

Appendix M

Health Risk Assessment Proposed Drill and Oil and Gas Operations

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**Health Risk Assessment
Kern County DEIR –
Proposed Drilling and Oil and Gas Operations**

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Table of Contents

1.0 - PROJECT OVERVIEW.....	2
2.0 - HEALTH RISK ASSESSMENT OVERVIEW.....	2
3.0 - EXPOSURE ASSESSMENT.....	6
4.0 - DOSE-RESPONSE	9
5.0 - SIGNIFICANCE THRESHOLDS	10
6.0 - HEALTH RISK ASSESSMENT RESULTS.....	11
7.0 - REFERENCES.....	15

1.0 - PROJECT OVERVIEW

This Health Risk Assessment (HRA) was prepared to support the Draft Environmental Impact Report (DEIR) currently being prepared for the proposed Amendment to Title 19 – Kern County Zoning Ordinance – Chapter 19.98 for Oil and Gas Local Permitting.

This HRA evaluates potential calculated cancer risk and acute and chronic health risk from toxic emissions associated with well construction, drilling, and completion as well as oil and gas processing equipment.

Typical well construction phasing and equipment lists were provided as part of our scope of work; along with emission calculations from all well drilling equipment. All well construction emissions were assumed to occur simultaneously for worst case, conservative assumptions.

In March 2015, the state of California released a new HRA guidance document and software. This new program was used to complete this analysis. Use of the new methodology results in calculated risk three to six times higher (300% - 600%) than results for the same emissions profiles using the model previously required for use from 1990 – February 2015.

2.0 - HEALTH RISK ASSESSMENT OVERVIEW

This HRA was performed following the Office of Environmental Health Hazard Assessment (OEHHA), Air Toxics Hot Spots Program Risk Assessment Guidelines (OEHHA, March 2015).

As recommended by the guidelines, the California Air Resources Board (CARB) Hotspots Analysis and Reporting Program, Version 2 (HARP2) (CARB, 2015) was used to perform a refined health risk assessment for potential future drilling and operational emissions. HARP2 includes three modules: a dispersion model, an exposure/dose module and a risk module. The dispersion model incorporates the United States Environmental Protection Agency (USEPA's) AERMOD model and the risk model includes the latest changes made by the State of California to the Risk Assessment inputs.

In general, risk assessments involve four steps:

- 1) Emissions Estimations of Hazardous Air Pollutants;
- 2) Exposure Assessments;
- 3) Dose-response Assessments; and
- 4) Potential Health Risk Quantification.

Emissions Estimations of Hazardous Air Pollutants

Emission estimates involve identifying and quantifying emissions of potential regulated toxic substances from each source. OEHHA determines the relative toxicity of chemicals regulated by the State of California and determines whether or not they are carcinogenic or possibly

associated with short-term or long-term non-cancer health impacts. Toxic emissions from each source were quantified.

“Hazardous air pollutants” is a term used by the federal Clean Air Act (CAA) that includes a variety of pollutants generated or emitted by industrial production activities. HAPs are also referred to as Toxic Air Contaminants (TACs) under California law (pursuant to the Tanner Act of 1983, codified at Health and Safety Code Section 39650 et. seq.).

California listed diesel exhaust or diesel particulate matter (DPM) as a toxic air contaminant in 1998. The state of California determines the toxicity of each pollutant and assigns each a potency factor. Those factors are built into the HARP2 risk assessment mode.

The diesel particulate matter (DPM) toxicity number incorporates the cumulative health effects of all of the constituents of diesel exhaust into one risk number. Therefore, the only TAC associated with diesel equipment from well construction and completion is DPM. The primary TACs of concern for this project are diesel exhaust associated with construction equipment and drill rigs and benzene (associated with oil processing equipment).

DPM was the only set of toxic emissions analyzed from drilling operations as it accounts for 100 percent of the risk from drilling operations. Benzene accounts for approximately 94 percent of the risk from the oil processing equipment. Although the oil processing equipment scenarios did not result in off-site risk greater than 10 in one million, the risk is attributable to benzene, formaldehyde and polycyclic aromatic hydrocarbons (PAHs). All three are byproducts of natural gas combustion. Potential health effects from these compounds are summarized here.

Diesel Particulate Matter (DPM)

Respirable particles (particulate matter less than about 10 micrometers in diameter [PM_{10}]) can accumulate in the respiratory system and aggravate health problems such as asthma, bronchitis, and other lung diseases. Children, the elderly, exercising adults, and those suffering from asthma are especially vulnerable to adverse health effects of PM_{10} and $PM_{2.5}$. For purposes of this study, all $PM_{2.5}$ from diesel equipment associated with well drilling (including potential dust and mobile equipment) is conservatively assumed to be toxic diesel particulate matter. DPM represents 100% of the risk associated with well drilling as it is the only TAC expected emitted during construction.

Benzene

The primary risk driver from oil processing equipment is benzene. Benzene is naturally occurring in oil and gas. Approximately 84 percent of the benzene emitted in California comes from motor vehicles, including evaporative leakage and unburned fuel exhaust. Currently, the benzene content of gasoline is less than 1 percent.

Benzene is potentially carcinogenic and naturally occurs throughout California. Benzene also has noncancer health effects. Brief inhalation exposure to high concentrations can cause central nervous system depression. Acute effects include central nervous system symptoms of nausea, tremors, drowsiness, dizziness, headache, intoxication, and unconsciousness.

Neurological symptoms of inhalation exposure to benzene include drowsiness, dizziness, headaches, and unconsciousness in humans. Ingestion of large amounts of benzene may result in vomiting, dizziness, and convulsions in humans. Exposure to liquid and vapor may irritate the skin, eyes, and upper respiratory tract in humans. Redness and blisters may result from dermal exposure to benzene.

Formaldehyde

Formaldehyde is a colorless, flammable, chemical typically used in building materials and many household products such as pressed-wood, particle board, plywood; glues and adhesives. Formaldehyde is also naturally occurring in the environment. It is a by-product of natural gas combustion.

PAHs

The term polycyclic aromatic hydrocarbons (PAHs) refers to a group of several hundred chemically-related, environmentally persistent organic compounds of various structures and varied toxicity. Most of them are formed by a process of thermal decomposition (pyrolysis) and subsequent recombination (pyrosynthesis) of organic molecules. PAHs enter the environment through various routes and are usually found as a mixture containing two or more of these compounds, e.g. soot. They have been shown to cause carcinogenic and mutagenic effects and are potent immunosuppressants. Effects have been documented on immune system development. They are by-products of natural gas combustion.

Well Drilling Emissions

Seven phases of drilling were considered as detailed below. All particulate matter of 2.5 microns (PM_{2.5}) was considered to be toxic diesel particulate matter.

Well depths of 2,000', 5,000' and 10,000' were evaluated. Using a very conservative approach, emissions from all seven phases were assumed to occur simultaneously. An initial year of 2015 was modeled and the final year of 2035 was modeled. For the 10,000' well, 2020 was also evaluated to account for a significant decrease in diesel exhaust emissions from drill rigs and off-road diesel engines as the next CARB regulatory limits become effective. CARB's OFFROAD emissions estimate model was used to calculate emissions from the primarily mobile and off-road diesel equipment. CARB has extensive regulations for diesel equipment with future compliance dates that will result in significant emission reductions of PM_{2.5} over time. CARB's OFFROAD model can only project emissions to 2029 based on today's available engine technologies. As a result, all emissions between 2029 – 2035 are assumed to be the same.

For this analysis, the following sources were included for evaluation:

- Well drilling (all aspects of construction, well drilling and completion) for a 2,000', 5,000' and 10,000' well.

Each well evaluation consists of the following phases:

- Land Preparation;
- Drilling Survey;
- Well Drilling;
- Well Completion;
- Well Flowline;
- Pump Unit; and
- Electrical.

Numbers and types of equipment associated with each well depth are listed below. An exact equipment list for each of the seven phases and their associated emissions is included as Appendix B.

Both drilling and operational emissions are assumed to occur along a fenceline shared by an oil producer and a private resident.

Table 1 – Equipment Associated with Well Construction, Drilling and Completion*

Depth Feet	Number of Trucks	Off-Road Construction Equip.	Drill Rig HP totals	Drilling Days
10,000	9	45	3 rigs at 1,040HP each	23
5000	9	45	3 rigs at 440HP each	8
2000	9	45	3 rigs at 440HP each	4

*As previously noted, this equipment is for the combined operation of all seven phases of construction, drilling and completion.

Table 2 – Emissions Associated with Well Construction, Drilling and Completion

Depth Feet	Year ¹	Total PM2.5 ² pounds	Annual PM2.5 ³ pounds	Days ⁴
10,000	2015	516.89	17.23	23
10,000	2018	444.00	14.8	23
10,000	2035	151.83	5.06	23
5000	2015	171.18	5.71	8
5000	2035	35.86	1.20	8
2000	2015	97.12	3.24	4
2000	2035	20.42	0.68	4

¹2029-2035 emissions are the same.

²From Vector Environmental Spreadsheet titled "DRL_EMISSIONS.xlsx", worksheet "EMF".

³Total emissions divided by 30 years per OEHHA's HARP2 exposure duration requirements.

⁴From Vector Spreadsheet titled "DRL_EMISSIONS.xlsx", worksheet "MUD".

Operational Equipment Emissions

Maximum daily and annual emissions were also quantified from an oil processing facility and a natural gas combustion facility. The equipment list and parameters was provided as part of our Scope of Work.

Oil Processing Equipment

Emissions from the following equipment were analyzed in the oil processing scenario:

- Two – 1,000 Bbl above-ground tanks;
- One – 3,000 Bbl above-ground tank;
- One 10 MMBtu/hour Flare;
- Truck loading rack;
- Fugitive emissions from valves, flanges, and one underground sump; and
- Thermally enhanced oil recovery (TEOR) equipment.

Natural Gas Combustion Equipment

Emissions from the following natural gas combustion equipment were analyzed in the natural gas scenario:

- One new 100 MMBtu/hour flare;
- One – 8 MMBtu/hour Process Heater;
- One – 10 MMBtu/hour Boiler;
- One – 85 MMBtu/hour Steam Generator; and
- One – 33 MW Cogeneration Plant.

Potential toxic emissions from each of these sources are summarized in Appendix A.

3.0 - EXPOSURE ASSESSMENT

Exposure assessment includes air dispersion modeling, identification of emission exposure routes and estimation of exposure levels. The modeling estimates ground level concentrations based on an emission rate of one gram per second. This rate is then multiplied by the worst case potential emission rate for each substance to obtain ground level concentrations. In addition to inhalation, potential pathways of exposure to offsite receptors include dermal exposure and ingestion.

HARP2 incorporates the USEPA AERMOD (v14134) model. AERMOD predicts resulting cumulative concentrations from various emission sources. The rural setting was selected in AERMOD for this analysis. AERMOD's terrain processor, AERMAP, was used to incorporate

actual terrain elevations for sources and receptors. Five years of meteorological data required for AERMOD was obtained from the San Joaquin Valley Air Pollution Control District (SJVAPCD). Bakersfield station 23155 was used for this analysis.

Three different locations within Kern County were assessed in order to capture various terrain characteristics within Kern County.

These areas were previously determined as being representative of various aspects of the county and were included as part of our Scope of Work: Western, Central and Eastern Kern County.

- Western Subarea – Midway Sunset Oilfield
- Central Subarea – No. Shafter Oilfield
- Eastern Subarea – Kern River Oilfield

Terrain in the Central Subarea is relatively flat, and modeling results would best represent dispersion characteristics with minimal terrain disturbances. More site location and terrain specific influences were observed in the Western Subarea and even more in the Eastern Subarea. Sufficient analysis of different factors that affect dispersion and other modeling inputs were covered by modeling three separate areas within Kern County. The rural setting in AERMOD was selected and the model selects the terrain variability based on real-world conditions.

Table 3 shows the UTM location of the project centers for each selected Subarea.

Table 3 - Modeled Kern County Project Locations¹

Subarea	Easterly	Northerly
Western	255,000	3918,100
Central	293,650	3934,400
Eastern	319,800	3925,150

¹Based on Subarea modeling locations provided by Vector dated 2/15/2015 and rounded to the nearest 164 feet. (UTM NAD83, Zone 11)

Source Modeling Parameters

Potential sources were modeled as described in the table below. Both drilling and operational emissions are assumed to occur along a fenceline shared by an oil producer and a private residence.

Table 4 - Modeling Source Characteristics and Release Parameters

Point Sources				
Source Name	Height, ft	Temp, °F	Velocity, fps	Diameter, ft
10 MMBtu/hr Flare ¹	49.3	1831.7	65.6	1.82
100 MMBtu/hr Flare ¹	68.0	1831.7	65.6	5.76
85 MMBtu/hr Steam Generator ²	20	200	32.0	2.5
33 MW Cogen	30	991	67.8	10.0
8 mm Btu/hour process heater ²	15	600	29.9	1.5
1000 bhp Natural Gas Engine ²	20	850	30	2
10 mm Btu/hour boiler ²	20	400	23.9	1.5
Area Sources				
Source Name	Release Height, feet	X, feet	Y, feet	
Fugitive leaks	3.28	65.5	65.6	
Sump	0	30	30	
Drilling Mud Sump	0	32.8	32.8	
TEOR	0	16.5	16.5	
Circular Area Sources				
Source Name	Height, ft	Radius, ft		
1000 Bbl Tank	16.0	10.8		
1000 Bbl Tank	16.0	10.8		
3000 Bbl Tank	24.1	14.9		
Volume Sources				
Source Name	Release Height, feet	Initial Lateral Dimension, feet	Initial Vertical Dimension, feet	
Drilling	30	16.5	16.5	
Vacuum Truck Loading	13.1	1.97	3.05	

¹Adjusted per Ohio EPA methodology.

²Per Scope of Work amendment 2-15-2015.

³Tank dimensions from tank vendor website.

4.0 - DOSE-RESPONSE

The dose-response assessment describes the quantitative relationship between a human's exposure to a substance (the dose) and the incidence or occurrence of an adverse health impact (the response). For carcinogens, OEHHA has developed cancer potency factors. A cancer potency factor represents the upper bound probability of developing cancer based on a continuous lifetime exposure. The cancer potency factor does not represent a threshold under which a person would not develop cancer, but instead is used to estimate the probability of developing cancer.

For non-carcinogenic chemicals, OEHHA has developed Recommended Exposure Limits (RELs) for acute and chronic impacts. RELs represent concentration thresholds at which no adverse noncancer health effects are anticipated. For chemicals that are not deemed by the State of California as possible carcinogens, but which may pose either short-term (acute) or other non-cancer long-term (chronic) health effects, a Hazard Index (HI) calculation of potential risk is also required by the air district and the state as part of a Health Risk Assessment.

Exposure Pathways

A receptor can be hypothetically exposed to a substance through several different pathways. Typically, the primary environmental exposure pathway in a health risk assessment is direct inhalation of gaseous and particulate air pollutants. However, there is the potential for exposure via non-inhalation pathways due to the deposition of particulate pollutants (diesel particulate matter) in the environment. For this analysis, HARP2 requires assumptions that diesel particulate matter could also be ingested via dermal (skin) absorption, soil ingestion and mother's milk ingestion. PAHs were the only pollutants analyzed for which there is a non-inhalation pathway.

Relative Toxicity

The following table represents the relative toxicity of the compounds which contributed to most of the calculated risk. For example, diesel particulate matter (DPM) (with an inhalation potency factor of 1.1) is approximately 10 times more toxic than benzene (inhalation potency factor of 0.10) and PAHs are almost four times more toxic than DPM.

Table 5 - Chemical Cancer Risk Factors¹

Chemical	Inhalation Unit Risk ²	Inhalation Potency Factor ²	Non-Inhalation Oral Slope Factor
	($\mu\text{g}/\text{m}^3$) ⁻¹	($\text{mg}/\text{kg-d}$) ⁻¹	($\text{mg}/\text{kg-d}$) ⁻¹
Diesel Particulate Matter	0.0003	1.1	NA (inhalation only)
Total PAHs ³	0.001	3.9	12.0
Formaldehyde	0.000006	0.02	NA (inhalation only)
Benzene	0.029	0.10	NA (inhalation only)

¹May 13, 2015.

²Inhalation cancer potency factor: The “unit risk factor” has been replaced in the new risk assessment algorithms by a factor called the “inhalation cancer potency factor”. Inhalation cancer potency factors are expressed as units of inverse dose [i.e., ($\text{mg}/\text{kg-day}$)-1]. They were derived from unit risk factors [units = ($\mu\text{g}/\text{m}^3$)-1] by assuming that a receptor weighs 70 kilograms and breathes 20 cubic meters of air per day. The inhalation potency factor is used to calculate a potential inhalation cancer risk using the new risk assessment algorithms defined in the OEHHA, *Air Toxics Hot Spots Program; Technical Support Document for Exposure Assessment and Stochastic Analysis* (August 2012).

³Polycyclic Aromatic Hydrocarbons (PAHs): (Not including naphthalene.) These substances are PAH or PAH-derivatives that have OEHHA-developed Potency Equivalency Factors (PEFs) which were approved by the Scientific Review Panel in April 1994 (see ARB document entitled *Benzo[a]pyrene as a Toxic Air Contaminant*). PAH inhalation slope factors listed here have been adjusted by the PEFs. See OEHHA’s Technical Support Document: Methodologies for Derivation, Listing of Available Values, and Adjustments to Allow for Early Life Exposures (2009) for more information about the scheme. Section 8.2.3 and Appendix G of OEHHA’s *The Air Toxics Hot Spots Program Guidance Manual for Preparation of Health Risk Assessments* (2003) also contains information on PAHs.

5.0 - SIGNIFICANCE THRESHOLDS

SJVAPCD publishes CEQA significance thresholds for potential health risk from proposed projects. Currently, risks from a project that are less than the following regulatory thresholds are considered not to be significant and are, therefore, acceptable:

- Cancer risk equal to or less than 10 in one million
- Chronic hazard index equal to or less than 1
- Acute hazard index equal to or less than 1

These metrics are generally applied to the maximally exposed individual (MEI). There are separate MEIs for residential exposure (i.e., residential areas) and for worker exposure (i.e., offsite work places).

Note: SJAPCD is currently planning to increase the risk standard to 20 in one million theoretical excess cancer cases. However, this study is based on the current standard of 10 in one million theoretical excess cancer cases.

6.0 - HEALTH RISK ASSESSMENT RESULTS

A refined health risk assessment was performed using the HARP2 model. As shown, calculated cancer risk from drilling a 10,000' well exceeds a threshold of 10 cases in one million (Table 6). The maximum distances from the shared property boundary (oil company and private resident) are illustrated in Figure 1 below.

The 5,000' well scenario also exceeds 10 in one million in 2015 only. Therefore, after 2015, any well drilled shallower than 5,000' would not result in a risk greater than 10 in one million. (Table 6)

None of the gas fired equipment exceeds a risk of 10 in one million (Table 7).

The scenario in which all of the oil processing equipment operates full time and is located in the exact same location with a shared fenceline to private property results in a 10 in one million risk level from 478 – 701 feet depending on the subarea of Kern County (Table 7).

None of the noncancer hazards for either an oil processing facility or a gas processing facility exceed the regulatory threshold of 1.0 (Tables 9 and 10).

Figure 1 -

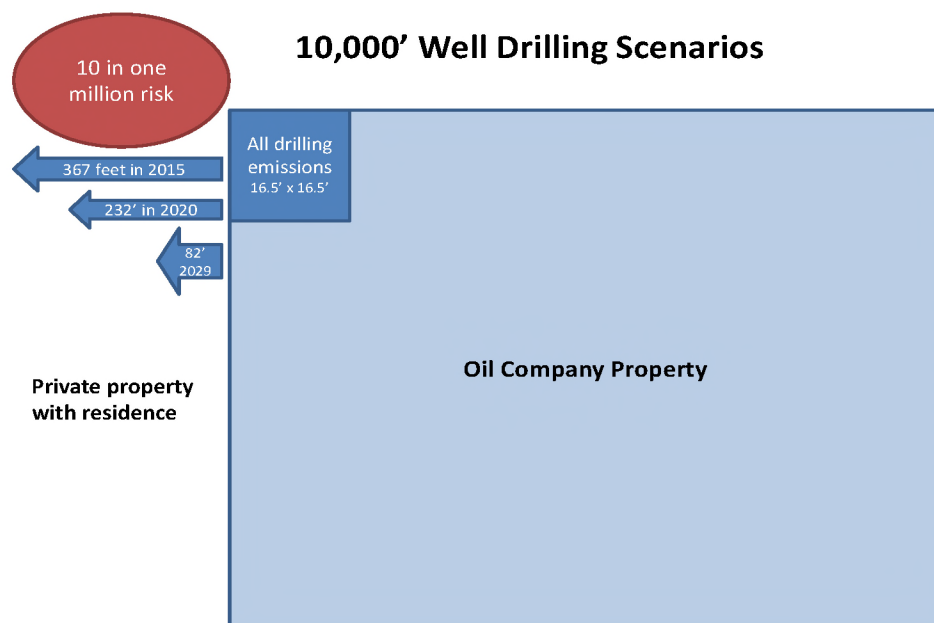


Table 6 –

Potential health risk from well construction, drilling and completion emissions

Well Depth (feet)	Year	Maximum distance from well site and project boundary to 10 in one million calculated risk
<i>Western Subarea</i>		
10,000	2015	367 feet
10,000	2020	232 feet
10,000	2029	82 feet
5000	2015	116 feet
5000	2029	NA*
2000	2015	NA
2000	2029/2035	NA
<i>Central Subarea</i>		
10,000	2015	367 feet
10,000	2020	232 feet
10,000	2029	82 feet
5000	2015	116 feet
5000	2029	NA
2000	2015	NA
2000	2029/2035	NA
<i>Eastern Subarea</i>		
10,000	2015	296 feet
10,000	2019	183 feet
10,000	2029	NA
5000	2015	NA
5000	2029	NA
2000	2015	NA
2000	2029/2035	NA

*NA = no offsite risk greater than 10 in one million.

**Table 7 -
Potential health risks from gas processing equipment**

Equipment	Risk greater than 10 in one million?
1000 bhp natural gas ICE	No
100 mmbtu/hr flare	No
85 mmbtu/hour steam generator	No
8 mm btu/hour boiler	No
33 MW cogen	No
TEOR Equipment	No

**Table 8 –
Potential health risks from all oil processing equipment**

Equipment	Western Subregion Cancer Risk Distance to 10 in one million*	Central Subregion Cancer Risk Distance to 10 in one million*	Eastern Subregion Cancer Risk Distance to 10 in one million*
1,000 bbl oil tank			
1,000 bbl oil tank			
3,000 bbl oil tank			
truck loading rack			
30'x30' sump			
10,000 btu/hour flare			
Fugitive VOCs			
TOTAL CUMULATIVE RISK Distances	701'	625'	478'

*Risk distances assume that all equipment is placed along a shared fence line between the oil site and a private residence.

NOTE: All of this equipment would require SVAPCD air permits. As such, the risk threshold must be complied with or permits cannot be issued. So, in this scenario either less equipment could be used and/or the receptors cannot share a fence line in order for this scenario to be viable.

Table 9
Potential Acute Impacts

Equipment	Western Subregion Acute Risk	Central Subregion Acute Risk	Eastern Subregion Acute Risk	Hazard Index Standard	Significant Risk?
Drilling Emissions 10,000' well	0.0098	0.0098	0.0090	1.0	No
Oil Processing Emissions	0.43	0.41	0.40	1.0	No
Gas Processing Emissions	0.88	0.88	0.89	1.0	No

Table 10
Potential Chronic (Non Cancer Impacts)

Equipment	Western Subregion Chronic Risk	Central Subregion Chronic Risk	Eastern Subregion Chronic Risk	Hazard Index Standard	Significant Risk?
Drilling Emissions 10,000' well	0.0009	0.0009	0.0008	1.0	No
Oil Processing Emissions	0.063	0.63	0.60	1.0	No
Gas Processing Emissions	0.034	0.034	0.030	1.0	No

7.0 - REFERENCES

California Code of Regulations, Title 22, Division 2, Chapter 3, Section 12000 “Safe Drinking Water and Toxic Enforcement Act of 1986.” California regulations can be downloaded at the following link: <http://www.oal.ca.gov/>.

CARB. 2015. “HARP User Guide.” The document can be downloaded at the following link: <http://www.arb.ca.gov/toxics/harp/harpug.htm>

SCAQMD. 2007. “General Instruction Book for the 2006-2007 Annual Emission Reporting Program.” The document can be downloaded at the following link: http://www.ecotek.com/aqmd/2006/forms_and_instructions_pdf/0607_GuideBook.pdf

SCAQMD. 2005. “Risk Assessment Procedures for Rules 1401 and 212”. The document can be downloaded at the following links: <http://www.aqmd.gov/prdas/pdf/riskassessmentprocedures-v7.pdf> and <http://www.aqmd.gov/prdas/pdf/attachmentpkg-l.pdf>.

SCAQMD. 2005. “Supplemental Guidelines for Preparing Risk Assessments for the Air Toxics “Hot Spots” Information and Assessment Act (AB2588). The document can be downloaded at the following link: http://www.aqmd.gov/prdas/AB2588/pdf/AB2588_Guidelines.pdf.

United States Environmental Protection Agency (U.S. EPA) 2004. User's Guide for the AMS/EPA Regulatory Model – AERMOD, EPA-454/B-03-001.

Meteorological data used by AERMOD was obtained by SJVAPCD for Bakersfield Station 23155.

OEHHA. 2003. “The Air Toxics Hot Spots Program Guidance Manual for Preparation of Health Risk Assessments.” The document can be downloaded at the following link: http://www.oehha.ca.gov/air/hot_spots/HRSguide.html.

Vector Environmental: Emissions from Offroad Mobile Sources and Portable Equipment Required for the Construction of Wells. 2015. Criteria pollutant emission data by activity, phase and task for years 2012-2029.

Vector Environmental: MS Excel spreadsheet entitled: “DRL_EMISSIONS.xlsx”.

Appendix A

Toxic Air Contaminants by Device

Source Name	Source ID	CAS #	Chemical Name	Pounds/year	Pounds/hour
Fugitive VOCs	FHC01	95636	"1,2,4 Trimethylbenzene"	0.01	0.00
Fugitive VOCs	FHC01	71432	Benzene	0.32	0.00
Fugitive VOCs	FHC01	110827	Cyclohexane	0.02	0.00
Fugitive VOCs	FHC01	100414	Ethylbenzene	0.10	0.00
Fugitive VOCs	FHC01	110543	n-Hexane	2.38	0.00
Fugitive VOCs	FHC01	108883	Toluene	0.36	0.00
Fugitive VOCs	FHC01	1330207	Xylenes	0.19	0.00
Fugitive VOCs	FHC01	7783064	Hydrogen sulfide	2.02	0.00
10 MMBtu/hr Flare	FLR01	75070	Acetaldehyde	3.77	0.00
10 MMBtu/hr Flare	FLR01	107028	Acrolein	0.88	0.00
10 MMBtu/hr Flare	FLR01	71432	Benzene	13.93	0.00
10 MMBtu/hr Flare	FLR01	110827	Cyclohexane	0.00	0.00
10 MMBtu/hr Flare	FLR01	100414	Ethylbenzene	126.49	0.01
10 MMBtu/hr Flare	FLR01	50000	Formaldehyde	102.40	0.01
10 MMBtu/hr Flare	FLR01	110543	n-Hexane	2.54	0.00
10 MMBtu/hr Flare	FLR01	7783064	Hydrogen sulfide	15.70	0.00
10 MMBtu/hr Flare	FLR01	91203	Naphthalene	0.96	0.00
10 MMBtu/hr Flare	FLR01	1151	PAH's	1.23	0.00
10 MMBtu/hr Flare	FLR01	115071	Propylene	213.74	0.02
10 MMBtu/hr Flare	FLR01	108883	Toluene	5.08	0.00
10 MMBtu/hr Flare	FLR01	1330207	Xylenes	2.54	0.00

Sump	SMP01	95636	"1,2,4 Trimethylbenzene"	0.23	0.00
Sump	SMP01	71432	Benzene	6.78	0.00
Sump	SMP01	110827	Cyclohexane	0.33	0.00
Sump	SMP01	100414	Ethylbenzene	2.16	0.00
Sump	SMP01	110543	n-Hexane	50.00	0.01
Sump	SMP01	108883	Toluene	7.60	0.00
Sump	SMP01	1330207	Xylenes	4.01	0.00
Sump	SMP01	7783064	Hydrogen sulfide	0.49	0.00
Truck Loading Rack	LDR01	95636	"1,2,4 Trimethylbenzene"	0.63	0.00
Truck Loading Rack	LDR01	71432	Benzene	18.92	0.00
Truck Loading Rack	LDR01	110827	Cyclohexane	0.92	0.00
Truck Loading Rack	LDR01	100414	Ethylbenzene	6.02	0.00
Truck Loading Rack	LDR01	110543	n-Hexane	139.46	0.02
Truck Loading Rack	LDR01	108883	Toluene	21.20	0.00
Truck Loading Rack	LDR01	1330207	Xylenes	11.18	0.00
Truck Loading Rack	LDR01	7783064	Hydrogen sulfide	1.36	0.00
Oil Storage Tank (1,000 bbls)	TNK03	95636	"1,2,4 Trimethylbenzene"	0.75	0.00
Oil Storage Tank (1,000 bbls)	TNK03	71432	Benzene	22.45	0.00
Oil Storage Tank (1,000 bbls)	TNK03	110827	Cyclohexane	1.10	0.00
Oil Storage Tank (1,000 bbls)	TNK03	100414	Ethylbenzene	7.15	0.00
Oil Storage Tank (1,000 bbls)	TNK03	110543	n-Hexane	165.48	0.02

Oil Storage Tank (1,000 bbls)	TNK03	108883	Toluene	25.16	0.00
Oil Storage Tank (1,000 bbls)	TNK03	1330207	Xylenes	13.26	0.00
Oil Storage Tank (1,000 bbls)	TNK03	7783064	Hydrogen sulfide	1.62	0.00
Oil Storage Tank (1,000 bbls)	TNK02	95636	"1,2,4 Trimethylbenzene"	0.75	0.00
Oil Storage Tank (1,000 bbls)	TNK02	71432	Benzene	22.45	0.00
Oil Storage Tank (1,000 bbls)	TNK02	110827	Cyclohexane	1.10	0.00
Oil Storage Tank (1,000 bbls)	TNK02	100414	Ethylbenzene	7.15	0.00
Oil Storage Tank (1,000 bbls)	TNK02	110543	n-Hexane	165.48	0.02
Oil Storage Tank (1,000 bbls)	TNK02	108883	Toluene	25.16	0.00
Oil Storage Tank (1,000 bbls)	TNK02	1330207	Xylenes	13.26	0.00
Oil Storage Tank (1,000 bbls)	TNK02	7783064	Hydrogen sulfide	1.62	0.00
Oil Storage Tank (3,000 bbls)	TNK01	95636	"1,2,4 Trimethylbenzene"	0.60	0.00
Oil Storage Tank (3,000 bbls)	TNK01	71432	Benzene	17.73	0.00
Oil Storage Tank (3,000 bbls)	TNK01	110827	Cyclohexane	0.87	0.00
Oil Storage Tank (3,000 bbls)	TNK01	100414	Ethylbenzene	5.64	0.00
Oil Storage Tank	TNK01	110543	n-Hexane	130.72	0.02

(3,000 bbls)					
Oil Storage Tank (3,000 bbls)	TNK01	108883	Toluene	19.87	0.00
Oil Storage Tank (3,000 bbls)	TNK01	1330207	Xylenes	10.48	0.00
Oil Storage Tank (3,000 bbls)	TNK01	7783064	Hydrogen sulfide	1.28	0.00
Process Heater	PHT01	83329	Acenaphthene	0.00	0.00
Process Heater	PHT01	208968	Acenaphthylene	0.01	0.00
Process Heater	PHT01	75070	Acetaldehyde	1.17	0.00
Process Heater	PHT01	107028	Acrolein	0.20	0.00
Process Heater	PHT01	120127	Anthracene	0.00	0.00
Process Heater	PHT01	56553	Benz(a)anthracene	0.00	0.00
Process Heater	PHT01	71432	Benzene	1.71	0.00
Process Heater	PHT01	50328	Benzo(a)pyrene	0.00	0.00
Process Heater	PHT01	205992	Benzo(b)fluoranthene	0.00	0.00
Process Heater	PHT01	191242	"Benzo(g,h,i)perylene"	0.00	0.00
Process Heater	PHT01	207089	Benzo(k)fluoranthene	0.00	0.00
Process Heater	PHT01	218019	Chrysene	0.00	0.00
Process Heater	PHT01	53703	"Dibenz(a,h)anthracene"	0.00	0.00
Process Heater	PHT01	206440	Fluoranthene	0.00	0.00
Process Heater	PHT01	86737	Fluorene	0.12	0.00
Process Heater	PHT01	50000	Formaldehyde	6.23	0.00
Process Heater	PHT01	7783064	Hydrogen sulfide	12.56	0.00
Process Heater	PHT01	193395	"Indeno(1,2,3-cd)pyrene"	0.00	0.00
Process Heater	PHT01	91203	Naphthalene	0.43	0.00

Process Heater	PHT01	85018	Phenanthrene	0.03	0.00
Process Heater	PHT01	108952	Phenol	0.15	0.00
Process Heater	PHT01	115071	Propylene	0.97	0.00
Process Heater	PHT01	129000	Pyrene	0.00	0.00
Process Heater	PHT01	108883	Toluene	2.12	0.00
Process Heater	PHT01	1330207	Xylenes	2.45	0.00
Steam Generator	SGR01	83329	Acenaphthene	0.00	0.00
Steam Generator	SGR01	208968	Acenaphthylene	0.01	0.00
Steam Generator	SGR01	75070	Acetaldehyde	19.88	0.00
Steam Generator	SGR01	107028	Acrolein	13.55	0.00
Steam Generator	SGR01	120127	Anthracene	0.00	0.00
Steam Generator	SGR01	56553	Benz(a)anthracene	0.00	0.00
Steam Generator	SGR01	71432	Benzene	4.62	0.00
Steam Generator	SGR01	50328	Benzo(a)pyrene	0.00	0.00
Steam Generator	SGR01	205992	Benzo(b)fluoranthene	0.00	0.00
Steam Generator	SGR01	191242	"Benzo(g,h,i)perylene"	0.00	0.00
Steam Generator	SGR01	207089	Benzo(k)fluoranthene	0.00	0.00
Steam Generator	SGR01	218019	Chrysene	0.00	0.00
Steam Generator	SGR01	53703	"Dibenz(a,h)anthracene"	0.00	0.00
Steam Generator	SGR01	100414	Ethylbenzene	13.85	0.00
Steam Generator	SGR01	206440	Fluoranthene	0.01	0.00
Steam Generator	SGR01	86737	Fluorene	0.01	0.00
Steam Generator	SGR01	50000	Formaldehyde	52.20	0.01
Steam Generator	SGR01	7783064	Hydrogen sulfide	133.42	0.02

Steam Generator	SGR01	193395	"Indeno(1,2,3-cd)pyrene"	0.00	0.00
Steam Generator	SGR01	91203	Naphthalene	0.41	0.00
Steam Generator	SGR01	85018	Phenanthrene	0.02	0.00
Steam Generator	SGR01	115071	Propylene	469.10	0.05
Steam Generator	SGR01	129000	Pyrene	0.01	0.00
Steam Generator	SGR01	108883	Toluene	22.93	0.00
Steam Generator	SGR01	1330207	Xylenes	30.01	0.00
1,000 hp ICE	ICE01	71432	Benzene	126.21	0.01
1,000 hp ICE	ICE01	50000	Formaldehyde	3118.12	0.36
1,000 hp ICE	ICE01	115071	Propylene	1187.86	0.14
1,000 hp ICE	ICE01	108883	Toluene	57.17	0.01
1,000 hp ICE	ICE01	1330207	Xylenes	28.95	0.00
1,000 hp ICE	ICE01	7783064	Hydrogen sulfide	13.30	0.00
Drilling Emissions	DRL01	9901.00	Diesel Particulate Matter	17.23	1
33 MW Cogen	COG01	71432	Benzene	36.07	0.00
33 MW Cogen	COG01	7783064	Hydrogen sulfide	442.64	0.05
33 MW Cogen	COG01	91203	Naphthalene	14.30	0.00
33 MW Cogen	COG01	1151	PAH's	0.63	0.00
33 MW Cogen	COG01	50000	Formaldehyde	454.54	0.05
Drilling Mud Sump	SMP02	95636	"1,2,4 Trimethylbenzene"	0.01	0.00
Drilling Mud Sump	SMP02	71432	Benzene	0.28	0.00
Drilling Mud Sump	SMP02	110827	Cyclohexane	0.01	0.00
Drilling Mud Sump	SMP02	100414	Ethylbenzene	0.09	0.00
Drilling Mud Sump	SMP02	110543	n-Hexane	2.10	0.00

Drilling Mud Sump	SMP02	108883	Toluene	0.32	0.00
Drilling Mud Sump	SMP02	1330207	Xylenes	0.17	0.00
Drilling Mud Sump	SMP02	7783064	Hydrogen sulfide	0.02	0.00
Boiler	BLR01	83329	Acenaphthene	0.00	0.00
Boiler	BLR01	208968	Acenaphthylene	0.00	0.00
Boiler	BLR01	75070	Acetaldehyde	2.34	0.00
Boiler	BLR01	107028	Acrolein	1.59	0.00
Boiler	BLR01	120127	Anthracene	0.00	0.00
Boiler	BLR01	56553	Benz(a)anthracene	0.00	0.00
Boiler	BLR01	71432	Benzene	0.54	0.00
Boiler	BLR01	50328	Benzo(a)pyrene	0.00	0.00
Boiler	BLR01	205992	Benzo(b)fluoranthene	0.00	0.00
Boiler	BLR01	191242	"Benzo(g,h,i)perylene"	0.00	0.00
Boiler	BLR01	207089	Benzo(k)fluoranthene	0.00	0.00
Boiler	BLR01	218019	Chrysene	0.00	0.00
Boiler	BLR01	53703	"Dibenz(a,h)anthracene"	0.00	0.00
Boiler	BLR01	100414	Ethylbenzene	1.63	0.00
Boiler	BLR01	206440	Fluoranthene	0.00	0.00
Boiler	BLR01	86737	Fluorene	0.00	0.00
Boiler	BLR01	50000	Formaldehyde	6.14	0.00
Boiler	BLR01	7783064	Hydrogen sulfide	15.70	0.00
Boiler	BLR01	193395	"Indeno(1,2,3-cd)pyrene"	0.00	0.00
Boiler	BLR01	91203	Naphthalene	0.05	0.00
Boiler	BLR01	85018	Phenanthrene	0.00	0.00

Boiler	BLR01	115071	Propylene	55.19	0.01
Boiler	BLR01	129000	Pyrene	0.00	0.00
Boiler	BLR01	108883	Toluene	2.70	0.00
Boiler	BLR01	1330207	Xylenes	3.53	0.00
Thermally Enhanced Oil Recovery Equipment	TEOR	95636	"1,2,4 Trimethylbenzene"	0.03	0.00
Thermally Enhanced Oil Recovery Equipment	TEOR	71432	Benzene	0.95	0.00
Thermally Enhanced Oil Recovery Equipment	TEOR	110827	Cyclohexane	0.05	0.00
Thermally Enhanced Oil Recovery Equipment	TEOR	100414	Ethylbenzene	0.30	0.00
Thermally Enhanced Oil Recovery Equipment	TEOR	110543	n-Hexane	6.98	0.00
Thermally Enhanced Oil Recovery Equipment	TEOR	108883	Toluene	1.06	0.00
Thermally Enhanced Oil Recovery Equipment	TEOR	1330207	Xylenes	0.56	0.00
Thermally Enhanced Oil	TEOR	7783064	Hydrogen sulfide	0.07	0.00

Recovery Equipment					
100 MMBtu/hr Flare	FLR02	75070	Acetaldehyde	37.67	0.00
100 MMBtu/hr Flare	FLR02	107028	Acrolein	8.76	0.00
100 MMBtu/hr Flare	FLR02	71432	Benzene	139.28	0.02
100 MMBtu/hr Flare	FLR02	110827	Cyclohexane	0.00	0.00
100 MMBtu/hr Flare	FLR02	100414	Ethylbenzene	1264.94	0.14
100 MMBtu/hr Flare	FLR02	50000	Formaldehyde	1024.04	0.12
100 MMBtu/hr Flare	FLR02	110543	n-Hexane	25.40	0.00
100 MMBtu/hr Flare	FLR02	7783064	Hydrogen sulfide	15.70	0.00
100 MMBtu/hr Flare	FLR02	91203	Naphthalene	9.64	0.00
100 MMBtu/hr Flare	FLR02	1151	PAH's	12.26	0.00
100 MMBtu/hr Flare	FLR02	115071	Propylene	2137.44	0.24
100 MMBtu/hr Flare	FLR02	108883	Toluene	50.81	0.01
100 MMBtu/hr Flare	FLR02	1330207	Xylenes	25.40	0.00

Appendix B – Equipment and Emissions for Well Depths

Appendix C – Modeling Files

Appendix D – HARP Output