4.5 GEOLOGY, SOILS, AND SEISMICITY

4.5.1 METHODOLOGY

This section analyzes the Project's potential impacts on geology, soils and seismicity, based on information from the *Geology, Soils, and Seismicity Technical Memorandum, Inglewood Oil Field Specific Plan* prepared by Kleinfelder, Inc. dated December 2016 and provided in Appendix E-1 of this Draft Environmental Impact Report (EIR). Appendix E-2 contains the Poisson Test- *Seismic Activity in the Inglewood Oil Field* conducted by Dr. Paul Segall dated November 9, 2016. Direct, indirect, and cumulative impacts are addressed for each threshold criteria below, and growth-inducing impacts are described in Sections 6.0, CEQA-Mandated Analyses, of this Draft EIR.

Throughout this Draft EIR, the City's portion of the Inglewood Oil Field (77.8 acres) is referred to as the "Project Site" or the "City IOF." The surface boundary limits[1] of the Inglewood Oil Field (IOF), including lands within both the City and County, is referred to as "Inglewood Oil Field." The portion of the Inglewood Oil Field that is only within the jurisdiction of the County of Los Angeles is referred to as the "County IOF."

The City IOF is located in a seismic area with high historic seismicity, and there are numerous tectonic faults in and around the IOF site. In general, seismic activities can be broadly divided into two categories: (1) tectonic and (2) induced. Tectonic seismic activity is related to natural movements of the faults and an earthquake happens when sudden slip on these faults initiates rupture and may release large amount of energy resulting in ground shaking and other associated hazards such as ground rupture, liquefaction, lateral spreading, sloped failures, and other hazards. Induced seismicity is defined as an event directly related to some manmade activity.

Recently, many parts of the country have experienced induced seismicity due to deep well wastewater disposal associated with oil extraction operations and, more recently, with well stimulation techniques. In areas of low tectonic activities, it is relatively easy to identify induced seismicity from the historical tectonic seismicity. However, in areas of high tectonic seismicity, differentiating induced seismicity from the tectonic seismicity is not simple and may require long term monitoring for assessment. This analysis includes discussions of both tectonic and induced seismicity as related to the City IOF, and the Inglewood Oil Field as a whole.

Independent of the California Environmental Quality Act (CEQA) process, there is a comprehensive regulatory framework implemented at the state and City level to mitigate potential hazards associated with geologic and soils conditions. The design-controllable aspects of building foundation support, protection from seismic ground motion, and soil instability are governed by existing regulations. Compliance with these regulations is required, not optional. Compliance must be demonstrated before permits would be issued. The analysis presented herein assumes compliance with all applicable laws, regulations, and standards.

4.5.2 ENVIRONMENTAL SETTING

Topography and Physiography

Culver City is on the western side of the Los Angeles Basin approximately 1.5 miles from the Pacific Ocean. Much of the terrain of Culver City is mostly level or slight rolling hills that vary in elevation from 40 feet above mean sea level (msl) on the west to approximately 100 feet in the

[1] Surface boundary limit refers to the physical extent of the ground surface for which the Oil Field Operator has access and land owner permission to establish and conduct oil drilling activity. Subsurface and mineral right limits may have different boundaries than the surface boundary.

central part. The Baldwin Hills are in the northeastern portion of the City and rise up to about 400 feet above msl on the Project Site representing 300 feet of relief between the Project Site to Ballona Creek. The Project Site comprises a 77.8-acre portion of the northwestern part of the Baldwin Hills.

The Baldwin Hills are part of a series of low hills that extend from the Santa Monica Mountains southeastward to Newport Beach. The hills are the result of a recent geological deformation along the Newport-Inglewood Fault Zone, which is a geologic structural feature, composed of faults and folds and associated oil fields. The Baldwin Hills are the highest of the hills along this fault zone, reaching a height of 511 feet above msl. They rise gently from the south and east and relatively steep from the north and west. The slopes descending the hills contain numerous scarps on the west, north, and east sides. Numerous canyons and gullies have incised into the scarps and extended to the top of the hills forming intervening flat-topped ridges. The central portion of hills is transected by a north-south trending graben[2] (tectonic depression). The eastern side of the graben is bounded by a west-facing scarp, ranging in height from 75 to 150 feet and is the surface expression of the Newport-Inglewood Fault. The most rugged and steep portions of the oil field have been highly modified over the years by construction of well and tank pads, access roads, treatment plants, oil, water and waste sumps.

Regional Geologic Setting and Geologic Units

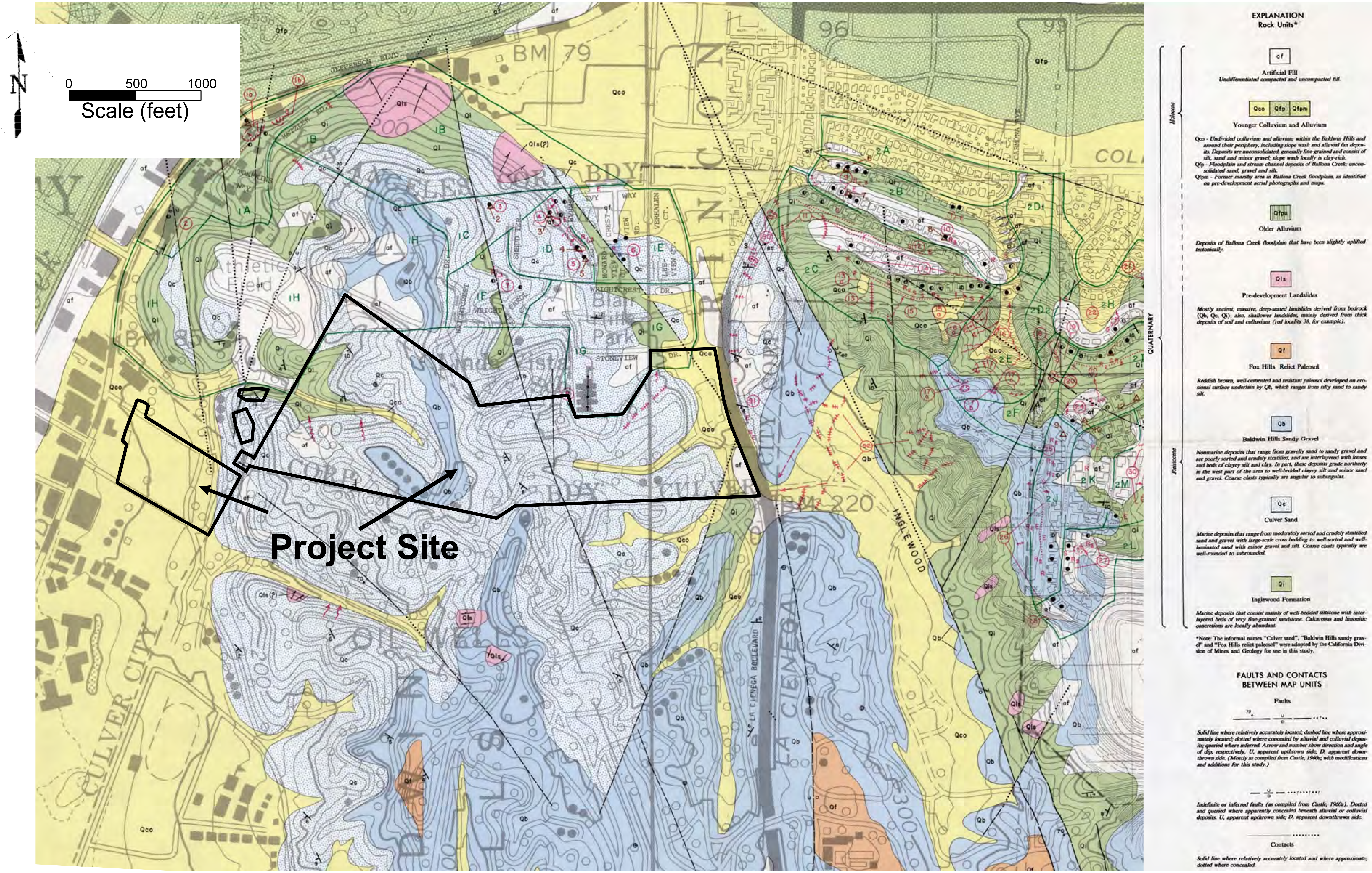
The Baldwin Hills and City IOF are located in the Peninsular Ranges Geomorphic Province and within the Los Angeles Basin. The Peninsular Ranges are characterized by northwest-trending blocks of mountain ridges and sediment-floored valleys. The dominant geologic structure features are northwest-trending fault zones that either fade out to the northwest or terminate at east-trending faults that form the southern margin of the Transverse Ranges. The Los Angeles Basin is bound on two sides by major faults: the Palos Verdes fault to the south, and the San Gabriel-Foothill fault to the north. The basin is bound to the east and southeast by the Santa Ana Mountains and San Joaquin Hills, and to the northwest by the Santa Monica Mountains. Erosion of the surrounding mountains has resulted in deposition of alluvial materials (unconsolidated sediments) in low-lying areas by the Los Angeles River and in the Culver City area, the Ballona Creek.

Deformation in the Baldwin Hills area may have begun as early as the middle Miocene (approximately 15–16 million years ago). Movement along the Newport-Inglewood Fault Zone gently arched and displaced the sedimentary formations comprising the hills. Some of the prominent fault scarps and youthful dissection of the slopes suggest the Baldwin Hills are still actively rising.

The Baldwin Hills and City IOF is underlain by a thick sequence of Tertiary and Quaternary age sedimentary layers and Holocene-age alluvium. The near-surface sedimentary formations exposed on the Project Site consist primarily of the early to middle-Pleistocene, marine San Pedro Formation and the late-Pleistocene, non-marine to shallow marine Inglewood Formation. Colluvial deposits are present at the toe of the slopes and may be present in the drainage channels and gullies emanating from the hill’s slopes. The weathering and erosion of the exposed rock layers and colluvium has resulted in a thin mantle of surficial soils and artificial fill in the Project area.

Exhibit 4.5-1, Project Geology Map, depicts the geology map of the City IOF in the context of the surrounding Baldwin Hills and identifies the location of the various soil units described below. The Project Site is underlain by unconsolidated surficial deposits of undocumented artificial fill, in situ

[2] A graben is a down-dropped block of the earth's crust resulting from extension, or pulling, of the crust.



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Source: Kleinfelder 2016

Project Geology Map

Exhibit 4.5-1

Inglewood Oil Field Specific Plan Project

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(09/07/17 MMD) R:\Projects\CUL\3CUL000100\Graphics\EIR\Ex4.5-1_geol_map_20170907.pdf developed soil and colluvium, and formational geologic units ranging in age from Pleistocene to Tertiary (approximately 10,000 to 15 million years old). Collectively these geologic formations are over 10,000 feet thick beneath the Project Site and include, in increasing age, the San Pedro, Inglewood, Pico, Repetto, Monterey (also referred to as Puente), and Topanga Formations. The formational units mapped at the surface within the Project Site are the San Pedro (which locally includes the Baldwin Hills Sandy Gravel and Culver Sand) and Inglewood Formations. These two formations as well as the surficial deposits will be discussed separately below. The Pico, Repetto, Monterey, and Topanga Formations are source rocks for the oil and gas exploration and have been undergone formation name changes during the years by the oil industry specific to the oil field. Therefore, to avoid confusion this study will discuss all of these units together below. However, for a detailed description of the separate oil- and gas-bearing zones the reader is directed to the *Hydraulic Fracturing Study, PXP Inglewood Oil Field* prepared by Cardno Entrix and dated October 12, 2012.

Artificial fill, Non-Engineered Fill (af)

Artificial fill comprises any earth material that is placed for construction purposes or any earth and non-earth material that is dumped as waste. Fills can be classified into two types: engineered fill and non-engineered fill. An engineered fill is a fill composed of earth material that is designed and placed under engineering supervision with documentation explaining its placement. It is compacted to a certain density and tested to verify its quality. Non-engineered fill is uncompacted fill or fill compacted without engineering control and without verification (documentation) of its quality by testing.

Most of the larger artificial fills in the Baldwin Hills area were placed during residential development in the very late 1940s and the 1950s for construction of roads and accompanying building pads without much preparation due to the lacking of proper grading codes. Since the 1920s, fill has been used in the Inglewood oil field for siting of roads and oil wells. On the Project Site the fill was most likely generated from on-site surficial sediments during the creation of numerous oil field service roads and relatively flat well-drilling pads. Most of the fill deposits will have a similar lithology as the underlying geologic unit and are considered non-engineered fill. The fill will typically be composed of various amounts of sand, silt, clay, gravel, and most likely some organic material.

Colluvium (Qco)

Colluvium accumulates at the toe of slopes and is derived as the weathering and erosion of the slopes' underlying bedrock. The weathered material slowly creeps down the slope to the bottom where it can accumulate thicknesses up to ten feet. The colluvium can also collect in small canyons, ravines, and swales. Colluvium is present underlying the western part of the Project Site along College Boulevard. Here the upslope source for colluvium is the Culver Sand to the east and the Inglewood Formation to the immediate north. Therefore, the colluvium will consist of an unconsolidated mixture of sand, silt, and clay. The on-site colluvium is considered expansive.

San Pedro Formation (Qsp)

The San Pedro Formation is mapped at the surface throughout most of the Project Site. The San Pedro Formation is a middle- to late-Pleistocene marine deposit consisting of medium- to coarse-grained sand and gravel, with localized lenses of very fine sand and clay. The formation is relatively unconsolidated to poorly consolidated and is approximately 200 feet thick in the Baldwin Hills area. On the Project Site the San Pedro Formation has been differentiated, based on local lithology, into the Baldwin Hills Sandy Gravel and Culver Sand.

Baldwin Hills Sandy Gravel (Qb). Baldwin Hills sandy gravel (Qb) is the most widely exposed rock in the Baldwin Hills, occupying nearly two-thirds of the area, commonly capping ridges. On the Project Site it is only present beneath the T-Vickers Tank Farm and the ridge trending to the north of the tanks. In the western part of the hills and the Project Site, the Baldwin Hills sandy gravel rests on Culver sand (Qc), in both erosional and transitional contact. The thickness of the Baldwin Hills sandy gravel is variable, ranging from about 50 feet to perhaps 100 feet. The unit comprises more clayey silt on the Project Site than the more abundant sand and gravel units found throughout the Baldwin Hills. The clayey silt facies unit consists of yellowish green to light gray, clayey silt with interbeds of angular-grained, sandy gravel and massive to laminated sand. The clayey silt beds are generally dense and hard, and more resistant to erosion than the sandy deposits. The unit was deposited in a nonmarine fluvial environment, which explains why it contains numerous interbeds of various lithology. The Baldwin Hills sandy gravel unit is prone to erosion on the Project Site.

Culver Sand (Qc). Culver sand is exposed mainly in the northwestern and western parts of the Baldwin Hills, where it rests unconformably (erosional) on the Inglewood Formation. It was deposited in nearshore marine environments and is the most widely mapped unit in the Project Site, reaching a maximum thickness of about 100 feet. On the Project Site, Culver Sand consists predominantly of crudely stratified to laminated, light brown, poorly consolidated and partly sorted, fine- to coarse-grained sand interbedded with lenses and thin beds of gravel. Also, the sand can contain thin beds of gray, dense, clayey siltstone which can be expansive. On the Project Site, the sand layers tend to be better cemented and denser than the sandy gravel layers. Both sand and gravel are poorly cemented and, therefore, commonly subject to erosion.

Inglewood Formation (Qi)

The early Pleistocene age Inglewood Formation is exposed mainly in the lower portions of steep slopes in the northern part of the Baldwin Hills and in slopes surrounding the Culver City Park and in an on-site, small canyon immediately north of the T-Vickers Tank Farm. The sediments of the Inglewood Formation were deposited in a shallow marine environment. Rocks of this unit can reach 300 feet thick and are overlain unconformably by coarser-grained rocks of the Culver sand in the Project area.

The Inglewood Formation consists principally of thinly interbedded, light-brown to gray-brown, well-consolidated siltstone and very fine-grained sandstone which locally can be clay-rich and which commonly contain calcareous and limonitic concretions. The sandstone generally is slightly coarser near the top of the unit; otherwise the lithology is relatively uniform. The rocks of the Inglewood Formation are generally dense and moderately expansive when weathered. A relatively higher incidence of surficial failure have occurred in slopes underlain by this unit than slopes underlain by other units, due to the more clayey soil and slope wash that tends to develop on this unit. Most of the bedrock landslides in the Baldwin Hills are derived from these rocks, apparently because of their clay content and because they are thinly-bedded, more fractured than the overlying rocks, and commonly dip adversely (downward) out of slopes.

Pico, Repetto, Monterey, and Topanga Formations

The Pico, Repetto, Monterey, and Topanga Formations represent approximately 9,000 feet of sedimentary rock spanning approximately 1.8 million to 15.0 million years of time before the present. The formations consist of thick layers of sandstone and shale that have folded upward and have been displaced and fractured by faulting of the Newport-Inglewood Fault Zone. The faulting and fracturing allows for the hydrocarbons trapped in the Nodular Shale reservoir, belonging to the Monterey Formation approximately 8,000 feet deep, to migrate upward into the overlying sandstone layers of the Pico and Repetto Formations. The sandstone layers from these two formations produce a majority of the oil and gas in the Baldwin Hills area.

There are nine hydrocarbon producing zones beneath the Project Site. These zones, in increasing age, include the Upper Investment-Investment (Pico Formation), Vickers (Pico and Repetto Formations), Rindge (Repetto Formation), Rubel (Repetto Formation), Upper and Lower Moynier (Repetto Formation), Bradna (Monterey Formation), City of Inglewood (Monterey Formation), Nodular Shale (Monterey Formation), and the Sentous (Monterey and Topanga Formations).

Table 4.5-1, Stratigraphy and Lithology of the Inglewood Oil Field, lists the formation, reservoir, lithology, and thickness of the producing formations in the Baldwin Hills, including the Project Site.

TABLE 4.5-1
STRATIGRAPHY AND LITHOLOGY OF THE INGLEWOOD OIL FIELD

<table>
<tr><th>Epoch</th><th colspan="2">Formation</th><th>Reservoir</th><th>Lithology, etc.</th><th>Thickness (ft)</th></tr>
<tr><td rowspan="3">Pleistocene</td><td colspan="2">San Pedro</td><td></td><td></td><td>0–200</td></tr>
<tr><td colspan="2">Inglewood</td><td></td><td></td><td>150–300</td></tr>
<tr><td rowspan="4">Pico</td><td>Upper</td><td></td><td>Cap rock to oil field</td><td>150–300</td></tr>
<tr><td rowspan="3">Upper Pliocene</td><td rowspan="2">Middle</td><td>Investment</td><td>Shale, some oil</td><td>200–600</td></tr>
<tr><td rowspan="3">Vickers</td><td rowspan="3">Sandstone producer</td><td rowspan="3">1,500–1,700</td></tr>
<tr><td>Lower</td></tr>
<tr><td rowspan="6">Lower Pliocene</td><td rowspan="6">Repetto</td><td rowspan="2">Upper</td></tr>
<tr><td>Rindge</td><td>Sandstone producer</td><td>900–1,000</td></tr>
<tr><td rowspan="2">Middle</td><td>Upper Rubel</td><td>Sandstone producer</td><td>250–300</td></tr>
<tr><td>Lower Rubel</td><td>Sandstone producer</td><td>699–700</td></tr>
<tr><td rowspan="2">Lower</td><td>Upper Moynier</td><td></td><td>300–400</td></tr>
<tr><td>Lower Moynier</td><td></td><td>600–700</td></tr>
<tr><td>Upper Miocene</td><td rowspan="4">Monterey</td><td></td><td>Bradna</td><td></td><td>700–1,800</td></tr>
<tr><td rowspan="4">Middle Miocene</td><td rowspan="2"></td><td>City of Inglewood</td><td></td><td>0–250</td></tr>
<tr><td>Nodular Shale</td><td>Shale, source of oil</td><td>150–175</td></tr>
<tr><td></td><td>Sentous</td><td>Sandstone producer</td><td>200–1,000</td></tr>
<tr><td>Topanga</td><td></td><td>Topanga</td><td></td><td>1,500</td></tr>
<tr><td colspan="6">Source: Kleinfelder 2016.</td></tr>
</table>

In 2012, there were 469 active production wells on the Inglewood Oil Field, and a majority of them have been drilled on a slant targeting one of the producing zones. The Vickers and Rindge zones, 2,000 to 4,000 feet deep, accounted for more than 74 percent of the total cumulative production at the oil field. Overall, the shallow and extensive Vickers and Rindge zones have produced more than half of all the oil produced over the life of the Inglewood Oil Field. The shallowest producing zone is the Investment Zone at approximately 1,000 feet, and the deepest is the Sentuos at approximately 8,500 feet.

Regional and Local Faults

A fault is a fracture or line of weakness in the earth's crust, along which rocks on one side of the fault are offset relative to the same rocks on the other side of the fault. Surface rupture occurs when movement on a fault deep within the earth breaks through to the surface. Fault rupture almost always follows preexisting faults, which are zones of weakness. Rupture may occur suddenly during an earthquake or slowly in the form of fault creep. Sudden displacements are more damaging to structures because they are accompanied by shaking. An earthquake on the Newport-Inglewood Fault Zone could cause ground rupture to occur along any of the splays within the fault zone.

Based on criteria established by the California Geological Survey (CGS), faults may be categorized as active, potentially active, or inactive. Active faults are those that show evidence of surface displacement within the last 11,000 years (Holocene age). Potentially active faults are those that show evidence of the last displacement within the last 1.6 million years (Quaternary age). Faults showing no evidence of displacement within the last 1.6 million years also may be considered inactive for most purposes, except for some critical structures. Table 4.5-2, Major Named Faults Considered Active in Southern California, provides a listing of major active faults in Southern California, including their range of maximum magnitude, slip rate, fault type, and largest most recent seismic event.

TABLE 4.5-2
MAJOR NAMED FAULTS CONSIDERED ACTIVE IN SOUTHERN CALIFORNIA

Fault	Maximum Magnitude (M)	Slip Rate (mm/yr)	Type of Fault	Largest Most Recent Seismic Event
Cabrillo	6.0–6.8	0.1	Right normal	Holocene
Cucamonga	6.5–6.7	5.0	Thrust	Holocene
Elsinore (Glen Ivy Segment)	6.7–6.9	5.0	Right lateral strike-slip	Late Quaternary
Hollywood	6.5–6.7	1.0	Left reverse	Holocene
Malibu Coast	6.7–7.0	0.3	Left reverse	Late Quaternary
Northridge Thrust	6.7–6.9	1.5	Thrust	1994
Newport-Inglewood Zone	7.0–7.5	1.3	Right lateral strike-slip	1933
Oak Ridge	7.0–7.4	3.6–4.0	Thrust	Holocene
Palos Verdes	7.3–7.7	3.0	Right reverse	Holocene
Raymond	6.5–6.8	1.5	Left lateral	Holocene
San Andreas (Southern Segment)	7.0–8.0	16.0–34.0	Right lateral strike-slip	1857
San Cayetano	7.1–7.2	6.0	Thrust	Uncertain
San Fernando	6.5–6.7	2.0	Thrust	1971
San Gabriel	7.2–7.3	1.0	Right-lateral strike-slip	Late Quaternary
San Jacinto (San Bernardino Segment)	6.9–7.1	6.0	Right lateral strike-slip	1968
Santa Monica	6.4–7.4	1.0–2.4	Left reverse	Late Quaternary
Santa Susana	6.7–6.9	5.0	Left reverse	Holocene
Sierra Madre	7.1–7.3	2.0	Reverse	Holocene
Verdugo	6.7–6.9	0.5	Reverse	Holocene
Elsinore (Whittier)	6.8–7.0	2.5	Right lateral strike-slip	1987

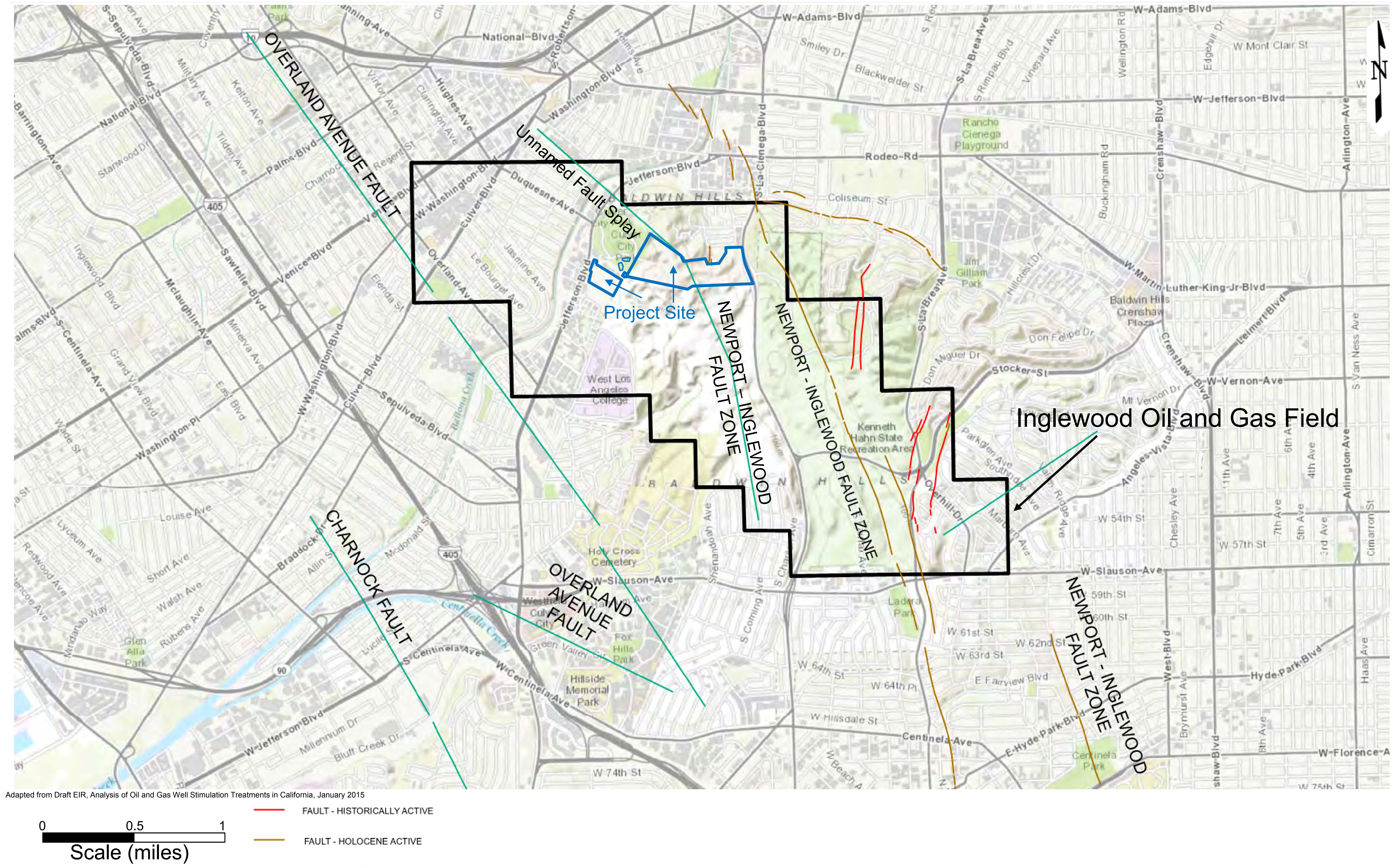
M: magnitude; mm/yr: millimeters per year

Source: Kleinfelder 2016

Exhibit 4.5-2, Regional Fault Map, depicts the boundary of the Inglewood Oil Field in relation to the City IOF, as well as historically active, holocene active, and late quaternary faults in the region. As shown on Exhibit 4.5-2, there are two major faults (active and inactive) in the vicinity of the Project Site: the Newport-Inglewood Fault Zone and the Overland Avenue/Charnock Faults. The Newport-Inglewood Fault Zone, which is seismically active and part of the San Andreas Fault System, extends at least 45 miles onshore, from the Cheviot Hills southeastward to the Newport Mesa, and beyond to the offshore area for a total of approximately 130 miles. This right-lateral fault zone is composed of numerous fault splays that collectively are capable of producing a Magnitude (M) 7.5 earthquake.

Exhibit 4.5-3, Regional Geologic and Fault Cross-Section, depicts a cross-section of the Newport-Inglewood Fault Zone in relation to the underlying formations beneath the Inglewood Oil Field. Not all the fault splays in the zone are active; however, they do form structural oil/gas-producing traps by juxtaposing differing lithologies of sedimentary rock layers against each other in the subsurface. The fault zone is up to approximately one mile wide and responsible for the Baldwin Hills uplift and the Inglewood Oil Field.

Approximately one to two miles northwest and west of the Project Site are two faults in Ballona Gap that are not associated with the Newport-Inglewood Fault. They are the Overland Avenue



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Source: Kleinfelder 2016

Regional Fault Map

Exhibit 4.5-2

Inglewood Oil Field Specific Plan Project

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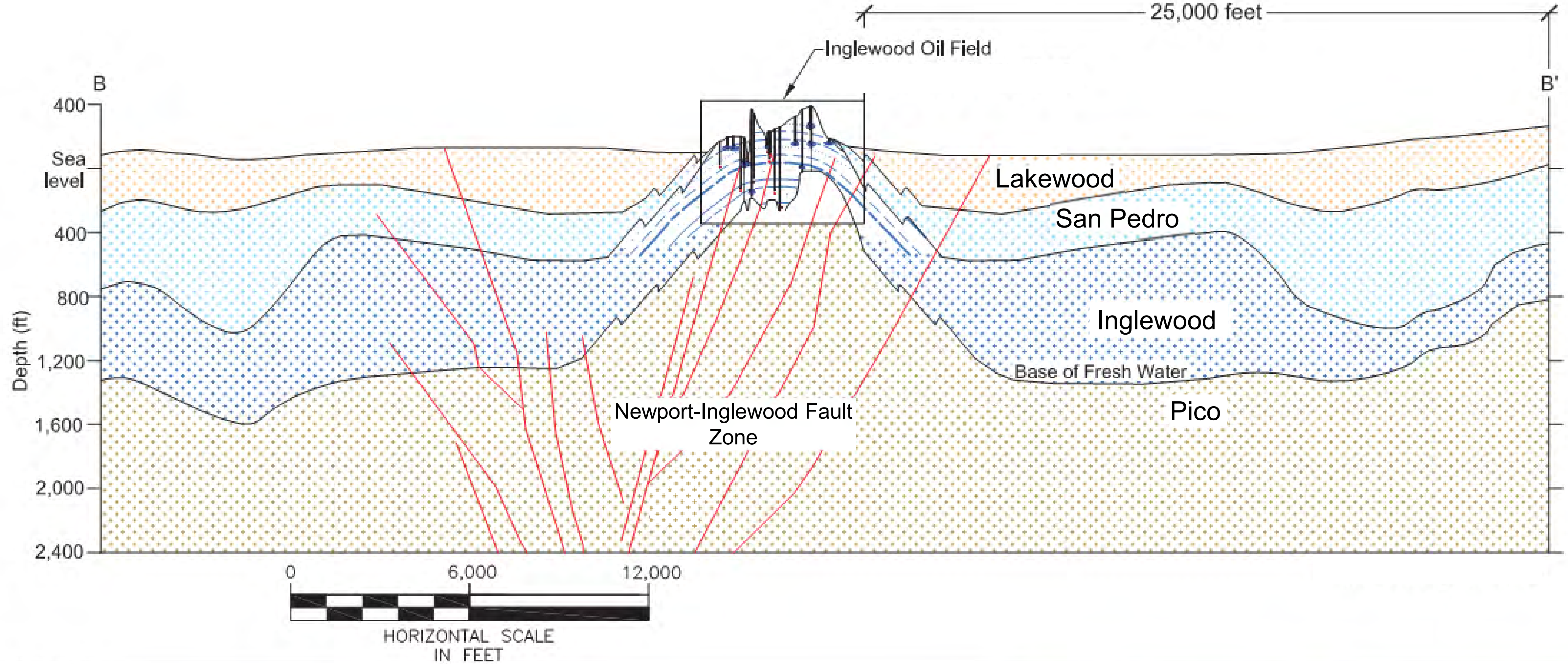


LEGEND

- Fault
- Fold Axis
- Geologic Formation
- Cross–Section

NOTES: 1. Vertical scale greatly exaggerated.
2. Both San Pedro and Inglewood formations are present at the oil field. Depiction is an estimate, as both formations crop out and have complex folds.
3. Cross–section depicted located as shown in inset map.

Source: USGS 2003

Source: U.S. Geological Survey (2003) Water Resources Investigation Report 03-0465

Source: Kleinfelder 2016

Regional Geologic and Fault Cross–Section

Exhibit 4.5–3

Inglewood Oil Field Specific Plan Project

PSOMAS

and the Charnock faults (see Exhibit 4.5-2). Both faults have been located by well-log and water-level data and form the east and west sides of a dropped block, or graben.[3] Both have been shown on the water-level contour maps of the Los Angeles County Flood Control District since 1938, where water levels are generally 40 to 50 feet higher to the east of the faults.

The Overland Avenue Fault, so named because of its inferred trace nearly coincides with Overland Avenue in Culver City, is about six miles long and trends to the northwest, from the southwestern part of the Baldwin Hills northwestward across Ballona Gap. The Charnock Fault is immediately west of the Overland Avenue Fault and forms the western edge of the graben. The area between the two faults has dropped as much as 140 feet during the Pliocene; however, the late Pleistocene and Holocene sediments have not been displaced. Therefore, the faults are only considered potentially active by the California Geological Survey (CGS).

Alquist-Priolo Earthquake Fault Zones

The purpose of the Alquist-Priolo Earthquake Fault Zones Act is to prevent the construction of buildings used for human occupancy across the surface trace of active faults. The law requires the State Geologist to establish regulatory zones (known as Earthquake Fault Zones [EFZs]) around the surface traces of active faults and to issue appropriate maps. The zones vary in width, but average about one-quarter mile wide. For the purposes of the Act, an active fault is one that has ruptured in the last 11,000 years. Most of the fault splays of the Newport-Inglewood Fault Zone have been included as an Alquist-Priolo EFZ within the Baldwin Hills area.

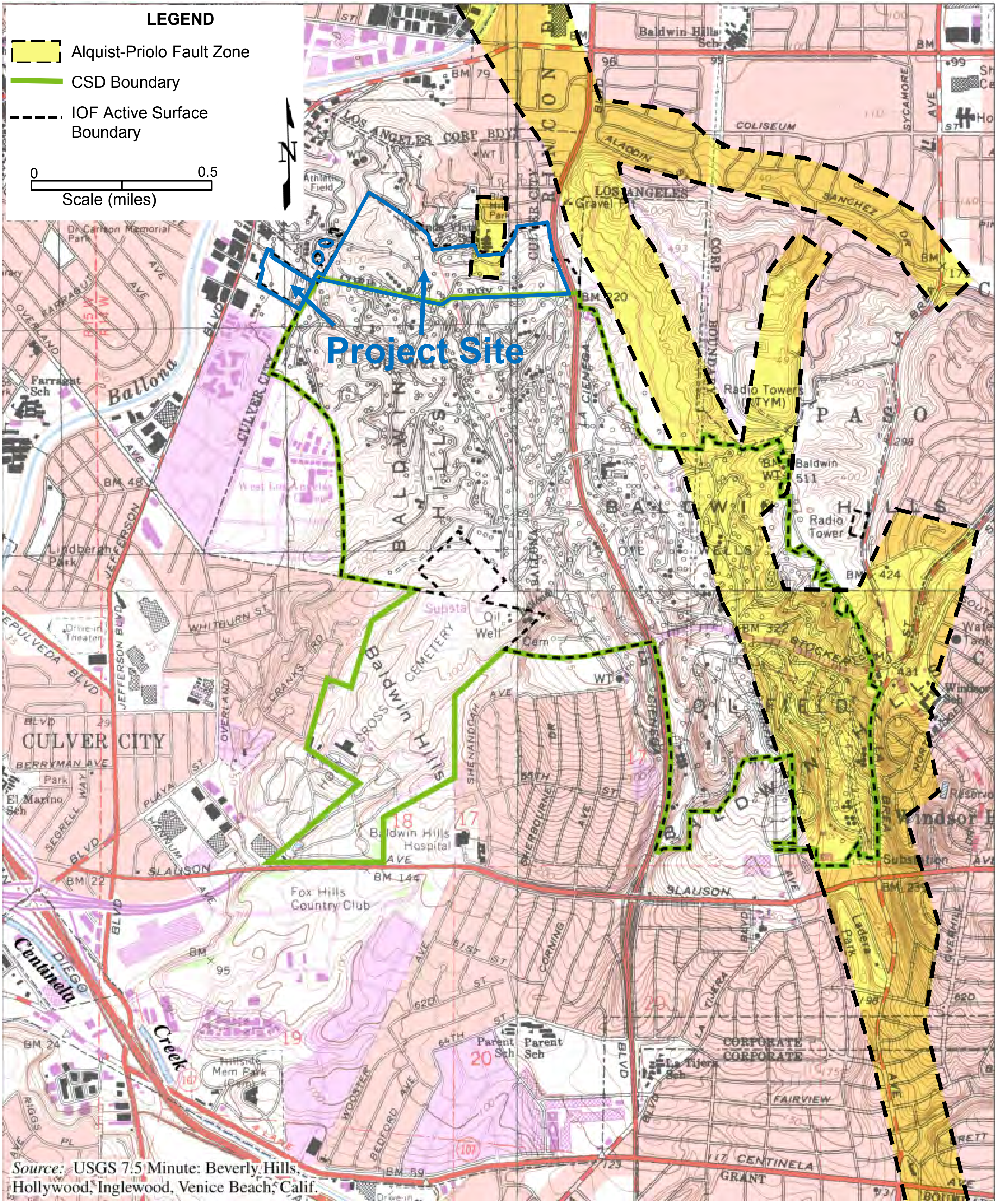
Exhibit 4.5-4, Alquist-Priolo Earthquake Fault Zones, depicts the Project Site in the context of the boundary of the Inglewood Oil Field with an overlay of the designated Alquist-Priolo Fault Zones. As shown, the majority of the Alquist- Priolo EFZ is located to the east of the Project Site and La Cienega Boulevard. However, a short splay of the Newport-Inglewood EFZ is mapped at the northeastern edge of the Project Site near the Stoneview Nature Center. Construction within this zone requires that a special geologic study be conducted to locate and assess any active fault traces within the EFZ prior to development/construction of structures.

Seismicity and Groundshaking

Earthquakes are caused by the violent and abrupt release of strain built up along faults. When a fault ruptures, energy spreads, sometimes unequally, in the form of seismic waves. Seismic waves are categorized into two groups, body waves and surface waves. Body waves travel through the crust and eventually reach the ground interface, creating surface waves. Body waves and surface waves cause the ground to vibrate up and down and side to side at different frequencies depending on the frequency content of the earthquake rupture mechanism, the distance from the earthquake source, and the path and material through which the seismic waves spreads.

The Project Site is located in a high seismic activity area. Many earthquakes in the past have happened in the region. Any building within the Project Site should follow the California Building Code (CBC) for the design purposes. Per 2013 CBC, a peak ground acceleration (PGA) of 0.7g should be used for any liquefaction and/or lateral spreading analysis within the Project Site. In order to evaluate the level of ground shaking that might be anticipated within Project Site, probabilistic PGA (peak ground acceleration) data available from the U.S. Geologic Survey (USGS) were reviewed. Since the City IOF is very close to the Newport-Inglewood Fault Zone, a major seismic event on this fault could cause strong ground shaking at the Project Site and PGA

[3] A graben is a down-dropped block of the earth's crust resulting from extension, or pulling, of the crust.



Adapted from Final EIR, Baldwin Hills Community Standards District, October 2009

Source: Kleinfelder 2016

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Alquist-Priolo Earthquake Fault Zones

Exhibit 4.5-4

Inglewood Oil Field Specific Plan Project

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(09/07/2017 MMD) R:\Projects\CUL\3CUL000100\Graphics\EIR\Ex4.5-4_geol_AP_zones_20170907.pdf of 0.5 to 0.9g for a 7.2 earthquake could be anticipated, which has been observed in past earthquakes of similar magnitude.

The principal seismic hazard occurring as a result of an earthquake produced by local faults is strong groundshaking. The intensity of groundshaking depends on several factors, including the magnitude of the earthquake, distance from the fault rupture, and the underlying soil conditions. In general, the larger the magnitude of an earthquake and the closer a site to the fault rupture, the greater will be the effects. However, soil conditions can also amplify the earthquake ground motions. Low bedrock motions can be significantly amplified by soft thick alluvium.

Earthquake Magnitude

The entire Southern California area is a seismically active region. Earthquakes are classified based on the amount of energy released, using logarithmic scales known as the Richter scale and the Moment Magnitude scale (M). Each whole number of Richter magnitude represents a tenfold increase in the wave amplitude (earthquake size) generated by an earthquake, as well as a 3.16-fold increase in energy released. Thus, a magnitude 6.3 earthquake is 10 times larger than a magnitude 5.3 earthquake and releases 31.6 times more energy. In contrast, a magnitude 7.3 event is 100 times larger than a magnitude 5.3, and releases 1,000 times more energy. One limitation of the Richter magnitude scale is that it has an upper limit at which large earthquakes appear to have about the same magnitude. As a result, the M scale, which does not have an upper limit magnitude, is used to characterize earthquakes greater than magnitude 3.5. Earthquakes of M6.0 to M6.9 are classified as “moderate”, M7.0 to M7.9 as “major”, and M8.0 and larger as “great”. The Newport-Inglewood Fault Zone is considered capable of generating a major earthquake with a M7.0 to M7.5.

Earthquake Intensity

The Modified Mercalli Intensity (MMI) Scale is a scale used for measuring the intensity of an earthquake. The scale quantifies the effects of an earthquake on the Earth's surface, humans, objects of nature, and man-made structures on a scale of I through XII, with I denoting a weak earthquake and XII one that causes almost complete destruction. Although this scale is useful in describing earthquake effects for the general public, it is not employed by engineers when designing seismic-resistant structures. Therefore, the MMI Scale is more applicable to understanding the effects from ground shaking in developed communities rather than agricultural areas. This is especially true in a city, such as Culver City, where there’s such a diverse mix (both in age and construction type) of residential and commercial structures, and greater density of population to be subjected to ground shaking. Table 4.5-3, Modified Mercalli Intensity Scale, provides abbreviated definitions of the scale ratings.

TABLE 4.5-3
MODIFIED MERCALLI INTENSITY SCALE

Scale Rating	Description
I	Not felt
II	Felt by persons at rest, on upper floors, or favorably placed.
III	Felt indoors; hanging objects swing; vibration like passing of light trucks; duration estimated; may not be recognized as an earthquake.
IV	Hanging objects swing; vibration like passing of heavy truck or sensation of a jolt like a heavy ball striking the walls; standing automobiles rock; windows, dishes, doors rattle; wooden walls and frame may creak.
V	Felt outdoors; direction estimated; sleepers wakened; liquids disturbed some spilled; small unstable objects displaced or upset; doors swing; shutters, pictures move; pendulum clocks stop, start, change rate.
VI	Felt by all; many frightened and run outdoors; persons walk unsteadily; windows, dishes, glassware broken; knickknacks, books, etc., off shelves; pictures off walls; furniture moved or overturned; weak plaster and Masonry D cracked.
VII	Difficult to stand; noticed by drivers of automobiles; hanging objects quiver; furniture broken; weak chimneys broken at roof line; damage to Masonry D, including cracks, fall of plaster, loose bricks, stones, tiles, and embraced parapets; small slides and caving in along sand or gravel banks; large bells ring.
VIII	Steering of automobiles affected; damage to Masonry C, partial collapse; some damage to Masonry B; none to Masonry A; fall of stucco and some masonry walls; twisting, fall or chimneys, factory stacks, monuments, towers, elevated tanks; frame houses moved on foundations if not bolted down; loose panel walls thrown out; decayed piling broken off. Branches broken from trees; changes in flow or temperature of sprigs and wells; cracks in wet ground and on steep slopes.
IX	General panic; Masonry D destroys; Masonry C heavily damaged, sometimes with complete collapse; Masonry B seriously damaged; general damage to foundations; frame structures, if not bolted, shifted off foundations; frames racked; serious damage to reservoirs; underground pipes broken; conspicuous cracks in ground and liquefaction.
X	Most masonry and frame structures destroyed with their foundations; some well-built wooden structures and bridges destroyed; serious damage to dams, dikes, embankments; large landslides; water thrown out of banks of canals, rivers, lakes, etc.; sand and mud shifted horizontally on beaches and flat land; rails bent slightly.
XI	Rails bent greatly; underground pipelines completely out of service.
XII	Damage nearly total; large rock masses displaced; lines of sight and level distorted; objects thrown in the air.

Definitions:
Masonry A = Good workmanship and mortar, reinforced designed to resist lateral force
Masonry B = Good workmanship and mortar, reinforced
Masonry C = Good workmanship and mortar, unreinforced
Masonry D = Poor workmanship and mortar and weak materials, like adobe

Source: Kleinfelder 2016

Table 4.5-4, Correlation Between Earthquake Magnitude and Modified Mercalli Intensity Scale, provides correlations between MMI and earthquake magnitudes that are typically observed at locations near the epicenter of earthquakes of different magnitudes.

TABLE 4.5-4
CORRELATION BETWEEN EARTHQUAKE MAGNITUDE AND THE MODIFIED MERCALLI INTENSITY SCALE

Magnitude (M)	Typical Maximum MMI Scale
1.0–3.0	I
3.0–3.9	II–III
4.0–4.9	IV–V
5.0–5.9	VI–VII
6.0–6.9	VII–IX
7.0 and higher	VIII or higher

MMI: Modified Mercalli Intensity
Source: Kleinfelder 2016

A major earthquake on the Newport-Inglewood Fault Zone could have an MMI ranging from VIII to XI within the City IOF. However, the City IOF is more likely to experience shaking intensity ranging from I to VI from either a natural or human induced quake (See Threshold 5-1). In April and May of 2015, three earthquakes ranging from IV to VI on the MMI Scale, with epicenters in the Baldwin Hills area were felt in Culver City.

Historic Seismicity

Seismic events present the most widespread threat of devastation to life and property. With an earthquake, there is no containment of potential damage. Since the late 1700s there have been approximately 60 damaging seismic events, or earthquakes, in the Los Angeles region. The following is a description of a few of the significant historical earthquakes of the Los Angeles Basin region in the last century.

A M4.9 earthquake occurred June 21, 1920, and was destructive only at Inglewood and was therefore was assumed to have a shallow epicenter at or west of Inglewood. The damage to buildings was due to poor construction rather than to the intensity of the vibrations. Thin brick walls built as fronts to wooden buildings and not tied in properly, toppled outward into the street. Poorly built brick cornices and fire walls along the fronts of buildings were shaken off.

The Long Beach earthquake (M6.3) of March 10, 1933, had a hypocenter just off the coast of Newport Beach at a depth of about 6 miles. Aftershocks (up to M5.4) occurred along the Newport-Inglewood Fault Zone from Newport Beach to Long Beach, a distance of 15 miles. Fault rupture was not identified at the surface, and no tsunami was observed. This earthquake had an MMI intensity VII to IX and caused damage from Laguna Beach to Marina del Rey and inland to Whittier.

In 1944, two earthquakes caused damage in Torrance and Gardena. On June 18, 1944, two earthquakes of M 4.5 and M 4.4, respectively, occurred in the Dominguez Hills and damaged oil wells in the Rosecrans oil field at depths of 3,000 feet to 6,000 feet.

The San Fernando earthquake (aka Sylmar earthquake, M6.4) on February 9, 1971 had an epicenter in the San Gabriel Mountains on the Sierra Madre Fault System along the mountain front. Fault rupture and strong ground shaking (lasting for 12 seconds) in the San Fernando Valley was extensive, causing widespread damage to hospitals, freeways, dams, schools, utility infrastructure and the collapse of buildings. This earthquake at MMI XI caused enough damage to lead to adoption of more stringent building codes. The mountainous areas experienced over 1,000 earthquake-induced landslides, causing the destruction and closure of many mountain roads. As a result of this earthquake, legislation was passed in 1972 known as the Alquist-Priolo Earthquake Fault Zoning Act, with the goal of reducing damage and losses due to surface fault ruptures. The act restricts construction of buildings designed for human occupancy across active faults.

The Whittier Narrows earthquake (M5.9) on October 1, 1987 happened in the Puente Hills near the town of Rosemead. The focus of the earthquake occurred on a splay of the Puente Hills Blind Thrust Fault System approximately 8.5 miles deep. Damage to freeways caused temporary closing and occurred mainly in buildings constructed prior to the adoption of more stringent building codes.

The Northridge earthquake on January 17, 1994 (M6.7), the most recent of these seismic episodes, produced strong ground motions over an extensive area. The earthquake occurred on a previously unrecognized blind thrust fault, and no surface rupture that can be unequivocally associated with the main shock has been identified. The earthquake's movement on the Northridge blind thrust fault initiated about 11 miles below the town of Reseda (epicenter) in the San Fernando Valley, and it is presumed that the subsurface rupture stopped about 3 miles below the surface. Two M6.0 aftershocks were recorded within the first day of the main shock. The main shock lasted between 1 and 20 seconds and produced the highest ground acceleration ever recorded on instruments in the United States of 16.7 meters/second. The earthquake affected a densely built-up, primarily low-rise area, with MMIs ranging from VII to IX. The moderate-sized Northridge earthquake was the most costly seismic event in the United States since the 1906 San Francisco earthquake, resulting in the loss of life, physical injury, psychological trauma, and property damage estimated to be up to $40 billion.

The Northridge earthquake was one of the most measured earthquakes in history because of extensive seismic instrumentation in buildings and on the ground throughout the region. The quake provided valuable data for evaluating existing standards and techniques and improving hazard mitigation. Two weeks after the Northridge quake, a seismic retrofit tilt-up (concrete walls poured and tilted up on the site) ordinance was adopted and made retroactive by the City of Los Angeles. Subsequently, Los Angeles adopted a series of ordinances that required retrofitting of certain existing structures (e.g., foundation anchoring of hillside dwellings) and for new construction, as well as an ordinance that required evaluation of structures by a structural engineer during the construction process.

More recently, there have been several earthquakes recorded by the U.S. Geological Survey (USGS) near the City IOF occurring along the Newport-Inglewood Fault Zone. On October 28, 2001, a M4.0 earthquake was recorded in Compton approximately 8.5 miles southeast of the City IOF. There was no damage from this quake and there were no reports of it being felt by anyone even though it occurred during the day at 11:27 AM. The earthquake's focus was 13.1 miles deep, which most likely is the reason for it not being felt by anyone. In 2009, at 8:39 PM local time, a M4.7 earthquake struck Inglewood followed by a M4.0 approximately 2 days later. These earthquakes occurred on May 17 and 19, 2009, approximately 5.5 and 6.0 miles (8.9 and 9.7 kilometers) southeast of the City IOF. Their epicenters were located north of Interstate (I) 105 and south of the former Hollywood Park Race Track. Both earthquakes were felt throughout the Los Angeles Basin and regionally from San Bernardino to San Diego (both quakes), with the M4.7 also being felt as far away as San Francisco; Las Vegas, Nevada; Phoenix, Arizona; and Rosarito in Baja California, Mexico. The M4.7 (MMI VI) also caused minor damage with a few broken windows being reported. No damage from the M4.0 (MMI IV) was reported. Analysis by the USGS determined both earthquakes occurred on the Newport-Inglewood Fault Zone at depths of 8.6 miles and 7.9 miles for the M4.7 and M4.0 quakes, respectively.

In April and May of 2015, three earthquakes occurred in the Baldwin Hills area (north of West Slauson Avenue) that were felt by local residents. The three earthquakes were M3.3 (April 12), M3.8 (May 3) and M3.1 (May 23) and ranged in depth from 7.4 miles to 6.5 miles. All three quakes occurred on fault splays of the Newport-Inglewood Fault Zone and were reportedly felt throughout the Los Angeles Basin including Culver City, and as far away as San Diego, Palm Desert, Ridgecrest, and parts of Ventura County. In the Baldwin Hills area the MMI of the these earthquakes was reported to be V (M3.1) and VI (M3.3 and M3.8). No damage from these earthquakes was reported.

Historic Well Stimulation Treatments in the Inglewood Oil Field

In October 10, 2012, the *Hydraulic Fracturing Study PXP Inglewood Oil Field* was conducted to evaluate the effects measured and monitored during the high-volume hydraulic fracturing and high rate gravel packing operations conducted in 2011 and 2012. This study, conducted by Cardno Entrix, also included an overview of the hydraulic fracturing in the Inglewood Oil Field. The following information is summarized directly from the Cardno Entrix study.

Hydraulic fracturing can generally take one of two forms, depending on whether the reservoir is tight sandstone or shale. Conventional hydraulic fracturing uses water, sand, and additives to fracture and stimulate the producing formation to a distance of up to several hundred feet from the well in order to enhance the permeability of the producing zone and stimulate the reservoir. It is typically applied in tight sandstone formations and some shales. High-volume hydraulic fracturing is a higher energy completion approach is generally applied to shales rather than sandstones. Sand and additives are used in the process similar to how they are used in conventional hydraulic fracturing; however, since shales have extremely low permeability, the high-volume hydraulic fracturing process uses increased treatment rates and material volumes (Cardno Entrix 2012).

Conventional hydraulic fracturing has been conducted on 21 wells in the past at the Inglewood Oil Field. These completions were conducted in the Sentous Moynier, Bradna, City of Inglewood, Rubel, and Nodular shale formations. Combined, a total of approximately 65 stages of conventional hydraulic fracturing have occurred at the Inglewood Oil Field between 2003 when PXP began operating the Inglewood Oil Field and 2012 when the study was completed. Conventional hydraulic fracturing has been used for every producing formation deeper than the Vickers and the Rindge at the Inglewood Oil Field. Most conventional hydraulic fracturing jobs were completed in the Sentous, the deepest producing formation at approximately 10,000 feet beneath the ground surface (Cardno Entrix 2012). None of the 21 wells that were subject to conventional hydraulic fracturing are within the City of Culver City.

In addition to the 21 conventional hydraulic fracturing events, PXP contracted Halliburton Energy Services to conduct two high-volume hydraulic fracture jobs at separate wells on the Inglewood Oil Field for the purposes of addressing feasibility and potential impacts of hydraulic fracturing. The first hydraulic fracture completion was conducted on September 15 and 16, 2011, at the VIC1-330 well. The second completion was conducted on January 5 and 6, 2012, at the VIC1-635 well. Neither of these well locations are within the City of Culver City.

Gravel packing differs from hydraulic fracturing in that it is not intended to create fractures in the producing formation. It is intended to place sand and gravel outside and adjacent to the well itself, with the intention of limiting the amount of fine-grained material that is pumped from the formation along with the fluids. As such, the purpose and techniques of gravel packing are distinctly different from hydraulic fracturing (Cardno Entrix 2012).

Prior to 2003, all of the gravel packs were conducted at pressures below the fracture gradient of the formation. Open hole gravel packs were used until 2003 in the Vickers-Rindge formation and were never installed above the fracture gradient of the surrounding formation. High-rate gravel packs were first used in 2003. Between 2003 and 2012, PXP conducted high-rate gravel pack completions on approximately 166 wells in the Inglewood Oil Field, all in the Vickers and the Rindge formation, with a single completion in the Investment Zone. Each high-rate gravel pack includes an average of five stages per well; therefore, approximately 830 stages have been completed at the Inglewood Oil Field between 2003 and 2012 (Cardno Entrix 2012). None of these high-rate gravel packs occurred within the City of Culver City.

Additional Seismic Hazards

Besides surface rupture along a fault, the primary seismic hazard associated with earthquakes is groundshaking, as discussed above. Secondary hazards associated with seismic activity include liquefaction, differential settlement, and landsliding/slope instability. Tsunamis and seiches are generally associated with seismic activity. Underwater landslides can also cause these phenomena. Because of the elevation of the City IOF and the absence of on-site water bodies, tsunamis and seiches are not considered hazards for the City.

Liquefaction

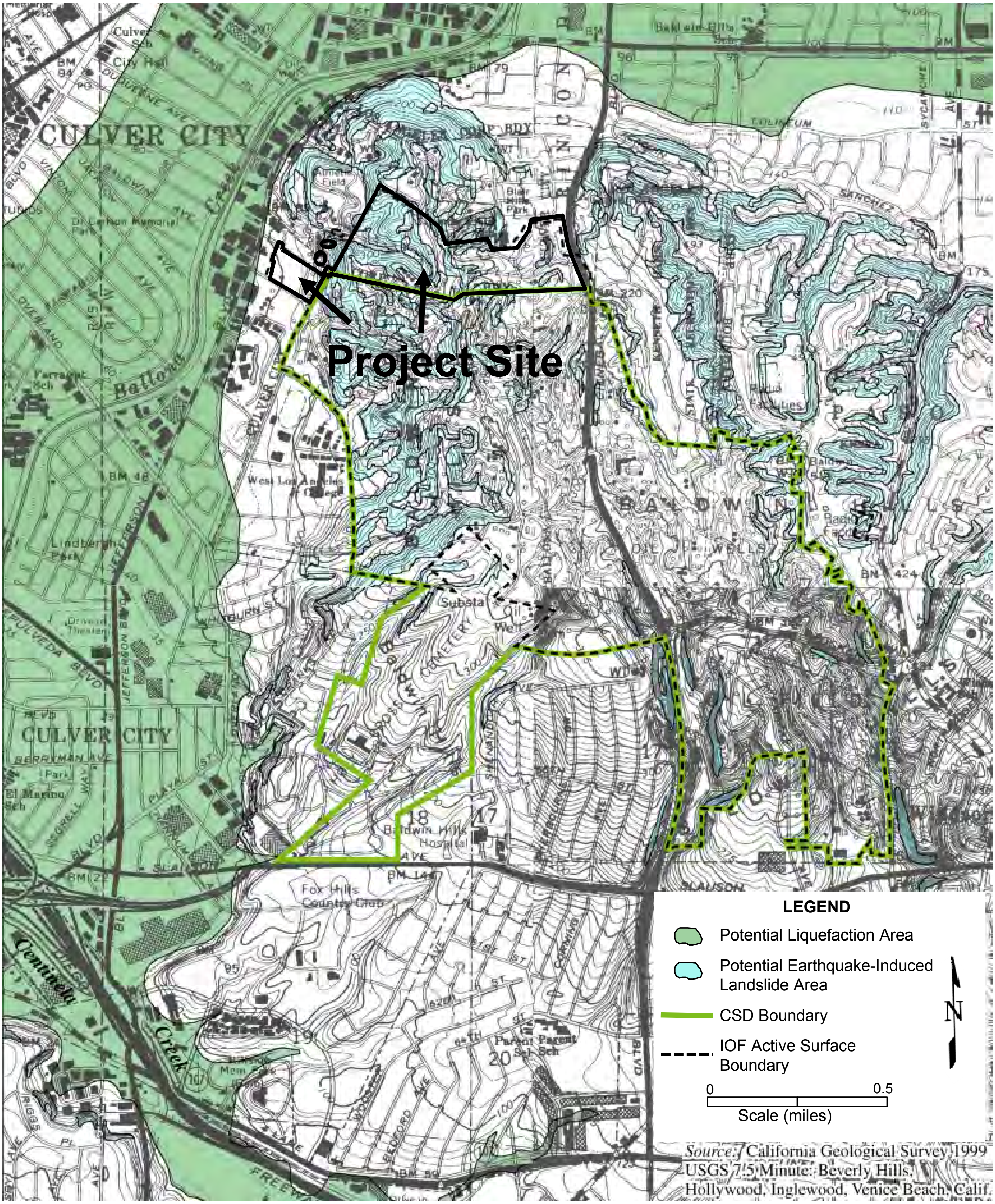
Liquefaction involves the sudden loss of strength in saturated, cohesionless soils that are subjected to ground vibration and which results in temporary transformation of the soil into a fluid mass. If the liquefying layer is near the surface, the effects are much like that of quicksand for any structures located on top of it. If the layer is deeper in the subsurface, it may provide a sliding surface for the material above it. The effects of liquefaction include the loss of the soil's ability to support footings and foundations, which may cause buildings and foundations to buckle. These failures were observed in the 1971 San Fernando and the 1994 Northridge earthquakes.

Exhibit 4.5-5, Liquefaction and Earthquake-Induced Landslide Zones depicts areas within Culver City that are susceptible to liquefaction, as delineated by the California Geological Survey. As shown, liquefaction-prone areas are limited to the Ballona Creek area to the west and north of Jefferson Boulevard. The City IOF is not located within a State of California delineated zone of possible liquefaction.

Earthquake-Induced Landslides

A landslide is a mass down-slope movement of earth materials under the influence of gravity, and includes a variety of forms including: rockfalls, debris slides, mudflows, block slides, soil slides, slumps, and creeps. These mass movements are triggered or accelerated by earthquake-induced ground motion, increased water content, excessive surface loading, or alteration of existing slopes by man or nature. Earthquake-induced landslides, usually associated with steep canyons and hillsides, can originate on or move down slopes as gentle as one degree in areas underlain by saturated, sandy materials.

As shown in Exhibit 4.5-5, Liquefaction and Earthquake Induced Landslide Zones, areas identified as potential earthquake-induced landslide zones include almost all of the descending slopes to the west of La Cienega Boulevard, which would encompass all of the Project Site. All of these



Adapted from Final EIR, Baldwin Hills Community Standards District, October 2009

Source: Kleinfelder 2016

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Liquefaction and Earthquake-Induced Landslide Zones

Exhibit 4.5-5

Inglewood Oil Field Specific Plan Project

PSOMAS

(09/27/2016 MMD) R:\Projects\CUL\3CUL000100\Graphics\EIR\Ex4.5-5_geol_landslide_liquifaction_20170907.pdf

State of California delineated zones of potential earthquake-induced landslides are required to be investigated prior to any development/construction activities.

Landslides

Slope failures, also commonly referred to as landslides, include many phenomena that involve the downslope displacement and movement of material, either triggered by static (i.e., gravity) or dynamic (i.e., earthquake) forces. Exposed rock slopes undergo rockfalls, rockslides, or rock avalanches, while soil slopes experience shallow soil slides, rapid debris flows, and deep-seated rotational slides. Landslides may occur on slopes of 15 percent or less; however, the probability is greater on steeper slopes that exhibit old landslide features such as scarps, slanted vegetation, and transverse ridges. Landslides typically occur within slide-prone geologic units that contain excessive amounts of water, are located on steep slopes, or where planes of weakness are parallel to the slope angle.

Subsidence

Subsidence has been a concern in the Baldwin Hills for decades and is one of the most serious environmental problems caused by oilfield operations within the Los Angeles Basin. Subsidence is caused by the reduction of pore pressure within the oil producing strata as the fluid is removed. The resulting compaction, which is propagated to the surface and typically causes a bowl-shaped subsidence at the surface, centered over the Inglewood Oil Field. Subsidence is often accompanied by large-scale earthcracking, and in some cases includes horizontal and/or vertical movement. Although the precise failure mechanism is unclear, subsidence due to uncontrolled oil withdrawal may have contributed to failure of the former 20-acre Baldwin Hills Reservoir in 1963, killing 5 people and damaging or destroying 277 homes.

As described in the Baldwin Hills Community Standards District (CSD) EIR, prior to 1971, the maximum cumulative subsidence of any of the areas along the Newport-Inglewood Fault Zone was centered over the Inglewood Oil Field, where 67,000 acre-feet of oil, water, and sand had been withdrawn from shallow production horizons (LACDRP 2008). The Culver City Seismic Safety Element reported that the northwest part of the hills was experiencing a subsidence rate of 0.24 to 0.36 inch per year from 1911 to 1963. However, that rate was slowing due to water injection (i.e., waterflooding as a countermeasure) into the Inglewood Oil Field and as of 1971, which effectively eliminated subsidence associated with oil and gas production.

The County IOF has an ongoing program of annual subsidence monitoring in accordance with requirements in the CSD. A baseline survey was established in 2010, and the survey stations utilized can be seen on the 2015 annual ground movement survey map. The latest survey event in May 2015 found that 28 of the 45 survey stations exceed the established threshold of allowable ground movement of 0.6 inch when compared to the 2010 baseline. Ground movement among the 28 stations ranged from 0.6 inch to 3.74 inches over the 5-year span. Within the City IOF, one of the stations (#109), located near the T-Vickers Tank Farm, shows ground movement of 0.88 inch from 2010 to 2015, which includes 0.37 inches in the past year (2014 to 2015). Ground movement for that same station (#109) between 2014 to 2015 was 0.37 inch. However, according to the previous operator, PXPP, none of these changes in ground surface are being attributed to oil and gas production activities. Determination of this will be possible after the additional surveys have been performed and compared to the baseline and other subsequent surveys. To note, measurements of subsidence before and after the high-volume hydraulic fracturing study did not detect a measurable change.

In response to the May 2015 survey results, the California Department of Conservation's Division of Oil, Gas and Geothermal Resources (DOGGR) issued Order 1105, on November 15, 2015, to the Oil Field Operator requesting well information, pressure data, maps, and reservoir rock information. The Oil Field Operator, on December 8, 2015, responded to the DOGGR Order, requesting an extension to providing the requested data, and to suggest that the CSD-mandated subsidence threshold of 0.6 inch should be replaced with a less stringent requirement similar to Long Beach's 1.5 inches. On December 21, 2015, DOGGR's letter acknowledged its review of the Operator's extension request, and expressed appreciation in exchanging information so that a science-based decision can be made. No other information to date is available, nor have any decisions been issued or publicly published by the DOGGR (Kleinfelder 2016).

Soil Erosion

The Baldwin Hills has had a history of erosion problems. On-site surficial sediments are generally characterized by unconsolidated to semi-consolidated sand, silt, and gravel. The topography of the Baldwin Hills, including the Project Site, has been modified by creation of numerous oil field service roads and relatively flat well-drilling pads. Steep cut slopes, with gradients up to approximately 0.75:1 (horizontal to vertical) to near-vertical, are present along many of the roads and on the perimeter of apparently old abandoned well pads. These slopes are subject to erosion, due to the generally unconsolidated nature of the exposed soils. Cut slopes adjacent to apparently newer well pads are less steep, with gradients up to approximately 1:1. Natural slopes are locally eroded with steep-sided gullies. Much of the Project Site has slopes in excess of 20 percent. Also, the Project Site is underlain by Baldwin Hills Sandy Gravel and the Culver Sand, both of which are particularly susceptible to erosion. Vegetation has been removed throughout much of the site, thus contributing to surficial slope instability.

Expansive Soils

The soil conditions in the Project area are directly related to the underlying geologic units. The soil profile is generated by in-place weathering of the native units and by slow downhill creep of surficial materials on the steeper slopes, resulting in local buildup of thick soil (colluvium) in the swales or at the toe of the slopes. The clayey soils within the Baldwin Hills are subject to significant volume change due to variation in soil moisture content. Changes in soil moisture could result from a number of factors, including rainfall, landscape irrigation, utility leakage, and/or perched groundwater. Clay-rich soils are known to develop on the Inglewood Formation and should be considered susceptible to expansion. The Inglewood Formation has been mapped in the canyon below Duquesne Avenue on the Project Site. Also, colluvium is mapped underlying the western part of the Project Site along College Boulevard and should be considered expansive. The remainder of the Project Site is underlain by sandier units belonging to the Baldwin Hills Sandy Gravel and the Culver Sand, which are generally not considered to be expansive.

4.5.3 REGULATORY SETTING

Federal

U.S. Code Title 42

The Earthquake Hazards Reduction Act was enacted in 1997 to "reduce the risks to life and property from future earthquakes in the United States through the establishment and maintenance of an effective earthquake hazards and reduction program". To accomplish this, the act established the National Earthquake Hazards Reduction Program (NEHRP). This program was significantly amended in November 1990 by the National Earthquake Hazards Reduction Program Act (NEHRPA), which refined the description of agency responsibilities, program goals, and objectives.

NEHRPA's mission includes improved understanding, characterization, and prediction of hazards and vulnerabilities; improvement of building codes and land use practices; risk reduction through post-earthquake investigations and education; development and improvement of design and construction techniques; improvement of mitigation capacity; and accelerated application of research results. The NEHRPA designates the Federal Emergency Management Agency (FEMA) as the lead agency of the program and assigns it several planning, coordinating, and reporting responsibilities.

State

Alquist-Priolo Earthquake Fault Zoning Act

The Alquist-Priolo Earthquake Fault Zoning Act was passed in 1972 to mitigate the hazard of surface faulting to structures for human occupancy. In accordance with this Act, the California State Geologist established regulatory zones, called earthquake fault zones (EFZ, which were formerly named Special Studies Zones), around the surface traces of active faults and has published maps showing these zones (Kleinfelder 2016). Within these zones, buildings for human occupancy cannot be constructed across the surface trace of active faults. Each EFZ extends approximately 200 to 500 feet on either side of the mapped fault trace because many active faults are complex and consist of more than one branch that may experience ground surface rupture. This Act applies to the proposed Project because an EFZ is mapped on the Project Site at the northeastern edge near the Stoneview Nature Center, as shown on Exhibit 4.5-4 (Kleinfelder 2016).

Seismic Hazards Mapping Act

The Seismic Hazards Mapping Act was developed to protect the public from the effects of strong ground shaking, liquefaction, earthquake-induced landslides, or other ground failure, and from other hazards caused by earthquakes. This act requires the State Geologist to delineate various seismic hazard zones and requires Cities, Counties, and other local permitting agencies to regulate certain development projects within these zones. Before a development permit is granted for a site within a seismic hazard zone, a geotechnical investigation of the site has to be conducted and appropriate mitigation measures incorporated into the Project design. In addition, CGS' Special Publication 117, Guidelines for Evaluating and Mitigating Seismic Hazards in California, provides guidance for the evaluation and mitigation of earthquake-related hazards for projects in designated zones of required investigations (Kleinfelder 2016). The State Geologist has prepared a map for the area and the Project Site includes land that is delineated as earthquake-induced landslide area, as shown on Exhibit 4.5-5.

California Building Code

The California Building Code (CBC, California Code of Regulations [CCR], Title 24, Part 2), provides minimum standards for building design in the State. Until January 1, 2008, the CBC was based on the then-current Uniform Building Code and contained Additions, Amendments and Repeals specific to building conditions and structural requirements in California. The 2016 CBC, effective January 1, 2017, is based on the current (2015) International Building Code (IBC) and ASCE 7-10. Each jurisdiction in California may adopt its own building code based on the 2016 CBC. Local codes are permitted to be more stringent than the 2016 CBC, but, at a minimum, are required to meet all State standards and enforce the regulations of the 2016 CBC beginning January 1, 2017. The City of Culver City is in the process of adopting the 2016 CBC.

Chapters 16 and 16A of the CBC deals with structural design requirements governing seismically resistant construction (Section 1604), including (but not limited to) factors and coefficients used to establish seismic site class and seismic occupancy category for the soil/rock at the building location and the proposed building design (Sections 1613.5 through 1613.7). Chapters 18 and 18A include (but are not limited to) the requirements for foundation and soil investigations; evaluation of seismic and geologic hazards such as liquefaction, lateral spreading, slope stability; excavation, grading, and fill; allowable load-bearing values of soils; and the design of footings, foundations, and slope clearances, retaining walls, and pier, pile, driven, and cast-in-place foundation support systems. Chapter 33 includes (but is not limited to) requirements for safeguards at work sites to ensure stable excavations and cut or fill slopes. Appendix J of the CBC includes (but is not limited to) grading requirements for the design of excavations and fills and for erosion control. Construction activities are subject to occupational safety standards for excavation, shoring, and trenching as specified in California Occupational Safety and Health Administration (CalOSHA) regulations (CCR, Title 8).

The Culver City's Department of Building Safety is responsible for enforcing all building codes adopted by the State and City, in accordance with City of Culver City's Municipal Code Title 15, Chapters 15.02 and 15.03. The City adopted the 2013 CBC, as incorporated into CCMC 15.02.102.

Well Stimulation Regulations, (Senate Bill 4)

California Senate Bill (SB) 4 ([SB4] Pavley; Chapter 313, Statutes of 2013) complements existing rules regulating the oil industry, and requires some of the strongest well construction standards in the nation by enacting further safeguards to public health and safety and the environment regarding the practices known as well stimulation, including hydraulic fracturing. Final SB 4 regulations became effective July 1, 2015.

SB 4 requires a permit from the DOGGR to conduct well stimulation. The permit application must include detailed information about the fluids to be used, a groundwater monitoring plan, a water management plan, and on-site seismic (earthquake) monitoring during and after the procedure. SB 4 also addresses important operational requirements such as pressure testing, well evaluation, geologic evaluation, well monitoring, and the storage and handling of fluids. Copies of an approved permit must be sent to neighboring property owners and tenants, and water well testing must be provided upon request. SB 4 requires the DOGGR to prepare regulations to ensure that well stimulation is done safely and to require detailed public disclosure about the well stimulation. The DOGGR must develop an internet website to facilitate public disclosure of well stimulation information, and the website must allow the public to easily search and aggregate the information.

As required by SB 4, the DOGGR has prepared an environmental impact report in July 2015, entitled *Final Environmental Impact Report, Analysis of Oil and Gas Well Stimulation Treatments in California,* consistent with CEQA, addressing the practice of well stimulation in California. Additionally, under SB 4 the Natural Resources Agency completed an independent scientific study in July 2015 on well stimulation treatments, entitled *An Independent Scientific Assessment of Well Stimulation in California, An Examination of Hydraulic Fracturing and Acid Stimulations in the Oil and Gas Industry*, by CCST, and the State Water Resources Control Board amended the Groundwater Quality Monitoring code to address necessary groundwater modeling criteria and needed groundwater monitoring programs.

Currently there are no hydraulic fracturing activities on the Project Site or in the Inglewood Oil Field. However, the past operator, PXP, has conducted both conventional and high-volume hydraulic fracturing. Both of these techniques were performed in vertical or slant borings. No horizontal drilling and/or associated hydraulic fracturing are known to have occurred on the Inglewood Oil Field. The previous operator, PXP, planned to perform conventional and high-volume hydraulic fracturing in wells penetrating the six of the deep (greater than 6,000 feet) hydrocarbon reservoirs (i.e., Rubel, Bradna, Moynier, City of Inglewood, Nodular and Sentous reservoirs). However, the former operator, Freeport McMoran (FM O&G), did not state whether well stimulation techniques would be employed at the Project Site. If future Oil Field Operators do decide to employ well stimulation techniques at the Project Site, at a minimum, they will be required to adhere to the SB 4 well stimulation regulations.

Underground Injection Control Program for Class II Injection Wells

In California, wells that inject fluids associated with oil and natural gas production operations and do not enhance the permeability of subsurface rock formations are classified as Class II injection wells. These wells are regulated by the DOGGR under its Underground Injection Control (UIC) Program. Injection operations regulated under the UIC Program include waterflood, steamflood, cyclic steam, gas storage, wastewater disposal, and other enhanced oil recovery projects. The DOGGR's UIC program is monitored and audited by the U.S. Environmental Protection Agency (USEPA) because in 1982 the DOGGR entered into a primacy agreement with the USEPA for regulation of Class II injection wells under the federal Safe Drinking Water Act (SDWA). The requirements of the DOGGR’s UIC Program are found in the Public Resources Code (PRC), the SDWA, and in State and federal regulations. The UIC Program includes permitting, inspection, enforcement, mechanical integrity testing, plugging and abandonment oversight, data management, and public outreach. Improvements to the program were made following an audit by the USEPA in 2011 (Kleinfelder 2016).

Under the UIC Program, a Class II well permit requires the operator to provide detailed data that, in the DOGGR’s judgment, are pertinent and necessary for the evaluation of a proposed injection project. The operator will be required to submit an application that includes a detailed engineering study, stating the primary purpose of the project; the reservoir and fluid characteristics of each injection zone; and the planned well drilling and plugging and abandonment program to complete the project, including a flood-pattern map showing all injection, production, plugged and abandoned wells, and unit boundaries. Additionally, a geologic study and injection plan must also be submitted. The geologic study must include a structural and isopach map, a cross section, and a representative electric log that identifies all geologic units, formations, freshwater aquifers, and oil or gas zones. The injection plan must include a map showing all injection facilities; maximum anticipated injection pressure and volumes; monitoring system or method used to ensure that injection fluid is confined to the intended zone or zones of injection; method of injection; corrosion protective measures; the source, analysis, and treatment of the injection fluid; and the location and depth of water-source wells to be used in conjunction with the project.

For water disposal wells with proposed injection into a non-hydrocarbon zone, the well's construction integrity should be consistent with that of wells completed into oil and gas zones. In order to ensure that injected fluids are confined to the intended zone, there must be 100 feet of cement across and above the top of the intended injection zone.

The previous Oil Field Operator, PXP, had a UIC permit for 168 water flood Class II injection wells for enhanced oil recovery (waterflooding). Also, PXP described possibly implementing steam injection for enhancing oil recovery (Kleinfelder 2016). However, the former operator, FM O&G, stated they did not intend to use steam along with waterflooding for enhanced oil recovery within the City IOF (FM O&G 2016). The intent of the current (or future) Oil Field Operator is unknown. To date, permits for Class II injection wells for wastewater disposal into the deeper IOF strata have not been issued. It is unknown whether future Oil Field Operators will ultimately decide to utilize this method of wastewater disposal. If so, they will, at a minimum, be required to adhere to the DOGGR regulations for UIC Class II injection wells.

City

City of Culver City General Plan

State law since 1975 has required city general plans to include a seismic safety element that addresses the issue of protection of its people from unreasonable risks associated with natural disasters (e.g., fires, floods, and earthquakes). The Seismic Safety Element of the General Plan contains policies that emphasize seismic safety issues because seismic events present the most widespread threat of devastation to life and property.

The Seismic Safety Element of the General Plan provides a contextual framework for understanding the relationship between hazard mitigation, response to a natural disaster, and initial recovery from a natural disaster. The policies of the Seismic Safety Element reflect the comprehensive scope of the City's Emergency Operations Center, which is tasked with integrating the City's emergency operations into a single operation. Culver City's Seismic Safety Element addresses many of the issues as required by State regulations; however, it was published in 1974 and is need of an update to reflect current information regarding the Newport-Inglewood Fault Zone, operations of the Inglewood Oil Field, as well as an analysis of current development and land use in the area.

Seismic Safety Element

While the City of Culver City General Plan does have a Seismic Safety Element, the Element does not describe goals or policies associated with seismic safety. Instead, the Element is a summation of a study and subsequent report prepared. Applicable procedures are recommended for geologic-soils investigations as described below:

1. Geologic investigations should be required in the hillside areas and along the Inglewood, Overland, and Charnock Faults. Major considerations in the hillside areas will be cut-slope stabilities, subsidence, possible surface cracking and faulting related to subsidence, oil field operations and related waste sumps, uncontrolled fills and over-steepened cut-slopes. The principal considerations along the fault zones will be their exact location and state of activity.

2. Soils investigations should be required for all developments within the City. Problems of expansive and boggy soil conditions will be particularly important considerations by

the soils engineer. Potentially high groundwater conditions could result in the future and should receive the attention of the soils engineer.

3. The above investigations should be required prior to City approval of the following three stages of development: (a) tentative tract design; (b) the final grading plan; and (c) following rough grading but prior to issuing building permits. Guidelines for geologic-soils investigation and reporting requirements for strengthening geologic-soils building and grading codes are provided in the report associated with the Seismic Safety Element.

4. Guidelines for municipal projects, geologic services and legal matters and for preparation of storm damage and other geologic hazards reports are also provided in the report associated with the Seismic Safety Element.

5. Specific studies that the City should consider making are (a) the monitoring of continued rate of subsidence based on continued survey data available from City and County engineering and survey divisions and (b) investigation of the Inglewood, Overland and Charnock faults in the subsurface.

Public Safety Element

The City of Culver City General Plan's Public Safety Element contains policies that address a fire and geologic hazards. Listed below are the policies that address seismic concerns:

Public Safety Element Policy 1. Establish and enforce standards and criteria to reduce unacceptable levels of fire and geologic risk.

Public Safety Element Policy 5. Develop stringent site criteria for construction in areas with fire and/or geologic problems and prohibit construction if these criteria are not met.

Public Safety Element Policy 6. Encourage continued research in the fields of geologic and fire safety.

Public Safety Element Policy 7. Strengthen existing codes and ordinances pertaining to fire and geologic hazards.

Public Safety Element Policy 9. Require all new development and selected existing development to comply with established fire and geologic safety standards.

City of Culver City Natural Hazard Mitigation Plan

The City of Culver City, along with the Culver City Unified School District approved its Natural Hazard Mitigation Plan (NHMP) in 2004. The plan identifies potential natural and human-caused hazards and potential scenarios and estimated losses and it addresses existing and proposed mitigation policies, programs and projects, and response programs. With regard to the Project Site, the NHMP identified earthquake, landslides, and wildfires as high-risk hazards, but high winds and dam failures are considered low-risk hazards. In May 2016, the City submitted a revised Draft Multi-Jurisdictional Hazard Mitigation Plan (MJHMP) to the California Office of Emergency Services and the Federal Emergency Management Agency (FEMA) for review. Once the plan is approved, it will be considered by the City of Culver City Council and the School Board for adoption (Culver City 2016a).

Municipal Code

The City of Culver City Municipal Code contains the City's building regulations. Section 15.02.105 of the City's Municipal Code adopts the 2013 California Building Code by reference as the "Building Code of the City of Culver City".

4.5.4 SPECIFIC PLAN AND REGULATORY REQUIREMENTS

Specific Plan Drilling Regulations

Section 10. Construction and Grading Permits, requires that the Operator shall be required to obtain the following construction and grading permits:

A. A construction permit for the erection of any Permanent Structure on the permitted premises. Plans of the structure to be erected must be submitted to the City's Building Safety Division prior to a permit being issued.

B. A grading permit from the City's Department of Public Works for all grading, except as defined in the Grading Guidelines as adopted by the Los Angeles County Department of Public Works. Grading design and grading plan preparation shall conform to the requirements of the Los Angeles County Grading Guidelines. A site-specific geotechnical investigation and hydrologic analysis may be required as described in Sections 24.B and 27, respectively.

C. The permits required by this Ordinance are in addition to any other applicable permits required by the Culver City Municipal Code (CCMC), including, but not limited to, building, electrical, fire and public works permits.

Section 24. Geotechnical.

Operator shall comply with the following provisions:

A. Review. All proposed grading shall be subject to prior review and approval by the Public Works Director/City Engineer.

B. Geotechnical Investigation. A site-specific geotechnical investigation shall be completed for permanent structures and for grading in excess of 1,000 cubic yards. The Public Works Director/City Engineer may waive this investigation requirement for grading involving between 1,000 and 5,000 cubic yards if there are no permanent structures proposed and grading would not create slopes higher than five feet. The investigation shall be completed by a licensed California Engineering Geologist and licensed California Geotechnical Engineer and submitted to the Public Works Director/City Engineer for review and approval. The following items must be addressed in the geotechnical investigation.

1. No slope of cut or fill shall have a gradient steeper than 2:1 (horizontal to vertical) unless specifically approved by a site-specific geotechnical report.
2. Erosion shall be controlled on all slopes and banks so that no sediment or other substances are washed onto public streets or surrounding

property. Such control measures may consist of planting and irrigation, dams, cribbing, riprap, sand bagging, netting, berms, or other devices.

3. Cuts and fills shall be minimized to avoid erosion and visual impacts.

4. Slopes shall be restored to their original grade within 30 days of the discontinuance of the use, unless extended by the Public Works Director for good cause shown.

C. Accumulated Ground Movement Plan. Within 180 days of the date of approval of the Comprehensive Drilling Plan or at such later date as may be approved by the Public Works Director/City Engineer, for good cause shown, the Operator shall submit an Accumulated Ground Movement Plan, including subsidence and uplift, which addresses post-Baldwin Hills Reservoir failure studies to be reviewed and approved by the Public Works Director/City Engineer. The Plan shall identify all measurement locations that will be used and shall include points within and beyond the Oil Field. Measurement locations shall extend a minimum of 1,000 feet beyond the horizontal limit of proposed Bottom Holes. Use of existing measurement locations within the Los Angeles County portion of the Oil Field may be included within the Plan. The Plan shall include both vertical and horizontal ground movement, and shall utilize Global Positioning System technology, as well as any other survey methods deemed appropriate by the Public Works Director/City Engineer to provide the level of accuracy required in monitoring ground movement. The Plan shall identify a monitoring period that extends five years after the end of Oil Operations. The Operator shall promptly address any changes, additions, revisions or modifications that may be required to receive the approval of the Plan by the California Department of Conservation's Division of Oil, Gas, and Geothermal Resources (DOGGR) and the Public Works Director/City Engineer. This requirement may be satisfied if the Operator can demonstrate, to the satisfaction of the Public Works Director/City Engineer, that an Accumulated Ground Movement Plan is being implemented and has been approved for other parts of the Inglewood Oil Field and can conclusively show that the Accumulated Ground Movement Plan applies to the Oil Field within the jurisdiction of the City. Additional information may be required by the Public Works Director/City Engineer to demonstrate compliance with this Section.

D. Accumulated Ground Movement Survey. Within 60 days of approval of the Accumulated Ground Movement Plan required in Section 24.C, above, the Operator shall implement the Accumulated Ground Movement Survey as described in the approved Accumulated Ground Movement Plan. For drilling proposed within the Oil Field, the Operator must submit the results of the Accumulated Ground Movement Survey to the Public Works Director/City Engineer. The study shall be prepared by a licensed expert approved or selected by the Public Works Director/City Engineer, for determining annual ground movement, including subsidence or uplift. The Accumulated Ground Movement Survey results shall identify ground movement during this first study period, including subsidence or uplift, and include a description of how future ground movement survey results will be analyzed and reported. Measurements shall be made using repeat pass Differentially Interferometric Synthetic Aperture Radar technology to establish baseline conditions, since the post-Baldwin Hills Reservoir failure, to measure future ground movement. Within 30 days of completing the Accumulated Ground Movement Survey, the results of the annual monitoring survey shall be forwarded to DOGGR for review and appropriate action and to the Public Works Director/City Engineer for review and comment, and the Operator shall see that any changes, additions, revisions or modifications that may be required to receive the approval of such agencies are promptly made and approved. Annual survey reports shall be submitted for a minimum of five years after cessation of Oil Operations and the fifth report shall provide conclusions and recommendations regarding the need for continued surveying and reports. If an annual study is not approved, the Operator shall promptly take such actions as are necessary to obtain approval. This requirement may be satisfied if the Operator can demonstrate to the satisfaction of the Public Works Director/City Engineer, that an annual Accumulated Ground Movement Survey is being implemented and has been approved for other parts of the Oil Field and can conclusively show that the annual Accumulated Ground Movement Survey applies to the Oil Field within the jurisdiction of the City. Additional information may be required by the Public Works Director/City Engineer to demonstrate compliance with this Section.

E. Ground Movement Threshold Limits. In the event that the annual monitoring surveys indicate that ongoing ground movement deviates from the baseline measurements, as established by the Accumulated Ground Movement Plan and the initial Accumulated Ground Movement Survey (as required per Section 24.C and 24.D, respectively), by a measurement equal to or greater than 0.6 inch or a lesser value determined by the Public Works Director/ City Engineer, at any given location 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 City by the public or a public entity in the 12 months since the last ground movement survey. Based on this information, 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 Public Works Director/City Engineer.

1. No further drilling or redrilling shall be commenced or approved until the cause of the movement has been determined.
2. If the Operator’s operations are the cause or a contributing factor, no further drilling or redrilling shall be commenced or approved until a remedy, such as adjustments in ground water flood operations, has been fully implemented to alleviate the ground movement to the satisfaction of DOGGR and the Public Works Director/City Engineer.
3. Injection pressures associated with secondary recovery operations shall not exceed reservoir fracture pressures as specified in California Code of Regulations Title 14, Division 2, Section 1724.10, and as approved by DOGGR.

F. Fault Investigation Report. Tanks or other permanent structures shall not be constructed across an active fault or within the Alquist-Priolo

Earthquake Fault Zone without preparation of a Fault Investigation Report by a California Certified Engineering Geologist, to be reviewed and approved by the Building Official.

G. **Seismic Activity Tracking.** Within 180 days of the date of approval of the Comprehensive Drilling Plan or at such later date as may be approved by the Public Works Director/City Engineer, for good cause shown, the Operator must demonstrate ability to track and record seismic activity relating to Oil Operations by using a fully operating and properly maintained accelerometer (in coordination with the CalTech Seismological Laboratory). The accelerometer data shall be used to determine site-specific ground accelerations as a result of any seismic event in the region (Los Angeles/Orange County and offshore waters of the Santa Monica Bay and San Pedro Channel). Readings from the accelerometer shall be recorded and transmitted in real-time to the California Integrated Seismic Network. The Operator shall cease operations and inspect all pipelines, tanks, and other infrastructure following any seismic event that exceeds a ground acceleration of 13 percent of gravity (0.13g). The Operator shall promptly notify the Public Works Director/City Engineer if there is a seismic event that necessitates the ceasing of operations. The Operator shall not reinstitute operations and use of associated pipelines until all infrastructure is structurally sound as determined by DOGGR and the Public Works Director/City Engineer in consultation with the Operator. Documentation of this requirement shall be submitted with each Annual Drilling Plan.

H. **Erosion Control Plan.** Within 180 days of the date of approval of the Comprehensive Drilling Plan or at such later date as may be approved by the Public Works Director/City Engineer, for good cause shown, Operator shall develop and submit for review and approval by the Public Works Director/City Engineer an Erosion Control Plan. All grading and other Drilling Project activities shall be in complete conformity with the approved Erosion Control Plan.

1. The Erosion Control Plan shall include, but is not limited to, the following measures:

   a. Graded areas shall be stabilized with riprap (i.e., crushed stone) or other ground cover as soon as grading is completed. The surface of slopes shall be roughened during the construction period to retain water, increase infiltration, and facilitate establishing vegetation. Tracked machinery shall be operated up and down (parallel with) slopes to leave horizontal (perpendicular) depressions in the soil, which run across the slope, on the contour.

   b. Slope breaks, such as diversions, benches, or contour furrows shall be constructed to reduce the length of cut- and fill-slopes, thus limiting sheet and rill erosion and preventing gully erosion.

   c. Sediment barriers shall be used around construction areas to retain soil particles on-site and reduce surface runoff velocities during rainfall events. Sediment barriers could include straw bales, silt fences, and gravel and earth berms. Silt fences shall be placed on slope contours in areas where shallow overland flow is anticipated.

d. Temporary and permanent drainages shall be employed, as necessary, to reduce slope erosion and prevent damage to construction areas. Sheet flow across or toward a disturbed area shall be intercepted and conveyed to a low to moderate gradient (one to five percent slope) sediment basin, erosion-resistant drainage channel, or a level, well-vegetated area. Drainages include swales, diversion dikes, and slope drains.

e. Waterbars, rolling dips, and outsloping roads shall be constructed as part of new road construction to disperse runoff and reduce the erosive forces associated with concentrated flows.

2. This requirement may be satisfied if the Operator can demonstrate, to the satisfaction of the Public Works Director/City Engineer, that an Erosion Control Plan is being implemented and has been approved for other parts of the Oil Field and can conclusively show that the Erosion Control Plan applies to the Oil Field within the jurisdiction of the City. Additional information may be required by the Public Works Director/City Engineer to demonstrate compliance with this Section.

I. Slope Restoration. Slopes shall be restored to their original grade, to the satisfaction of the Public Works Director/City Engineer, once the use that required the grading of the slope has been discontinued. However, if restoration of a slope would negatively affect existing drainage patterns or slope stability, then the slope shall be restored to a grade that avoids these negative effects, as determined by the Public Works Director/City Engineer.

Section 32. Well Stimulation Treatments.

(***NOTE:*** *The EIR for the Proposed Inglewood Oil Field Specific Plan Project ("Specific Plan EIR") will evaluate the potential environmental impacts of conducting Well Stimulation Treatments, within the Oil Field, performed in a manner consistent with DOGGR's Senate Bill 4 regulations as of July 1, 2015, and the site-specific requirements set forth in this draft Specific Plan. In taking action on the Specific Plan, the City Council will consider the available information, including the Specific Plan EIR, in making a determination as to whether and upon what terms the adopted Specific Plan would allow Well Stimulation Treatments to be conducted within the Oil Field.*)

Section 38. Public Roadways and Private Road Construction has the following requirements for construction of private roads.

B. Construction of Private Roads. Roads and other excavations shall be designed, constructed, and maintained to provide stability of fill, minimize disfigurement of the landscape, prevent deterioration of vegetation, maintain natural drainage, and minimize erosion, dust and debris. Prior to construction of any new road, the Operator shall prepare and submit to the Public Works Director/City Engineer for review and consideration of approval a Private Road Construction Plan. The Operator shall thereafter comply with all provisions of the approved Private Road Construction Plan. All new private access roads leading off any surfaced public street or highway shall be paved with asphalt or concrete not less than three inches thick for the first 50 feet of said access road from the public street or highway.

Regulatory Requirements

RR GEO-1 Oilfield operations at the Project Site must be constructed, maintained, monitored, operated, and decommissioned in compliance with all applicable federal, State, and local regulations, including but not limited to the California Building Code; Hazardous Liquid Pipeline Safety Act, Hazardous Materials Transportation Act, Hazardous Waste Control Law, California Pipeline Safety Act, Oil Pipeline Environmental Responsibility Act, and other pertinent regulations of the U.S. Environmental Protection Agency (USEPA)/California Environmental Protection Agency (CalEPA), the U.S. Department of Transportation (USDOT)/California Department of Transportation (Caltrans), the U.S. Occupational Safety and Health Administration (OSHA)/California Occupational Safety and Health Administration (CalOSHA), the Department of Toxic Substances Control (DTSC), the DOGGR, the State Water Resources Control Board (SWRCB)/Regional Water Quality Control Board (RWQCB), the South Coast Air Quality Management District (SCAQMD), the California Office of Emergency Services (CalOES), the State Fire Marshall, the Los Angeles County Fire Department as the Certified Unified Program Agency (CUPA), the Culver City Fire Department, and other Culver City Municipal Code requirements.

The DOGGR determined that several of the mitigation measures developed in the SB4 EIR should be converted into formal regulations, including SB4 GEO-1a (Avoid active Faults if Necessary), SB4 GEO-1b (Implement an Appropriate Setback if Necessary), and SB4 GEO-1e (Include an Earthquake Response Plan with the Spill Contingency Plan). These measures are intended to be applied without change throughout the State because (1) they address the direct environmental effects of well stimulation treatment; (2) they relate to activities that occur physically very close to the oil and gas wells; and (3) they already reflect the lessons of a considerable amount of scientific input and empirical experience. These measures are temporarily included within the DOGGR Draft Mitigation Policy Manual (see Appendix B-2 of this Draft EIR) until such time as formal regulations are duly adopted and in place (DOC 2015b). Interim MM GEO-3, MM GEO-4 and MM GEO-5, which correspond to the SB4 measures listed below, will be implemented and enforced by the City until such time as DOGGR adopts the measures as formal regulations.

SB4 GEO-1a Avoid Active Faults if Necessary. DOGGR shall require, as part of the application for a well stimulation treatment permit, that the applicant provide documentation to DOGGR and demonstrate to DOGGR's satisfaction that the location and trend of the proposed well will not be within or enter into an active earthquake fault, unless the applicant can show to DOGGR's satisfaction that established or proposed well control and well shut-in procedures will adequately address the consequences of a rupture of a known fault, seismically induced ground shaking, and/or ground failure occurring during the well stimulation process. These procedures shall be included within the Spill Contingency Plan for the affected well required by Section 1722.9 of Title 14 of the California Code of Regulations.

SB4 GEO-1b Implement an Appropriate Setback if Necessary. In approving a well stimulation treatment permit, DOGGR shall impose a condition that prohibits the applicant from conducting well stimulation treatments within an appropriate setback of a known active fault as established by the Department of Conservation (DOC), unless the applicant can show to DOGGR's satisfaction that established or proposed well control and well shut-in procedures will adequately address the consequences of a rupture of a known fault, seismically induced ground shaking, and/or ground failure occurring during the well stimulation process. These procedures shall be included within the Spill Contingency Plan for the affected well required by Section 1722.9 of Title 14 of the California Code of Regulations.

SB4 GEO-1e Include an Earthquake Response Plan within the Spill Contingency Plan. In approving a well stimulation treatment permit, DOGGR shall impose a condition requiring the applicant to demonstrate to for DOGGR's satisfaction that the spill contingency plan required by Section 1722.9 of Title 14 of the California Code of Regulations adequately addresses the consequences of an earthquake occurring during the well stimulation process, for however many well stimulation treatments are proposed to occur simultaneously at any given time. The Spill Contingency Plan shall include requirements for adequate on-site personnel and equipment that may be necessary to conduct post-earthquake inspection and repair plans to evaluate any damage that has occurred. The Spill Contingency Plan shall include spill prevention, control and countermeasure plans to address the hazardous substances associated with well stimulation activities. The inspection procedures shall ensure the integrity of the mechanical systems and well integrity of wells used for stimulation or wastewater injection and idle wells that might have become conduits for escaping fluids or gases. The plan shall include procedures describing the necessary steps to be taken after service is disrupted in order to make the facilities secure, operational and safe as soon as possible.

4.5.5 THRESHOLDS OF SIGNIFICANCE

Thresholds Addressed in the Initial Study

The Initial Study prepared for the Project (included in Appendix A-1) concludes that the Project would have no impact on the following threshold, and further analysis of this threshold is not required in the Draft EIR:

- Would the Project have soils incapable of adequately supporting the use of septic tanks or alternative wastewater disposal systems where sewers are not available for the disposal of wastewater?

Thresholds Addressed in this Environmental Impact Report

The Initial Study for the Project concludes that additional project-level analysis of the following thresholds of significance is required in this Draft EIR. These thresholds are mostly based on Appendix G of the California Environmental Quality Act (CEQA) Guidelines along with some additional thresholds determined to be relevant to the Project. A project would have a significant adverse impact on geology, soils, and seismicity if it would:

Threshold 5-1: Expose people or structures to potential substantial adverse effects, including the risk of loss, injury, or death involving:

i) Rupture of a known earthquake fault, as delineated on the most recent Alquist-Priolo Earthquake Fault Zoning Map issued by the State Geologist for the area or based on other substantial evidence of a known fault? Refer to Division of Mines and Geology Special Publication 42.

ii) Strong seismic ground shaking?

iii) Seismic-related ground failure, including liquefaction?

iv) Landslides?

Threshold 5-2: Result in substantial soil erosion or the loss of topsoil?

Threshold 5-3: Be located on a geologic unit or soil that is unstable, or that would become unstable as a result of the Project, and potentially result in onsite or offsite landslide, lateral spreading, subsidence, liquefaction, or collapse?

Threshold 5-4: Be located on expansive soil, as defined in Table 18-1-B of the Uniform Building Code (1994), creating substantial risks to life or property?

Threshold 5-5: Cause an induced seismic event including ground shaking and ground failure?

4.5.6 IMPACT ANALYSIS

Threshold 5-1: Would the project expose people or structures to potential substantial adverse effects, including the risk of loss, injury, or death involving:

i) Rupture of a known earthquake fault, as delineated on the most recent Alquist-Priolo Earthquake Fault Zoning Map issued by the State Geologist for the area or based on other substantial evidence of a known fault? Refer to Division of Mines and Geology Special Publication 42.

The Inglewood Oil Field is located in the Baldwin Hills, which were formed as a result of uplift and deformation of sedimentary rock layers due to movement of the Newport-Inglewood Fault Zone. This fault zone, which is seismically active, is comprised of many smaller faults and fault splays (see Exhibit 4.5-3). An active fault is one that has had movement within Holocene time (approximately the last 11,000 years). However, not all of the faults and fault splays within the Newport-Inglewood Fault Zone are active; some are ancient and with estimated movement older than the Holocene. All of the faults within the fault zone have displaced and deformed the subsurface strata, which helped in developing the structural oil traps for the Inglewood Oil Field. Some of the faults terminate in the subsurface while others extend to the ground surface. Some of the faults at the surface were determined by CGS to possibly be active. Therefore, under the Alquist-Priolo Act, CGS placed a zone around the faults known as Earthquake Fault Zones (EFZs).

All faults within an EFZ are assumed to be active until a detailed investigation confirms it or not, and generally a construction setback from the active faults is established. Due to the lack of datable soils, an active fault may not be zoned as an EFZ. Also, construction, which predates the implementation of the Alquist-Priolo Act, may have placed buildings and roadways above active faults obscuring them from detection. At the northern end of the Project Site within the 400-foot buffer zone is the only EFZ within the Project Site (see Exhibit 4.5-4). This EFZ extends northward into the parking area of the Stoneview Nature Center. The Alquist Priolo Act, CCR Title 14, Article 3, Section 3603(a) requires:

> No structure for human occupancy, identified as a project under Section 2621.6 of the Act, shall be permitted to be placed across the trace of an active fault. Furthermore, as the area within fifty (50) feet of such active faults shall be presumed to be underlain by active branches of that fault unless proven otherwise by an appropriate geologic investigation and report prepared as specified in

Section 3603(d) of this subchapter, no such structures shall be permitted in this area.

Additionally, Drilling Regulations Section 24F would prohibit the construction of any tanks or permanent structures within an Alquist Priolo Fault Zone without the preparation of a Fault Investigation Report, which would determine the location of all active fault traces before any work could be conducted within this EFZ or along any active fault on the City IOF. Currently, there is no minimum distance requirement for a setback; however, 50 feet represents the generally applied setback. Ultimately, the Fault Investigation Report would determine the fault location and the appropriate setback requirement on a case-specific basis.

Ground rupture caused by naturally occurring earthquakes cannot be prevented or mitigated; therefore, avoidance of known active faults is the only feasible course of action. Criteria set forth in the Drilling Regulations, Alquist-Priolo Act, adherence to the State Building Code, and requirements of Culver City's Public Works Department provide the best procedures and standards for avoidance of hazards associated potential rupture of an earthquake fault due to naturally occurring earthquakes within the City IOF. Impacts associated with conventional oil/gas extraction and development on the Project Site per the Drilling Regulations would be less than significant and no mitigation is required.

However, possible ground rupture caused by induced earthquakes is avoidable. The topic of induced seismicity is discussed under Threshold 5-5 below in detail. In summary, in the last decade, there have been examples of earthquake activity related to oil and gas production (i.e., well stimulation) as well as numerous examples of earthquake activity due to injection of fluids (e.g., wastewater disposal). Almost all induced seismicity associated with oil production-related activities can be traced to either fluid injection or extraction and, in many cases, is either due to well stimulation and/or waste disposal activities; however, no cases of surface rupture are known to have occurred as a result.

As discussed under Threshold 5-5, the DOGGR's SB4 GEO-1a (interim MM GEO-3) and SB4 GEO-1b (interim MM GEO-4) address seismicity, fault rupture, and groundshaking hazards due to well stimulation treatments, and SB4 GEO-1e (interim MM GEO-5) addresses post-earthquake response requirements as part of the spill contingency plan for well stimulation treatments.

Additionally, MM GEO-1 is required to reduce potential impacts from induced seismicity due to well stimulation (i.e., hydraulic fracturing) and requires the development of a "traffic light" system (discussed under Threshold 5-5 below) for screening and evaluation of seismic activity in the City IOF. However, without a longer and more comprehensive history of study of hydraulic fracturing and similar well stimulation techniques, MM GEO-1 and DOGGR measures SB4 GEO-1a, -1b, and 1e (interim MM GEO-3 through MM GEO-5) cannot be assured to reduce the potential for induced seismicity to less than significant, and impacts would remain significant and unavoidable. Therefore, because hydraulic fracturing may result in induced seismicity, if this technique were to occur within the City IOF, then the potential for surface rupture due to induced seismicity would also be significant and unavoidable.

Threshold 5-1: Would the project expose people or structures to potential substantial adverse effects, including the risk of loss, injury, or death involving:

ii) Strong seismic ground shaking?

Seismic ground shaking is the direct result of earth's movement along a fault. The City IOF is in a location adjacent to the active Newport-Inglewood Fault Zone and will most likely be subjected to ground shaking in the future. Ground shaking caused by naturally occurring earthquakes is inevitable, and avoidance is not possible.

There are two primary methods to estimate expected ground motions at a site: probabilistic and deterministic. The building codes are based on USGS data, which uses a combination of both methods to estimate ground motions.

In the probabilistic method, all of the known seismic sources in the region (e.g., background seismicity and their relative rate of seismicity) are taken into consideration and the expected values are determined of either peak or spectral acceleration associated with certain probability of exceedance or an earthquake return period. The CBC and the IBC are based on ground motions having 2 percent probability of exceedance in 50 years (return period of about 2,475 years).

There is a 2 percent probability that the City IOF and areas within 2 kilometers (km) of the City IOF may experience a peak ground acceleration (PGA) of 0.8g or higher within next 50 years. Within 5 km of the City IOF, expected PGA is 0.8g for a seismic event associated with 2 percent probability of exceedance in 50 years, except at small portion in the south-southwest where expected PGA is about 0.6g.

In the deterministic method, it is assumed that the closest seismic sources will experience the maximum earthquake expected for that fault during the life of the project. Using the earthquake magnitude, distance to the fault, fault mechanism, and site conditions as input parameters, and using Ground Motion Prediction Equations (GMPE), PGA and spectral accelerations can be estimated. There are five GMPEs currently being used in California for shallow crustal events such as associated with the faults in the project region. These GMPEs are based on statistical analysis of worldwide seismicity data and therefore, provide median values with standard deviations resulting in a range of expected values. These GMPEs are only valid for M3 or higher events and are not applicable for lower magnitude events. The deterministic method is typically used for emergency response and planning purposes. For example, for the City IOF and for a M3 event with 0-km distance, deterministically expected PGA would be less than 0.1g. This PGA value would increase to about 0.1g to 0.25g for M4 event and to about 0.3g to 0.6g for M5. Similarly, a M7.5 event on the Newport-Inglewood Fault Zone and at a distance of 0 km for a soil site could produce PGA of about 0.5g to 0.9g.

As previously discussed, strong ground shaking should be anticipated within the Project Site, where a peak ground acceleration ranging from 0.5g to 0.9g (50 to 80 percent of the acceleration due to gravity) could occur during a M7.2. According to USGS, a maximum M7.5 is associated with the Newport-Inglewood Fault Zone. Damage to on-site structures and facilities, including pump jacks, tanks, and pipelines, could result from strong groundshaking. Ground shaking caused by naturally occurring earthquakes is inevitable, and minimizing their effects by advanced preparation is generally the accepted method.

As stated in RR GEO-1, all oilfield operations at the Project Site must be constructed, maintained, monitored, operated, and decommissioned in compliance with all applicable federal, State, and local regulations. Modern, well-constructed buildings are designed to resist ground shaking through the use of shear walls and reinforcements. The California Building Code (CBC) includes regulations and requirements designed to reduce risks to life and property from ground shaking to the maximum extent feasible. The CBC is enforced by Culver City's Department of Building Safety, in accordance with City of Culver City's Municipal Code Title 15, Chapters 15.02 and 15.03. Compliance with applicable building codes and seismic design standards and pipeline safety regulations (see Section 4.7, Hazards and Hazardous Materials, of this Draft EIR) would ensure that potential impacts due to groundshaking from naturally occurring earthquakes would be less than significant and no mitigation is required.

However, groundshaking caused by induced earthquakes is avoidable. The topic of induced seismicity is discussed under Threshold 5-5 below in detail. In summary, in the last decade, a number of examples of earthquake activity related to oil and gas production (i.e., well stimulation) as well as injection of fluids (e.g., wastewater disposal) have been observed. Almost all induced seismicity associated with oil production can be traced to either fluid injection or extraction, and in many cases is either due to well stimulation and/or waste disposal activities.

As such, potential impacts associated with induced seismicity are discussed in detail under Threshold 5-5. The DOGGR's SB4 GEO-1a (interim MM GEO-3) and SB4 GEO-1b (interim MM GEO-4) address seismicity, fault rupture, and groundshaking hazards due to well stimulation treatments, and SB4 GEO-1e (interim MM GEO-5) addresses post-earthquake response requirements as part of the spill contingency plan for well stimulation treatments . Additionally, MM GEO-1 is required to reduce potential impacts from induced seismicity due to well stimulation (i.e., hydraulic fracturing) and requires the development of a "traffic light" system for screening and evaluation of seismic activity in the City IOF. However, without a longer and more comprehensive history of study and hydraulic fracturing and similar well stimulation techniques, MM GEO-1 and DOGGR measures SB4 GEO-1a, -1b, and 1e (interim MM GEO-3 through MM GEO-5) cannot be assured to reduce the potential for induced seismicity to less than significant, and impacts would remain significant and unavoidable. Therefore, because hydraulic fracturing may result in induced seismicity, if this technique were to occur within the City IOF, then the potential for strong seismic groundshaking due to induced seismicity would also be significant and unavoidable.

Threshold 5-1: Would the project expose people or structures to potential substantial adverse effects, including the risk of loss, injury, or death involving:

iii) Seismic-related ground failure, including liquefaction?

iv) Landslides?

As shown in Exhibit 4.5-5, liquefaction-prone areas in Culver City are primarily limited to the Ballona Creek area to the west and north of Jefferson Boulevard. However, the City IOF is not located within a State of California delineated zone of possible liquefaction. Therefore, implementation of the Project's Maximum Buildout Scenario would not expose people or structures to liquefaction hazards.

Slope failures, also commonly referred to as landslides, include many phenomena that involve the downslope displacement and movement of material, either triggered by static (e.g., gravity) or dynamic (e.g., earthquake) forces. Exposed rock slopes undergo rockfalls, rockslides, or rock avalanches, while soil slopes experience shallow soil slides, rapid debris flows, and deep-seated rotational slides. Landslides may occur on slopes of 15 percent or less; however, the probability is greater on steeper slopes that exhibit old landslide features such as scarps, slanted vegetation, and transverse ridges. Landslides typically occur within slide-prone geologic units that contain excessive amounts of water, are located on steep slopes, or where planes of weakness are parallel to the slope angle.

There is a mitigation measure in the DOGGR's Draft Mitigation Policy Manual prepared pursuant to the SB4 EIR, which is included in Appendix B-2 of this Draft EIR, that is applicable to the analysis of landslides and other forms of geotechnical instability, as listed below (DOC 2015b):

- SB4 GEO-3a: Prepare Geotechnical Report if Necessary

As discussed previously, this section analyzes the Project's potential impacts on geology, soils and seismicity, based on information from the *Geology, Soils, and Seismicity Technical Memorandum* prepared by Kleinfelder, Inc. and provided in Appendix E-1 of this Draft EIR. Also, the Drilling Regulations require conduct of a Geotechnical Investigation for any permanent structures and grading in excess of 1,000 cy. Therefore, the intent of this DOGGR SB4 measure is already incorporated into requirements set forth in the Drilling Regulations of the Specific Plan, and no new or additional measures related to these SB4 MMs are required.

The Baldwin Hills have a well-documented history of chronic shallow landslide and erosion problems. On-site surficial sediments are generally characterized by unconsolidated to semi-consolidated sand, silt, and gravel. Well-defined bedding planes, which might be subject to deep-seated landslides, are generally absent. Potential slope failures are generally a result of surficial (i.e., less than 10 feet deep) slumping and unraveling of sediments as a result of steep slopes and saturated conditions; however, deep-seated landslides/slumps are located within the City IOF. Debris flows have also occurred in many areas of steep slopes, during or subsequent to successive heavy rainfall events. Vegetation has been removed throughout much of the active surface field within the City IOF, thus contributing to surficial slope instability.

Following the heavy rains of 1969, 1978, and 1980, the Baldwin Hills suffered widespread damage from slope failures. The problems of the slope instability during these rainy years were particularly severe in the Baldwin Hills for two reasons. First, the hills were mostly developed in the very late 1940s and the 1950s, prior to enactment of stringent grading codes by local governments. Second, the terrain developed consisted mostly of steep natural slopes underlain by soft sedimentary rocks. The resulting tracts contain graded and natural slopes with angles as steep as 45 degrees, or even steeper, commonly without proper drainage devices and retaining walls. Modern grading codes require that cut and fill slopes be designed no steeper than 26 degrees, unless steeper angles can be shown to be stable. Additionally, fills were not placed as effectively as they would have been under today's more stringent compaction and supervision requirements.

Previous investigations in 1972 did not identify any landslides on the Project Site (Kleinfelder 2016). A few small debris flows have been observed falling into the canyon below Duquesne Avenue on the Project Site, but these were too small to delineate aerially on maps (Kleinfelder 2016). The Inglewood Formation is mapped in the canyon where the small debris flows are located on the Project Site. The Inglewood Formation is susceptible to slope instability due to the surficial soils that develop on the formation are clay-rich. The remainder of the Project Site is underlain by Baldwin Hills Sandy Gravel and the Culver Sand, which are particularly susceptible to erosion (Kleinfelder 2016).

As shown in Exhibit 4.5-5, the western and northwestern portion of the City IOF is located in an earthquake-induced landslide hazards zone. The Project Site is underlain by weak bedrock and unfavorable (out of slope) bedding angles that make the slopes extremely prone to failure during heavy rainfall and/or strong ground shaking. Landslides could result in damage to structures and facilities within the City IOF, including pump jacks, tanks, and pipelines.

As stated in RR GEO-1, all oilfield operations at the Project Site must be constructed, maintained, monitored, operated, and decommissioned in compliance with all applicable federal, State, and local regulations. The Drilling Regulations include various requirements for site development to address slope stability, including landslides. Drilling Regulations Section 10 requires that a grading permit be obtained from the City's Department of Public Works for all grading, except as defined in the Grading Guidelines as adopted by the Los Angeles County Department of Public

Works. Grading design and grading plan preparation shall conform to the requirements of the Los Angeles County Grading Guidelines.

Drilling Regulations Section 24.B requires that a site-specific geotechnical investigation shall be completed for permanent structures and for grading in excess of 1,000 cubic yards. The Public Works Director/City Engineer may waive this investigation requirement for grading involving between 1,000 and 5,000 cubic yards if there are no permanent structures proposed and grading would not create slopes higher than five feet. The investigation shall be completed by a licensed California Professional Geologist and Geotechnical Engineer and submitted to the Public Works Director/City Engineer for review and approval. The investigation must include erosion control, minimization of cut/fill, and restoration of slopes to their original grade.

Landslide hazards are an existing condition on the Project Site and surrounding areas, and can be induced by seismic events, heavy rains, or other localized site disturbance activities. However, implementation of the Project's Maximum Buildout Scenario would not substantively increase risks associated with existing landslide hazards. All earth-moving and construction activities on the Project Site would be required to comply with the Drilling Regulations, the State Building Code, grading requirements of Culver City's Public Works Department, and adherence to the Seismic Hazards Mapping Act. These requirements and standards are intended to protect on-site and off-site property and structures from geotechnical hazards, including landslides. Compliance with regulations and the Drilling Regulations of the Specific Plan would ensure that potential impacts from landslides would be less than significant to both on-site and off-site property, and no mitigation is required.

Threshold 5-2: Would the project result in substantial soil erosion or the loss of topsoil?

Soil erosion is caused by a number of factors including, lack of vegetation to hold soils in place, steep slopes, and weather (wind and rain). Under the Specific Plan, several activities may contribute to soil erosion, including well pad development, earthmoving of cut materials, construction of new tanks and their containment structures, new wells, new well cellars, new access roads, construction of possible sites where personnel are permanently stationed, worker and work truck activity, rework activities, mobilization and demobilization activities associated with well stimulation activities, and decommissioning activities. During these activities, sediments can be released that are associated with exposing previously stable soils to potential mobilization or erosion by rainfall, runoff or wind. The poorly consolidated nature of the Culver sand and Baldwin Hills sandy gravel could readily erode during construction activities.

Drilling Regulations Section 24 requires that geotechnical investigations be conducted for permanent structures and for grading in excess of 1,000 cubic yards. The investigations would address erosion control and cut/fill restrictions to avoid erosion. Drilling Regulations Section 24.H requires an Erosion Control Plan be developed, and submitted to the Public Works Director/City Engineer for review and approval. This Erosion Control Plan shall include measures to stabilize graded areas; installation of slope breaks; installation of sediment barriers; and other measures to reduce erosion potential. Also, Drilling Regulations Section 38.B requires roads and other excavations to be designed to minimize erosion.

As stated in RR GEO-1, all oilfield operations at the Project Site must be constructed, maintained, monitored, operated, and decommissioned in compliance with all applicable federal, State, and local regulations. The CBC regulations, grading requirements of Culver City's Public Works Department in accordance with City of Culver City's Municipal Code Title 15, and compliance with the Drilling Regulations would ensure that potential impacts from soil erosion and/or the loss of topsoil would be less than significant.

Threshold 5-3: Would the project be located on a geologic unit or soil that is unstable, or that would become unstable as a result of the Project, and potentially result in onsite or offsite landslide, lateral spreading, subsidence, liquefaction, or collapse?

The Project's Maximum Buildout Scenario allows for several structures or equipment to be located on a geologic unit or soil that is unstable and/or may potentially result in an on-site or off-site landslide, lateral spreading, subsidence, liquefaction, or collapse. The Project allows continued operation of oil and gas production activities within the Project Site and for the drilling of up to 30 new wells within the Project Site, as well as well pad development; earth moving of cut materials; construction of new tanks and their containment structures; new wells; new well cellars; new access roads; construction of possible sites where personnel are permanently stationed; worker and work truck activity; rework activities; and decommissioning activities. The topics of landslides and liquefaction are discussed under Threshold 5-1 above.

One of the more serious environmental problems caused by oilfield operations within the Los Angeles Basin has been subsidence, which exists in the Inglewood Oil Field. The subsidence occurs when the fluid (oil and water) withdrawal from the porous subsurface formations reduces the pore pressure in the formation. The void space once occupied by the oil and water becomes occupied by air, which leaves the formation susceptible to compaction under the weight of overlying geologic materials. Filling this void space with a fluid, such as, produced water (i.e., waterflooding) helps to prevent or lessen the effects of subsidence.

As discussed above, the County's CSD requires an annual ground movement survey at the County IOF, which currently includes several survey monuments within the City IOF boundaries. A baseline survey was established in 2010. The latest survey event in May 2015 found that 28 of the 45 survey stations exceed the established threshold of allowable ground movement of 0.6 inch when compared to the 2010 baseline. Ground movement among the 28 stations ranged from 0.6 inch to 3.74 inches over the 5-year span. Although 2014–2015 data from Station 109 (located near the T-Vickers Tank Farm) within the City IOF reported movement of 0.37 inch within that year, that same station reported a total ground movement of 0.88 inch from 2010 to 2015, which would be considered a significant impact.

Currently, the Oil Field Operator treats all produced water on-site and then injects it (i.e., waterflooding) back into the oil producing formation to help control subsidence. Section 24 of the Specific Plan requires the Operator to submit, for approval, a Comprehensive Ground Movement Plan within 180 days of the approval of the City IOF Comprehensive Drilling Plan. The ground movement survey (defined in the Comprehensive Ground Movement Plan) will commence within 60 days of Plan's approval by the Culver City's Public Works Department Director/City Engineer. The City IOF survey may include survey location points utilized by the County IOF survey but, at a minimum, it should include locations 1,000 feet beyond the horizontal limit of the proposed borehole bottoms. The ground movement survey will occur annually up to five years after the oil field operations have ceased. The results of all surveys will be submitted to Culver City's Public Works Department Director/City Engineer and the DOGGR for review and compliance.

Surveying for both vertical and horizontal ground movement is accomplished using satellite-based Global Positioning System (GPS) technology. Accumulated subsidence or uplift is measured using repeat pass Differentially Interferometric Synthetic Aperture Radar (inSAR) technology. The data are then evaluated to determine whether the City IOF operations are related to any detected subsidence or uplift. In the event that ground movement monitoring indicates that ongoing uplift or subsidence, 0.6 inch or greater, at any given location in the vicinity of the Inglewood Oil Field has occurred, then the City's Public Works Department Director/City Engineer and the DOGGR will be notified and the Operator will cease oil operations on the City IOF until the cause has been determined. If the Inglewood Oil Field operations are determined to be the cause or a contributing factor, then a remedy must be submitted by the Oil Field Operator, to the satisfaction of the DOGGR and the Public Works Director/City Engineer before City IOF oil operations can resume.

The County's CSD requires annual ground movement monitoring in the Baldwin Hills area, including the City IOF and County IOF, and the proposed Specific Plan's Accumulated Ground Movement Plan and Survey section requires monitoring in the City IOF. If either survey detects ongoing uplift or subsidence of 0.6 inch or greater, at any location, then the Director of Los Angeles County Public Works, the Oil Field Operator, and the DOGGR shall inspect the Inglewood Oil Field for damages and evaluate the Oil Field Operator's fluid injection and withdrawal rates to determine where adjustments to these rates may be needed. The injection pressures associated with secondary recovery operations (i.e., waterflooding) shall not exceed the formation's fracture pressures as specified by the DOGGR. Waterflooding must continue in the oil producing formations in the City IOF and County IOF for subsidence mitigation to be successful. Therefore, compliance with the monitoring requirements of the proposed Specific Plan (e.g., Accumulated Ground Movement Plan and Survey), regulations by the DOGGR and Los Angeles County Department Public Works, and requirements of the CSD would address potential subsidence impacts at the City IOF would be less than significant.

Threshold 5-4: Would the project be located on expansive soil, as defined in Table 18-1-B of the Uniform Building Code (1994), creating substantial risks to life or property?

The soil profile in the City IOF is generated by in-place weathering of the native units and by slow downhill creep of surficial materials on the steeper slopes, resulting in local buildup of thick soil (colluvium) in the swales or at the toe of the slopes. Clayey soils are known to exist within the Project Site and are subject to significant volume change due to variation in soil moisture content. Changes in soil moisture could result from a number of factors, including rainfall, landscape irrigation, utility leakage, and/or perched groundwater. Clay-rich soils are known to develop on the Inglewood Formation and should be considered susceptible to expansion. Also, potentially expansive colluvium is mapped underlying the western part of the Project Site along College Boulevard. Structures built on expansive soils may experience shifting and cracking as soils expand and contract. Structural damage to on-site infrastructure such as storage tanks and pipelines could occur if constructed directly on expansive soils.

As stated in RR GEO-1, all oilfield operations at the Project Site must be constructed, maintained, monitored, operated, and decommissioned in compliance with all applicable federal, State, and local regulations. Compliance with proper grading techniques in accordance with the CBC, grading requirements of Culver City's Public Works Department, and requirements of the proposed Specific Plan (e.g., Geotechnical Investigation) would ensure that potential impacts related to expansive soils would be less than significant.

Threshold 5-5: Would the project cause an induced seismic event including ground shaking and ground failure?

Induced seismicity is earthquake activity resulting from manmade activity that causes a rate of energy release, or seismicity, which would be expected beyond the normal level of tectonic seismic activity. For example, if there is already a certain level of seismic activity before manmade activities begin, one would expect that this "historical" seismic activity would continue at the same rate in the future. Therefore, if manmade activity causes an increase in seismic activity, then this increase in seismic activity would be considered "induced". In addition, if the seismic activity returns to background levels after the manmade activity stops, that would be another indication that the seismic activity was induced.

Although the vast majority of earthquakes have natural causes, some earthquakes are related to manmade activities and are called induced seismic events or induced earthquakes. Induced seismic activity has been documented since at least the 1930s and has been attributed to a range of manmade activities, including the impoundment of large reservoirs behind dams, controlled explosions related to mining or construction, and underground nuclear tests. In addition, energy technologies that involve injection or withdrawal of fluids from the subsurface can also create induced seismic events that can be measured and felt. Historically known induced seismicity has generally been small in both magnitude and intensity of ground shaking.

The most famous early instance was in Wilmington, California, where oil production triggered a series of damaging earthquakes, from 1947 to 1961, up to a maximum M4.7. The cause of these “slump earthquakes” was traced to subsidence due to rapid extraction of oil without replacement of fluids into the producing strata. Once this was realized, the oil extraction was balanced with waterflooding to both mitigate the seismicity and enhance the oil recovery. Since then, the oil and gas industry has adopted these practices not only to mitigate seismicity, but also to mitigate damage to the producing oil wells that could be sheared off as subsidence occurred.

In the last decade, a number of examples of earthquake activity related to oil and gas production (i.e., well stimulation) and well injection of fluids (e.g., wastewater disposal) have been observed. Almost all induced seismicity associated with oil production can be traced to either fluid injection or extraction, and in many cases is either due to well stimulation and/or waste disposal activities. It is generally accepted that well stimulation induced seismicity produces lower magnitude earthquakes. However, the disposal of wastewater through deep well injection has produced significant seismic events, occasionally yielding larger magnitude earthquakes than those associated with well stimulation. In some cases, such as in California, Texas, Colorado, Oklahoma, and Arkansas, wastewater volume exceeds the volume of water needed to balance pore pressure in the producing zone. Therefore, as further discussed below, the excess wastewater, which is disposed in deep disposal wells can sometimes induce significant seismicity by increasing the fluid pressure within the destination disposal formation.

Induced Seismicity from Hydraulic Fracturing

Two main types of stress cause induced seismicity: shear and tensile. A tensile stress is responsible for volumetric strains, also known as hydrostatic stress, and is applied uniformly throughout the rock affecting pore pressure, while a shear stress is responsible for deformation of a material usually parallel to a fault or fracture. Almost all of the significant activity (recorded and felt) is associated with the type of failure called shear failure. These types of earthquakes can be any size depending on the geologic environment and available forces to cause the earthquake.

Well stimulation activities (e.g., hydraulic fracturing) aims to improve the production of wells by increasing the number and extending the reach of fluid pathways (i.e., fractures) between the formation and the well. This is achieved by injecting fluid, typically water, at high pressure into low-permeability rocks, such that the fluid pressure fractures the rocks or stimulates slip across pre-existing faults or fractures. Increasing the fracture density and extent of the fracture network enhances fluid flow and allows for more distant fluids to be accessed by a well. In addition to fluid, a propping agent (e.g. silica sand or ceramic beads in the Inglewood Oil Field) is injected to keep the newly formed fractures open. Well stimulation usually takes a few hours to a few days to complete and there is a period where the hydraulic fracturing fluid is allowed to flow back to the surface when it is collected for disposal, treatment, or reuse. Currently, the Oil Field Operator treats all produced water on-site and then injects (i.e., waterflooding) it back into the oil producing formation, but not through deep well wastewater disposal, to help control subsidence.

The fracturing of the rock during well stimulation activities generates microseism[4] that may be numerous but are of very low magnitude. Observations made at numerous fracturing wells indicate that induced earthquakes are generally less than M2.0. Hydraulic fracturing is distinct from many types of shear-induced seismicity, because it applies forces that create tensile fractures. Shear failure has been associated with hydraulic fracturing as the fluid leaks off into existing fractures; however, due to the very high-frequency nature of tensile failure only the associated shear failure is observed by microseismic monitoring. However, hydraulic fracturing is rarely a seismic hazard when used to enhance oil production permeability, partly because such operations include relatively low volume of fluid injected for a short duration (hours or days at the very most), compared to months and years for the other types of fluid injections, such as deep well wastewater disposal (discussed below).

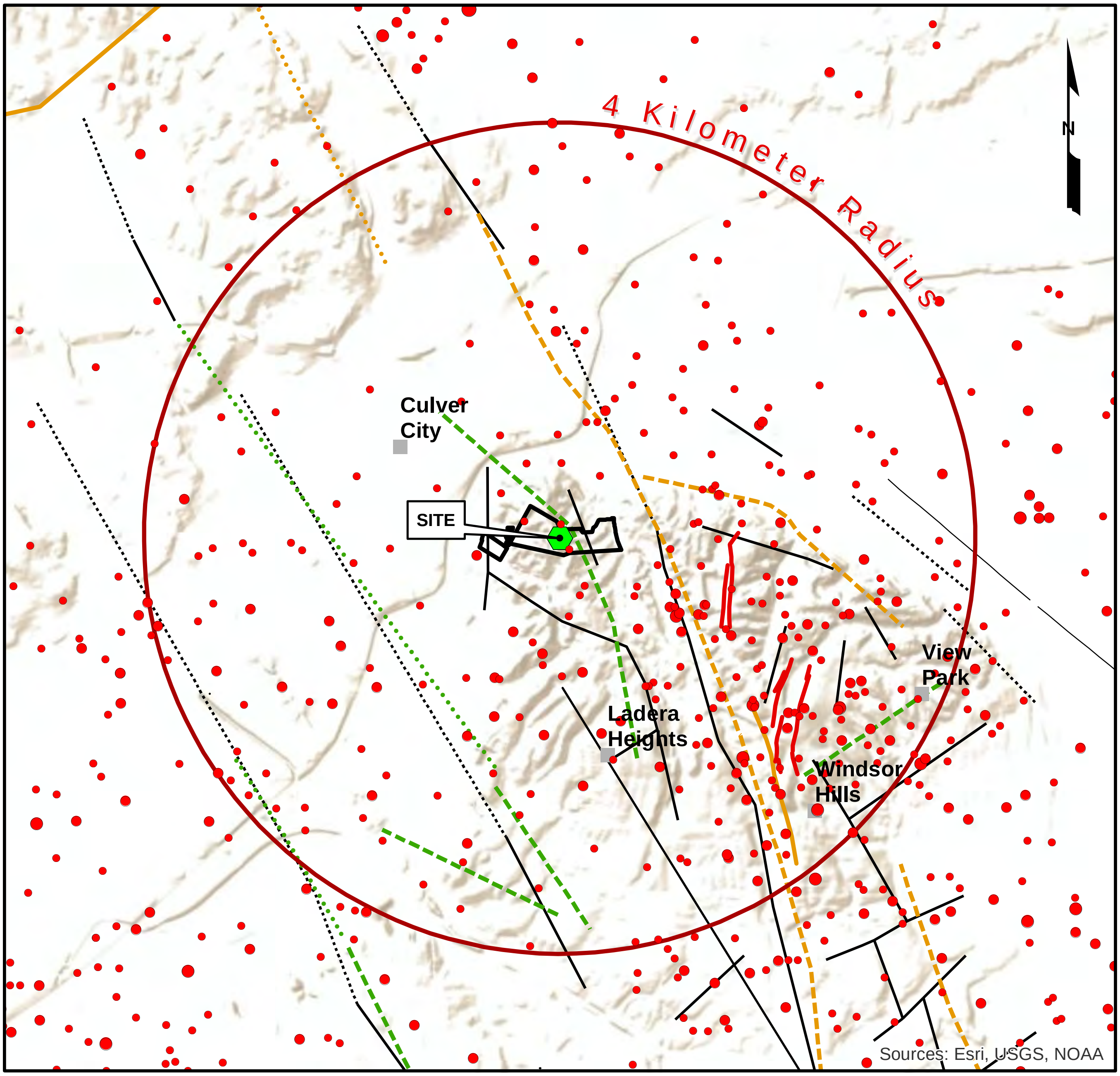
Generally, well stimulation appears to pose a lower risk of inducing destructive earthquakes compared to risk associated with the high-pressure or high-volume injection of oil and gas wastewater. Hydraulic fracturing is intended to cause earthquakes, albeit very small, with the intent to fracture the rock. The intentionally produced earthquakes, called microseisms, are generally small earthquakes of less than a magnitude 1 (M<1), and are typically not felt at the surface. However, several studies in the past six years have reported that well stimulation activities have mostly induced earthquakes up to M3 in Ohio, Oklahoma, and Canada, and recent studies have uncovered a M4.5 event (discussed below). Although some of these induced earthquakes were large enough to be felt, they were too small to be cause damage. However, these cases do illustrate that hydraulic fracturing activities can induce larger magnitude earthquakes (i.e., larger than M1.0) if the induced fracture network intersects a fault. No induced earthquakes due to well stimulation are known to have been reported in California.

Lower Magnitude Events in the Inglewood Fault Zone

In addition to the larger earthquakes discussed in Section 4.5.2 above under “Historic Seismicity”, the Project Site has experienced many seismic events with magnitudes less than 3. Usually, these lower magnitude events are not damaging but are relevant in terms of oil exploration activities. However, measurement of the small magnitude events was not that reliable prior to 1980 due to limitations of the measuring instruments. Available earthquake databases were searched for information from 1980 to August 24, 2016, for all events with M ≥ 1. The earthquake database is principally comprised by the Advanced National Seismic System (ANSS). The ANSS catalog is a worldwide earthquake catalog, which is created by merging the master earthquake catalogs from contributing ANSS member networks and then removing duplicate events, or non-unique solutions from the same event. The ANSS network includes the Northern and Southern California Seismic Networks, Pacific Northwest Seismic Network, University of Nevada, Reno Seismic Network, University of Utah Seismographic Stations, and United States National Earthquake Information Service. Results of the search for this Project are plotted on Exhibit 4.5-6, 4 KM Radius for Historical Seismicity (M>=1), and Exhibit 4.5-7, 10 KM Radius for Historical Seismicity (M>=1) for 0 to 4 kilometers (km) and 4 to 10 km from the center of the Project Site, respectively.

For each event, coordinated universal time (UTC) and associated date, latitude, longitude, depth and magnitude, were gathered. A total of 293 events with magnitude 1 or higher were recorded since 1980 within 4 km (or 2.5 miles) of the Project Site. Out of these events, 61 events were M2 or higher and only 8 were M2.7 or higher. Since 1980, this translates into about 1½ events per

4 In seismology, a microseism is defined as a faint earth tremor or small earthquake generally less than magnitude 1.



Quaternary Faults (Bryant, 2005; USGS, 2009)

Faulting Legend

Historic displacement (< 200 years)
- Mapped Fault Location
- Dashed were Approximated
- Concealed

Holocene displacement (< 11,000 years)
- Mapped Fault Location
- Dashed were Approximated
- Concealed

Late Quaternary displacement (< 750,000 years)
- Mapped Fault Location
- Dashed were Approximated
- Concealed

Quaternary displacement (< 1,600,000 years)
- Mapped Fault Location
- Dashed were Approximated
- Concealed

Pre-Quaternary Geologic Structures (CGS, 2000)
- fault, approx. located
- fault, approx. located, queried
- fault, certain
- fault, concealed
- fault, concealed, queried
- fault, inferred, queried

ANSS Earthquakes

Magnitude
- 1.0 - 1.9
- 2.0 - 2.9
- 3.0 - 3.9
- 4.0 - 4.9
- 5.0 - 5.9
- 6.0 - 6.9

0 0.5 1 2
Kilometers

Source: Kleinfelder, 2016

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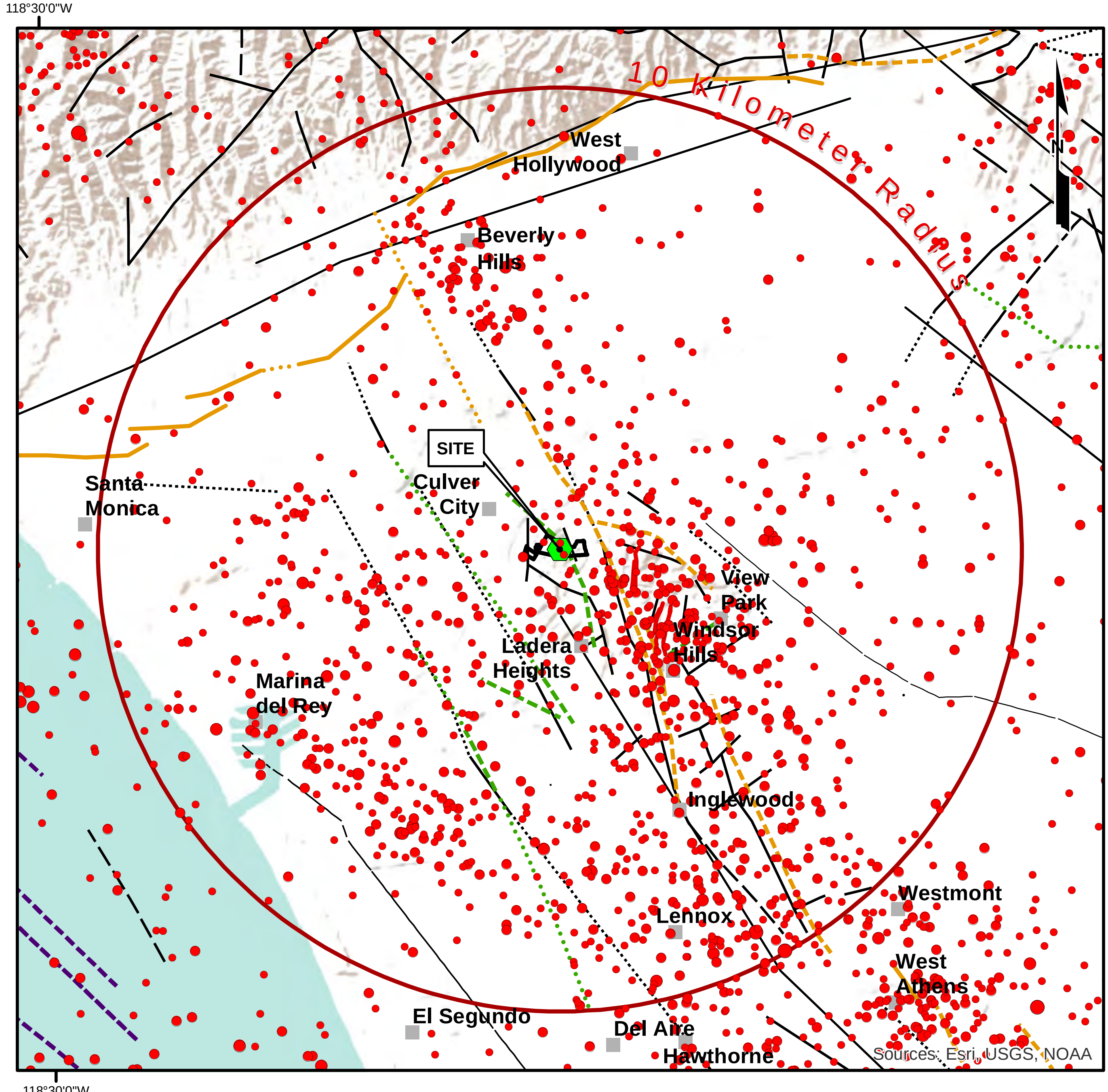
4 KM Radius for Historical Seismicity (M>=1)

Exhibit 4.5-6

Inglewood Oil Field Specific Plan Project

PSOMAS

(09/07/2017 MMD) R:\Projects\CUL\3CUL000100\Graphics\EIR\Ex4.5-6_Seismic_History_4km_20170907.pdf



Quaternary Faults (Bryant, 2005; USGS, 2009)

Faulting Legend

Historic displacement (< 200 years)
- Mapped Fault Location
- Dashed were Approximated
- Concealed

Holocene displacement (< 11,000 years)
- Mapped Fault Location
- Dashed were Approximated
- Concealed

Late Quaternary displacement (< 750,000 years)
- Mapped Fault Location
- Dashed were Approximated
- Concealed

Quaternary displacement (< 1,600,000 years)
- Mapped Fault Location
- Dashed were Approximated
- Concealed

Pre-Quaternary Geologic Structures (CGS, 2000)
- fault, approx. located
- fault, approx. located, queried
- fault, certain
- fault, concealed
- fault, concealed, queried
- fault, inferred, queried

ANSS Earthquakes

Magnitude
- 1.0 - 1.9
- 2.0 - 2.9
- 3.0 - 3.9
- 4.0 - 4.9
- 5.0 - 5.9
- 6.0 - 6.9

0 1 2 4 Kilometers

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Source: Kleinfelder, 2016

10KM Radius for Historical Seismicity (M>=1)

Exhibit 4.5-7

Inglewood Oil Field Specific Plan Project

PSOMAS

(09/07/2017 MMD) R:\Projects\CUL\3CUL000100\Graphics\EIR\Ex4.5-7_Seismic_History_10km_20170907.pdf year that measured between M2 and M2.7, and about one; event every 4½ years that measured M2.7 or higher. If the study radius is extended to 10 km (or 6.2 miles), there were additional 804 events with M1 or higher since 1980. Out of these 804 events, 177 were M2 or higher and 41 were M2.7 or higher. This translates into about 4 events (M2 to 2.7) per year and little more than 1 event of M2.7 or higher every year since 1980.

As discussed in the Cardno Entrix Hydraulic Fracturing Study (2012), conventional hydraulic fracturing started within the County IOF in 2002 and "High Volume" hydraulic fracturing occurred during 2011. Considering all M≥1 events within 4 km of the center of the Project Site for each year since 1980, the maximum number of events in a single year of 31 was recorded in 2003. Although these events were recorded in the year immediately after the commencement of hydraulic fracturing, the data do not show any significant pattern to draw any conclusions. Considering all M≥2 events within 4 km of the center of the Project Site for each year since 1980, the maximum number of events (M≥2) in a single year is 6 recorded in 1999, 2002, and 2015. Considering all M≥2.7 within 4 km of the center of the Project Site for each year since 1980, the maximum number of (M≥2.7) events in a single year is 3 recorded in 2015. This shows that the data are not sufficient to establish a correlation between seismicity and hydraulic fracturing.

Considering all M≥1 events within 4 to 10 km of the center of the Project Site for each year since 1980, the maximum number of events in a single year of 75 was recorded in 2009. Considering all M≥2 events within 4 to 10 km of the center of the Project Site for each year since 1980, the maximum number of M≥2 events in a single year is 19 recorded in 2009. Considering all M≥2.7 within 4 to 10 km of the center of the Project Site for each year since 1980, the maximum number of M≥2.7 events in a single year is 6 recorded in 2013. This similarly suggests that the data are not sufficient to establish a correlation between seismicity and hydraulic fracturing.

A similar conclusion was reported by Dr. Segall, in which he conducted a Poisson Test on the seismicity data reported in Tables A1 and A2 to assess whether these events are random in time or not. Events following Poisson process are random in time. His analysis of the data shows that it cannot be proven that data are not random in time. Thus, a correlation between seismicity and hydraulic fracturing cannot be established. The *Seismic Activity in the Inglewood Oil Field* conducted by Dr. Paul Segall is included in this Draft EIR as Appendix E-2.

Induced Earthquakes in Ohio

A total of 86 earthquakes were recorded in eastern Ohio in 2 sequences between October 2013 and March 2014. A series of 10 earthquakes greater than M0.0, including 6 in the range M1.7–M2.2, were recorded in Harrison County by the Ohio regional seismic network between October 2 and 19, 2013. The first of these events occurred 26 hours after the initiation of hydraulic fracturing operations in one of three nearby wells. No felt seismicity was reported. The entire event sequence occurred at a depth of 9,842 to 11,811 feet, or about 1,640 to 3,280 feet below the bottom of the perforation interval (depth at 7,874 feet). The hypocenters delineated an approximately 1,600 feet long basement fault.

A sequence of 77 induce earthquakes, M1.0–M3.0 were recorded close to a hydraulic fracturing operation in Poland, Ohio between March 4 and 12, 2014. The induced events coincided with 6 hydraulic fracturing events located between 2,461 and 2,625 feet away from the zone of seismicity. No previous seismicity had been detected in the area before hydraulic fracturing began, and none occurred during almost 100 more distant fracture stages. The seismicity rate decayed rapidly after the well was shut down on March 10, 2014 with only 6 events during the following 12 hours and then only 1 over the next 2 months. Earthquake hypocenter locations sharply define a 1,640-foot-long vertical plane that is assumed to be a pre-existing fault. The focal mechanism solution for the M3.0 induced event is consistent with the fault strike/dip and with the regional tectonic stress orientation.

Induced Earthquakes in Oklahoma

Several earthquakes were reported felt by residents living near a well that was hydraulically fractured in south-central Oklahoma. The first of 86 earthquakes occurred within 24 hours of the initiation of hydraulic injection, which began on January 16, 2011. The largest earthquake recorded in the sequence had a magnitude 2.9. The foci of the earthquakes were located at the fluid injection depth of approximately 8,200 feet and ranged up to 6,560 feet away from the well. The area was highly faulted, and after receiving the oil field pumping data concluded that the hydraulic fracturing triggered the earthquakes observed in this study.

Also, two sequences of earthquakes occurred in Oklahoma in June 1978 and May 1979. The largest event was magnitude 1.9, and 2 of the events were reported to have been felt. In each case, nearby hydraulic fracturing operations correlated with the seismic events, but a lack of local seismic recording resulted in large location uncertainties and precluded a definite determination that the events were induced.

Induced Earthquakes in British Columbia and Alberta, Canada

The largest magnitude earthquakes (maximum M4.5) attributed to hydraulic fracturing occurred between April 2009 and August 2015 in the Western Canada Sedimentary Basin (WCSB) in British Columbia and Alberta. Twenty-two earthquakes in the series were larger than M3.0, and 69 larger than M1.5. Nearly all events occurred in the depth range 9,186 to 9,416 feet and within 650 feet of the perforation interval of several (at least six) wells. The well field is located within the Snowbird Tectonic Zone (Fox Creek, Alberta), which comprises numerous north-south trending subparallel faults in the region. The investigation into the cause of these events concluded that the events were caused by hydraulic fracturing in proximity of pre-existing faults. Two of the well stimulation events were recorded by dense seismometer deployments at the surface. Precise hypocentral locations showed that the induced earthquakes occurred on previously unknown faults located outside of the stimulation interval that were well oriented for failure in the ambient stress field.

In June 2015, a M3.9 earthquake occurred in the Horn River basin in northern British Columbia and Alberta and is the first induced-earthquake to trigger the “stop light” for well stimulation operation in compliance with a newly enacted “traffic light” regulation in Canada. Although the earthquake size (i.e., M3.9) falls slightly below the red light (cease all operations) threshold (M4.0) as defined by the provincial traffic light regulation, it was the initial magnitude determination of M4.4 that the red light designation was predicated. A month later, August 2015, a M4.5 (originally reported as M4.6) quake occurred in Fort St. John about 300 miles south of the Horn River Basin’s M3.9 event. This M4.5 quake is potentially the largest hydraulic fracturing-induced earthquake in the world.

The WCSB is located approximately 500 miles east of the nearest tectonic plate boundary in an area of relatively low seismic activity. Most of the observed M≥3 earthquakes since 1985 are considered to be associated with oil and gas production activities. Between 2010 and 2015, the number of observed M≥3 earthquakes rose sharply in the WCSB as did the number of hydraulic fracturing events/wells, but not the number of disposal wells. Statistical analysis determined that of the 107 earthquakes (M≥3) that occurred between 2010 and 2015, 65 were related to hydraulic-fracturing events and 33 were caused by deep-well disposal of wastewater and the remaining 7 were due to natural causes. However, it should be noted that within the WCSB the seismicity associated with wells that undergo hydraulic fracturing is still lower than seismicity associated with the number of deep wells used for wastewater disposal. Kleinfelder's research could not establish a correlation between the maximum magnitude of a seismic event with the volume of injected fluid during hydraulic fracturing. However, their analysis did determine that the potential for hydraulic fracturing-induced earthquakes could linger weeks to months following well stimulation.

Impact Conclusion for Well Stimulation

Currently, well stimulation is not occurring in the Inglewood Oil Field, and has not previously occurred; however, the Oil Field Operator may choose to commence well stimulation activities in the future (subject to the DOGGR review and permit procedures), which would introduce increased pore pressure on the existing faults of the Newport-Inglewood Fault Zone. The very nature of hydraulic fracturing is to fracture the bedrock thus creating microseisms (i.e., small earthquakes of M<1). However, research has shown that larger earthquakes (up to M4.5 recorded thus far) can be produced, and the potential for induced seismicity could last weeks to months following the associated well stimulation activities.

In summary, the consensus among most researchers is that the likelihood of a large and damaging earthquake induced by well stimulation appears to be remote. However, a minor- to light-size earthquake (i.e., M3 to M4.5) could happen. To date, the largest observed event attributed to hydraulic-fracture well stimulation is an M4.5 earthquake that occurred in the WCSB of British Columbia in 2015. The generally lower magnitudes of events associated with hydraulic fracturing relative to those induced by wastewater disposal are usually attributed to the short injection durations, smaller injection volumes, and flowback of injection fluids following stimulation, which result in smaller regions affected by elevated fluid pressures compared with the longer time periods and much higher volumes of wastewater injection. None of the reported events related to hydraulic fracturing have occurred in California.

The only way to avoid the possibility of induced seismicity with a high degree of certainty is to eliminate or avoid the manmade activity that could generate the seismic event. Scientific data and studies are being generated on an annual basis that inform the risks of induced seismicity, but the risks of induced seismicity that could potentially be caused by activities within the City IOF cannot be definitively determined based on existing scientific studies. As such, based on the assessment of existing research and data on induced seismicity that could result from hydraulic fracturing activities, it is assumed that M0 to M4.5 earthquakes could be induced on nearby faults due to well stimulation within the City IOF. As shown in Table 4.5-4 above, a M4.5 earthquake would translate to approximately MMI IV to MMI V, which could result in felt surface impacts as follows:

- **MMI IV:** Hanging objects swing; vibration like passing of heavy truck or sensation of a jolt like a heavy ball striking the walls; standing automobiles rock; windows, dishes, doors rattle; wooden walls and frame may creak. An induced earthquake of this magnitude would be considered a significant impact.
- **MMI V:** Felt outdoors; direction estimated; sleepers wakened; liquids disturbed some spilled; small unstable objects displaced or upset; doors swing; shutters, pictures move; pendulum clocks stop, start, change rate.

An induced earthquake of this magnitude would be considered a significant impact. SB4 requires monitoring for, and reporting to the DOGGR, any earthquakes of M2.7 or greater that occur on site during the process of well stimulation and up to 10 days after its completion. Additionally, the Drilling Regulations require the installation of a seismometer and monitoring of earthquake activity when oil operations are being conducted on the City IOF. However, given the risks associated with induced seismicity for Culver City and the proximity of the Newport-Inglewood Fault Zone, mitigation is required.

MM GEO-1 requires the development of a “traffic light” system for screening of seismic activity in the City IOF. The “traffic light” system is a risk-based mitigation plan that allows for a response if induced seismicity is detected relating to injection-induced seismicity. MM GEO-1 would allow for low levels of seismicity (M1.9 or lower) that would not be felt or detectable, but requires the modification or cessation of operations if the level of seismic impacts becomes unacceptable. Each color of the traffic lights should correspond to a measured level of seismicity. MM GEO-1 requires that RED would correspond to a M2.7 or greater earthquake (near the threshold of a felt earthquake), which would trigger the requirement to stop all pumping, injection, and hydraulic fracturing activity. This would be similar to the level of detected earthquake required in SB 4 and the proposed Specific Plan, Seismic Activity Tracking section. MM GEO-1 requires that YELLOW would correspond to a M2.0 to M2.6, which would trigger the requirement that any pumping, injection, and hydraulic fracturing proceed with caution at reduced flow rates until a study determines whether there is a correlation between oil field activities and the seismic event.

MM GEO-1 sets forth the current best practices for addressing potential induced seismicity. However, as of 2014, there has not been an application of a traffic light system that has been successful in limiting the impact of induced earthquakes (Bommer et al. 2015). Although the traffic light represents the best available technology, which would be most effective when applied in consideration of the in situ state of the geologic features and with rapid response to changes in pumping rates or volumes, the systems are not yet proven sufficiently reliable to be depended upon to adequately reduce risks of induced seismicity (Bommer et al. 2015). This risk for the City IOF is notable because the recent instances of hydraulic fracturing-induced seismicity have not occurred on active faults. The location of the Inglewood Oil Field directly above the seismically active Newport-Inglewood Fault Zone, and the proximity of urban populations and development along the fault zone that would be subject to the hazards associated with an induced seismic event, presents a unique circumstance that mandates conservative efforts to protect the public health, safety and welfare, and the environment. The DOGGR’s SB4 GEO-1a (interim MM GEO-3) and SB4 GEO-1b (interim MM GEO-4) address seismicity, fault rupture, and groundshaking hazards due to well stimulation treatments, and SB4 GEO-1e (interim MM GEO-5) addresses post-earthquake response requirements as part of the spill contingency plan for well stimulation treatments. In addition to these three DOGGR measures, there are mitigation measures in the DOGGR’s Draft Mitigation Policy Manual prepared pursuant to the SB4 EIR, which is included in Appendix B-2 of this Draft EIR, that are applicable to the analysis of induced seismicity during well stimulation treatments, as listed below (DOC 2015b):

- SB4 GEO-1c: Implement Industry Accepted Practices
- SB4 GEO-1d: Conduct Ground Monitoring

The intent of these two DOGGR SB4 measures are already incorporated into requirements set forth in the Drilling Regulations of the Specific Plan, and no new or additional measures related to these SB4 MMs are required. Given the unacceptable consequences of an induced seismic event in the heavily populated and urbanized vicinity of Culver City, MM GEO-1; DOGGR measures SB4 GEO-1a, -1b, and 1e (interim MM GEO-3 through MM GEO-5); and DOGGR measures SB4 GEO-1c and SB4 GEO-1d cannot be assured to reduce the potential for induced seismicity to less than significant, and impacts would remain significant and unavoidable.

Induced Seismicity from Wastewater Injection

Wastewater is a byproduct of many oil and gas extraction operations. At times these fluids can be cleaned and reused or applied for other purposes. Currently, the Oil Field Operator treats all produced water and injects (i.e., waterflooding) it back into the oil producing formations, although not through deep well injection, to help control subsidence and enhance oil recovery. Waterflooding typically aims to keep the fluid pressure in the oil producing formation near original level. However, if the wastewater is unsuitable for waterflooding or other uses it must be disposed of in some other manner, such as through deep well injection or off-site treatment. Flowback of injection fluids generally has impurities that make it unusable, requiring disposal of the flowback. Typical wastewater disposal includes injection deep underground into high-permeability formations, usually deeper than the production reservoirs, for permanent sequestration and isolation from oil/gas reservoirs and drinking-water aquifers. Underground disposal of wastewater has a lengthy history because it is typically considered an economic and safe option. Unfortunately, in recent years the volume of wastewater needing disposal has increased, requiring more disposal wells and leading to higher injection pressures to force the wastewater into the surrounding rock formations. Injection rates of disposal wells range widely from 100 barrels (35,000 gallons)/month to in excess of 1 million barrels (35 million gallons)/month.

Deep well disposal of wastewater can induce earthquakes in four different ways: (1) the injected wastewater raises pore-fluid pressure within a fault; (2) the wastewater injection fills and compresses fluids within pore spaces causing deformation (poro-elastic effects); (3) the injection of the wastewater is colder than the rock formation it is being injected into causes thermoelastic deformation, and (4) the injected wastewater adds mass to the injection formation. This is the same mechanism that hydraulic fracturing could cause earthquakes; however, induced earthquakes from hydraulic fracturing tend to be smaller due to the lower fluid volumes and shorter duration. In California there are no requirements for earthquake monitoring during wastewater disposal like there is for well stimulation activities. SB4 requires monitoring for, and reporting to DOGGR, any earthquakes of magnitude M2.7 or greater that occur onsite during the process of well stimulation and up to 10 days after its completion.

Observations and numerical modeling indicate that increased fluid pressure within faults most strongly influences whether a wastewater disposal well will induce earthquakes. Also, injected wastewater does not need travel the entire distance from the disposal well to a fault for the injection to affect the fault's behavior. The increased pore pressure in the rock can affect a fault's behavior over a great distance, up to 20 miles. As wastewater is injected into a formation, the pore pressure within that rock rises. If this pore pressure increase is transmitted to a fault, the increase in pore pressure counteracts the stresses locking the fault, resulting in a lower effective stress. As the effective stress locking the fault reduces, the fault's frictional resistance to slip is lowered and the fault is more prone to move. If a fault is suitably oriented with respect to the local stress field, it may slip causing an earthquake.

In the past decade the number of recorded earthquakes made a dramatic increase in the midwest and eastern parts of the United States. Where typically these parts of the country would experience approximately 24 M3.0 or greater earthquakes per year, the number jumped to 326 per year since 2009. The states experiencing the elevated levels of earthquake activity include Oklahoma, Arkansas, Texas, Colorado, New Mexico, Ohio, and West Virginia, which also happen to be experiencing a boom of hydraulic fracturing activities and wastewater disposal injections in deep wells. Earthquakes up to M5.6 have been scientifically linked to wastewater injection wells in at least six of the Midwestern states: Oklahoma, Texas, Colorado, New Mexico, Arkansas, and Ohio. In these areas of seismic quiescence, the abrupt appearance of earthquakes were easily attributed to nearby injection of wastewater into deep disposal wells. A recent investigation reports that a 2005 earthquake swarm in southern Kern County, California was also caused by deep well disposal of wastewater. This is the first documented case of an induced earthquake occurring along an active fault, as well as the first reported in California.

Induced Earthquakes in Oklahoma

Oklahoma's earthquake activity has increased dramatically since 2009, with the increase linked to wastewater injection wells. About 90 percent of Oklahoma's earthquakes are associated with wastewater injection activities. The state has experienced more than 200 earthquakes of M3.0 or greater since 2009 (approximately 40 per year), compared to 1–2 per year between 1975 and 2008. The largest of these was a M5.8 earthquake near Pawnee, Oklahoma on September 3, 2016. The other larger event was a M5.7 earthquake near Prague, Oklahoma, outside of Oklahoma City. It destroyed 14 homes, damaged infrastructure and numerous buildings, and injured two people. These earthquakes have been linked to wastewater disposal wells. Additional earthquake swarms have been recorded in southern and northern Oklahoma, which have also been linked to wastewater injection wells.

Induced Earthquakes in Arkansas

Earthquake activity in central Arkansas increased sharply in 2010 and 2011, when earthquake swarms were recorded and felt near the towns of Guy and Greenbrier. The induced earthquakes, which were near several wastewater injection wells, included a M4.7 earthquake in February 2011. After the first wastewater disposal well became operational in April 2009, the rate of M≥2.5 earthquakes increased from one in 2007 to 157 in 2011. A preexisting fault, later named the Guy-Greenbrier Fault Zone, was present in the basement rock units beneath the disposal rock formations. This inactive fault was unknown prior to wastewater disposal. As the wastewater disposal increased the pore pressure within the disposal units underlying the Guy-Greenbrier Fault Zone began to bleed off wastewater. The wastewater now entering into the fault zone decreased the effective stress allowing the fault zone to slip creating the Guy-Greenbrier earthquake swarm. Following the M4.7 earthquake, the disposal wells were shut down and the rate and size of earthquakes steadily dropped during the first three months following shutdown as the pore pressure buildup from months of injection returned to the pre-injection level. Only six earthquakes occurred on the Guy-Greenbrier Fault Zone in the six months following the permanent shutdown.

Induced Earthquakes in Texas

Several regions of Texas have experienced increased seismic activity near wastewater disposal wells in areas where no previous seismic activity had been recorded. In regions near Dallas-Fort Worth, Cleburne, and Timpson, scientists have linked increased earthquake activity to wastewater injection wells. The Dallas-Fort Worth region has experienced a series of 180 small earthquakes between 2008 and 2009, which have been linked to wastewater disposal injection. Since 2009, the region has been hit by stronger earthquakes between M3.0 and M4.0.

Timpson, Texas has experienced a series of damaging earthquakes, including the largest ever recorded in eastern Texas, a M4.8 in May 2012. This earthquake caused significant structural damage to chimneys and brick veneer in the area. The earthquake sequence lasted between May 2012 and January 2013 and included a M4.0 foreshock and aftershocks of M4.1 and 4.3. The earthquakes' focal depths were shallow ranging between 1.6 to 4.6 kilometers deep and have been attributed to wastewater disposal activities nearby. An M2.8 earthquake was felt on June 9, 2009 in the Cleburne, Texas, an area close to two wastewater disposal wells. The wells were located approximately 0.8 mile and 2 miles from the epicenter. Like the Dallas-Fort Worth earthquakes, the Cleburne area had no previous history of felt earthquakes. At least 50 smaller seismic events were recorded on a temporary micro-earthquake network installed shortly after the initial June 9 event.

Induced Earthquakes in Colorado/New Mexico

Seismicity near Trinidad, Colorado within the Raton Basin of Colorado and New Mexico that occurred between August 2011 and December 15, 2011, is believed to have been caused by injection of wastewater near the southern extension of a local fault zone. The sequence included three earthquakes M≥4, the largest of which was M5.3. Between 2001 and 2013, 16 M>3.8 earthquakes have been attributed to expanded wastewater disposal activity in the Raton Basin. During this time, the median fluid injection rate increased from 119 million gallons/month to 2.6 billion gallons/month. Prior to 2001, only one M>3.8 earthquake was recorded in the Raton Basin. The 2011 earthquake sequence occurred within 6.2 miles of 5 injection wells, 4 of which are high injection-rate, high-volume wells. At the end of August 2011, cumulative injection into these wells ranged from 475–700 million gallons/month.

Induced Earthquakes in California

An earthquake swarm in 2005 occurred at the southern end of the Central Valley, California, along the left-lateral strike-slip White Wolf fault. The White Wolf fault is an active fault that has produced one of the largest earthquakes in the past decade, the 1952, M7.3 Kern County earthquake. The White Wolf swarm occurred at the southern end of Kern County in the largest oil-producing (>75 percent of the state's oil production) and fluid-injecting (>80 percent of all injection wells) county in California.

Fluid injection rates at the southern end of the Central Valley increased rapidly from about 4.4 million gallons/month to more than 22 million gallons/month between 2001 and 2010. Effective well depths are reported between 4,000 and 5,000 feet. The wastewater disposal target zone was a highly permeable stratigraphic layer within the Monterey Formation. About 5 months prior to the swarm, approximately 75 percent of the high-rate wastewater injection occurred in only 1 well, WD05. Well WD05 is located in an area of closely spaced, buried, northwest striking faults. Based on geological mapping, seismicity, and well-log data, the buried fault is referred to as "Tejon Fault". Both seismicity and well-log data suggest that the Tejon Fault is shallow, close to the well WD05 injection site (approximately 2 kilometers deep), and deepens toward the northwest before intersecting with the White Wolf Fault at approximately 9 kilometers deep.

The White Wolf swarm in 2005 deviates from standard main shock-aftershock patterns. It was comprised of a M4.5 event on September 22, followed by two M4.7 events and a M4.3 event the same day as well as some smaller magnitude foreshocks. Identification of the White Wolf swarm was based on a statistical assessment of injection and seismicity rate changes. The statistical assessment showed that an abrupt increase in injection rates in 2005 was followed by a large increase in seismicity rates when compared to previous rate variations since 1980. This sequence deviates from commonly observed tectonic sequences in the area by showing significantly elevated seismicity rates above the background associated with a rapid increase in injection rates. Also, the seismicity sequence showed evidence for deep migration within the crystalline basement between injection wells and the nearby White Wolf Fault suggesting that wastewater disposal likely contributed to triggering the earthquake swarm. Once the induced earthquakes of the White Wolf swarm were differentiated from earthquakes of natural causes, the seismic parameters of the swarm earthquakes were analyzed (i.e., focal depth, location) and the subsurface geologic structure was evaluated.

Analyses suggest that the rock pore pressure at the 1.5 kilometer deep injection well (WD05) was being bled off by the Tejon Fault. This channeling effect may have been further intensified if the White Wolf Fault acted as flow barrier, thereby trapping the pressure front resulting in more rapid pressure increase at the intersection between the two faults, White Wolf and Tejon. This, in turn, reduces reduced the effective stress along the White Wolf Fault, triggering slip and the initiation of the earthquake swarm.

The research on the 2005 White Wolf earthquake swarm of four earthquakes ranging from M4.3 to M4.7 is significant because (1) it documents California's first induced earthquake due to wastewater disposal and (2) it documents the first induced earthquake along a known active fault. This research is significant because it documents the occurrence of well stimulation-induced earthquakes ranging from M3 to M4.5, where previous research suggested that M3 earthquake was the largest known to exist. The research also determined that the potential for deep well injection-induced earthquakes could linger weeks to months.

Impact Conclusion for Deep Wastewater Injection for Disposal

Well stimulation activities produce flowback. If the volume of flowback from well stimulation activities exceeds the volume needed for waterflooding, then the excess wastewater will need to be disposed. In the City IOF, it is assumed that extra flowback would be disposed into wells drilled below the oil producing zones (possibly the Topanga Formation), which could result in circumstances similar to the White Wolf swarm discussed above. That is, wastewater disposal that increases pore pressure in the subsurface, resulting in several faults within the Newport-Inglewood Fault Zone channeling the pressure to reduce the effective stress on the active faults within the fault zone. This could trigger slip on the active faults generating an earthquake large enough to cause substantial ground shaking. Other cases of relatively deep induced seismicity far from wastewater injection sites have been reported in several other regions such as Oklahoma, Colorado, and Arkansas, where induced earthquakes occurred at an 8-kilometer (approximately 5 miles) depth and from a 7- to 35-kilometer (approximately 4.5- to 22.0-mile) distance from the wastewater injection well.

Large-scale, continuous injection of wastewater into a single formation over time periods of months to years commonly generates overpressure fields of much larger extent than those resulting from well stimulation activities. Therefore, the likelihood of inducing larger seismic events increases as the volume of injected wastewater increases. The largest of these was a M5.8 earthquake near Pawnee, Oklahoma on September 3, 2016. The other larger event was a M5.7 earthquake near Prague, Oklahoma, outside of Oklahoma City, but the cause of this event is still the subject of active research, and the possibility that it was a natural tectonic earthquake cannot confidently be ruled out at present. However, the largest earthquake for which there is clear evidence for a causative link to wastewater injection is the 2011 M5.3 event in the Raton Basin of Colorado and New Mexico. Although it may be low in absolute terms, the seismic risk of damage associated with wastewater disposal through deep well injection is relatively much greater than that associated with well stimulation activities. The increase in seismicity associated with the increase in deep well injected wastewater disposal may increase the likelihood of damage, as well as nuisance.

The location of the Inglewood Oil Field directly above seismically active Newport-Inglewood Fault Zone, and the proximity of urban populations and development along the fault zone that would be subject to the hazards associated with an induced seismic event, presents a unique circumstance that mandates conservative efforts to protect the public health, safety and welfare, and the environment.

The only way to avoid the possibility of induced seismicity is to eliminate or avoid the manmade activity that could generate the seismic event. Scientific data and studies are being generated on an annual basis that inform the risks of induced seismicity, but the risks of induced seismicity that could potentially be caused by activities within the City IOF cannot be definitively determined based on existing scientific studies. As such, based on the assessment of existing research and data on induced seismicity that could result from deep well wastewater disposal activities (either through high volume or high pressure), it is assumed that M0 to M5.6 earthquakes could be induced on nearby faults due to deep well wastewater injection within the City IOF. As shown in Table 4.5-4 above, a M5.6 earthquake would translate to approximately MMI VI to MMI VII, which could result in felt surface impacts such as:

- **MMI VI:** Felt by all; many frightened and run outdoors; persons walk unsteadily; windows, dishes, glassware broken; knickknacks, books, etc., off shelves; pictures off walls; furniture moved or overturned; weak plaster and Masonry D cracked.
- **MMI VII:** Difficult to stand; noticed by drivers of automobiles; hanging objects quiver; furniture broken; weak chimneys broken at roof line; damage to Masonry D, including cracks, fall of plaster, loose bricks, stones, tiles, and embraced parapets; small slides and caving in along sand or gravel banks; large bells ring.

An induced earthquake of this magnitude would be considered a significant impact. In California, there are no requirements for earthquake monitoring during wastewater disposal as there is for well stimulation activities through SB4. Given the unacceptable consequences of an induced seismic event in the heavily populated and urbanized vicinity of Culver City, MM GEO-2 would prohibit the practice of deep well injection for wastewater disposal within the City IOF until such time that it could be proven that a site-specific mitigation system (e.g., traffic light) is effective at avoiding large seismic events associated with deep well injection for wastewater disposal. Compliance with MM GEO-2 would ensure that there would be no impact associated with induced seismicity due to deep well injection for wastewater disposal.

4.5.7 CUMULATIVE IMPACTS

Section 2.7, Cumulative Projects, summarizes the related past, present, and reasonably foreseeable probable future projects that are applicable to the proposed Project. In summary, well drilling in the County IOF is regulated by the Baldwin Hills CSD and its associated Settlement Agreement, which allows for the drilling of no more than 500 new wells (including bonus wells and wells drilled since approval of the CSD) through October 1, 2028, or during the remaining life of the CSD, whichever is later.

Geotechnical impacts (e.g., fault rupture, landslides, expansive soils, liquefaction, lateral spreading) tend to be site-specific in nature, while seismic conditions that could result in strong groundshaking are regional in nature. As discussed above, implementation of the Project's Maximum Buildout Scenario, with the exception of impacts related to hydraulic fracturing and deep well injection for wastewater disposal, would result in less than significant impacts to related to fault rupture; seismic ground shaking; ground failure (e.g., landslide, liquefaction, settlement, lateral spreading); or location on an unstable geologic unit (e.g., collapse, expansive soils). Each cumulative project development site would be subject to uniform construction standards relative to seismic and other geologic conditions and would also have to comply with current State and City building codes and development requirements as they pertain to protection against geotechnical hazards. Development projects would be subject to applicable Seismic Design requirements and the Alquist-Priolo Earthquake Fault Zone Act, which restricts development on the traces of active faults. Site development and earthmoving in conformance with the Drilling

Regulations would not exacerbate or otherwise influence any geotechnical hazards for off-site development and the Project's incremental contribution to cumulative geotechnical impacts would be less than significant. Similarly, the related projects are not expected to have an adverse impact on the geologic conditions on the Project Site.

As discussed above, even with implementation of the DOGGR measures and MM GEO-1, given the unacceptable consequences of an induced seismic event (and including related ground rupture and strong seismic shaking associated with such an induced seismic event) in the heavily populated and urbanized vicinity of Culver City, potential impacts of induced seismicity due to hydraulic fracturing would result in significant and unavoidable direct impacts.

It is anticipated that hydraulic fracturing would occur throughout the Inglewood Oil Field, and it is unknown whether multiple hydraulic fracturing events occurring within the same oil field, with or without restriction on timing, overlap of events, physical proximity, injection pressures, injection rates, and/or other constraints, would increase the likelihood of induced seismicity. The restrictions in the CSD do not address induced seismicity from hydraulic fracturing, so well stimulation within the County IOF would be subject to regulations set forth in SB4. Given the lack of site-specific knowledge of the risks of induced seismicity related to hydraulic fracturing within the Newport Inglewood Fault Zone, it is assumed that potential risks from the proposed Project would contribute to a cumulative impact when considering the seismicity risks associated with allowable development within the County IOF. Similarly, induced seismicity hazards due to activities that may occur within the County IOF, even if prohibited within the City IOF, would have an effect on the Project Site and vicinity.

With implementation of MM GEO-2, induced seismicity hazards associated with deep well injection of wastewater would be eliminated because MM GEO-2 would prohibit such activities until/unless proven to be safe. Therefore, with implementation of MM GEO-2, the proposed Project would not contribute to cumulatively significant impacts due to induced seismicity from deep well injection of wastewater. However, induced seismicity hazards due to activities that may occur within the County IOF, even if prohibited within the City IOF, would have an effect on the Project Site and vicinity.

As discussed above, the proposed Project would result in less than significant impacts related to subsidence. The County's CSD program requires annual ground movement monitoring in the Baldwin Hills area, including the City IOF and County IOF, and the Accumulated Ground Movement Plan and Survey in the Drilling Regulations requires monitoring in the City IOF. Because the County IOF's ground movement monitoring applies to areas that extend under the City IOF and other areas within the City, there is overlap between the areas encompassed by each juridiction's surveys. If either survey detects ongoing uplift or subsidence of 0.6 inch or greater, at any location, then the Director of Los Angeles County Public Works, Oil Field Operator, and DOGGR shall inspect the Inglewood Oil Field for damages and evaluate the Oil Field Operator's fluid injection and withdrawal rates to determine where adjustments to these rates may be needed.

Because waterflooding must continue in the oil producing formations in the City IOF and County IOF for subsidence mitigation to be successful, and because subsidence monitoring is required by the State, the County, and the City, the issue of subsidence is being addressed with a regional and multi-governmental approach and the proposed Project would not result in impacts that would be cumulatively considerable.

Cumulative impacts associated with landform alteration are more of an aesthetic issue than a geotechnical constraint. This is addressed is Section 4.1, Aesthetics. Erosion and downstream sedimentation is addressed as a water quality issue in Section 4.8, Hydrology and Water Quality.

4.5.8 MITIGATION MEASURES

MM GEO-1 Prior to the issuance of any Drilling Use Permit for the construction of a new well that may be completed with well stimulation treatment, or for a permit to conduct a well stimulation treatment on an existing well, the Oil Field Operator shall develop an Induced Seismicity Avoidance, Monitoring, Evaluation, and Mitigation Protocol to be submitted to the City for review. The Mitigation Protocol shall be modeled after the "traffic light" system recommended by the National Research Council. The minimum requirements for this Mitigation Protocol include:

- Establish a dense high-resolution microseismic network to map microseismic events at appropriate locations to accurately monitor seismicity at and near the well location subject to well stimulation treatments.
- Develop a traffic light threshold system where GREEN allows for seismicity of M<1.9; YELLOW requires that operation-specific measures involving oil/gas extraction, waterflooding, and well stimulation throughout the City IOF, be immediately taken to reduce the risks of a larger seismic event, including options such as reduced injected volumes, reduced pumping rates, reduced proppant concentrations, eliminating stages of the stimulation event, and/or flowing back the fracture fluids, for seismic events between M2.0 and M2.6; and RED requiring the cessation of all oil field activities/operations including oil/gas extraction, waterflooding, and well stimulation for seismic events of M2.7 or larger. The purpose of the traffic light system is to prevent the occurrence of an earthquake that could be felt at the surface.
- For seismic events in the YELLOW or RED, conduct an evaluation to determine if the well stimulation event is correlated in any way to the seismic event.
- Establish a notification protocol for informing the City of Culver City and the DOGGR about seismic event for review and evaluation. Resumption of activity can only resume at the explicit direction, based on approval of the evaluation, from the DOGGR and the City of Culver City.

MM GEO-2 The construction and operation of deep wells within the Project Site for disposing wastewater (e.g., flowback) through injection into a non-hydrocarbon zone in the deeper strata beneath the Inglewood Oil Field shall be prohibited indefinitely, subject to the discretion of the City of Culver City. The prohibition may be lifted in total or partially with the provision of a site-specific geotechnical investigation prepared by a qualified engineer that demonstrates the feasibility of deep wastewater disposal well(s) on the Project Site while adequately mitigating for hazards associated with induced seismicity, to the satisfaction of the City of Culver City.

MM GEO-3 The following measure is an interim MM to be implemented and enforced by the City until such time as DOGGR adopts the equivalent measure listed as a

Regulatory Requirement in this Draft EIR (SB4 GEO-1a Avoid Active Faults if Necessary). This MM shall become inapplicable when DOGGR enacts this measure as a formal regulation; the regulation shall then become applicable as part of approving a well stimulation treatment permit.

The City shall require, as part of the application for a well stimulation treatment permit, that the Oil Field Operator provide documentation to the DOGGR and demonstrate to the DOGGR's satisfaction that the location and trend of the proposed well will not be within or enter into an active earthquake fault, unless the Oil Field Operator can show to the DOGGR's satisfaction that established or proposed well control and well shut-in procedures will adequately address the consequences of a rupture of a known fault, seismically induced ground shaking, and/or ground failure occurring during the well stimulation process. These procedures shall be included within the Spill Contingency Plan for the affected well required by Section 1722.9 of Title 14 of the California Code of Regulations. Prior to approving an Annual Drilling Plan, the Oil Field Operator shall provide evidence to the City that the actions prescribed in this measure have been completed, including but not limited to an approved well stimulation permit from DOGGR for the well(s) addressed in the proposed Annual Drilling Plan.

MM GEO-4 The following measure is an interim MM to be implemented and enforced by the City until such time as DOGGR adopts the equivalent measure listed as a Regulatory Requirement in this Draft EIR (SB4 GEO-1b Implement an Appropriate Setback if Necessary). This MM shall become inapplicable when DOGGR enacts this measure as a formal regulation; the regulation shall then become applicable as part of approving a well stimulation treatment permit.

The City shall impose a condition that prohibits the Oil Field Operator from conducting well stimulation treatments within an appropriate setback of a known active fault as established by the California Department of Conservation, unless the Oil Field Operator can show to the DOGGR's satisfaction that established or proposed well control and well shut-in procedures will adequately address the consequences of a rupture of a known fault, seismically induced ground shaking, and/or ground failure occurring during the well stimulation process. These procedures shall be included within the Spill Contingency Plan for the affected well required by Section 1722.9 of Title 14 of the California Code of Regulations. Prior to approving an Annual Drilling Plan, the Oil Field Operator shall provide evidence to the City that the actions prescribed in this measure have been completed, including but not limited to an approved well stimulation permit from DOGGR for the well(s) addressed in the proposed Annual Drilling Plan.

MM GEO-5 The following measure is an interim MM to be implemented and enforced by the City until such time as DOGGR adopts the equivalent measure listed as a Regulatory Requirement in this Draft EIR (SB4 GEO-1e Include an Earthquake Response Plan within the Spill Contingency Plan). This MM shall become inapplicable when DOGGR enacts this measure as a formal regulation; the regulation shall then become applicable as part of approving a well stimulation treatment permit.

The City shall impose a condition requiring the Oil Field Operator to demonstrate to the DOGGR's satisfaction that the spill contingency plan required by Section 1722.9 of Title 14 of the California Code of Regulations adequately addresses the consequences of an earthquake occurring during the well stimulation process, for however many well stimulation treatments are proposed to occur simultaneously at any given time. The Spill Contingency Plan shall include requirements for adequate on-site personnel and equipment that may be necessary to conduct post-earthquake inspection and repair plans to evaluate any damage that has occurred. The Spill Contingency Plan shall include spill prevention, control and countermeasure plans to address the hazardous substances associated with well stimulation activities. The inspection procedures shall ensure the integrity of the mechanical systems and well integrity of wells used for stimulation or wastewater injection and idle wells that might have become conduits for escaping fluids or gases. The plan shall include procedures describing the necessary steps to be taken after service is disrupted in order to make the facilities secure, operational and safe as soon as possible. Prior to approving an Annual Drilling Plan, the Oil Field Operator shall provide evidence to the City that the actions prescribed in this measure have been completed, including but not limited to an approved well stimulation permit from DOGGR for the well(s) addressed in the proposed Annual Drilling Plan.

4.5.9 LEVEL OF SIGNIFICANCE

Hydraulic fracturing has been proven to directly induce earthquakes, the largest of which were the M4.5 earthquakes in the Western Canada Sedimentary Basin (WCSB) in British Columbia and Alberta. Even with implementation of MM GEO-1, which requires implementation of an Induced Seismicity Avoidance, Monitoring, Evaluation, and Mitigation Protocol (e.g., traffic-light system), and with MM GEO-2, which prohibits deep well injection of wastewater in the City IOF unless otherwise approved by the City, the potential for high-volume or high-energy well stimulation treatments to result in induced seismicity cannot definitively be reduced to a level less than significant. As such, the proposed Project could result in both direct and cumulative significant and unavoidable impacts for induced seismicity, rupture of a known earthquake fault, and for strong seismic groundshaking, as summarized below.

Significant Unavoidable Impact GEO-1: Even with implementation of MM GEO-1, which requires implementation of an Induced Seismicity Avoidance, Monitoring, Evaluation, and Mitigation Protocol (e.g. traffic-light system); MM GEO-2, which prohibits deep well wastewater disposal in the City IOF unless otherwise approved by the City; interim MMs GEO-3 and MM GEO-4, which address seismicity, fault rupture, and groundshaking hazards from well stimulation activities; and interim MM GEO-5, which addresses post-earthquake response requirements are part of the spill contingency plan for well stimulation treatments, the potential for well stimulation treatments to result in induced seismicity cannot definitively be reduced to a level less than significant. As such, the Project could result in both direct and cumulative significant and unavoidable impacts for induced seismicity, rupture of a known earthquake fault, and for strong seismic groundshaking, also resulting in significant and unavoidable direct and cumulative impacts related to accident conditions associated with induced seismicity.

All other impacts associated with landslides, liquefaction, unstable soils, and subsidence would be less than significant with compliance with Drilling Regulations, the State Building Code, grading requirements of Culver City's Public Works Department, and adherence to the Seismic Hazards Mapping Act.

Table 4.5-5 below summarizes the significance finding of each threshold addressed in this section before and after mitigation, where applicable.

**TABLE 4.5-5
SIGNIFICANCE SUMMARY**

Threshold		Project Level of Significance	Mitigation Measure(s)	Level of Significance after Mitigation
5-1	Expose people or structures to potential substantial adverse effects, including the risk of loss, injury, or death involving:			
	i) Rupture of a known earthquake fault, as delineated on the most recent Alquist-Priolo Earthquake Fault Zoning Map issued by the State Geologist for the area or based on other substantial evidence of a known fault? Refer to Division of Mines and Geology Special Publication 42.	Potentially Significant	MM GEO-1 through MM GEO-5	Significant and Unavoidable
	ii) Strong seismic ground shaking?	Potentially Significant	MM GEO-1 through MM GEO-5	Significant and Unavoidable
	iii) Seismic-related ground failure, including liquefaction?	Less than Significant	N/A	Less than Significant
	iv) Landslides?	Less than Significant	N/A	Less than Significant
5-2	Result in substantial soil erosion or the loss of topsoil?	Less than Significant	N/A	Less than Significant
5-3	Be located on a geologic unit or soil that is unstable, or that would become unstable as a result of the Project, and potentially result in onsite or offsite landslide, lateral spreading, subsidence, liquefaction, or collapse?	Less than Significant	N/A	Less than Significant
5-4	Be located on expansive soil, as defined in Table 18-1-B of the Uniform Building Code (1994), creating substantial risks to life or property?	Less than Significant	N/A	Less than Significant
5-5	Cause an induced seismic event including ground shaking and ground failure?	Potentially Significant	MM GEO-1 through MM GEO-5	Significant and Unavoidable
N/A: not applicable				

4.5.10 REFERENCES

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