volatile organic compounds (VOCs) occurred during liquid unloadings. While intermittent spikes in emission may not impact regional atmospheric concentrations, they are likely to be associated with increased exposures to local populations in close proximity to the source of emission activity. Thus, regional concentrations of air pollutants may provide estimates of low- to moderate-level chronic exposures experienced by a regional population, but it is important to consider the proximity of receptors to sources in order to capture the range of potential public health risks.

Using United States Environmental Protection Agency (U.S. EPA) guidance to estimate chronic and sub-chronic non-cancer hazard indices (HIs) as well as cancer risks, a study in Colorado suggested that those living in closer geographical proximity to active oil and gas wells (≤ 800 m; 0.5 mile or ≤ 2,640 feet) were at an increased risk of acute and sub-chronic respiratory, neurological, and reproductive health effects, driven primarily by exposure to trimethyl-benzenes, xylenes, and aliphatic hydrocarbons. It also suggested that slightly elevated excess lifetime cancer risk estimates were driven by exposure to benzene and aliphatic hydrocarbons (McKenzie et al., 2012). The findings of this study are corroborated by atmospheric dilution data of conserved pollutants, for instance a U.S. EPA report on dilution of conserved TACs indicates that the dilution at 800 m (0.5 mile) is on the order of 0.1 mg/m^3 per g/s (U.S. EPA, 1992). Going out to 2,000 m (6,562 ft) increases this dilution to 0.015 mg/m^3 per g/s, and going out to 3,000 m (9,843 ft) increases dilution to 0.007 mg/m^3 per g/s. Given that, for benzene, there is increased risk at a dilution of 0.1 mg/m^3, it is not clear that atmospheric concentrations of benzene out to 2,000 m and 3,000 m (6,652 ft and 9,843 ft) can necessarily be considered safe. However, beyond 3,000 m (9,843 ft), where concentrations fall more than two orders of magnitude via dilution relative to the ½ mile radius, there is likely to be a sufficient margin of safety for a given point source.

In contrast, an oil and gas industry study in Texas compared volatile organic compound (VOC) concentration data from seven air monitors at six locations in the Barnett Shale with federal and state health-based air concentration values (HBACVs) to determine possible acute and chronic health effects (Bunch et al., 2014). The study found that shale gas activities did not result in community-wide exposures to concentrations of VOCs at levels that would pose a health concern. The key distinction between McKenzie et al. (2012) and Bunch et al. (2014) is that Bunch and colleagues used air quality data generated from monitors focused on regional atmospheric concentrations of pollutants in Texas, while McKenzie et al. (2012) included samples at the community level. Finer geographically scaled air sampling often captures local atmospheric concentrations that are more relevant to human exposure than sampling at the regional scale (Shonkoff et al., 2014).

Arriving at similar results as the Bunch et al. (2014) study, a cursory public health outcome study was conducted by the Los Angeles County Department of Public Health near the Inglewood Oil Field in Los Angeles County in 2011 (Rangan et al., 2011). This study compared incidence of a variety of health endpoints including all cause mortality, low birth weight, birth defects, and all cancer among populations nearby the Inglewood Oil Field and Los Angeles County as a whole. The study found no statistically significant difference in these endpoints between these two populations. While this may seem to indicate that there is no health impact from oil and gas development, as the study notes, the epidemiological methods employed in this study do not allow it to pick up changes in "rare events" such as cancer and birth defects in studies with relatively small numbers of people. In addition to this study being underpowered, the Inglewood Oil Field Study is a cluster investigation with exposure assigned at the group level (i.e., an ecological study). It also appears that only crude incidence ratios were calculated. This type of study design is insufficient for establishing causality and has many major limitations, including exposure misclassification and confounding, which may have obscured associations between exposure to environmental stressors from oil and gas development and health outcomes.

Using a community-based monitoring approach, Macey et al. (2014) analyzed air samples from locations near oil and gas development in Arkansas, Colorado, Ohio, Pennsylvania, and Wyoming found levels for eight volatile chemicals, including benzene, formaldehyde, hexane, and hydrogen sulfide, exceeded federal guidelines Agency for Toxic Substances and Disease Registry (ATSDR) minimal risk levels (MRLs) and U.S. EPA Integrated Risk Information System (IRIS) cancer risk levels in a number of instances (Macey et al., 2014). Of the 35 grab samples taken in the study, 16 contained chemicals at concentrations that exceeded these health-based risk levels, and those samples that exceeded thresholds were mostly collected in Wyoming and Arkansas. Fourteen out of 41 passive samples collected for formaldehyde exceeded health-based risk levels, and these were mostly collected in Arkansas and Pennsylvania. No samples collected in Ohio contained chemicals with concentrations exceeding health-based risk levels. The Macey et al. (2014) study does not specify whether or not well stimulations were used in the oil development being monitored. Importantly, the chemicals that exceeded health-based risk levels were primarily detected in samples collected near separators, gas compressors, and discharge canals.

Macey et al. (2014) noted two exceedances of hydrogen sulfide concentrations reported in samples collected near an operation that may have involved well stimulation. One was collected near a work-over rig and the other near a well pad. The residents who collected the samples self-reported a number of common health symptoms, including "headaches, dizziness or light-headedness, irritated, burning, or running nose, nausea, and sore or irritated throat" (Macey et al., 2014). This study suggests that concentrations of hazardous air pollutants near oil and gas development operations may be elevated to levels where health impacts could occur, although epidemiological studies would need to be performed to understand the extent to which health impacts have occurred. As noted elsewhere in Volume II, Chapter 6, and throughout this case study, the hazardous air pollutants observed in this study are all not directly attributable to well stimulation (e.g., they are not often added to well stimulation fluids), but rather are compounds that are co-produced with the development of oil and gas in general.

In addition to population health hazards at varying distances from active oil and gas development, other studies have assessed the effect of the density of oil and gas development on health outcomes. In a retrospective cohort study in Colorado, McKenzie et al. (2014) examined associations between maternal residential location and density of oil and gas development. The researchers found a positive dose-response association between the prevalence of some adverse birth outcomes, including congenital heart defects and increasing density of natural gas development (McKenzie et al., 2014). The observed risk of congenital heart defects in neonates was 30% (odds ratio (OR) = 1.3 (95% confidence interval (CI): 1.2, 1.5)) greater among those born to mothers who lived in the highest density of oil and gas development (> 125 wells per mile) compared to those neonates born to mothers who lived with no oil and gas wells within a 16 km (10-mile) radius. Similarly, the data suggest that neonates born to mothers in the highest density of oil and gas development were twice as likely (OR = 2.0, 95% CI: 1.0, 3.9) to be born with neural tube defects than those born to mothers living with no wells in a 10-mile radius (McKenzie et al., 2014). The study, however, showed no positive association between the density and proximity of wells and maternal residence for oral clefts, preterm birth, or term low birth weight. The authors of this retrospective cohort study report that one explanation given for the observed increased risk of neural tube defects and congenital heart disease with increasing density of gas development could be increased atmospheric concentrations of benzene, a compound known to be associated with both of these conditions (Lupo et al., 2011). However, given that there was no air quality monitoring or field-based exposure assessment, this study may suffer from exposure misclassification.

It should be noted that the presence and concentration of VOCs that are known air toxics associated with oil and gas development, such as benzene, varies between and within oil and gas reservoirs throughout the United States and abroad. The presence and concentration of these TACs in the source (the oil and gas reservoir) partially drives the potential emissions of benzene and other natural gas liquids; if they are more concentrated, it is more likely that they could be emitted. As such, on this point, there is uncertainty as to how directly applicable current out-of-state public health studies on oil and gas development may be to California. However, as noted in our analysis below, benzene emissions from upstream oil and gas development in the Los Angeles Basin are a significant percentage of the total South Coast Air Basin benzene emission inventory from all sources.

Given that exposures to conserved air pollutants (that tend to not be strongly reactive in the atmosphere) such as benzene decrease with distance from a pollutant source and approach background or regional exposures at some distance (U.S. EPA, 1992)—as explained above and in Volume II, Chapter 6 (Human Health)—the question arises, "How far is far enough to protect human health?" Residents and sensitive receptors near oil and gas wells—stimulated or not—may be more exposed either acutely or chronically to TACs emitted by oil and gas development compared to the general population. California has no setback requirement for oil and gas development, well-stimulation-enabled or otherwise, but some local jurisdictions have set minimum distances from which oil and gas development and associated ancillary infrastructure is allowed to be from residences and sensitive receptors. In the United States, setback distances range from 91 m (300 ft) in Pennsylvania to 457 m (1,500 ft or 0.28 miles) in the Dallas-Fort Worth metropolitan area, in order to reduce potential exposures of human populations to air pollutant emissions, odors, noise, and other environmental stressors (City of Dallas, 2013; Richardson et al., 2013).

4.3.3.3. The Context of Air Quality Non-Attainment in the Los Angeles Basin

The South Coast Air Basin has historically had very poor air quality, with portions of the region often in non-attainment for national and state ambient air quality standards. For example, in 2014, the Los Angeles-Long Beach area was listed #1 in ozone pollution (see Figure 4.3-1), #3 in year-round particulate matter pollution, and #4 in short-term particle pollution (see Figure 4.3-2) out of all cities in the United States (American Lung Association (ALA), 2015). The reasons for poor air quality in the Los Angeles Basin are myriad—from the diverse mobile and stationary emission sources to the topographical characteristics that discourage the transport of atmospheric pollutants out of the basin (ALA, 2015).

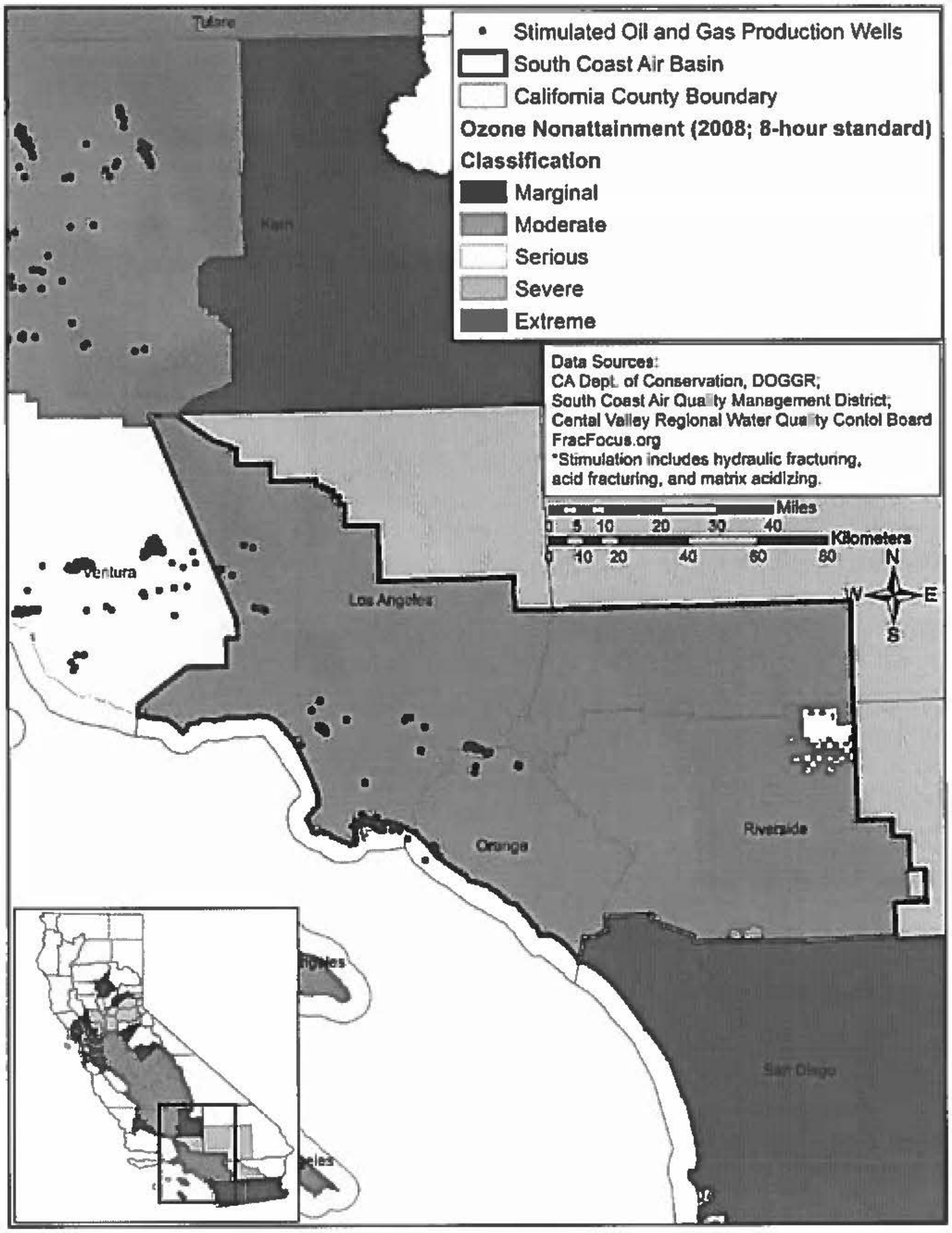


Figure 4.3-1. Ozone attainment by county in California. Note that the South Coast Air Basin (Los Angeles County, Orange County, and part of Riverside Countyy are in extreme non-attainment status.

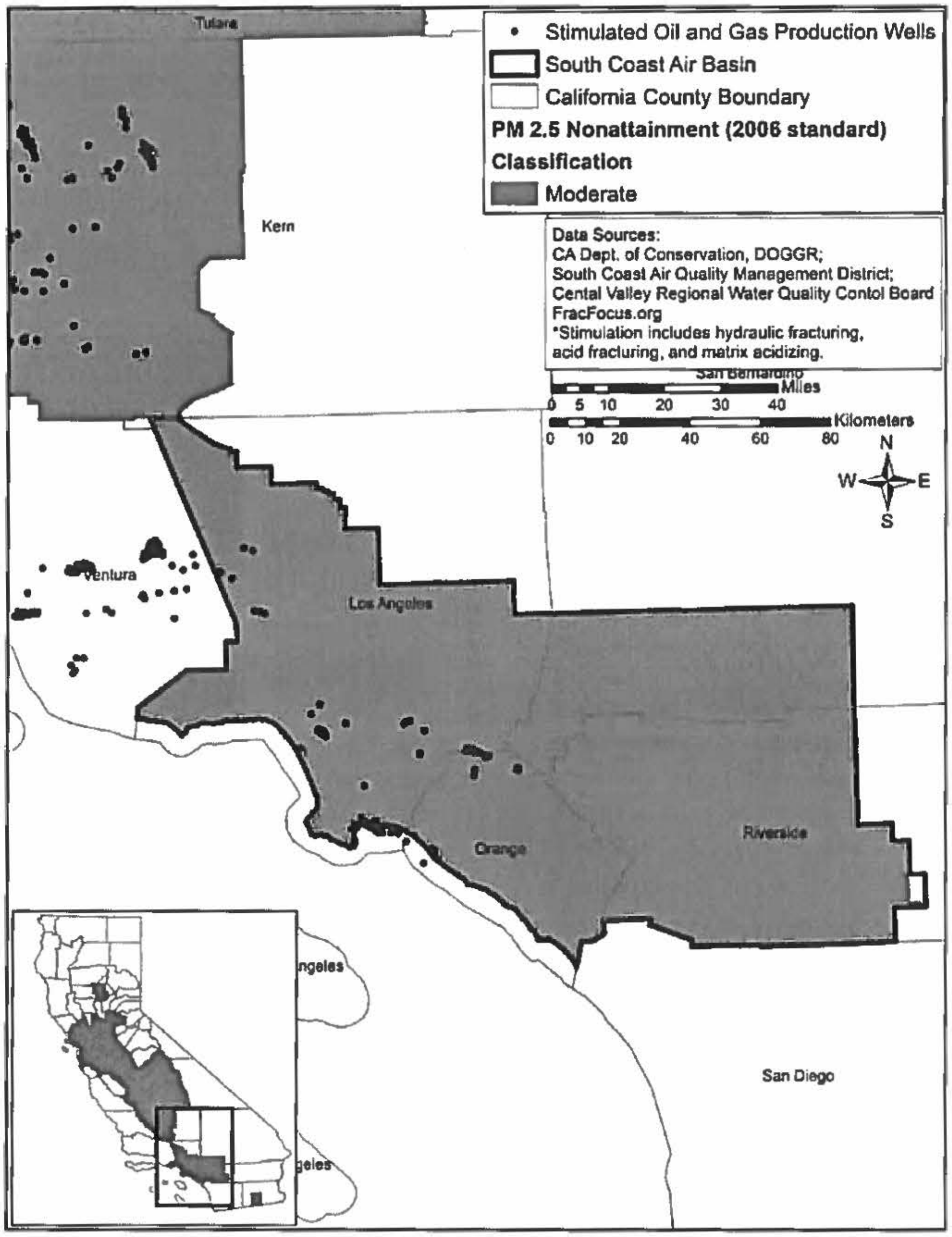


Figure 4.3-2. $PM_{2.5}$ attainment by county in the South Coast Air Basin on California. Note that. the South Coast Air Basin is in moderate non-attainment status.

Data suggests that environmental public health risks associated with an emission source should be approached from a cumulative risk perspective that takes into account the air pollution context within which these emissions occur (Pope et al., 2009). The California Air Resources Board (CARB) and the United States Environmental Protection Agency (U.S. EPA) have noticed this issue and now conduct air pollution and public health assessments in the context of a cumulative risk framework (Sadd et al., 2011). Populations exposed to cumulative air pollution burdens from multiple sources tend to be at increased risk of negative health impacts compared to populations that are exposed to lower concentrations of air pollutants from fewer sources (Morello-Frosch 2002; Morello-Frosch et al., 2010; Morello-Frosch et al., 2011).

Due to the air quality issues of the Los Angeles Basin, populations in this region are often exposed to elevated atmospheric concentrations of air pollutants (e.g., benzene, particulate matter, and VOCs), many of which are emitted by oil and gas development as well as numerous other sources within the Basin. Any additional emissions of volatile organic compounds, reactive organic gases (ozone precursors), nitrogen oxides, particulate matter, and TACs from the development of oil and gas (enabled by stimulation or not) in this region stacks additional emissions upon the cumulative air pollution burden that populations are already disproportionately exposed to.

4.3.3.4. Regional Air Pollutant Emissions in the Los Angeles Basin

Air pollutant emissions in the South Coast Region are discussed in Volume II, Chapter 3. In that volume, emissions of criteria air pollutants, greenhouse gases, and TACs are discussed, and emissions by air districts are derived from regional inventories. In Volume II, the South Coast Air Quality Management District (SCAQMD) is used as the indicator region of interest for the Los Angeles Basin.

Counties are the only common jurisdiction where all oil and gas development occurs in the Los Angeles Basin. We henceforth focus our regional air pollutant emission analysis on Los Angeles and Orange counties (See Figure 4.3-1. above), including fields partially or fully contained in the offshore areas of these counties, as per DOGGR definitions. These counties contain nearly all oil production in the greater Los Angeles metropolitan area. These counties also line up with the most populous regions of the South Coast Air Quality Management District, although that district contains some portions of nearby suburban regions (e.g., parts of Riverside and San Bernardino counties). Therefore, the alignment between these counties and the SCAQMD is expected to be generally close. These counties also do not contain production in the Santa Barbara/Ventura regions, which are not included in the SCAQMD and suffer from fewer air quality impacts.

In this case study, we take a more detailed look at regional contributions of air pollutants from all active oil and gas development, as well as that enabled or supported by well stimulation within the South Coast Region. In order to make these estimations, we join datasets from DOGGR and CARB air pollution inventories. Because DOGGR regional jurisdictions do not align with CARB air districts, we perform an analysis using counties as the regions of interest.

The data in regional inventories are not of sufficient spatial resolution to allow emissions estimates of TACs and reactive organic gases (ROGs) at the local level, and a full photochemical modeling assessment is beyond the scope of this report. Only two studies, neither of which is peer-reviewed, have attempted to answer these questions. Sonoma Technology, Inc. (2015) conducted monitoring of particulate matter (measured as black carbon as a surrogate) and limited monitoring of VOCs and heavy metals at four sites near the periphery of the Inglewood oil field. The study found a marginal contribution of particulate matter (PM) emissions that was only a small fraction of total PM emissions in the region. There were similar findings for VOCs. It is not clear, however which operations were active and at what geographic distance from the air pollutant monitors, and as such, the interpretation of these data is limited.

4.3.3.4.1. Emission Inventory Estimate of Air Pollutants from All Sources in the South Coast Region

Estimates of criteria air pollutant and TAC emissions from all active upstream oil and gas activities, and the fraction of these activities that are supported or enabled by well stimulation, requires information on total emissions of criteria air pollutants and TACs in the region of interest. From the most recent CARB criteria air pollutant inventory from 2012, emissions of criteria air pollutants from all sources in the South Coast Region are summarized in Table 4.3-1. TAC emissions for ten indicator TACs discussed in Volume II, Chapter 3, are listed in Table 4.3-2. These TAC emissions are derived from the California Toxics Inventory for 2010, reported by county for all sources, including point sources, aggregated point sources, area wide sources, diesel sources, gasoline sources, and natural sources. While many TAC species are co-emitted during hydrocarbon development (see Volume II, Chapter 3), these 10 species are prevalent in hydrocarbon production and of human health relevance. In the following sections, we evaluate the subset of these data that is attributable to all active oil and gas development, and then the portion of that which is associated with active oil development from wells that have been stimulated.

Table 4.3-1. Total emissions in 2012 of criteria air pollutants and ROGs in the South Coast Region from all sources (tones/d).

Pollutant	Los Angeles County	Orange County	South Coast Region
Reactive organic gases (ROG)	267.8	87.2	355.0
Nitrogen oxides (NO_x)	330.2	79.0	409.2
Sulphur oxides (SO_x)	14.5	1.5	16.0
PM_{10}	90.3	21.4	111.7
$PM_{2.5}$	39.1	9.7	48.8

Table 4.3-2. Total emissions in 2010 of selected TACs in the South Coast Region from all sources (tonnes/y). Data from California Toxics Inventory (CTI) county-level data.

	Los Angeles County	Orange County	South Coast Region
1,3-Butadiene	293.2	89.1	382.3
Acetaldehyde	1,238.7	313.5	1,552.1
Benzene	1,239.6	419.6	1,659.2
Carbonyl sulfide	0.0	0.0	0.0
Ethyl Benzene	749.1	251.1	1,000.2
Formaldehyde	1,827.0	548.2	2,375.1
Hexane	1,197.6	410.7	1,608.3
Hydrogen Sulfide	6.2	0.0	6.2
Toluene	5,050.1	1,810.0	6,860.2
Xylenes (mixed)	937.2	338.3	1275.5

4.3.3.4.2. Emission Inventory Estimate of Air Pollutants from All Upstream Oil And Gas Development Activities in the South Coast Region.

Here, we estimate the contribution to South Coast air pollutant emissions from all upstream oil and gas development activities. We combined emissions of criteria pollutants and TACs reported above in Tables 4.3-1 and 4.3-2 with estimates of active oil development activities in the counties of interest. As described in detail in Volume II, Chapter 3, a variety of sources in the criteria pollutants inventory and facility-level toxics database can be linked to the oil and gas industry.

In order to estimate criteria pollutant emissions from the oil and gas sector in the South Coast Region, we sum the emissions from the following sources (see Volume II, Chapter 3, for a detailed listing of the constituent subsectors and sources and attributes of each emission inventory):

- Stationary sources + petroleum production and marketing + oil and gas production + all subsectors and sources
- Stationary sources + fuel combustion + oil and gas production (combustion) + all subsectors and sources
- Mobile sources + other mobile sources + off-road equipment + oil drilling and workover

The oil and gas sector will also likely cause emissions from use of on-road light and heavy-duty trucks (e.g., maintenance trucks used in non-drilling operations and therefore not included in the "Oil drilling and workover" subsector). We cannot differentiate these emissions using reported inventory information (on-road vehicles are classified by weight class rather than industry).

Table 4.3-3 below shows the result of summing all oil- and gas-sector sources in the South Coast Region. We report the estimate from our bottom-up inventory analysis. It should be noted that recent top-down analyses of methane have noted that the methane emission inventory may be underestimated by two to seven times what is reported in the emissions inventories (Peischl et al., 2013; Jeong et al., 2013). Emissions of methane may provide insight into the emission of light alkane VOCs (a subset of ROGs) and to a certain extent, TACs, as they are often co-emitted during oil and gas development processes. As such, the values provided below should be taken as a conservative estimate of emissions from this sector. More field-based research should be conducted to understand to what degree the criteria air pollutant emission inventories are accurate and how to improve them. Additionally, these publicly available data do not allow us to analyze the geographic, corporate, or facility distribution of emissions, only the total amount emitted by the entire upstream oil and gas sector. For a detailed assessment of the discrepancy between these bottom-up inventories and recent field-based monitoring, see Volume II, Chapter 3.

Table 4.3-3. Contribution of upstream oil and gas sources to criteria pollutants and ROGs emissions in South Coast Region, data for 2012. (tonnes/d).

	ROG	NO_x	SO_x	PM_{10}	$PM_{2.5}$
Stationary oil and gas	0.99	1.64	0.02	0.09	0.09
Mobile oil and gas	0.09	1.06	0.00	0.04	0.04
Total oil and gas	1.08	2.70	0.02	0.12	0.12
Oil and gas fraction of all sectors	0.31%	0.66%	0.12%	0.11%	0.25%

Table 4.3-4. lists upstream oil and gas development stationary source facility-reported contributions to selected TACs in the South Coast Region. It also lists all source emissions of these TACs for 2010 in comparison (most recent year for which data are available). In addition, a number of potential TACs are injected into formations as part of fracturing fluids, as noted in SCAQMD datasets. These potential TACs are discussed in Volume II, Chapter 3.

Hydrogen sulfide and carbonyl sulfide emissions were not reported from the upstream oil and gas sector in the South Coast Region (Table 4.3-4). The reporting facilities in the state inventories include refineries and landfills, but none of the oil production sectors. As these compounds are reported in the San Joaquin Valley, they are likely also emitted in the South Coast Region. Moreover, a U.S. EPA preliminary risk assessment places carbonyl sulfide near the top of its table of emissions of TACs by mass from studied facilities (U.S. EPA, 2011). The lack of records could be a reporting loophole or an error in the database, and deserves further investigation. Because these data are missing, the proportion of the total emissions of hydrogen sulfide and carbonyl sulfide emissions attributable to upstream oil and gas development in the Los Angeles Basin remains unknown.

Table 4.3-4 Contribution of upstream oil and gas sources to TAC emissions in South Coast Region (kg/y). Fraction is approximate because all source inventory of TACs was last completed for year 2010 emissions.

	Stationary oil and gas sources (kg/y) (2012)	Fraction of emissions from stationary sources	Emissions from all stationary and mobile sources (kg/y) (2010)	Fraction of all emissions from all sources (kg/y) (stationary and mobile)
1,3-Butadiene	56	1.60%	382,307	0.01%
Acetaldehyde	1	0.00%	1,552,128	0.00%
Benzene	2,361	9.60%	1,659,155	0.14%
Carbonyl sulfide	not available	not available	20	not available
Ethyl Benzene	28	0.50%	1,000,213	0.00%
Formaldehyde	5,846	3.80%	2,375,149	0.25%
Hexane	1	0.00%	1,608,302	0.00%
Hydrogen Sulfide	not available	not available	6,238	not available
Toluene	1	0.00%	6,860,168	0.00%
Xylenes (mixed)	1	0.00%	1,275,480	0.00%

4.3.3.4.3. Emission Inventory Estimate of Air Pollutants Attributable to Well Stimulation-Enabled Upstream Oil and Gas Development in the South Coast Region

Following the methodology used in Volume I to identify hydrocarbon pools considered to be facilitated or enabled by well stimulation, we generated a list of stimulated pools and fields in the South Coast Region. This list is generated from Volume I, Appendix N. DOGGR county codes that represent the South Coast Region include Los Angeles (code 37), Los Angeles Offshore (code 237), Orange County (code 59) and Orange County Offshore (code 259). These pools are presented in Table 4.3-5.

Using queries to the DOGGR well-level production database, we can sum all production from these facilitated or enabled pools in 2013 and compare this to all production in the South Coast Region. As can be seen from Table 4.3-5, the well-stimulation-facilitated or -enabled pools represented a total of 874,430 m^3 (5.5 million bbl) of production, approximately 19% of production in the South Coast Region.

Table 4.3-5. Pools in South Coast Region determined to be facilitated or enabled by hydraulic fracturing. Production derived from queries to 2013 full-year well-level DOGGR database for wells that match the field, area, and pool combinations noted to be stimulated in Volume I, Appendix N.

DOGGR county code	Field	Area	Pool	Oil production (2013 bbl)
237, 259	Belmont Offshore	Surfside Area	No Pool Breakdown	243,034
37, 59	Brea-Olinda	Any Area	No Pool Breakdown	1,111,985
37	Inglewood	Any Area	No Pool Breakdown	2,731,733
37	Montebello	West Area	No Pool Breakdown	15,299
37	San Vicente	Any Area	Clifton, Dayton and Hay	271,235
37	Whittier	Rideout Heights Area	No Pool Breakdown	31,766
37	Whittier	Rideout Heights Area	Pliocene	39,982
37, 237	Wilmington	Fault Block 90	Ford	105,564
37, 237	Wilmington	Fault Block 90	Union Pacific	503,655
37, 237	Wilmington	Fault Block 98	237	0
37, 237	Wilmington	Fault Block 98	Ford	20,604
37, 237	Wilmington	Fault Block 98	Union Pacific	18,892
37, 237	Wilmington	Fault Block I	237	6,815
37, 237	Wilmington	Fault Block IV	Ford	15,442
37, 237	Wilmington	Fault Block VII	Union Pacific (ABD)	28,902
37, 237	Wilmington	Fault Block VIII	Terminal	212,055
37, 237	Wilmington	Fault Block VIII	Union Pacific	148,305
37, 59, 237, 259	Total production from facilitated pools			5,505,268
37, 59, 237, 259	Total production in South Coast Region			29,150,660
37, 59, 237, 259	Fraction of production from facilitated or enabled pools			18.9%

We use these activity factors for production and drilling to scale the stationary source and mobile source emissions from the entire oil and gas sector. (For more information on specific emission sources used for this analysis please see Volume II, Chapter 3.) This result then generates an estimate of those emissions enabled or facilitated by well stimulation. Note that we estimate added emissions resulting from stimulation-enabled production, but do not attempt to estimate the emissions associated directly with the well stimulation activity.

We scale all stationary oil and gas related source emissions (combustion and non-combustion) shown in Table 4.3-5 by the fraction of oil production in the facilitated or enabled pools (19%). We scale mobile source off-road emissions from rigs and workover equipment shown in Table 4.3-5 by the fraction of wells drilled in facilitated or enabled pools (31%). The results of this scaling for criteria air pollutants are shown below in Table 4.3-6 and the results for the representative TACs are shown in Table 4.3-7. An important assumption inherent to this analysis is that oil and gas development has the same emission intensity across all pools. This may or may not be the case and deserves further study.

Table 4.3-6. Fraction of South Coast total criteria and TAC emissions from well stimulation facilitated or enabled pools.

	ROG	NO_x	SO_x	PM_{10}	$PM_{2.5}$
Fraction of all criteria pollutants from well stimulation-enabled oil and gas activities	0.05%	0.14%	0.02%	0.01%	0.04%

Table 4.3-7. Fraction of South Coast total toxic air contaminant emissions from well stimulation facilitated or enabled pools.

	Fraction from well stimulation enabled or facilitated pools
1,3-Butadiene	0.000%
Acetaldehyde	0.001%
Benzene	0.000%
Carbonyl sulfide	0.020%
Ethyl Benzene	0.001%
Formaldehyde	0.009%
Hexane	0.000%
Hydrogen Sulfide	0.000%
Toluene	0.049%
Xylenes (mixed)	0.000%

4.3.3.4.4. Known TACs Added to Well Stimulation Fluids in the South Coast Air Quality Management District

As noted in Volume II, Chapter 3, there are more than 30 TACs that are reported to the SCAQMD as included in hydraulic fracturing and acidizing fluids in the South Coast. While the TACs are known (See Volume II, Chapter 3), there are no data on the rate at which these TACs are emitted and in what quantity (the emission factors have not been studied) these TACs are emitted during oil and gas development. As such, it is not possible to estimate their emissions and in turn their potential risks to public health.

4.3.3.4.5. Discussion of Regional Air Pollutant Emissions from Oil and Gas Development in the South Coast Region

California inventories suggest that the upstream oil and gas development sector is likely responsible for a small fraction (<1%) of criteria pollutants emitted in the South Coast

Region. This is expected, because the South Coast Region is a comparatively small oil production region compared to the San Joaquin Valley, and is also home to large numbers of other mobile and industrial emission sources of these pollutants. We found that 2,361 kg/year of benzene is emitted by the stationary components of upstream oil and gas development in the Los Angeles Basin. This amount represents a significant proportion of stationary sources (9.6%) and a smaller proportion of benzene emissions from all sources (including mobile source emissions) (0.14%) in the South Coast Air Basin. Our state inventory analysis also indicates that 5,846 kg/year or 3.8% of the stationary source emissions of formaldehyde and <1% of all source emissions (including mobile) are attributable to the upstream oil and gas sector. Smaller proportions of other indicator TAC species were identified. These indicator TAC species included in our assessment are not used in well stimulation fluids, but rather are co-produced with oil and natural gas during development.

Since approximately only 26% of the wells currently active in the Los Angeles Basin are hydraulically fractured, emissions of TACs and ROGs are a smaller subset of those emitted by the upstream oil and gas sector in general.

The proportion of the total TAC inventory (mobile and stationary sources) attributable to upstream oil and gas development is not high, and from a regional air quality perspective, these results seem to indicate that TAC emissions from the upstream oil and gas sector are unimportant. However, from a public health perspective, fractions of total emissions are not as important as the quantity or the mass of pollutants emitted, or the location and proximity to humans where the emissions occur. Some of the TACs—especially benzene and formaldehyde and potentially hydrogen sulfide, but problems with the inventory does not allow us to be sure—are emitted in large masses (but not in large fractions of the total inventory) in the upstream oil and gas sector in a densely populated urban area. In the sections below, we discuss the implications of these TAC emissions occurring in the Los Angeles Basin in close proximity to people in general and sensitive demographics in particular.

Given that benzene is known to be highly toxic (Lupo et al., 2011) and emissions from upstream oil and gas development in the Los Angeles Basin constitute more than 2,360 kg/year (9.6%) of the total stationary source emission inventory, we briefly review the public health literature and current exposures to benzene in the South Coast Region below. Benzene is generally not included in stimulation fluids, but rather is a compound that is co-produced (and co-emitted) with oil and gas during production, processing, and other processes.

4.3.3.4.6. Discussion of Benzene and Human Health Risks

Benzene is naturally occurring in hydrocarbon deposits and is released into the air throughout the oil and gas development process (Adgate et al., 2014; Werner et al., 2015; Shonkoff et al., 2014). Other large environmental sources of benzene emissions in the Los Angeles Basin are the burning and refining of oil and gasoline, environmental tobacco smoke (second-hand cigarette smoke), and vapors emitted from gas stations (Centers for Disease Control and Prevention (CDC), 2013). Active cigarette smoking exposes individuals to elevated dosages of benzene as well, but is not considered to be an environmental source as it is at an individual level. Comparing the mass of benzene and other TAC emissions among the largest sources in the South Coast, we see that in the south coast region, mobile emissions (gasoline and diesel vehicles) are the largest contributor in the total inventory (See Volume II, Chapter 3, Table 9). In our analysis of publicly available TAC inventories, we found that 2,361 kg/year of benzene is emitted by the stationary components of upstream oil and gas development in the Los Angeles Basin. This amount represents a significant proportion of stationary source (9.6%) and a small proportion of all benzene source emissions (including mobile source emissions) (0.14%) in the South Coast Air Basin.

With the exception of when diesel is used as an ingredient—and available data suggests that such use is rare in California, as noted in Volume II, Chapter 2 and Chapter 6—benzene is not found in well stimulation fluids. Thus, benzene is a hazard that is not specific to oil and gas development that is enabled or supported by well stimulation; rather, it is a compound intrinsic to the oil and gas development process in general.

There are no studies on benzene exposure attributed to oil and gas development in the Los Angeles Basin; however, adverse human health outcomes can occur through inhalation, oral, or dermal exposure, and benzene can volatilize into the air from water and soil (ATSDR, 2007; U.S. EPA, 2007). In the Los Angeles Basin context, however, potential exposures to benzene attributable to oil and gas development are likely to occur via inhalation. Benzene is a known carcinogen (Glass et al., 2003; Vlaanderen et al., 2010) and is associated with various other health outcomes associated with chronic and acute exposures, including birth defects (Lupo et al., 2011) and respiratory and neurological effects (ATSDR, 2007). Numerous studies on oil and gas development out of state have identified benzene as a potential health risk (Helmig et al., 2014; Macey et al., 2014; McKenzie et al., 2012, 2014; Pétron et al., 2014).

Acute effects of benzene inhalation exposure in humans include the following: (1) neurological symptoms such as drowsiness, vertigo, headaches, and loss of consciousness; (2) respiratory effects such as pulmonary edema, acute granular tracheitis, laryngitis, and bronchitis; and (3) dermal and ocular effects such as skin irritation or burns and eye irritation (ATSDR, 2007; U.S. EPA, 2012). While it is not known if children are more susceptible to benzene poisoning than adults, there has been some research to measure the effects of benzene exposure among children. For instance, an association has been shown between benzene exposure and respiratory effects in children such as bronchitis, asthma, and wheezing (Buchdahl et al., 2000; Rumchev et al., 2004).

Chronic (noncancerous) effects of benzene inhalation in humans include the following: (1) hematological effects such as reduced numbers of red blood cells, aplastic anemia, excessive bleeding, and adverse effects on bone marrow; (2) immunological and lymphoreticular effects such as damage to both humoral (antibody) and cellular (leukocyte) responses; and (3) possible reproductive effects such a neural tube defects and low birth weight (Lupo et al., 2011; U.S. EPA, 2012) there have been no studies assessing the association between environmental levels of hazardous air pollutants, such as benzene, and neural tube defects (NTDs).

Cancer risks include acute and chronic nonlymphocytic leukemia, acute myeloid leukemia, and chronic lymphocytic leukemia. Based on human and animal studies, benzene is classified by the U.S. EPA in Category A (known human carcinogen).

In June 2014, the California Environmental Protection Agency Office of Environmental Health Hazard Assessment (OEHHA) finalized updated benzene reference exposure limits (RELs) (OEHHA, 2014). RELs are airborne concentrations of a chemical that are anticipated to not result in adverse non-cancer health effects for specified exposure durations in the general population, including sensitive subpopulations. The three RELs that OEHHA adopted on 27 June 2014 cover three different types of exposure to benzene in air: infrequent 1-hour exposures, repeated 8-hour exposures, and continuous long term exposure. These three RELs are as follows:

- 1-hour REL: 27 mg/m^3 (0.008 ppm; 8 ppb)
- 8-hour REL: 3 mg/m^3 (0.001 ppm; 1 ppb)
- Chronic REL: 3 mg/m^3 (0.001 ppm; 1 ppb)

Table 4.3-8 shows benzene exposure levels at multiple locations in the South Coast Air Basin. Note that while the mean exposure levels do not exceed 1 ppb on annual averages, these data do not describe 1-hour or 8-hour benzene exposure values. It should also be noted that in both years of sampling, the maximum benzene exposure values exceeded the benzene 8-hour and chronic RELs in some cases up to 350%. Moreover, in some cases, these average exposures are within 0.5 ppb and 0.18 ppb of exceeding the 8-hour and the chronic RELs, which does not leave a large margin of safety. Additionally, the standard deviations indicate that exceedances do occur, in some cases frequently. Average exposure does not take into account potentially more elevated exposures that can occur in close proximity to emission sources where atmospheric concentrations are most elevated.

Table 4.3-8. Average benzene levels (parts per billion (ppb)) at 10 fixed sites in South Coast in 2004 – 2006.

	Year 1 (4/2004 - 3/2005)				Year 2 (4/2005 – 3/2006)			
Location	Mean	SD	N	Max	Mean	SD	N	Max
Anaheim	0.44	0.28	118	1.44	0.42	0.33	115	2.06
Burbank	0.73	0.42	118	2.16	0.69	0.44	122	1.85
Central Los Angeles	0.59	0.30	117	1.83	0.57	0.31	121	1.53
Compton	0.82	0.70	118	3.50	0.78	0.67	118	3.53
Inland Valley	0.49	0.24	115	1.26	0.49	0.24	116	1.24
Huntington Park	0.76	0.46	98	2.20	-	-	-	
North Long Beach	0.56	0.35	119	1.62	0.48	0.34	118	1.70
Pico Rivera	0.57	0.32	121	1.86	-	-	-	
Rubidoux	0.45	0.25	114	1.23	0.43	0.26	120	1.32
West Long Beach	0.57	0.44	114	1.95	0.50	0.38	120	1.77

Source: OEHHA (2014)

4.3.3.5. Screening Exposure Assessment Approach for Air Pollutant Emissions in the Los Angeles Basin

In this screening exposure assessment approach, we focus on the jurisdictional boundaries of the South Coast Air Basin (SoCAB), which includes Los Angeles County, Orange County, and parts of both Riverside and San Bernardino counties and includes the active oil and gas wells within the Los Angeles Basin. In order to assess the public health risks of air pollutant emissions from oil development operations in a region such as the Los Angeles and South Coast Air Basin (SoCAB), one needs information on three factors—pollutant emission rates (mass per time), a population exposure assessment (mass of pollutant inhaled per mass emitted), and toxicity (health impact per mass inhaled) (Bennett et al., 2002).

4.3.3.5.1. Intake Fraction Analysis

In previous sections of this case study, we compiled information on the emissions attributable to oil and gas development, as well as the fraction associated with those that have been fractured in the region. Here, we consider an exposure assessment that relates emissions mass to population intake. This analysis provides the basis for assessing health risks. With unlimited resources, we would identify the location of each emission, track the dispersion of these emissions as they spread out over the regional landscape, and then track population density and activity of the entire regional population to assess the magnitude and range of population intake. Unfortunately, for this report there is neither time nor resources for an analysis with this level of detail. Thus, we rely on the extensive body of analyses of source receptor relationships that has been compiled over the last decade for distributed pollutant emissions in the SoCAB. In particular, we rely on the extensive research and analysis of "intake fraction" relationships in the SoCAB as a of way of gaining important insights without carrying out extensive new analyses.

For air pollutant emissions, intake fraction (iF) is the mass of a pollutant inhaled by all potentially exposed populations divided by the mass of the pollutant emitted (Bennett et al., 2002). In other words, an intake fraction is the number of kilograms inhaled divided by the number of kilograms emitted, typically reported as "mg inhaled per kg released" or ppm. Intake fraction provides a transparent and parsimonious description of the complex atmospheric transport and human activity patterns that define exposure (Bennett et al., 2002). Because mass inhaled is a more reliable metric of potential adverse health impacts to populations than either mass emitted or airborne concentration, iF also provides key insights for assessing health risks. However, there are limitations to iF. As a measure of cumulative intake among a population over time, it lacks the ability to track exposure variation among individuals or exposure variations within populations over relatively short time periods, such as one hour or less.

Intake fraction is a metric, not a method. Values of the intake fraction for the South Coast Region have been determined from models and from measurements. Typical values for the intake fraction for pollutants released to outdoor air are as low as 0.1 per million (ppm) for air pollutant releases in remote rural areas, to 50 ppm or more for releases near ground level in urban areas. Three factors are dominant in determining the magnitude of the intake fraction for air pollutant emissions—(1) the size of the exposed population within reach of the pollutant emission, (2) the proximity between the emission source and the exposed population, and (3) the persistence of the pollutant in the atmosphere. A useful attribute of intake fraction is that it can be applied to groups of pollutants, rather than one pollutant at a time. When two pollutants are emitted from the same source, and have the same fate and transport characteristics, their intake fraction values will be the same, even if their chemical composition and mass emission rates differ.

The literature on intake fraction is diverse and growing. We identified multiple studies that address inhalation exposures of primary and secondary pollutants from a variety of sources, such as motor vehicles, power plants, and small-scale area sources. We identified five studies that provide detailed calculations on intake fraction for the Los Angeles region, and we make use of the results from these studies to estimate the intake fraction of oil and gas development in the Los Angeles Basin. Although these studies are not directed specifically at oil and gas development, they are well suited to the type of screening exposure assessment that is within our goal of assessing exposure potential of oil and gas.

In the first study considered, we examined the results of Marshall et al. (2003), who focused on the SoCAB as a case study and combined ambient monitoring data with time-activity patterns to estimate the population intake of carbon monoxide and benzene emitted from motor vehicles distributed throughout the SoCAB.

In the second study, we consider results from Heath et al. (2006), who assessed the exposure implications of a shift toward distributed petroleum-powered generation (DG) in California. For this, they combined Gaussian plume modeling and a GIS-based inhalation exposure assessment applied to existing and hypothetical power-generation facilities in California. To carry out this study, they assessed intake fraction for hypothetical DG emissions sources originating in the downtown areas of the eleven most populous cities in California.

In a third relevant study, Lobsheid et al. (2012) used source-receptor relationships derived from the U.S. EPA's AERMOD steady-state plume model to quantify the intake fraction of conserved pollutants (pollutants that are not strongly reactive in air or rapidly deposited to surfaces) emitted from on-road mobile sources. For this analysis, they used source-receptor relationships at census-block scale, and then aggregated and reported results for each of the 65,000 census tracts in the conterminous United States. Their study includes iF values for every census tract and county of California—thus providing useful information for the current case study.

In a fourth considered study, Apte et al. (2012) modeled intra-urban intake fraction (iF) values for distributed ground-level emissions in all 3,646 global cities with more than 100,000 inhabitants. Among all these cities, they found that for conserved primary pollutants, the population-weighted median, mean, and interquartile range iF values are 26, 39, and 14–52 ppm, respectively. They found that intake fractions vary among cities, owing to differences in population size, population density, and meteorology. Their reported iF value for Los Angeles is 43.

For the four studies noted above, Table 4.3-9 provides a summary of the best estimate (typically the median) value as well as the range of iF values that are relevant to the Los Angeles region. We see here that most of the studies converge toward a value of 40 ppm as most typical for this region. In the Lobsheid et al. (2012) study, which calculated iF for every census tract in Los Angeles and Orange counties, we also list ranges that reflect the 95% value interval for all census tracts for which iF is calculated. Lobsheid et al. (2012) also gives insight on variability with iF by census tract, varying from less than 1 ppm to slightly over 100 ppm.

Table 4.3-9. Published values of intake fraction relevant to the well stimulation-enabled oil and gas development emissions in the South Coast Air Basin.

Sources	Region	Pollutants	Method	Best estimate (range) ppm	Reference
Motor vehicles	South Coast air basin	Primary pollutants (CO, benzene)	Data analysis of tracers of opportunity	47 (34-85)	Marshall et al. (2003)
Distributed generators	Central locations in the 11 most populous cities of California	Primary pollutants ($PM_{2.5}$, formaldehyde)	Dispersion modeling	16 (7 – 30)	Heath et al. (2006)
Motor vehicles and distributed sources	Los Angeles county (2052 census tracts)	Primary conserved pollutants	Source-receptor air modeling for 65,000 US census tracks	38 (29 – 77)*	Lobsheid et al. (2012)
Motor vehicles and distributed sources	Orange county (577 census tracts)	Primary conserved pollutants	Source-receptor air modeling for 65,000 US census tracks	27 (19 – 50)*	Lobsheid et al. (2012)
Distributed ground level emissions	Los Angeles city	Conserved primary pollutants	High resolution dispersion model	43 (n/a)	Apte et al. (2012)

** This range reflects the 95% value range (that is 2.5% lower bound and 97.5% upper bound) of the iF for all census tracts in the county.*

Because of the lack of TAC emissions data on the census and local levels, we are unable to estimate the iF of oil and gas development at the census tract and local levels in the SoCAB context. This type of study is an important next step to understanding exposure to benzene and other TACs emitted by oil and gas development in the Los Angeles Basin. Nonetheless, below, we walk through some of the preliminary steps necessary to conduct such an analysis.

The intake fraction values provided above can be used to translate emissions in kg/d of any conserved pollutant into population exposures, and also into exposure concentration estimates. The intake fraction values above (for example, 38 ppm) provide an estimate of how many mg/day of a pollutant enters the lungs of the South Coast Population for every kg/d emitted. This is a cumulative intake obtained by identifying source locations and tracking exposures out to the limits of the South Coast Region—the cumulative integral of population intake. In the case of Marshall et al. (2003), the sources were roadways; for Heath et al. (2006), the sources were located at the commercial centers of large cities; and for Lobsheid et al. (2012), sources were located at the center of all census tracts, with dispersion followed out to all other census tracts in the region. In all three studies, the intake was obtained from concentrations using representative breathing rates (~14 m^3/d per individual). We note that the high spatial resolution of the Lobsheid et al. (2012) study allows us to consider not only the middle range iF for South Coast emissions, but also the effect of releases to areas with very high population density. In Lobsheid et al. (2012), the mean iF value is 38 ppm, with an upper bound of 77.

The next step of this assessment would be to take the regional emissions of air pollutants from oil and gas development, and multiply by the regional iF, to get an estimate of population intake. To get an estimate of health effects, we would need to divide the iF by the appropriate regional population to get the median (or mean) individual intake estimate, which can be compared to RELS, reference doses (RfDs), or reference concentrations (RfCs).

We could add more detail to this effort by calculating the iF for each census tract in the region and use the population impacted by emissions from that tract to do a bottom-up estimate of the range of iF values. As an example, we can use the Lobsheid et al. (2012) results to determine the types of concentrations that are associated with an iF in smaller regions. In L.A. County, with a median iF of 38 and assuming that the substantial amount of intake occurs within 3 km of the source (impacting some 50,000 people), the concentration imposed on this population from an additional 1 kg/day emissions is 0.05 $\mu g/m^3$. In Orange County, a similar calculation gives 0.04 $\mu g/m^3$ for each additional kg emitted to a representative census tract.

While we know the intake fraction potential at the census tract level, we are unable to estimate the iF of oil and gas development at the census tract and local levels in the SoCAB context, due to the lack of TAC emissions data on the census and local levels. But this would be an important next step to understanding exposure to benzene and other TACs emitted by oil and gas development in the Los Angeles Basin.

4.3.3.5.2. Summary of Screening Exposure Assessment for Air Pollutant Emissions in the Los Angeles Basin

The high population intake fractions that are possible in the SoCAB are primarily due to the high population density of the region. In other words a larger proportion of air pollutant emissions in the South Coast Air Basin enter human lungs compared to places with lower population density (fewer breathing lungs).

Those living in close proximity to emitting sources will likely be more exposed to these emissions than those that live further away. The reason that proximity to the source is important is that the contaminant in question will be at its highest atmospheric concentration at the source. The concentration generally falls off exponentially with distance from the source (via dilution), so that exposures near the source can be much larger than average regional exposures. So, for example, the regional contribution of the oil and gas production for benzene is 2,361 kg/year and is dispersed throughout the air basin. However, near emission sources, on or near active well pads, the atmospheric concentrations can be much higher than the regional average.

4.3.3.6. Proximity Analysis of Oil and Gas Development and Human Populations

In the previous sections, we have identified that TACs are emitted by oil and gas development in general, and that the concentrations of these emissions may be elevated near active oil and gas development. Wells are considered to be active if they are categorized as such in the Oil and Gas Well Database maintained by DOGGR. In this section, we quantify and locate all currently active oil and gas wells, and also the fraction that are stimulated. We then conduct an analysis of spatial relationships between currently active oil and gas wells and those that are hydraulically fractured and surrounding human populations and sensitive receptors.

4.3.3.6.1. Study Area

The geographic focus of this proximity analysis includes the California Air Resources Board (CARB) South Coast Air Basin (SoCAB), which includes Los Angeles County, Orange County, and parts of both Riverside and San Bernardino counties and the active oil and gas wells within this jurisdictional boundary. For a list of the methods we used to determine the number of active oil and gas wells—and the numbers and locations of those wells that have been hydraulically fractured, frac-packed, high-rate gravel packed, or acidized in the Los Angeles Basin—please see Appendix 4.A.

4.3.3.6.2. Numbers and Types of Active Oil and Gas Wells by Oil Field in the Los Angeles Basin

We used the methodology for calculating the number and proportion of stimulated wells as was used statewide in Volume I, with only minor modifications and focused specifically on the Los Angeles Basin (see Appendix 4.A). Our results indicate that there are approximately 5,256 wells that are currently active, according to DOGGR. Of these wells, 3,691 are located in oil and gas pools with estimated stimulation rates. When the stimulations rates for the pools are applied to the total number of wells in each pool, there are an estimated 1,341 wells that have been enabled or supported by hydraulic fracturing, frac-packing, or high-rate gravel packing (hereafter referred to as fracturing) (Table 4.3-10). The estimated number of wells that have been fractured thus represents approximately 26% of the 5,256 currently active wells listed as active by DOGGR as of July 2014, and 36% of the active wells in pools that were queried. These numbers should be considered conservative, given that we only have oil pool-level information on type of oil development (stimulation) for approximately 29% of the wells listed as active by DOGGR. As such, it is probable that more pools may have been hydraulically fractured, frac-packed, or high-rate gravel packed, but we do not have access to these data. While a report by Cardno ENTRIX (2012) found that as of 2012 there were 23 hydraulically fractured wells in the Inglewood Oil Field, as discussed in Volume I, DOGGR data suggest that this might be an underestimate, or that most of the other wells were supported or enabled by frac-packing and high rate gravel packing which was not included in the Cardno ENTRIX estimate. For a more detailed explanation of methods and approaches, please see Appendix 4.A. Please also refer to

Volume II, Appendix 5.E, for more information.

Table 4.3-10. Numbers of all currently active wells and the proportion that are supported by hydraulic fracturing, frac-packing, or high-rate gravel packing (HRGP) in the Los Angles Basin by oil field.

Oil Field	Total Active Wells	Total Wells Fractured	% Fractured
Brea-Olinda	551	551	100%
Inglewood	503	503	100%
Wilmington	1,716	179	10%
San Vicente	35	32	91%
Aliso Canyon	50	21	42%
Whittier	29	18	62%
Las Cienegas	60	10	17%
Esperanza	11	6	55%
Temescal	5	5	100%
Newhall-Potrero	45	4	9%
Tapia	30	3	10%
Del Valle	37	3	8%
Montebello	123	2	2%
Salt Lake	24	2	8%
Huntington Beach	306	1	0%
Wayside Canyon	10	1	10%
Playa Del Rey	28	0	0%
Torrance	128	0	0%
Total Assigned to Fields	**3,691**	**1,341**	**36%**
Unassigned to Fields	1,565	unavailable	
TOTAL	**5,256**	**1,341**	**26%**

4.3.3.6.3. New Wells and Wells Going Into First Production (2002-2012)

There are 1,403 oil and gas wells that were either new or went into first production between 2002 and 2012 in the SoCAB. Of these wells, 435 (31%) have been identified as having been hydraulically fractured (Table 4.3-11). Given the uncertainty in the data, this proportion (31%) is similar to the 26% of all active wells, and thus shows agreement with and corroboration of our data analysis.

Table 4.3-11. New wells or wells going into first production and the proportion that are hydraulically fractured, frac-packed, or high-rate gravel packed (HRGP) (2002-2012).

Oil Field	Total New Wells (2002-2012)	Total New Wells Fractured	% New Wells Fractured
Inglewood	219	219	100%
Brea-Olinda	29	29	100%
Wilmington	831	159	19%
Aliso Canyon	26	0	0%
Cascade	7	0	0%
Long Beach Airport	2	0	0%
Los Angeles Downtown	1	0	0%
Newhall-Potrero	12	1	8%
Richfield	1	0	0%
San Vicente	6	6	100%
Sansinena	7	0	0%
Santa Fe Springs	57	3	5%
Tapia	21	1	7%
Wayside Canyon	4	0	0%
Playa Del Rey	3	3	100%
Beverly Hills	83	0	0%
Las Cienegas	9	3	33%
Del Valle	5	0	0%
Montebello	21	0	0%
Huntington Beach	8	4	47%
Belmont Offshore	32	0	0%
Torrance	12	0	0%
Whittier	7	7	100%
TOTAL	**1403**	**435**	**31%**

4.3.3.6.4. Acidizing

Hydrofluoric and hydrochloric acid are frequently used in the development of oil in the Los Angeles Basin. Based upon the SCAQMD dataset, there are ~20 events per month that use hydrofluoric acid (SCAQMD, 2015). The SCAQMD reports a total of 22.5 events per month, including both acidization and hydraulic fracturing (excluding gravel packing). As described in Volume I, there is insufficient data in available datasets to distinguish matrix acidizing from maintenance acidizing, although operators were required to distinguish starting April 02, 2014.

4.3.3.6.5. Summary: Numbers and Types of Oil and Gas Wells in the Los Angeles Basin

Approximately 26% of currently active oil and gas wells (1,341/5,256) and 31% of wells that went into first production between 2002 and 2012 (435/1,403) are likely enabled or supported by hydraulic fracturing, frac-packing, and high-rate gravel packing.

Data from the SCAQMD mandated reporting suggest that the use of hydrofluoric and hydrochloric acid in oil production wells is common in the Los Angeles Basin (SCAQMD, 2015). However, the use of acid is supportive of current development and unlikely to be used to significantly increase expanded development.

4.3.3.7. Proximity of Human Populations to Oil and Gas Development

Our analysis of available state emission inventories indicates that 2,361 kg/year of benzene is emitted by upstream oil and gas development in the Los Angeles Basin. This amount represents a significant proportion of stationary source (9.6%) and <1% from all sources (including mobile source emissions) in the South Coast Air Basin. Our analysis of California emission inventories also indicates that 5,846 kg/year or 3.8% of the stationary source emissions and <1% of all source emissions (including mobile sources) of formaldehyde are attributable to the upstream oil and gas sector (Table 4.3-4). As a basis for understanding potential public health hazards attributable to upstream oil and gas development, we evaluated the spatial relationships of all active oil and gas wells, and then those that are stimulated, to the surrounding population, and selected sites considered to be "sensitive receptors." We also characterized the demographics, vulnerability factors, and socioeconomic profiles of the communities in proximity to well stimulation events.

Our choice to include all oil and gas wells as opposed to only considering the fraction that are stimulated was based on our finding that benzene, a health-damaging indicator TAC as described above, is emitted from oil and gas development in general and is not specific to, or even related directly to, well stimulation. To evaluate proximity of populations within the Los Angeles Basin to only those wells that are stimulated is misleading and potentially would leave out communities that are potentially submitted to the same level of environmental public health hazard as those communities that live near stimulated wells.

For a complete description of our methods and approach to the spatial proximity analysis, please see Appendix 4.B.

4.3.3.7.1. Spatial Distribution of All Active Oil Wells and Active Stimulated Wells

Figure 4.3-3 shows the South Coast Air Basin with stimulated wells. As discussed in the methods above, we identified 4,487 active oil wells and 1,205 active wells that have been fractured, and at least 60 wells that have been supported by acidizing in the South Coast Air Basin that are still in production as of 14 December 2014. Figure 4.3-4 shows the density of active oil and gas wells in the SoCAB.

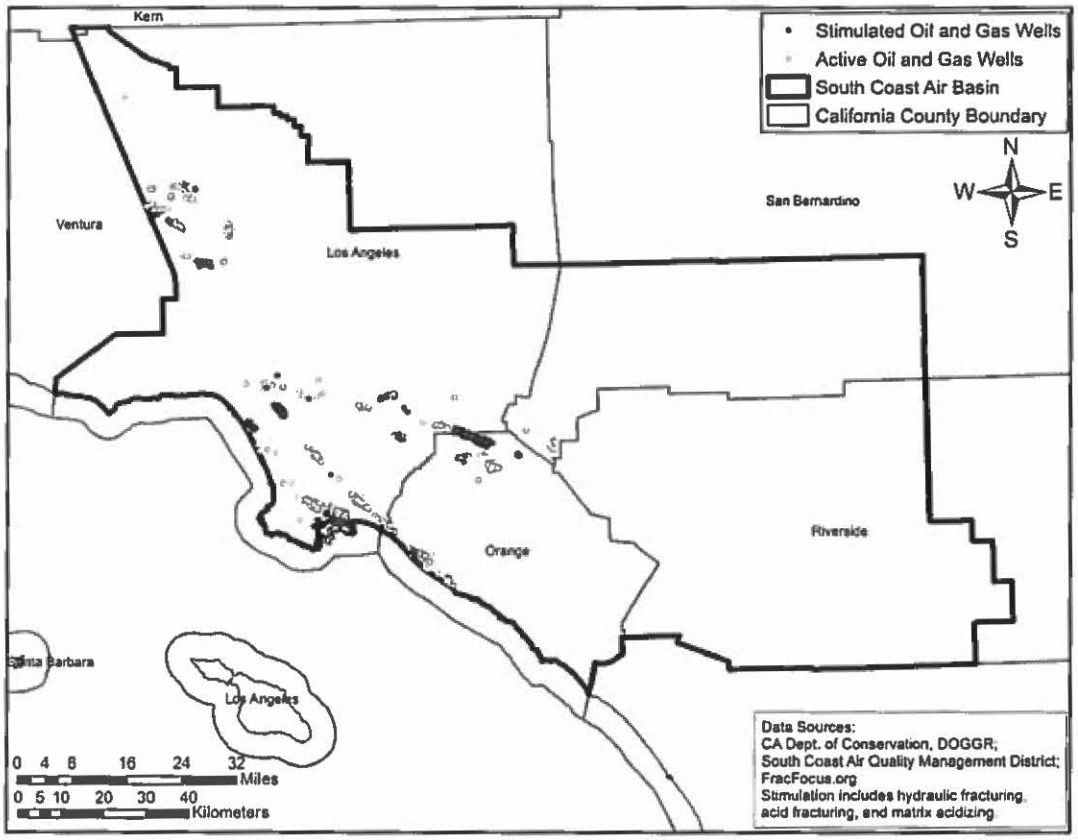
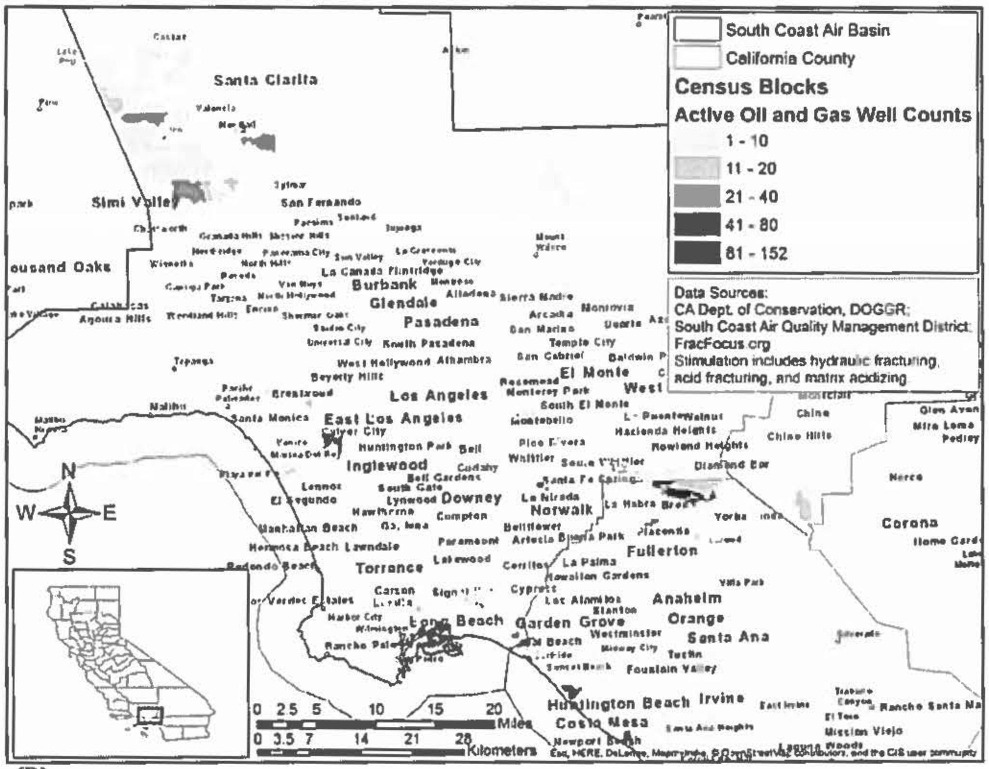


Figure 4.3-3. All active oil production wells in the South Coast Air Basin with those that are stimulated shown in red.



(B)

Figure 4.3-4. Density of active oil and gas well counts in the South Coast Air Basin.

4.3.3.7.2. Human Population Proximity Analysis

Figure 4.3-5 shows the population density in the Los Angeles Basin and the boundaries of 2,000 m (6,562 feet) distance from all active oil wells and the fraction of active oil wells that have been stimulated. It is evident that stimulated wells in the Los Angeles Basin exist both within and in close proximity to high population density areas. It is also evident that a slightly larger portion of the Los Angeles Basin population lives within 2,000 m (6,562 feet) of an active oil well than the population that lives within 2,000 m (6,562 feet) of a well that has been stimulated. This makes sense, because there are approximately 75% more oil wells that are not stimulated than those that are.

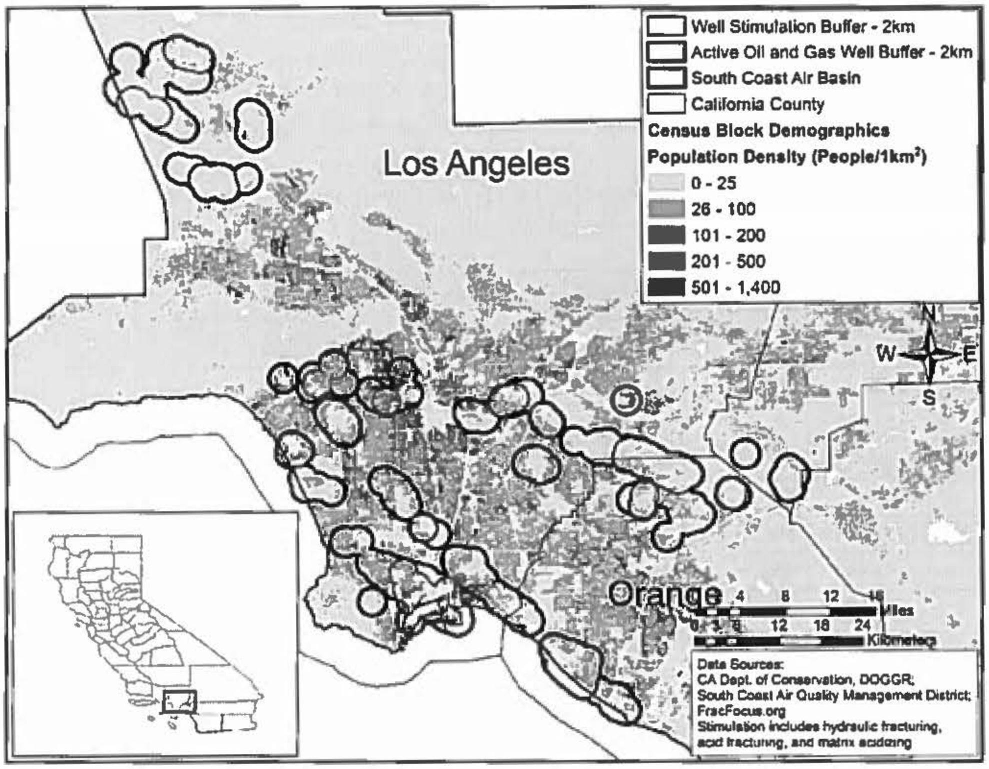


Figure 4.3-5. Population density within 2,000 m (6,562 feet) of currently active oil production wells and currently active wells that have been stimulated.

As summarized in Tables 4.3-12 and Table 4.3-13, a number of residents and sensitive receptors are in proximity to active oil development and the fraction of this development from wells that have been stimulated. Approximately 2,258,000 people (12% of the SoCAB population) live within 2,000 m (6,562 feet) of an active oil well. Additionally, there are 130 schools, 184 daycare facilities, 213 residential elderly homes and nearly 628,000 residents within 800 m (½ mile or 2,625 feet) of an active oil well. More than 50,000 children under the age of five, and over 43,500 people over the age of 75, live within 2,000 m (6,562 ft) of an active oil production well. Even within only 100 m (328 ft) of a well, there are more than 32,000 residents, nearly 2,300 of who are children under five (Table 4.3-12).

Fewer residents and sensitive receptors are located in close proximity to oil wells that have been stimulated in the SoCAB, largely because only a subset of the wells in this basin is stimulated. Approximately 760,000 people (4% of the SoCAB population) live within 2,000 m (6,562 feet) of a stimulated well. Additionally listed in Table 4.3-13 is the number of sensitive populations and facilities in proximity to stimulated wells. For instance, there are 20 schools, 39 daycare facilities, 27 residential elderly homes, and nearly 128,000 residents within 800 m (½ mile or 2,625 feet) of a stimulated well. More than 120,000 children under the age of five and over 90,000 people over the age of 75 live within a mile (1,600 m or 5,249 feet) of a stimulated well (Table 4.3-13).

Table 4.3-12. Proximity of human populations and sensitive human receptors to active oil wells in the South Coast Air Basin.

Buffer Distance (m)	Number of Residents	Number of Schools	Number of Children Attending Schools	Number of Elderly Facilities	Number of Daycare Facilities	Under 5	Over 75
100	32,071	4	3,290	12	5	2,295	1,664
400	233,102	50	34,819	94	72	16,685	14,005
800	627,546	130	89,241	213	184	45,050	35,189
1,000	866,299	180	135,797	258	262	62,547	47,759
1,600	1,677,594	348	242,833	429	524	122,321	91,452
2,000	2,257,933	470	332,855	582	718	164,992	122,737

Table 4.3-13. Proximity of human populations and sensitive human receptors to stimulated wells in the South Coast Air Basin.

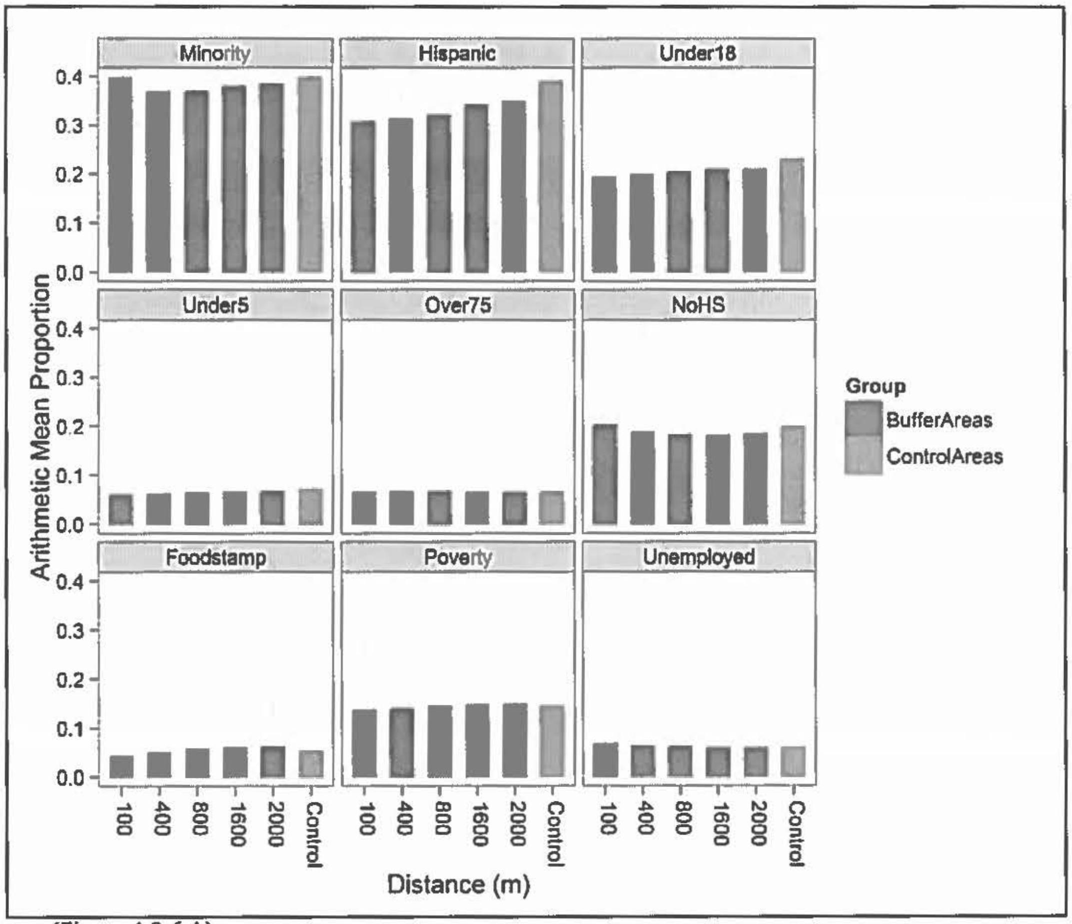
Buffer Distance (m)	Number of Residents	Number of Schools	Number of Children Attending Schools	Number of Elderly Facilities	Number of Daycare Facilities	Under 5	Over 75
100	3,661	2	2,135	1	0	285	163
400	33,928	7	3,738	4	8	2,170	2,301
800	127,896	20	12,302	27	39	7,653	8,849
1000	267,994	49	36,286	39	80	17,856	16,148
1600	494,831	125	91,585	111	181	31,199	29,827
2000	759,513	181	131,158	158	277	50,067	43,466

In summary, there are >65% more people that live within proximity of any active oil and gas well compared to those that live within proximity of only those active wells that are associated with well stimulation. As explained above, the TAC emissions of concern from a public health perspective do not differ between oil and gas wells that have been stimulated and those that have not, and the subsequent public health hazard associated with both are essentially the same as it pertains to TAC emissions.

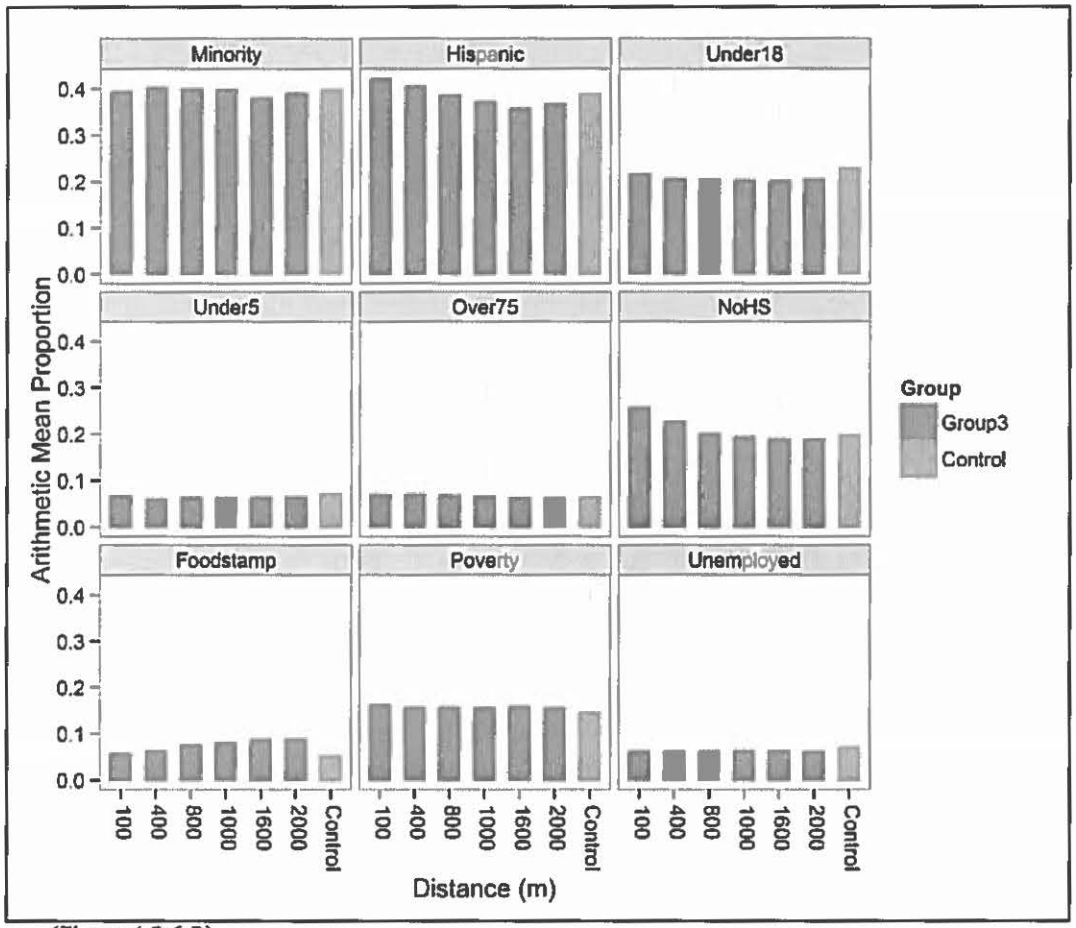
4.3.3.7.3. Comparing Population Demographics Near vs. Far from Oil and Gas Wells

At the regional scale, demographic characteristics of populations were similar among all studied distances from active oil and gas development and stimulation-facilitated development (Figure 4.3-6.A and Figure 4.3-6.B). Moreover, the studied distances were also similar in demographics compared to the control population, those farther than

2,000 m (6,562 ft) distance from the closest active well. As such, while it is clear that oil and gas is being developed in low-income communities and communities of color, there does not appear to be a disproportionate burden of oil and gas development on any one demographic in the Los Angeles Basin. In other words, oil and gas wells are not located disproportionately near the rich, the poor, or any race/ethnicity more than any other. Differences in average proportions were less than 0.05 (i.e., 5%) across buffer distances from active oil and gas wells and versus control areas (Figure 4.3-6.A). The only exception to this was that at the 100-meter (328 ft) buffer distances, the proportion of residents without high school education was more than 5% greater than the population at 800 m (2,625 ft), 1,000 m (3,280 ft), 1,600 m (5,249 ft) , and 2,000 m (6,562 ft) buffer distances and the control population. The proportion of individual households that qualify for food stamps and the proportion under the poverty line were slightly more elevated among residents close to hydraulically fractured wells compared to control sites (Figure 4.3-6.B). Residents that are under 18 years of age and those that are unemployed are slightly lower, and the non-Hispanic minority, those less than 5 years of age, and those more than 75 years of age, were essentially the same as control sites. Proportions of Hispanic residents exhibited variations with buffer distance, such that those at 100-meter (328 ft) and 400-meter (1,312 ft) distances were higher, whereas those at 1,000, 1,600, and 2,000-meter (3,280; 5,249; and 6,562 ft) distances were lower than control areas (Figure 4.2-2). Arithmetic averages, medians, standard deviation, and empirical 90th percentile values were also similar. Density plots also indicated similar distributional shape among the groupings and control population, suggesting that they represent samples from a similar population overall.


Minority
Hispanic
Under18
Under5
Over75
NoHS
Foodstamp
Poverty
Unemployed
Arithmetic Mean Proportion
0.0
0.1
0.2
0.3
0.4
100
400
800
1600
2000
Control
Distance (m)
Group
BufferAreas
ControlAreas

(Figure 4.3-6.A)



(Figure 4.3-6.B)

Figure 4.3-6.A and 4.3-6.B. Proportion of demographic characteristics at studied geographic distance from (A) all active oil and gas wells; and (B) stimulated wells compared to the control (areas beyond 2,000 meter buffer distance). Minority = non-Hispanic minorities; NoHS = not completed high school education; Foodstamp = household income qualifies for food stamps (< $15,000); Poverty = below poverty; Under5=Children less than 5 years of age; Over75=adult more than 75 years of age; Foodstamp=receives food stamps.

4.3.4. Potential Risks to Ground Water Quality in the Los Angeles Basin

Most water delivered to homes and businesses in the Los Angeles Basin is delivered via pipelines and canals from distant water sources. Los Angeles' Department of Water and Power (LADWP) brings water to its 3.9 million residents from the Owens Valley via the Los Angeles Aqueduct (LADWP, 2013). The Metropolitan Water District of Southern

California (MWD) indirectly serves another 14 cities and 12 municipal water districts, indirectly providing water to 18 million people. MWD obtains water from the State Water Project, a system of dams and reservoirs in Northern California, and an aqueduct to the Colorado River on California's border with Arizona (MWD, 2012). These water sources are far removed from oil and gas development and are unlikely to be contaminated by such operations. However, groundwater makes up one-third of the water supply for the 4 million residents of the Los Angeles coastal plain (Hillhouse et al., 2002), and chemicals from oil and gas development, including well stimulation, could possibly contaminate some groundwater wells.

Potential pathways for contamination of groundwater from well stimulation activities are described in Volume II, Section 2.6.2 (Table 2.6.2). For example, potential risks to groundwater may be related to subsurface leakage via loss of wellbore integrity or hydraulic fractures intercepting an aquifer, accidental releases at the surface, and inappropriate disposal of recovered and produced water, as described in detail in Volume II, Chapter 2 of this report. Regarding subsurface leakage, the risk of water contamination from a hydraulic fracture intercepting a protected aquifer is minimal if the hydraulic fracturing operation is sufficiently deeper than the aquifer. However, as described below, some hydraulic fracturing in the Los Angeles Basin takes place in close vertical proximity to protected aquifers.

Much of the groundwater consumed by the cities of Santa Monica, Long Beach, and other nearby districts is extracted from the coastal plain aquifer system, which underlies much of the coastal area of Los Angeles and Orange Counties. The portion of the coastal plain aquifer system in Los Angeles County is shown in Figure 4.3-7.

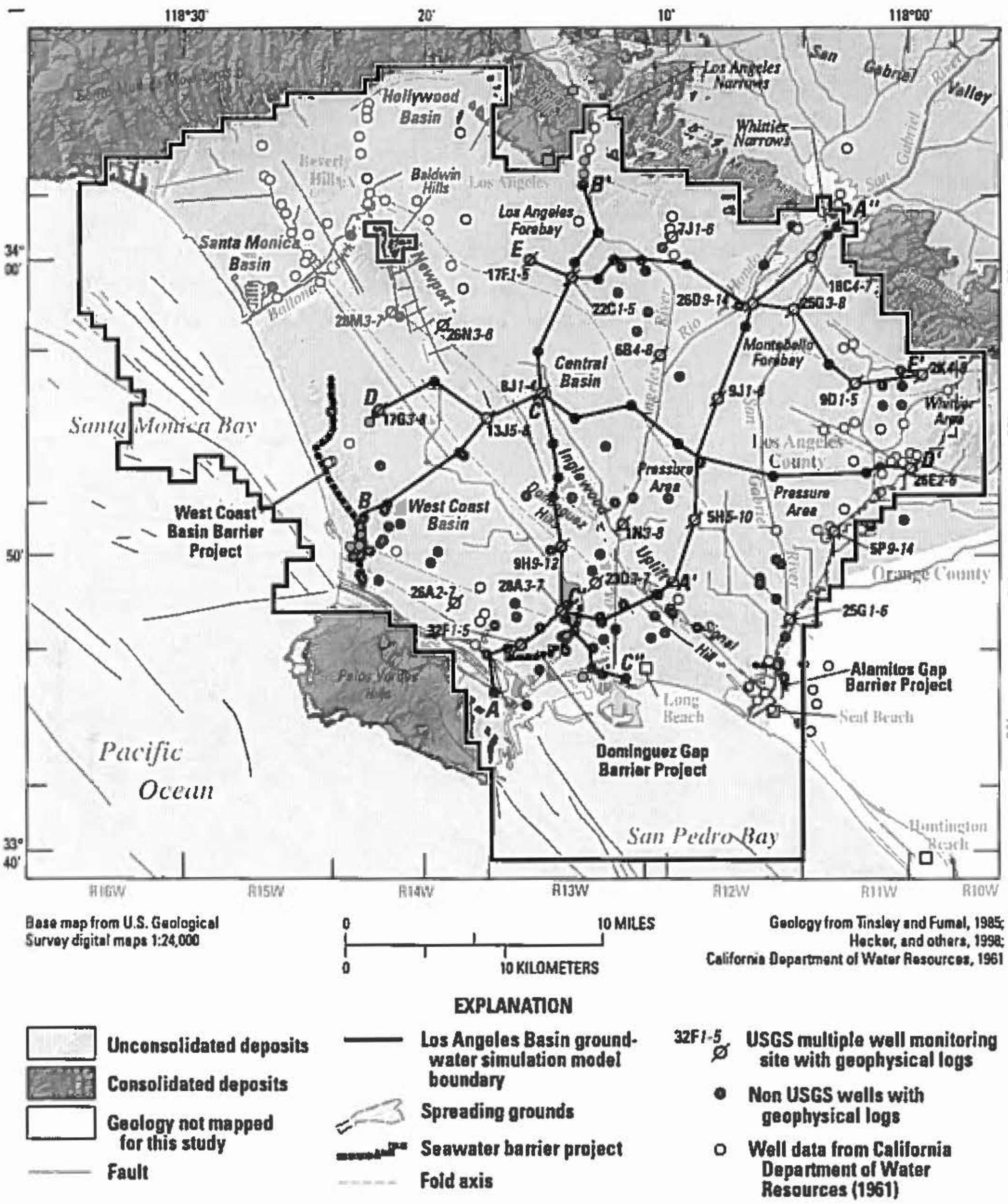
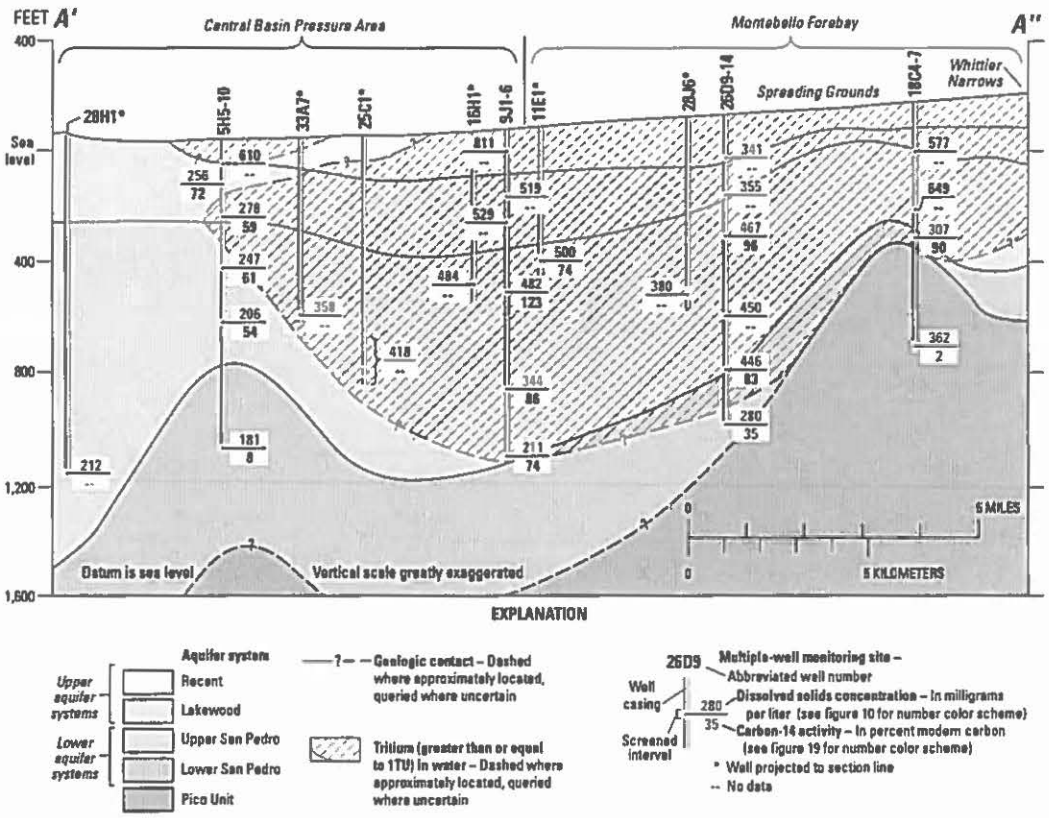


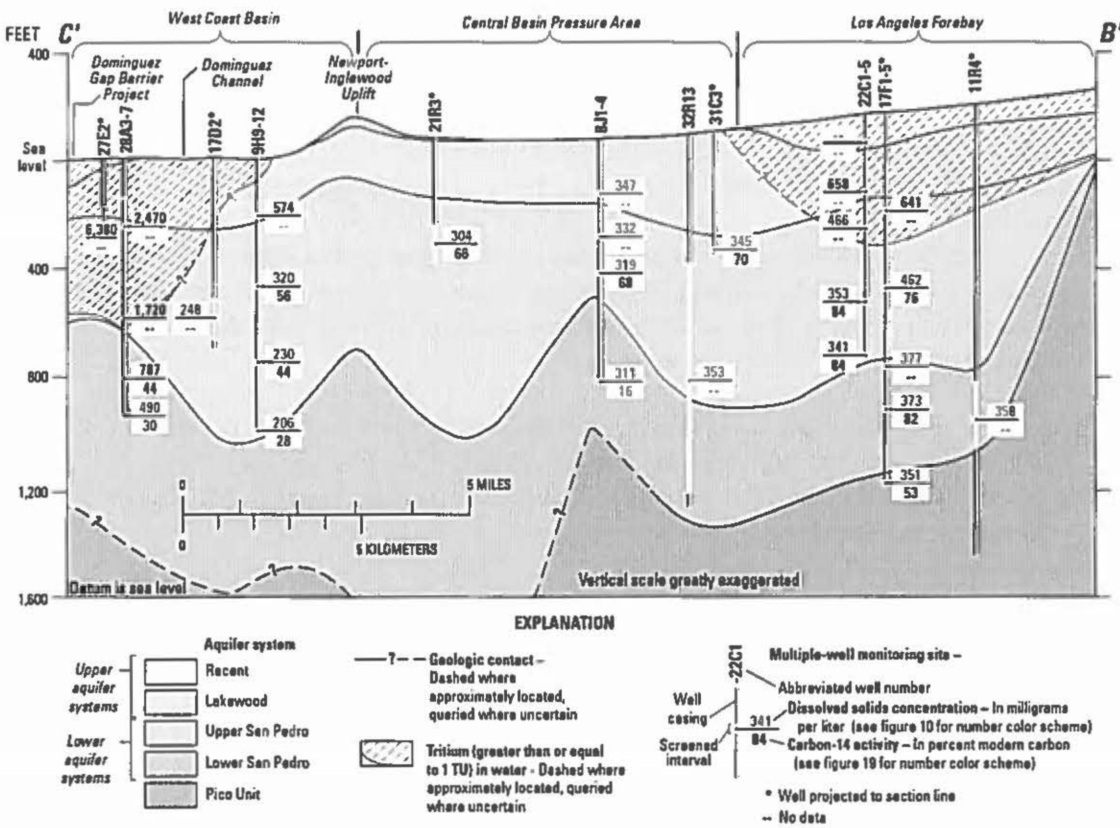
Figure 4.3-7. Coastal Plain of Los Angeles Groundwater Basin as defined by Department of Water Resources (DWR, 2012) consists of the contiguous unconsolidated deposits in the center of the figure. The unconsolidated deposits shown to the northeast are part of the San Gabriel Valley Groundwater Basin defined by DWR (2012). The geohydrologic sections shown on Figure 4.3-8 are located, along with some other sections not included in this report (Reichard et al., 2003).

Senate Bill 4 (SB 4) requires operators to monitor groundwater in aquifers in the vicinity of stimulated oil and gas wells. The main freshwater body of the coastal plain aquifer system extends from depths of less than 30 m up to 1,200 m (100 ft up to approximately 4,000 ft) (Planert and Williams, 1995). Two of the hydrologic sections located in Figure 4.3-7 are shown in Figure 4.3-8. Groundwater with less than 500 mg/L total dissolved solids (TDS) occurs at the lowest sampling points along the sections, which are typically 300 to 400 m (1,000 to 1,300 ft) deep. At many wells, the TDS concentration decreases with depth, indicating that water quality improves with increased depth. Most water supply wells in the Los Angeles coastal basin are drilled to depths of 155 to 348 m (510 to 1,145 ft) (Fram and Belitz, 2012), which accords with the TDS distribution on Figure 4.3-8 (Reichard et al., 2003).



a)

Figure 4.3-8. Dissolved-solids concentration, measurable tritium activity, and carbon-14 activity in ground water from wells sampled along geohydrologic sections A'–A" (a) and C'–B' (b), Los Angeles County, California (Reichard et al., 2003).



b)

Figure 4.3-8. Continued.

Based on the hydraulic fracturing data for the last decade, we estimate about 40 to 80 fracturing operations are conducted each year on average in the Los Angeles Basin (see Volume I, Appendix K). Approximately three quarters of these are hydraulic fracturing operations, and one quarter are frac-packing operations (Volume I, Chapter 3). Volume I, Appendix M provides the well head locations for all wells where hydraulic fracturing operations were conducted, along with depths as available from the various data sets considered by this study. The appendix includes records of 314 fracturing operations in the Los Angeles Basin conducted from 2002 to mid-2014. Depths were available for 244 of these operations. All of these depths were either true vertical or measured total well depth. The shallowest well in these records was 401 m (1,320 ft), and 5% were shallower than 840 m (2,762 ft). This well depth distribution suggests that hydraulic fracturing may occur in close proximity to protected groundwater (defined as non-exempt groundwater with less than 10,000 TDS), and perhaps even in proximity to groundwater with less than 3,000 mg/L TDS. This is particularly the case, because the depth of the hydraulically fractured interval in an oil and gas well is less than the total well depth.

To assess the possibility that hydraulic fracturing is occurring at shallow depths, which may contaminate drinking water sources, we analyzed the spatial relationship between hydraulically fractured oil and gas wells and water wells in the Los Angeles Basin. The wellhead locations of hydraulically fractured wells were compared to the location of water wells in a database from the Department of Water Resources (DWR) provided by the United States Geological Survey (USGS) (Faunt, personal communication). The water well data are from well completion reports filed with the DWR.[1] These data are incomplete, and the California-wide dataset is missing at least 50,000 water wells drilled over the past 65 years plus wells drilled prior 1949 (Senter 2015, California Department of Water Resources, pers. comm.). However, the water well data does allow an initial screen for the proximity of hydraulically fractured wells.

The water well dataset indicates the purpose of the wells included in the set. For this study, we only included wells indicated as supply ("PROD") or with no purpose listed. The remainder of the dataset consists of wells involved in seawater barriers, groundwater remediation, and observation.

All hydraulically fractured wells in Volume I, Appendix M with a wellhead located within 1 km (0.6 mi.) laterally of the water wells considered were selected for further analysis. The locations of these 18 wellheads are shown in Figure 4.3-9. The true vertical depth to the top of the hydraulically fractured interval in each was collected from their well record, and is also shown in Figure 4.3-9.

1. Since 1949, California law has required that landowners submit well completion reports to DWR, containing information on newly constructed, modified, or destroyed wells.

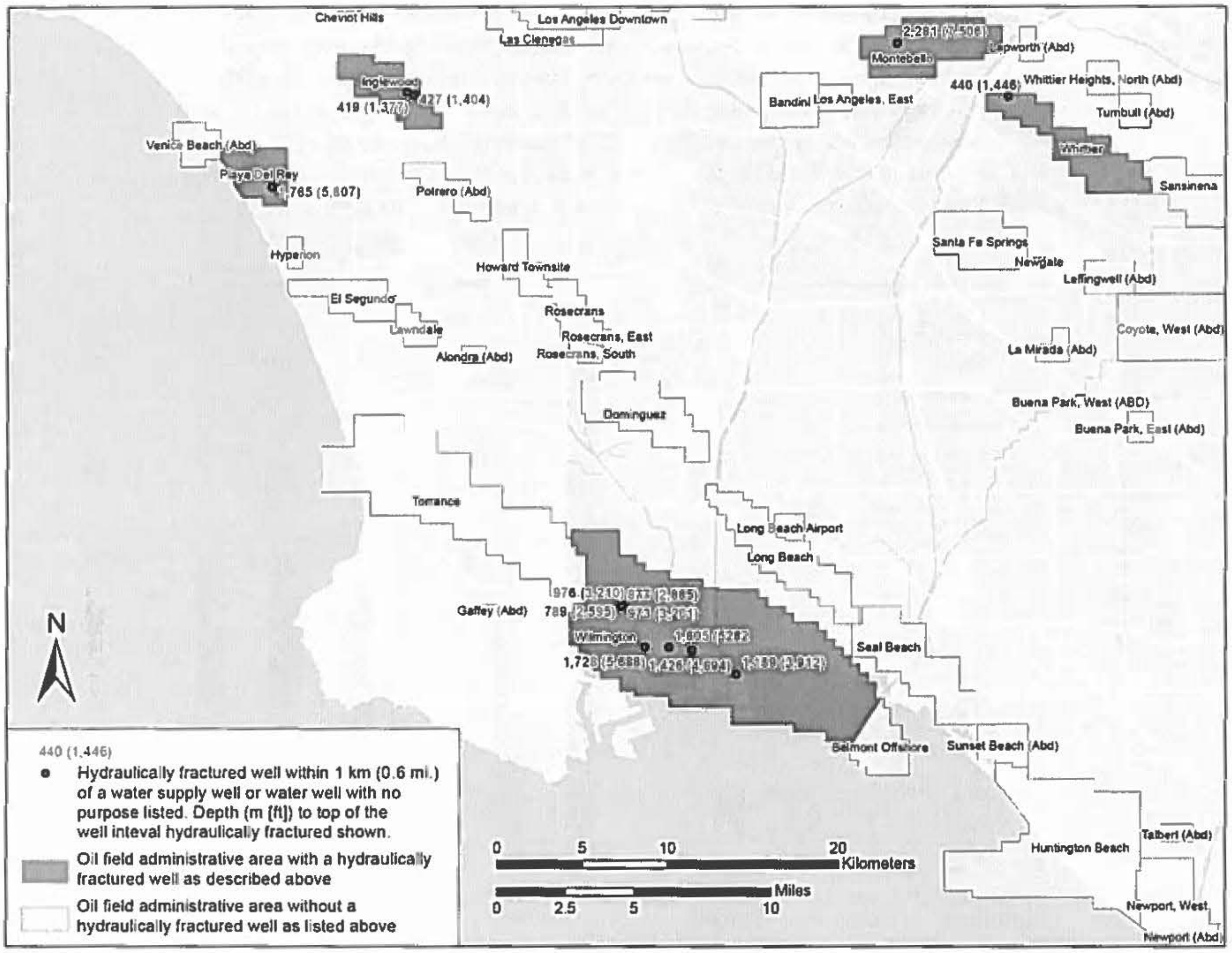


Figure 4.3-9. Depth in meters (and feet) to the top of the hydraulically fractured interval in each well in Volume I, Appendix M, with a wellhead within 1 km (0.6 mi.) laterally of a water supply well or a water well with no purpose stated. Note the depth to the top of the well interval hydraulically fractured is shown for 13 of the 18 wells assessed. The five wells without labels are in the northwestern-most cluster in the Wilmington field. Labels are shown for the four shallowest well interval tops in this cluster.

To assess the vertical separation between the hydraulic fracturing intervals and water wells, the depths of the water wells were subtracted from the depth to the top of each well interval hydraulically fractured for nearby wellheads. The depth to the base of the perforations were available for more than half of the water wells considered, and the total well depth was available for the rest. Figure 4.3-10 shows the depth separation between the base of the water well and the top of the well interval hydraulically fractured for each of the 18 wells stimulated, separated by the oil field in which they are located.

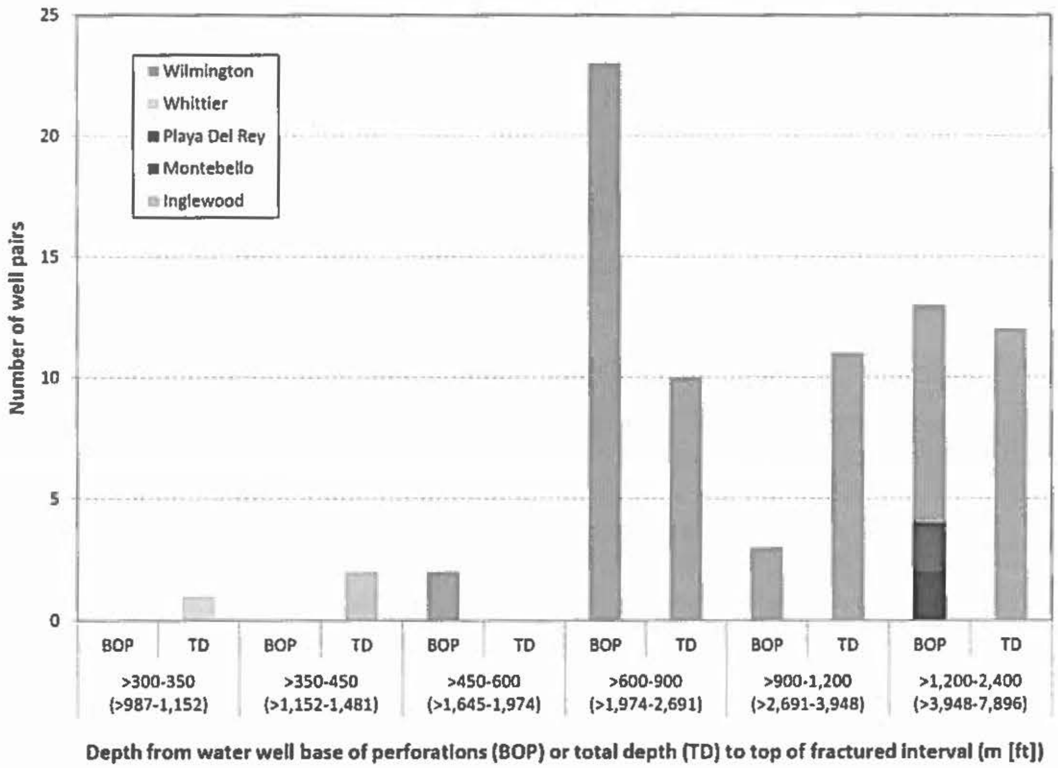


Figure 4.3-10. Depth separation between the base of each water well and the top of each well interval hydraulically fractured for wells with well heads within 1 km (0.6 mi.) of each other Note the bin intervals are not uniform in order to provide more detail for the smaller separations.

Figure 4.3-10 suggests that the vast majority of the selected hydraulic fracturing operations was conducted with large vertical separation to water wells between 600 m (1,974 ft) and 2,400 m (7,896 ft). The operations within four wells within the Wilmington and Inglewood oil fields had the vertical separation between 350 m (1,150 ft) and 600 m (1,974 ft). The operation in one well in the Whittier field has a vertical separation of

300 to 350 m (1,000 to 1,150 ft) from a water well. Given the small number of operations identified that are close to protected groundwater, and the relatively small overall number of hydraulic fracturing operations conducted in the basin, the risk of a hydraulic fracture impacting an existing water well is considered small, but does warrant further investigation (Volume II, Chapter 2).

Proximity to existing water wells is only one indicator of proximity to protected groundwater. Water supply wells typically only extend as deep as necessary to secure the desired supply of groundwater from aquifers that are reasonably secure from contamination by surface and near-surface releases. They typically do not necessarily extend to the base of protected groundwater (i.e., non-exempt groundwater with up to 10,000 mg/L TDS). For instance, most of the depths of the top of the fractured oil and gas well intervals are less than the maximum depth of the coastal plain aquifer of 1,200 m (3,900 ft). Some of these depths are also within 100 m (330 ft) of the deepest sampling intervals shown in Figure 4.3-8, which have water with <500 mg/L TDS, and deeper water supply wells.

A more detailed understanding of the depth to the base of protected water relative to the depth of the well intervals hydraulically fractured (Figure 4.3-9) is provided by the field rules from DOGGR, in combination with the reservoir water salinities listed in California Oil and Gas Field Volume II (DOGGR, 1992). Table 4.3-14 lists the TDS for each field indicated in Figure 4.3-9, along with the depth range of the top of the well interval hydraulically fractured from the 18 operations shown on Figure 4.3-9 for each field. The data in Table 4.3-14 are shown graphically on Figure 4.3-11.

The table and figure show that one fracturing operation in the Whittier field occurred within perhaps 300 m (1,000 ft) of water with <3,000 mg/L TDS, and actually within water with <10,000 mg/L TDS. Two fracturing operations occurred within 150 m (490 ft) of water with <10,000 mg/L TDS in the Inglewood field. The shallowest operation in the Wilmington field occurred within 200 to 350 m (660 to 1,100 ft) of water with <3,000 mg/L TDS. As these results are based on only 18 of the 341 known hydraulically fractured wells in the Los Angeles Basin, it is possible the minimum depth separation between well intervals hydraulically fractured and groundwater of these various qualities is even less.

Table 4.3-14. Groundwater TDS data compared to the depth to the top of select hydraulic fracturing well intervals (TDS data from field rules).

Field	Base of freshwater (<3,000 mg/L TDS) (m [ft])	Deepest reservoir with water <10,000 mg/L TDS (m [ft])	Shallowest reservoir listed with water >10,000 mg/L TDS (m [ft])	Top of stimulation well interval for selected operations (m [ft])
Inglewood	~90 (~300)	290 (950)	320 (1,050)	419-427 (1,377-1,404)
Montebello	490 (~1,600)	NA	670 (2,200)	2,281 (7,506)
Playa Del Rey	210 (~700)	NA	1,880 (6,200)	1,765 (5,807)
Whittier	46-200 (150-650)	490 (1,600)	1,230 (4,050)	440 (1,446)
Wilmington	~460-590 (~1,500-1,950)	NA	670 (2,200)	789-1,728 (2,595-5,688)

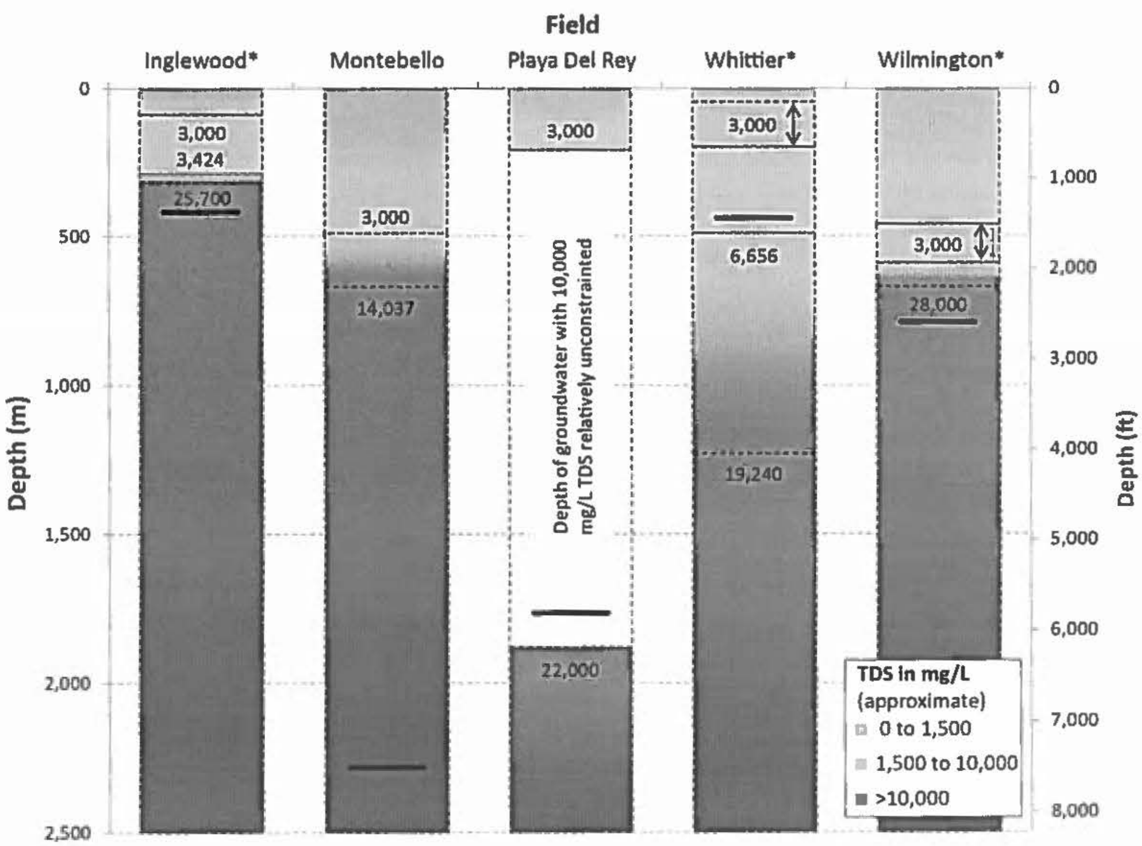


Figure 4.3-11. Depth of 3,000 mg/L TDS and data bracketing the depth of 10,000 mg/L TDS in each field with the hydraulically fractured wells selected for study (data from field rules and DOGGR (1992). The heavy black horizontal line indicates the shallowest well interval hydraulically fractured in each field.

4.3.4.1. Conclusion of Potential Risks to Ground Water Quality in the Los Angeles Basin and Potential Public Health Hazards

The results of our investigation, based upon the available data, indicate that a small amount of hydraulic fracturing in the Los Angeles Basin has occurred within groundwater with <10,000 mg/L TDS and in proximity to groundwater with <3,000 mg/L TDS, creating the risk of hydraulic fractures extending into or connecting with protected groundwater and contaminating aquifers with fracturing fluids and other compounds. If such contamination occurs, this could create an exposure pathway for people that rely on these water resources for drinking and other uses. As such, the recommendations regarding shallow fracturing near protected groundwater in Volume III, Chapter 5 should also be applied to such operations in the Los Angeles Basin if this practice continues. Among these recommendations we suggest there be special requirements to: 1) control fracturing stimulation design and reporting, 2) increase groundwater monitoring requirements; and 3) implement corrective action planning. Additionally, characterization of the base of the deepest groundwater with less than 10,000 mg/L TDS in the Los Angeles Basin is needed in some locations.

4.3.5. Conclusions of the Los Angeles Basin Public Health Case Study

In this case study, we investigated locations of currently active oil and gas development, the proportion of these wells that have been enabled or supported by well stimulation treatments, the emissions of criteria air pollutants and TACs from this development, and the numbers and demographics of residents and sensitive receptors that are in proximity to these operations. These components were discussed together in an effort to elucidate where and who might be exposed to emissions of air pollutants from the development of oil and gas in the Los Angeles Basin. We also examined the possibility that groundwater supplies in the Los Angeles Basin could become contaminated due to hydraulic fracturing-enabled oil and gas development. Our results, based upon available data, indicate that a small amount of hydraulic fracturing in the Los Angeles Basin has occurred within groundwater with <10,000 mg/L TDS, and in proximity to groundwater with <3,000 mg/L TDS. This creates a risk of hydraulic fractures extending into or connecting with protected groundwater, and could result in fracturing fluids mixing with these water resources, introducing a potential exposure hazard for populations that rely on these groundwater resources.

4.3.5.1. Air Pollutant Emissions and Potential Public Health Risks

Many of the constituents used in and emitted to the air by oil and gas development are known to be health damaging and pose risks to people if they are exposed—especially to sensitive populations, including children, the elderly, and those with pre-existing respiratory and cardiovascular conditions. We found that oil and gas development poses more elevated population health risks when conducted in areas of high population density, such as the Los Angeles Basin, because it results in larger population exposures to TACs (there are more breathing lungs nearby) than when conducted in areas of low population density (fewer breathing lungs nearby). Relatedly, emissions of TACs in close proximity to human populations often results in more elevated risks of exposures compared to those populations that are far from emission sources. Most of the documented public health risks associated with air pollutant emissions from oil and gas development are associated with oil and gas development in general, and are not unique to well stimulation.

Our emission inventory analysis found that 2,361 kg/year of benzene is emitted by the stationary components of upstream oil and gas development in the Los Angeles Basin. This amount represents a significant proportion of stationary source (9.6%) and a smaller proportion of benzene emissions from all sources (including mobile source emissions) (0.14%) in the South Coast Air Basin. Our state inventory analysis also indicates that 5,846 kg/year or 3.8% of the stationary source emissions of formaldehyde, and <1% of all source emissions (including mobile), are attributable to the upstream oil and gas sector. Smaller proportions of other indicator TAC species were identified. These indicator TAC species included in our assessment are not often used in well stimulation fluids, but rather are co-produced with oil and natural gas during development. Since only ~26% of the wells currently active in the Los Angeles Basin are hydraulically fractured and responsible for approximately 19% of oil production in the region, emissions of TACs and ROGs are a smaller subset of those emitted by the upstream oil and gas sector in general.

The proportion of the total TAC inventory (mobile and stationary sources) attributable to upstream oil and gas development is not high, and from a regional air quality perspective, these results seem to indicate that TAC emissions from the upstream oil and gas sector are unimportant. However, from a public health perspective, fractions of total emissions are not as important as the quantity or the mass of pollutants emitted at specific locations, as well as the proximity to humans where the emissions occur. Some of the TACs—especially benzene and formaldehyde and potentially hydrogen sulfide (but problems with the inventory do not allow us to be sure)—are emitted in large masses (but not in large fractions of the total inventory) in the upstream oil and gas sector in a densely populated urban area.

The Los Angeles Basin reservoirs have the highest concentrations of oil in the world, and Los Angeles is also a global megacity. Oil and gas development in Los Angeles occurs in close proximity to human populations. In the Los Angeles Basin, approximately 1.7 million people live, and large numbers of schools, elderly facilities, and daycare facilities are located within one mile of—and more than 32,000 people live within 100 m of—an active oil and gas well. The closer citizens are to these industrial facilities, the more likely they are to be exposed to TACs, and the more elevated their risk of associated health effects. Studies from outside of California indicate that community public health risks of exposures to TACs such as benzene and aliphatic hydrocarbons are most significant within 800 m (½ mile) from active oil and gas development. These risks will depend on local conditions and the type of petroleum being produced. California impacts may or may not be similar, but they have not been measured.

4.3.5.2. Potential Water Contamination Pathways in the Los Angeles Basin

Our assessment of hazards to groundwater by hydraulic-fracturing-enabled oil and gas development in the Los Angeles Basin indicates that while data is limited, a small amount of hydraulic fracturing in the Los Angeles Basin has occurred within a short vertical distance to potable aquifers. Given the small number of operations identified that are close to protected groundwater, and the relatively small overall number of hydraulic fracturing operations conducted in the basin, the overall risk of a hydraulic fracture impacting an existing water well is considered small, but the potential hazard to groundwater quality from shallow fracturing operations does warrant enhanced requirements to: 1) control fracturing stimulation design and reporting, 2) increase groundwater monitoring requirements; and 3) implement corrective action planning. No water contamination from well-stimulation-enabled oil and gas development has been noted in the Los Angeles Basin thus far, but this may be because there has been little to no systematic monitoring of aquifers in the vicinity of these oil production sites.

4.3.6. Data Gaps and Recommendations

An overarching recommendation from these analyses is to conduct studies in the Los Angeles Basin and throughout California to document public health risks and impacts as a function of proximity to all oil and gas development—not just those that are stimulated—and promptly develop policies that decrease potential exposures. Such policies might incorporate, for example, increased air pollutant emission control technologies, as well as science-based minimum surface setbacks between oil and gas development and places where people live, work, play and learn.

There are data gaps that contribute to uncertainty with regards to the environmental and public health dimensions of oil and gas development in the South Coast Air Basin. Below we have identified a number of important data gaps and recommendations that are pertinent to the issues explored in this case study:

- **Conduct epidemiological investigations designed to assess the association between proximity to producing wells and human health.** There has only been one epidemiological study that assessed the associations between oil and gas development (distance) and public health outcomes in the Los Angeles Basin, but this study was inappropriate for detecting statistical differences in disease outcomes between the population near the Inglewood Oil Field and Los Angeles County. Study designs—most likely longitudinal in nature and with good baseline environmental and public health measurements—are needed to understand the potential burden of adverse health outcomes associated with the development of oil and gas in the South Coast Air Basin, especially among groups in close proximity to these operations.

- **Study the numbers of residents with pre-existing respiratory and cardiovascular diseases in proximity to oil and gas development.** Populations with respiratory and cardiovascular diseases are disproportionately vulnerable to adverse health outcomes associated with exposures to criteria air pollutants and TACs. To date, no studies have investigated the numbers and concentrations of people with these conditions in close proximity to oil and gas development in the South Coast Air Basin or throughout California.

- **Conduct regional-scale field monitoring of VOC and TAC emission factors from oil and gas development in the South Coast Basin.** Top-down monitoring studies in the South Coast and throughout California have found oil and gas development-scale methane emissions to be potentially three to seven times greater than emissions reported in state inventories. There are no similar studies on the agreement or disagreement of state inventories (such as those analyzed for this case study) and field monitoring of TACs such as benzene (See Volume II, Chapter 3). Current state inventories on these TACs may agree with or be dwarfed by the findings of such field monitoring studies. Findings of such studies could hold policy implications for how VOC and TAC emissions are addressed in the South Coast Air Basin and throughout California.

- **Conduct community-scale monitoring of air pollutant emissions from oil and gas development.** Over the past two decades, the South Coast Region has made impressive strides in reducing criteria air pollutant and toxic air contaminant emissions, and the South Coast Air Basin has enjoyed cleaner air as a result. Nonetheless, the region still experiences severe non-attainment, especially with regards to tropospheric ozone and particulate matter concentrations, and only limited monitoring in close proximity to emitting facilities has been undertaken. Regional air pollutant concentrations, especially of toxic air contaminants and particulate matter, have limited relevance to public health assessments, largely due to the dilution of these air pollutants as they are transported in the atmosphere away from their sources. Exposures to air pollutants can increase with closer proximity to an emission source (e.g., active oil development operations). In order to more accurately understand the composition and magnitude of exposures to air pollutants emitted from the oil and gas development process, more community-scale monitoring activities and sufficient baseline environmental and public health measurements should be undertaken. Community-scaled air quality monitoring activities should be conducted collaboratively between air pollution researchers and community members to increase the relevance and representativeness of the sampling.

- **Investigate the emission and toxicological profiles of TACs associated with oil and gas development.** In this case study we examined the toxicological profiles and emission rates of only four indicator TACs, out of dozens that are known to be associated with oil and gas development. Investigations of emission and toxicological profiles of a larger subset of TACs associated with oil and gas development should be undertaken.

- **Conduct research on emission factors of TACs with no emission factors.** We identified more than 30 compounds known to be TACs that are added to hydraulic fracturing and acidizing fluids in the SoCAB in the SCAQMD oil and gas reporting dataset, yet none of them have known emission factors from oil and gas development processes. Research on the emission factors and the development of an emission inventory of these compounds should be a priority.

- **Require increased air pollutant emission reduction technologies on all processes and ancillary infrastructure.** All oil and gas development in the close proximity to human populations, especially in the dense urban context should be required to install air pollutant emission-reduction technologies, including but not limited to reduced emissions resulting from well completions. Emphasis should be placed on venting, flaring, and fugitive leakage that emit TACs and ROGs, given the non-attainment status and high population density of the Los Angeles Basin. Similar measures can be applied to limit emission of methane to reduce climate impacts.

- **Conduct research on the depth of hydraulic fracturing in relation to usable aquifers in the Los Angeles Basin, especially those used for drinking water.** Our research indicates that active oil and gas development is occurring in the same geographic extent as potable aquifers, such as the Coastal Plain aquifer, which underlies much of the coastal areas of Los Angles and Orange Counties. A full assessment of depth of fractures and the extent to which fractures intersecting aquifers in the Los Angeles Basin would inform regulators and the public as to whether this subsurface pathway presents a risk in this region.

- **Conduct research to identify exact locations of water wells, the use of their water, their geospatial relationship to active and historical oil and gas development, including that enabled by well stimulation, and potential for groundwater contamination.** Precise locations of water wells throughout California are not publicly available. As such, it is difficult to conduct accurate analyses on the potential risks posed by well-stimulation-enabled and other forms of oil and gas development to water quality used by human populations. Future research should identify locations of water wells and perform analyses on potential contamination pathways and potential contamination attributable to oil and gas development.

- **Implement the recommendations regarding shallow fracturing near protected groundwater from Volume III, Chapter 5 (San Joaquin Valley Case Study) should such operations in the Los Angeles Basin continue.** Among these recommendations and should this practice continue in the Los Angeles Basin we suggest there be special requirements to: 1) control fracturing stimulation design and reporting, 2) increase groundwater monitoring requirements; and 3) implement corrective action planning. Additionally, characterization of the base of the deepest groundwater with less than 10,000 mg/L TDS in the Los Angeles Basin is needed in some locations.

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An Independent Scientific Assessment of Well Stimulation in California

Executive Summary

An Examination of Hydraulic Fracturing and Acid Stimulations in the Oil and Gas Industry

July 2015

CCST
CALIFORNIA COUNCIL ON SCIENCE & TECHNOLOGY

BERKELEY LAB
Lawrence Berkeley National Laboratory

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About CCST

CCST is a non-profit organization established in 1988 at the request of the California State Government and sponsored by the major public and private postsecondary institutions of California and affiliate federal laboratories in conjunction with leading private-sector firms. CCST's mission is to improve science and technology policy and application in California by proposing programs, conducting analyses, and recommending public policies and initiatives that will maintain California's technological leadership and a vigorous economy.

Note

Any opinions, findings, conclusions, or recommendations expressed in this publication are those of the author(s) and do not necessarily reflect the views of the organizations or agencies that provided support for the project.

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In 2013, the California Legislature passed Senate Bill 4 (SB 4), setting the framework for regulation of hydraulic fracturing and acid stimulation technologies in California. SB 4 also requires the California Natural Resources Agency to conduct an independent scientific study to assess current and potential future well stimulation practices, including the likelihood that these technologies could enable extensive new petroleum production in the state; the impacts of well stimulation technologies (including hydraulic fracturing, acid fracturing and matrix acidizing) and the gaps in data that preclude this understanding; potential risks associated with current practices; and alternative practices that might limit these risks.

The California Council on Science and Technology (CCST) organized and led the study. Members of the CCST steering committee were appointed based on technical expertise and a balance of technical viewpoints. Lawrence Berkeley National Laboratory (LBNL) and subcontractors (the science team) developed the findings based on original technical data analyses and a review of the relevant literature. The science team studied each of the issues required by SB 4, and the science team and the steering committee collaborated to develop a series of conclusions and recommendations. Final responsibility for the conclusions and recommendations in this report lies with the steering committee. All steering committee members have agreed with these conclusions and recommendations. Any steering committee member could have written a dissenting opinion, but no one requested to do so.

This report has undergone extensive peer review; peer reviewers are listed in Appendix E of the Summary Report, "Expert Oversight and Review." Eighteen reviewers were chosen for their relevant technical expertise. More than 1,500 anonymous review comments were provided to the authors. The authors revised the report in response to peer review comments. In cases where the authors disagreed with the reviewer, the response to review included their reasons for disagreement. Report monitors, appointed by CCST, then reviewed the response to the review comments and when satisfied, approved the report.

To create a hydraulic fracture, an operator increases the pressure of a mixture of water and chemicals in an isolated section of a well until the surrounding rock breaks, or "fractures." Sand injected into these fractures props them open after the pressure is released. Acid fracturing, in which a high-pressure acidic fluid fractures the rock and etches the walls of the fractures, is hardly used in California and not discussed further. Matrix acidizing does not fracture the rock; instead, acid pumped into the well at relatively low pressure dissolves some of the rock and makes it more permeable. This study identified seven equally important major principles required for safe hydraulic fracturing and acid stimulation in California. Organized by principle, we draw conclusions and recommendations.

Principle 1. Maintain, expand and analyze data on the practice of hydraulic fracturing and acid stimulation in California.

Public records provide substantial information about the location, frequency of use, and water and chemical use for hydraulic fracturing and acid stimulation in California.

Conclusion 1.1. Most well stimulations in California are hydraulic fracturing and most hydraulic fracturing occurs in the San Joaquin Valley.

About 95% of reported hydraulic fracturing operations in California occur in the San Joaquin Basin, nearly all in four oil fields in Kern County. Over the last decade, about 20% of oil and gas production in California came from wells treated with hydraulic fracturing. Hydraulic fracturing accounts for about 90% of all well stimulations in California; matrix acidizing accounts for only 10%; and acid fracturing operations nearly none. Operators in California commonly use acid for well maintenance, but acid stimulation will not likely lead to major increases in oil and gas production due to the state's geology. Operators of dry (non-associated) gas wells located in Northern California rarely use hydraulic fracturing (Volume I, Chapter 3).

Conclusion 1.2. The California experience with hydraulic fracturing differs from that in other states.

Present-day hydraulic fracturing practice and geologic conditions in California differ from those in other states, and as such, recent experiences with hydraulic fracturing in other states do not necessarily apply to current hydraulic fracturing in California (Volume I, Chapters 2 and 3).

Conclusion 1.3. Hydraulic fracturing in California does not use a lot of fresh water compared to other states and other human uses.

Operators in California use about 800 acre-feet (about a million cubic meters [m^3]) of water per year for hydraulic fracturing. This does not represent a large amount of freshwater compared to other human water use, so recycling this water has only modest benefits. However, hydraulic fracturing takes place in relatively water-scarce regions. Where production was enabled by hydraulic fracturing, at least twice and possibly fourteen times as much fresh water was used for subsequent enhanced oil recovery using water or steam flooding than all the water used for hydraulic fracturing throughout the state. The state has recently begun requiring detailed reporting of water use and produced water disposal in California's oil and gas fields under Senate Bill 1281 (SB 1281). In the future, these data could help optimize oil and gas water practices, including water use, production, reuse, and disposal.

Recommendation 1.1. Identify opportunities for water conservation and reuse in the oil and gas industry.

When roughly a year of water data becomes available from implementation of SB 1281, the state should begin an early assessment of these data to evaluate water sources, water production, reuse, and disposal for the entire oil and gas industry. Early assessment will shed light on the adequacy of the data reporting requirements and identify additional requirements that could include additional information about the quality of the water used and produced. When several years of data become available, a full assessment should identify opportunities to reduce freshwater consumption or increase the beneficial use of produced water, and regularly update opportunities for water efficiency and conservation (Volume I, Chapter 3).

Conclusion 1.4. A small number of offshore wells use hydraulic fracturing.

California operators currently use hydraulic fracturing in a small portion of offshore wells, and we expect hydraulic fracturing to remain incidental in the offshore environment. Policies currently restrict oil and gas production offshore, but if these were to change in the future, production could largely occur without well stimulation technology for the foreseeable future (Volume III, Chapter 2 [Offshore Case Study]).

Conclusion 1.5. Record keeping for hydraulic fracturing and acid stimulation in federal waters does not meet state standards.

Current record-keeping practice on stimulations in federal waters (from platforms more than three nautical miles offshore) does not meet the standards set by the pending SB 4 well treatment regulations and does not allow an assessment of the level of activity or composition of hydraulic fracturing chemicals being discharged in the ocean. The National Pollutant Discharge Elimination System permits that regulate discharge from offshore platforms do not effectively address hydraulic fracturing fluids. The limited publicly available records disclose only a few stimulations per year.

Recommendation 1.2. Improve reporting of hydraulic fracturing and acid stimulation data in federal waters.

The state of California should request that the federal government improve data collection and record keeping concerning well stimulation conducted in federal waters to at least match the requirements of SB 4. The U.S. Environmental Protection Agency should conduct an assessment of ocean discharge and, based on these results, consider if alternatives to ocean disposal for well stimulation fluid returns are necessary (Volume III, Chapter 2 [Offshore Case Study]).

Principle 2. Prepare for potential future changes in hydraulic fracturing and acid stimulation practice in California.

Conclusion 2.1. Future use of hydraulic fracturing in California will likely resemble current use.

Future use of hydraulic fracturing will most likely expand production in and near existing oil fields in the San Joaquin Basin that currently require hydraulic fracturing. Oil resource assessment and future use of hydraulic fracturing and acid stimulation in the Monterey Formation of California remain uncertain. In 2011, the U.S. Energy Information Administration (EIA) estimated that 15 billion barrels (2.4 billion m^3) of recoverable shale-oil resources existed in Monterey source rock. This caused concern about the potential environmental impacts of widespread shale-oil development in California using hydraulic fracturing. In 2014 the EIA downgraded the 2011 estimate by 96%. This study reviewed both EIA estimates and concluded that neither one can be considered reliable. Any potential for production in the Monterey Formation would be confined to those parts of the formation in the "oil window," that is, where Monterey Formation rocks have experienced the temperatures and pressures required to form oil. The surface footprint of this subset of the Monterey Formation expands existing regions of oil and gas production rather than opening up entirely new oil and gas producing regions.

Recommendation 2.1. Assess the oil resource potential of the Monterey Formation.

The state should request a comprehensive, science-based and peer-reviewed assessment of source-rock ("shale") oil resources in California and the technologies that might be used to produce them. The state could request such an assessment from the U.S. Geological Survey, for example.

Recommendation 2.2. Keep track of exploration in the Monterey Formation.

As expansive production in the Monterey Formation remains possible, Division of Oil, Gas, and Geothermal Resources (DOGGR) should track well permits for future drilling in the "oil window" of the Monterey source rocks (and other extensive source rocks, such as the Kreyenhagen) and be able to report increased activity (Volume I, Chapter 4; Volume III, Chapter 3 [Monterey Formation Case Study]).

Principle 3. Account for and manage both direct and indirect impacts of hydraulic fracturing and acid stimulation.

Hydraulic fracturing or acid stimulation can cause direct impacts. Potential direct impacts might include a hydraulic fracture extending into protected groundwater, accidental spills of fluids containing hydraulic fracturing chemicals or acid, or inappropriate disposal or reuse of produced water containing hydraulic fracturing chemicals. These direct impacts do not occur in oil and gas production unless hydraulic fracturing or acid stimulation has occurred. This study covers potential direct impacts of hydraulic fracturing or acid stimulation.

Hydraulic fracturing or acid stimulation can also incur indirect impacts, i.e., those not directly attributable to the activity itself. Some reservoirs require hydraulic fracturing for economic production. All activities associated with oil and gas production enabled by hydraulic fracturing or acid stimulation can bring about indirect impacts. Indirect impacts of hydraulic-fracturing-enabled oil and gas development usually occur in all oil and gas development, whether or not the wells are stimulated.

Conclusion 3.1. Direct impacts of hydraulic fracturing appear small but have not been investigated.

Available evidence indicates that impacts caused directly by hydraulic fracturing or acid stimulation or by activities directly supporting these operations appear smaller than the indirect impacts associated with hydraulic-fracturing-enabled oil and gas development, or limited data precludes adequate assessment of these impacts. Good management and mitigation measures can address the vast majority of potential direct impacts of well stimulation.

> **Recommendation 3.1. Assess adequacy of regulations to control direct impacts of hydraulic fracturing and acid stimulations.**
>
> *Over the next several years, relevant agencies should assess the adequacy and effectiveness of existing and pending regulations to mitigate direct impacts of hydraulic fracturing and acid stimulations.*

Conclusion 3.2. Operators have unrestricted use of many hazardous and uncharacterized chemicals in hydraulic fracturing.

The California oil and gas industry uses a large number of hazardous chemicals during hydraulic fracturing and acid treatments. The use of these chemicals underlies all significant potential direct impacts of well stimulation in California. This assessment did not find recorded negative impacts from hydraulic fracturing chemical use in California, but no agency has systematically investigated possible impacts. A few classes of chemicals used in hydraulic fracturing (e.g. biocides, quaternary ammonium compounds, etc.) present larger hazards because of their relatively high toxicity, frequent use, or use in large amounts. The environmental characteristics of many chemicals remain unknown. We lack information to determine if these chemicals would present a threat to human health or the environment if released to groundwater or other environmental media. Application of green chemistry principles, including reduction of hazardous chemical use and substitution of less hazardous chemicals, would reduce potential risk to the environment or human health.

Recommendation 3.2. Limit the use of hazardous and poorly understood chemicals.

Operators should report the unique Chemical Abstracts Service Registry Number (CASRN) identification for all chemicals used in hydraulic fracturing and acid stimulation, and the use of chemicals with unknown environmental profiles should be disallowed. The overall number of different chemicals should be reduced, and the use of more hazardous chemicals and chemicals with poor environmental profiles should be reduced, avoided, or disallowed. The chemicals used in hydraulic fracturing could be limited to those on an approved list that would consist only of those chemicals with known and acceptable environmental hazard profiles. Operators should apply green chemistry principles to the formulation of hydraulic fracturing fluids, particularly for biocides, surfactants, and quaternary ammonium compounds, which have widely differing potential for environmental harm. Relevant state agencies, including DOGGR, should as soon as practical engage in discussion of technical issues involved in restricting chemical use with a group representing environmental and health scientists and industry practitioners, either through existing roundtable discussions or independently (Volume II, Chapters 2 and 6).

Conclusion 3.3. The majority of impacts associated with hydraulic fracturing are caused by the indirect impacts of oil and gas production enabled by the hydraulic fracturing.

Impacts caused by additional oil and gas development enabled by well stimulation (i.e. indirect impacts) account for the majority of environmental impacts associated with hydraulic fracturing. A corollary of this conclusion is that all oil and gas development causes similar impacts whether the oil is produced with well stimulation or not. As hydraulic fracturing enables only 20-25% of production in California, only about 20-25% of any given indirect impact is likely attributable to hydraulically fractured reservoirs.

Recommendation 3.3. Evaluate impacts of production for all oil and gas development, rather than just the portion of production enabled by well stimulation.

Concern about hydraulic fracturing might cause focus on impacts associated with production from fractured wells, but concern about these indirect impacts should lead to study of all types of oil and gas production, not just production enabled by hydraulic fracturing. Agencies with jurisdiction should evaluate impacts of concern for all oil and gas development, rather than just the portion of development enabled by well stimulation. As appropriate, many of the rules and regulations aimed at mitigating indirect impacts of hydraulic fracturing and acid stimulation should also be applied to all oil and gas wells (Volume II, Chapters 5 and 6).

Conclusion 3.4. Oil and gas development causes habitat loss and fragmentation.

Any oil and gas development, including that enabled by hydraulic fracturing, can cause habitat loss and fragmentation. The location of hydraulic-fracturing-enabled development coincides with ecologically sensitive areas in the Kern and Ventura Counties.

Recommendation 3.4. Minimize habitat loss and fragmentation in oil and gas producing regions.

Enact regional plans to conserve essential habitat and dispersal corridors for native species in Kern and Ventura Counties. The plans should identify top-priority habitat and restrict development in these regions. The plan should also define and require those practices, such as clustering multiple wells on a pad and using centralized networks of roads and pipes, which will minimize future surface disturbances. A program to set aside compensatory habitat in reserve areas when oil and gas development causes habitat loss and fragmentation should be developed and implemented (Volume II, Chapter 5; Volume III, Chapter 5 [San Joaquin Basin Case Study]).

Principle 4. Manage water produced from hydraulically fractured or acid stimulated wells appropriately.

Large volumes of water of various salinities and qualities get produced along with the oil. Oil reservoirs tend to yield increasing quantities of water over time, and most of California's oil reservoirs have been in production for several decades to over a century. For 2013, more than 3 billion barrels (.48 billion m^3) of water came along with some 0.2 billion barrels (.032 billion m^3) of oil in California. Operators re-inject some produced water back into the oil and gas reservoirs to help recover more petroleum and mitigate land subsidence. In other cases, farmers use this water for irrigation; often blending treated produced water with higher-quality water to reduce salinity.

Conclusion 4.1. Produced water disposed of in percolation pits could contain hydraulic fracturing chemicals.

Based on publicly available data, operators disposed of some produced water from stimulated wells in Kern County in percolation pits. The effluent has not been tested to determine if there is a measureable concentration of hydraulic fracturing chemical constituents. If these chemicals were present, the potential impacts to groundwater, human health, wildlife, and vegetation would be extremely difficult to predict, because there are so many possible chemicals, and the environmental profiles of many of them are unmeasured.

Recommendation 4.1. Ensure safe disposal of produced water in percolation pits with appropriate testing and treatment or phase out this practice.

Agencies with jurisdiction should promptly ensure through appropriate testing that the water discharged into percolation pits does not contain hazardous amounts of chemicals related to hydraulic fracturing as well as other phases of oil and gas development. If the presence of hazardous concentrations of chemicals cannot be ruled out, they should phase out the practice of discharging produced water into percolation pits. Agencies should investigate any legacy effects of discharging produced waters into percolation pits including the potential effects of stimulation fluids (Volume II, Chapter 2; Volume III, Chapters 4 and 5 [Los Angeles Basin and San Joaquin Basin Case Studies]).

Conclusion 4.2. The chemistry of produced water from hydraulically fractured or acid stimulated wells has not been measured.

Chemicals used in each hydraulic fracturing operation can react with each other and react with the rocks and fluids of the oil and gas reservoirs. When a well is stimulated with acid, the reaction of the acid with the rock minerals, petroleum, and other injected chemicals can release contaminants of concern in the oil reservoirs, such as metals or fluoride ions that have not been characterized or quantified. These contaminants may be present in recovered and produced water.

Recommendation 4.2. Evaluate and report produced water chemistry from hydraulically fractured or acid stimulated wells.

Evaluate the chemistry of produced water from hydraulically fractured and acid stimulated wells, and the potential consequences of that chemistry for the environment. Determine how this chemistry changes over time. Require reporting of all significant chemical use, including acids, for oil and gas development (Volume II, Chapters 2 and 6).

Conclusion 4.3. Required testing and treatment of produced water destined for reuse may not detect or remove chemicals associated with hydraulic fracturing and acid stimulation.

Produced water from oil and gas production has potential for beneficial reuse, such as for irrigation or for groundwater recharge. In fields that have applied hydraulic fracturing or acid stimulations, produced water may contain hazardous chemicals and chemical byproducts from well stimulation fluids. Practice in California does not always rule out the beneficial reuse of produced water from wells that have been hydraulically fractured or stimulated with acid. The required testing may not detect these chemicals, and the treatment required prior to reuse necessarily may not remove hydraulic fracturing chemicals.

Recommendation 4.3. Protect irrigation water from contamination by hydraulic fracturing chemicals and stimulation reaction products.

Agencies of jurisdiction should clarify that produced water from hydraulically fractured wells cannot be reused for purposes such as irrigation that could negatively impact the environment, human health, wildlife and vegetation. This ban should continue until or unless testing the produced water specifically for hydraulic fracturing chemicals and breakdown products shows non-hazardous concentrations, or required water treatment reduces concentrations to non-hazardous levels (Volume II, Chapter 2; Volume III, Chapter 5 [San Joaquin Basin Case Study]).

Conclusion 4.4. Injection wells currently under review for inappropriate disposal into protected aquifers may have received water that contains chemicals from hydraulic fracturing.

DOGGR is currently reviewing injection wells in the San Joaquin Valley for inappropriate disposal of oil and gas wastewaters into protected groundwater. The wastewaters injected into some of these wells likely included stimulation chemicals because hydraulic fracturing occurs nearby.

Recommendation 4.4. In the ongoing investigation of inappropriate disposal of wastewater into protected aquifers, recognize that hydraulic fracturing chemicals may have been present in the wastewater.

In the ongoing process of reviewing, analyzing, and remediating the potential impacts of wastewater injection into protected groundwater, agencies of jurisdiction should include the possibility that hydraulic fracturing chemicals may have been present in these wastewaters (Volume II, Chapter 2; Volume III, Chapter 5 [San Joaquin Basin Case Study]).

Conclusion 4.5. Disposal of produced water by underground injection has caused earthquakes elsewhere.

Fluid injected in the process of hydraulic fracturing will not likely cause earthquakes of concern. In contrast, disposal of produced water by underground injection could cause felt or damaging earthquakes. To date, there have been no reported cases of induced seismicity associated with produced water injection in California. However, it can be very difficult to distinguish California's frequent natural earthquakes from those possibly caused by water injection into the subsurface.

Recommendation 4.5. Determine if there is a relationship between wastewater injection and earthquakes in California.

Conduct a comprehensive multi-year study to determine if there is a relationship between oil and gas-related fluid injection and any of California's numerous earthquakes. In parallel, develop and apply protocols for monitoring, analyzing, and managing produced water injection operations to mitigate the risk of induced seismicity. Investigate whether future changes in disposal volumes or injection depth could affect potential for induced seismicity (Volume II, Chapter 4).

Conclusion 4.6. Changing the method of produced water disposal will incur tradeoffs in potential impacts.

Based on publicly available data, operators dispose of much of the produced water from stimulated wells in percolation pits (evaporation-percolation ponds), about a quarter by underground injection (in Class II wells), and less than one percent to surface bodies of water. Changing the method of produced water disposal could decrease some potential impacts while increasing others.

Recommendation 4.6. Evaluate tradeoffs in wastewater disposal practices.

As California moves to change disposal practices, for example by phasing out percolation pits or stopping injection into protected aquifers, agencies with jurisdiction should assess the consequences of modifying or increasing disposal via other methods (Volume II, Chapter 2; Volume II, Chapter 4).

Principle 5. Add protections to avoid groundwater contamination by hydraulic fracturing.

Conclusion 5.1. Shallow fracturing raises concerns about potential groundwater contamination.

In California, about three quarters of all hydraulic fracturing operations take place in shallow wells less than 2,000 feet (600 meters) deep. In a few places, protected aquifers exist above such shallow fracturing operations, and this presents an inherent risk that hydraulic fractures could accidentally connect to the drinking water aquifers and contaminate them or provide a pathway for water to enter the oil reservoir. Groundwater monitoring alone may not necessarily detect groundwater contamination from hydraulic fractures. Shallow hydraulic fracturing conducted near protected groundwater resources warrants special requirements and plans for design control, monitoring, reporting, and corrective action.

Recommendation 5.1. Protect groundwater from shallow hydraulic fracturing operations.

Agencies with jurisdiction should act promptly to locate and catalog the quality of groundwater throughout the oil-producing regions. Operators proposing to use hydraulic fracturing operation near protected groundwater resources should be required to provide adequate assurance that the expected fractures will not extend into these aquifers and cause contamination. If the operator cannot demonstrate the safety of the operation with reasonable assurance, agencies with jurisdiction should either deny the permit, or develop protocols for increased monitoring, operational control, reporting, and preparedness (Volume I, Chapter 3; Volume II, Chapter 2; Volume III, Chapter 5 [San Joaquin Basin Case Study]).

Conclusion 5.2. Leakage of hydraulic fracturing chemicals could occur through existing wells.

California operators use hydraulic fracturing mainly in reservoirs that have been in production for a long time. Consequently, these reservoirs have a high density of existing wells that could form leakage paths away from the fracture zone to protected groundwater or the ground surface. The pending SB 4 regulations going into effect July 2015 do address concerns about existing wells in the vicinity of well stimulation operations; however, it remains to demonstrate the effectiveness of these regulations in protecting groundwater.

Recommendation 5.2. Evaluate the effectiveness of hydraulic fracturing regulations designed to protect groundwater from leakage along existing wells.

Within a few years of the new regulations going into effect, DOGGR should conduct or commission an assessment of the regulatory requirements for existing wells near stimulation operations and their effectiveness in protecting groundwater with less than 10,000 TDS from well leakage. This assessment should include comparisons of field observations from hydraulic fracturing sites with the theoretical calculations for stimulation area or well pressure required in the regulations (Volume II, Chapter 2; Volume III, Chapters 4 and 5 [San Joaquin Basin and Los Angeles Basin Case Studies]).

Principle 6. Understand and control emissions and their impact on environmental and human health.

Gaseous emissions and particulates associated with hydraulic fracturing can arise from the use of fossil fuel in engines, outgassing from fluids, leaks, or proppant. Emissions can also result from all production processes. Such emissions have potential environmental or health impacts.

Conclusion 6.1. Oil and gas production from hydraulically fractured reservoirs emits less greenhouse gas per barrel of oil than other forms of oil production in California.

Burning fossil fuel to run vehicles, make electricity, and provide heat accounts for the vast majority of California's greenhouse gas emissions. In comparison, publicly available California state emission inventories indicate that oil and gas production operations emit about 4% of California total greenhouse gas emissions. Oil and gas production from hydraulically fractured reservoirs emits less greenhouse gas per barrel of oil than production using steam injection. Oil produced in California using hydraulic fracturing also emits less greenhouse gas per barrel than the average barrel imported to California. If the oil and gas derived from stimulated reservoirs were no longer available, and demand for oil remained constant, the replacement fuel could have larger greenhouse gas emissions.

> **Recommendation 6.1. Assess and compare greenhouse gas signatures of different types of oil and gas production in California.**
>
> *Conduct rigorous market-informed life-cycle analyses of emissions impacts of different oil and gas production to better understand GHG impacts of well stimulation (Volume II, Chapter 3).*

Conclusion 6.2. Air pollutant and toxic air emissions from hydraulic fracturing are mostly a small part of total emissions, but pollutants can be concentrated near production wells.

According to publicly available California state emission inventories, oil and gas production in the San Joaquin Valley air district likely accounts for significant emissions of sulfur oxides (SO_x), volatile organic compounds (VOC), and some air toxics, notably hydrogen sulfide (H_2S). In other oil and gas production regions, production as a whole accounts for a small proportion of total emissions. Hydraulic fracturing facilitates about 20% of California production, and so emissions associated with this production also represent about 20% of all emissions from the oil and gas production in California. Even where the proportion of air pollutant and toxic emissions caused directly or indirectly by well simulation is small, atmospheric concentrations of pollutants near production sites can be much larger than basin or regional averages, and could potentially cause health impacts.

> **Recommendation 6.2. Control toxic air emissions from oil and gas production wells and measure their concentrations near productions wells.**
>
> *Apply reduced-air-emission completion technologies to production wells, including stimulated wells, to limit direct emissions of air pollutants, as planned. Reassess opportunities for emission controls in general oil and gas operations to limit emissions. Improve specificity of inventories to allow better understanding of oil and gas emissions sources. Conduct studies to improve our understanding of toxics*

concentrations near stimulated and un-stimulated wells (Volume II, Chapter 3; Volume III, Chapter 4 [Los Angeles Basin Case Study]).

Conclusion 6.3. Emissions concentrated near all oil and gas production could present health hazards to nearby communities in California.

Many of the constituents used in and emitted by oil and gas development can damage health, and place disproportionate risks on sensitive populations, including children, pregnant women, the elderly, and those with pre-existing respiratory and cardiovascular conditions. Health risks near oil and gas wells may be independent of whether wells in production have undergone hydraulic fracturing or not. Consequently, a full understanding of health risks caused by proximity to production wells will require studying all types of productions wells, not just those that have undergone hydraulic fracturing. Oil and gas development poses more elevated health risks when conducted in areas of high population density, such as the Los Angeles Basin, because it results in larger population exposures to toxic air contaminants.

Recommendation 6.3. Assess public health near oil and gas production.

Conduct studies in California to assess public health as a function of proximity to all oil and gas development, not just stimulated wells, and develop policies such as science-based surface setbacks, to limit exposures (Volume II, Chapter 6; Volume III, Chapters 4 and 5 [San Joaquin Basin and Los Angeles Basin Case Studies]).

Conclusion 6.4. Hydraulic fracturing and acid stimulation operations add some occupational hazards to an already hazardous industry.

Studies done outside of California found workers in hydraulic fracturing operations were exposed to respirable silica and VOCs, especially benzene, above recommended occupational levels. The oil and gas industry commonly uses acid along with other toxic substances for both routine maintenance and well stimulation. Well-established procedures exist for safe handling of dangerous acids.

Recommendation 6.4. Assess occupational health hazards from proppant use and emission of volatile organic compounds.

Conduct California-based studies focused on silica and volatile organic compounds exposures to workers engaged in hydraulic-fracturing-enabled oil and gas development processes based on the National Institute for Occupational Safety and Health occupational health findings and protocols (Volume II, Chapter 6).

Principle 7. Take an informed path forward.

Conclusion 7.1. Data reporting gaps and quality issues exist.

Significant gaps and inconsistencies exist in available voluntary and mandatory data sources, both in terms of duration and completeness of reporting. Because the hydrologic and geologic conditions and stimulation practices in California differ from other unconventional plays in this country, many data gaps are specific to California.

> **Recommendation 7.1. Improve and modernize public record keeping for oil and gas production.**
>
> *DOGGR should digitize paper records and organize all datasets in databases that facilitate searches and quantitative analysis. DOGGR should also institute and publish data quality assurance practices, and institute enforcement measures to ensure accuracy of reporting. When a few years' reporting data become available, a study should assess the value, completeness, and consistency of reporting requirements for hydraulic fracturing and acid treatment operations—and as necessary, revise or expand reporting requirements. The quality and completeness of the data collected by the South Coast Air Quality Management District provides a good example of the completeness and availability the state should seek to emulate. The Department of Conservation should reevaluate well stimulation data trends after 3–5 years of reporting.*

Conclusion 7.2. Future research would fill knowledge gaps.

Questions remain at the end of this initial assessment of the impacts of well stimulation in California that can only be answered by new research and data collection. Volumes II and III of this report series provide many detailed recommendations for filling data gaps and additional research. Some examples of key questions include:

- Has any protected groundwater been contaminated with stimulation chemicals in the past, and what would protect against this occurrence in the future? No records of groundwater contamination due to hydraulic fracturing were found, but there were also few investigations designed to look for contamination.

- What environmental risks do stimulation chemicals pose, and are there practices that would limit these risks?

- Can water being produced from hydraulically fractured wells become a resource for California?

- How does oil and gas production as a whole (including that enabled by hydraulic fracturing) affect California's water system?

- Does California's current or future practice of underground injection of wastewater present a significant risk of inducing earthquakes?
- How can the public best be protected from air pollution associated with oil and gas production?
- What are the ecological impacts of oil and gas development in California?

Recommendation 7.2. Conduct integrated research to close knowledge gaps.

Conduct integrated research studies in California to answer key questions about the environmental, health, and seismic impacts of oil and gas production enabled by well stimulation. Integrated research studies should include regional hydrologic characterization and field studies related to surface and groundwater protection, induced seismicity, ecological conditions, as well as air and health effects.

Conclusion 7.3. Ongoing scientific advice could inform policy.

As the state of California digests this assessment and as more data become available, continued interpretation of both the impacts of well stimulation and the potential meaning of scientific data and analysis would inform the policy framework for this complex topic.

Recommendation 7.3. Establish an advisory committee on oil and gas.

The state of California should establish a standing scientific advisory committee to support decisions on the regulation of oil and gas development.

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ATTACHMENT #6

COUNTY OF LOS ANGELES
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July 27, 20015

Supervisor Mark Ridley-Thomas
Second Supervisorial District
866 Kenneth Hahn Hall of Administration
Los Angeles, CA 90012

Dear Supervisor Ridley-Thomas:

I am writing in response to your July 17, 2015 letter requesting our review of the California Council on Science and Technology (CCST) Report on Well Stimulation in California, and to comment specifically on the DPH Community Health Assessment of the Inglewood Oil Field (IOF) Communities.

As you recall, the DPH Health Assessment was designed to compare health outcomes in the communities near the IOF with health outcomes in the rest of Los Angeles County. DPH conducted a random telephone survey of 1,020 adults in the Inglewood communities, utilizing questions about health conditions from the Los Angeles County Health Survey. DPH also analyzed secondary data, including cancer reports from the USC Cancer Surveillance Registry; and birth defects, low-birth-weight births, and mortality data from both County and State databanks. DPH concluded that the health outcomes in the IOF Communities were similar to those found in the rest of the County.

The DPH Health Assessment was not designed to determine whether specific health outcomes were attributable to living near the Inglewood Oil Field; rather, it simply compared health outcomes in these communities to health outcomes in the rest of the County. To determine whether living near the IOF impacts the health of the community would require a prospective cohort study requiring several years of controlled research, typically involving a population size of tens of thousands of individuals. Such a study may be impractical and cost tens of millions of dollars. Even if such a study were performed, in this case, the study population for the IOF communities would simply be too small to generate meaningful results. For these reasons, concerns about community health risks are best addressed by continued monitoring and surveillance of the environment and oil field operations.

The California Council on Science and Technology (CCST) report correctly notes the limitations of the DPH Health Assessment, which were also noted in a written report submitted to your Board on April 11, 2012. These limitations listed below were also presented to the community at a public meeting on August 22, 2013. The three key limitations were:

1) The DPH Community Assessment was not designed to confirm whether oil drilling activities were associated with health outcomes.

2) The DPH Community Assessment did not take into account other determinants of health such as behavioral risk factors (e.g., smoking, physical activity), social factors (e.g., education, income, access to care), and environmental exposures (e.g., traffic-related pollution).

3) The DPH Community Assessment was not designed to establish causal relationships between emissions and specific health outcomes.

We are in agreement with the CCST Report that more study is needed at the State and Federal level on the health and safety implications of oil well stimulation and related activities. This could include a comprehensive evaluation of emissions from the operation of equipment; assessment of potential discharges into water and air; and assessment of the risks of earthquakes and other geological impacts. The results of such studies should be interpreted in the context of all risks associated with oil field operations. A thorough review of the public health implications of oil field production would provide an overall sense of cumulative public health risks, and inform local decision-making related to existing or proposed oil field operations.

Please let me know if you have questions or need additional information.

Sincerely,

Cynthia A. Harding

Cynthia A. Harding
Interim Director

CAH:cr
PH:1507:005

ATTACHMENT #D

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Carlos Castillo-Salgado, MD, JD, MPH, Dr.PH
Adjunct Associate Professor

April 19, 2011

Mr. Ridley-Thomas
Supervisor, Second District
Board of Supervisors
County of Los Angeles
866 Kenneth Hahn Hall of Administration
Los Angeles, California 90012
SENT VIA EMAIL

Dear Mr. Ridley-Thomas:

Thank you for your invitation to review the report entitled "Inglewood Oil Field Communities Health Assessment" that was completed by the Los Angeles County Department of Public Health at the request of the Los Angeles County Board of Supervisors.

Please find my review of the Final Report of Community Health Evaluation and the Inglewood Oil Field as requested:

The soundness of the methods. Methods used in the Health Situation Analyses.

This evaluation study included the calculation, estimation and assessment of different key health indicators related to the potential health impact of risks factors associated with the exposure of petroleum products in the communities in proximity of the Inglewood Oil Field.

These assessments included review of the leading causes of mortality and premature death, analysis of low-birth weight births, analysis of birth defect data and analysis of cancer data for five types of blood-related cancers for the periods 1972-1999 and 2000-2002.

It is important to note that the assessments done are not etiologic epidemiological studies and their study designs do not allow the recognition of a causal relationship between exposure to petroleum risk factors and population health outcomes. These are ecological studies and health situation analyses that explore the associations between living in risk areas in the proximity of the oil fields and several specific health outcomes known to be linked to petroleum products.

Several factors may affect this ecological association, including migration, misclassification of populations and events and other environmental, social and behavioral risk factors.

When evaluating these types of health situation analyses, it is advisable to recognize the following patterns of the key health indicators: (1) Extent; (2) Severity and (3) Trends. All of these patterns were reviewed adequately by including different types of risk assessments: mortality rates analysis, low-birth weight births analysis, birth defects analysis and cancer analysis.

Among the important methodological considerations for these assessments is the definition of the potential risk area and population included in this risk area. Census tracts and zip codes near the Inglewood Oil Field were selected as study area/population.

All assessments included comparisons of the health indicators of residents of the Inglewood Oil Field communities (IOFC) and Los Angeles Country as a whole. To complete these assessments, the study properly used age and race/ethnicity adjustment of rates. The effect of age and race/ethnicity was controlled to better identify the potential association of exposure and risk in the study area. If the study area experienced intensive migration during the period of the assessments, there is a potential source of selection bias.

The sources of vital statistics and health information are the best available for LA. The level of data coverage was very high: 100 % for mortality data and almost 100% for Low-Birth-Weight Births. Because of this high level of coverage rates no additional correction for under-registration or ill-defined causes was required in the calculation of rates. For birth defects information, not all birth defects were collected for all birth years (1998 was excluded because of incomplete data for this year); however the observed pattern of rates of birth defects did not show statistically significant difference in the Inglewood Oil Field communities compared to the county as a whole for 28 of the 29 categories of birth defects (1990-2002). The only category that showed an increased risk was "limb defect" for babies born in the IOF communities between 1990 and 1997 when compared countywide. This category is not known to be caused by exposure to benzene or other petroleum products. A potential source of bias in the assessment of birth defects is present if exposed pregnant women left the IOF area and babies were born in other parts of the country or outside the US. However, the observed pattern is consistent with no differences in the rates of birth defects during the 1990-2002 covered periods.

The selection of the causes for the cancer incidence distributions was adequate since it included the rates of five blood-related cancers linked to petroleum products, including the acute myelogenous leukemia (AML). The source of information was the USC-CSP as it is the population-based cancer registry for Los Angeles County. This is the best available source for cancer incidence data.

There is a potential bias in the information if high migration occurred in the study area, since information from exposed individuals is lost. It is not clear why the two periods were selected: 1972 to 1999 and 2000 to 2005. The time frames for these periods are very different. It is noted that an increased risk of chronic myelogenous leukemia (CML) in non-Hispanic whites was observed in the 2000 to 2005 period. Although it is stated that "CML has not been consistently linked with exposure to petroleum products from oil field or refineries", it is important to implement a monitoring surveillance system following the incidence trend for this type of cancer.

Also, it is recommended that Standardized Incidence-Morbidity Ratios (similar to the Standardized Mortality Ratios "SMR's") be incorporated in the assessments. Table 1 of the Keck's School of Medicine report included the observed and expected numbers of selected hematopoietic cancers in census tracts of IOFC during 1972-1999 and 2000-2005. The expected cases were presented as ranges. It is recommended that the expected cases and their confidence intervals be included. It is also recommended that SIR's be included in this assessment to recognize the excess of incidence rates and of mortality rates (for SMR's).

The interpretation of the results and acknowledgement of limitations

As stated in the presentation of the assessment, the analyses did not contemplate examination of causal associations; since specific data of exposure and health outcomes were not available in the study population and the study designs were not appropriate for recognizing causal relationships between exposure to risk factors related to petroleum products and selected health outcomes.

The four types of health assessments included in this study showed that the mortality rates, low-birth weight births rates, rates of birth defects for 28 categories of birth defects and the rates of four types of blood-related cancers in the periods covered were similar to the rates reported countrywide and that there were no statistically significant differences in the Inglewood Oil Field communities compared to the country as a whole. The assessments used the adequate rate adjustments and the statistical testing/confidence intervals needed to conclude that differences were not significant at the ecological level of the assessment. However, these assessments did not have the methodological strength to recognize small changes in the epidemiologic risk in this area.

It is noted that the four health assessments included the best available information and the assessments used proper epidemiologic and statistical methods for recognizing any significant risk differences at the ecological level of the IOFC population and LA county as a whole.

Recommendations

(1) As noted above, it is recommended that Standardized Incidence Ratios and Standardized Mortality Rates be included in future assessments, particularly due to the relative small areas of the IOF communities.

(2) Since no geospatial exploratory analysis was done to identify geospatial auto-correlations of cancer incident cases or cancer deaths in the IOF communities, it is recommended that a GIS application be included in future follow-ups assessments. Expanding the health analysis using geospatial statistics to explore the possibility of spatial clustering of cases and deaths related to the exposure will be of great analytical value.

(3) It is recommended that Equity Focused Health Impact Assessments be included as part of the next Community-wide health assessment. One of the aims of this type of assessment will be to assess the health consequences to the different population groups of the IOF communities of the new health monitoring system to be implemented.

(4) The development and regular analysis of an active health monitoring process for the IOF related health outcomes is strongly recommended.

(5) The incorporation of the civil society and community representatives in the Health Impact Assessment and Monitoring process will be of critical importance to the success of the public health monitoring process.

Thank you again for the opportunity to review this important health situation analysis for LA County. Please do not hesitate to contact me if you need additional clarification of my review.

Yours truly,

Carlos Castillo-Salgado

Carlos Castillo-Salgado MD, JD, MPH, DrPH
Associate Professor of Epidemiology

April 7, 2011

Dear Los Angeles County Board of Supervisors:

My staff and I reviewed the finding in the Inglewood Oil Field Communities Health Assessment, Bureau of Toxicology and Environmental Assessment, Los Angeles County Department of Public Health, February 2011". Our review focuses on the following aspects of the report: the soundness of the methods, the interpretation of the results and the acknowledgment of limitation.

Sincerely Yours,

Stephen Thacker

CDC Review of Inglewood Oil Field Communities Health Assessment

Introduction:

The Centers for Disease Control and Prevention (CDC) received a request from Los Angeles County (LAC) Board of Supervisors to review a report of a health assessment in the Inglewood Community of LAC. This evaluation is in response to this request.

Background:

Although background information was not included, information on the web provided some background. Oil and gas exploration and production in the Inglewood Oil Field, Los Angeles County, California, date back to the 1920s. Current oil field operations include drilling, subsurface extraction of oil and gas, removal of impurities like water, hydrogen sulfide, and gas liquids (e.g. propane and butane), and shipping of crude oil and gas via pipeline to Southern California customers and refineries. Regional development has continued such that the Inglewood Oil Field is surrounded by residences, schools, commercial and other urban use properties (PXP 2009). In October 2008, the Baldwin Hills Community Standards District (CSD) was established to implement regulations, safeguards, and controls to monitor current and future site plans for drilling and extraction of oil and gas reserves. The Los Angeles County Regional Planning Director is authorized to enforce the CSD. The CSD monitoring and compliance requirements of the Environmental Quality Assurance Program are to be conducted by the oil field operator, Plains Exploration and Production Company (PXP) (LACBS 2008; PXP 2009a).

In February 2011, the Los Angeles County Department of Public Health (LACDPH) released a health assessment for the Baldwin Hills Community in response to health concerns voiced by community residents. To provide a health profile, this assessment reviewed health indicators arising among residents living within ~1.5 miles from the Inglewood Oil Field, by tracts or zip codes, and compared the rates to the total number in the Los Angeles County by age and race/ethnicity standardization. In summary, the LACDPH presented the following rates by years of available records: 1) 2000-2007 mortality; 2) 2000-2007 low-birth-weight births, 3) 1990-2002 birth defects, excluding 1998; and 4) 1972-1999 and 2000-2005 cancer (LACDPH 2011). Frequencies < 20 are suppressed.

CDC review:

Overall, this seems to be a sound assessment of mortality, low birth weight, birth defects and cancers in the Inglewood community and the results appear to be valid. However in order to provide a more comprehensive review, additional information is needed. We need a better understanding of why these specific health outcomes were chosen for assessment. Also, the purpose of the study and how these results will be used is unclear. For example, while all cause and leading cause mortality analysis is informative, especially for resource allocation, it is not specific to exposures potentially associated with present and future Inglewood Oil Field drilling and extraction operations. In order to assess the appropriateness of the investigation, we need a better understanding of these issues and the context in which this community health assessment was conducted.

Given these limitations we do have some specific comments related to the soundness of methods, interpretation of results and limitations which are outlined below.

The soundness of the methods

A strength of this analysis is that it takes advantage of readily available sources of health data. Several of the data sources used were comprehensive and complete. For example, mortality data, the electronic death registration system uses data from death certificates. This data source is 100% complete as death certificates are required to be filed under state law. The cancer registry for LAC, University of Southern California Cancer Surveillance Program (USC-CSP), has an estimated completeness of reporting to the registry of over 95%. In addition, The California Birth Defects Monitoring Program collects data from in-patient facilities, genetic offices and cytogenetic laboratories. Trained staff reviews all relevant records.

The analytic methods used were appropriate for a community health assessment. Comparison of health outcome rates in a community to the larger county rates is a standard method. One recommendation however is to limit the analysis to those health outcomes relevant to the objectives. As stated above the reasons for choosing these health outcomes were unclear.

The interpretation of the results

Overall, LACDPH found that the rates of the health assessment indicators for the population living in the vicinity of Inglewood Oil Field were consistent with those for the county. This interpretation of the results presented in the report seems appropriate. However, as mentioned above the analysis seemed to combine several potential purposes and the objective was unclear. Thus although the interpretation of the analysis and results presented seem appropriate, it is difficult to determine if the correct analysis or data was used and therefore difficult to interpret the results. In addition, we recommend including some basic demographic characteristics about the population such as mean age, gender distribution, average income level, changes in population (In- and out- migration) and occupational sector in the results. This would be useful in interpreting the public health impact.

The acknowledgment of limitations

The limitations acknowledged were correct however there are some additional limitations. Again, depending on the objective it may be important for several of the health outcomes assessed (birth outcomes, cancer) to know the length of time spent in the community.

Summary

Thank for providing us the opportunity to review this community health assessment. We recommend obtaining the additional information requested above (clarification of objectives and purpose). We would be happy review the report again with this additional context.

April 23, 2011

Dear Dr. Teutsch,

Thanks for the opportunity to review the report on the Inglewood Oil Fields. After reading the report in the face of the data available to use I think that LA County Department of Public Health has done a solid job. In light of the many types of confounding exposures that could occur it would be hard to exactly pinpoint the actual source responsible for significant findings. My review of the data employed, the strategy for analyses, and the resulting findings, all appear reasonable and indicated. However, having said that what may be useful for the public use of the report is to avoid the use of epidemiologic jargon in presenting and explaining the findings. Most of comments are actually directed at the Executive Summary as comments are easier to understand later in the report when there are accompanying charts, figures and graphs. As they say a picture is worth a thousand words is well illustrated in the sections that follow the Summary.

Let me give a few examples. As statisticians we understand when and why to use leading cause of deaths versus all causes of death. It might help in the report to help the reader understand that leading causes of death are commonly used as it helps to sharpen our focus on those things that occur most often and are often the targets of policies and procedures. This stands in contrast to using all causes of deaths which may include rare events or unusual circumstances that would not be the best use of developing policies and procedures except in unusual cases. If rare events can be shown to coincide with petroleum based exposures then it would be very helpful as a warning sign for further investigations and examinations. However at this point this does not seem to be the case but it could help those reading better understand the difference in the use of the two types of approaches to mortality statistics.

Also since most individuals are not familiar with when low birth weight is really problematic birth weight would suggest giving the number or range. I think the extra detail not only serves to let people know what the figure is for clinically defined low birth weight but also is just good public health information for the general public. I think that the group who has requested this report may benefit from any additional health information that can be imparted.

Another example of where a bit more detail would be helpful to facilitate ease in reviewing the report is to help the reader understand early in the Summary what the expected heath consequences would be as determined by scientific data on heath consequences from exposures to petroleum. While our knowledge is still developing in this area there is a body of information that can be provided to help the reader know what in general the responses are to petroleum exposures. I think the first thing that most individuals will look for is cancer in any form but there are other possibilities and it would help to just do a bit of elaboration so that as one reads the findings that they have in mind whether they have experienced any of the association consequences.

Also another area of helpful clarification is on page 12 where you talk about the risk of colorectal cancer and the dangers of cooking meat at a high temperature. Most people will see nothing wrong with this statement as one successful public health message has been that cooked meat is better than raw meat. I might have said that cooking meats particularly grilling beef, fish and pork at high temperatures produces carcinogens from the chargrill process. Similar comments of avoidance of being near smoking to giving examples of what near is would be great public health education while at the same time presenting the data on the oil field exposure.

These are relatively minor comments meant to enhance the usefulness of the report. The report as it stands reflects good scientific practices. It is also always heartwarming to see data being used in support of community questions. Keep up the good work and if I can be of any further assistance let me know.

Sincerely,

Vickie M. Mays, Ph.D., MSPH
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