4.6 Geology and Soils

	Potentially Significant Impact	Less-Than-Significant With Mitigation Incorporated	Less-Than-Significant Impact	No Impact
Would the project:				
a) Expose people or structures to potential substantial adverse effects, including the risk of loss, injury, or death involving:	☐	☒	☐	☐
i) Risk of encountering subsurface natural gas or petroleum at the surface	☐	☒	☐	☐
ii) 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?	☐	☐	☒	☐
iii) Strong seismic ground shaking?	☐	☒	☐	☐
iv) Seismic-related ground failure, including liquefaction?	☐	☒	☐	☐
v) Landslides?	☐	☒	☐	☐
b) Result in substantial soil erosion or the loss of topsoil?	☐	☐	☒	☐
c) 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 on- or off-site landslide, lateral spreading, subsidence, liquefaction or collapse?	☐	☒	☐	☐
d) Be located on expansive soil, as defined in Table 18-1-B of the Uniform Building Code (1994), creating substantial risk to life or property?	☐	☐	☐	☒
e) 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?	☐	☐	☐	☒

ENVIRONMENTAL SETTING

Regional Setting

The Los Angeles Basin geological setting has produced numerous oil and gas fields. One of these is Montebello Oil Field, which is comprised of three separate producing areas (Stolz 1939). West Montebello Oil Field, underlying the Project Area, is the westernmost of the three areas. Initially, it was the site for oil development, and then later gas storage in this central location of the Los Angeles metropolitan region. Drilling for oil in West Montebello Oil Field began in 1936. By June 1938, more gas was being produced than could be used by the local area, resulting in some gas being vented to the atmosphere. Deeper geological formations (approximately 7000 to 8000 feet, or about 1.5 miles deep) produced even greater quantities of gas, until 1941 when these zones were largely depressurized (Duke 1997).

Because of the gas production history of the West Montebello field, it was selected for gas injection and storage. In 1956 facilities were completed and gas was injected / stored at depths of about 7550 to 7630 feet (the 8^{th} Zone with 8-1, 8-2, and 8-3 sub-zones; Figure 1 shows the 8-1 sub-zone sand). By July 1958 approximately 27 billion cubic feet (bcf) of cushion gas was stored. Since that time numerous wells have been utilized for storage and retrieval of the gas. Currently 28 wells and 3 observation wells, directionally drilled from a single drilling area, are used. Southern California Gas Company's (SCG's) Main Facility for the Montebello Gas Storage Facility (MGSF) is in a gravel quarry several 100 ft north of Lincoln Avenue.

The proposed Project actions (see Section 2) may generate changes in the gas, oil, and geological hazard conditions in and around the West Montebello Oil Field area, and could contribute to changes in gas migration pathways. These potential changes may result in adverse effects to the overlying urban setting and would be the indirect effects of the Project actions. Mitigation would be required to detect and control any adverse gas migration and effects to urban uses and activities.

The MGSF Project area is located on the southerly flanks (Montebello Plains) of the Repetto-Montebello Hills (hereafter Montebello Hills) of the central Los Angeles Basin and between the Los Angeles Forebay (west) and Montebello Forebay (east, Whittier Narrows). MGSF area is approximately 9 miles east of the Los Angeles city center. The Project area is separated from the Long Beach harbor area to the south by a coastal plain roughly 15 miles wide, and from the lower margin of the San Gabriel Mountains on the north by about 9 miles of alluvial fan slopes. Cenozoic (as old as 65 million years) sedimentary and volcanic bedrock is expected to underlay this portion of the Los Angeles Basin to depths of 10-20,000 feet. Much deeper, and much older, Pre-Cambrian-age crystalline basement (gneiss, schist, and granite) may be present below these Cenozoic sedimentary and volcanic rocks. In the West Montebello area, the upper 8000 feet of sedimentary bedrock is of interest for this project.

These sedimentary units have been uplifted, tilted, and folded due to tectonic forces that also produce earthquakes and faults. The chain of hills extending northwest-southeast from north of Los Angeles to the Santa Ana River area has been formed by these tectonic forces along surface faults (e.g., the Whittier, Chino, Alhambra Wash, and minor faults) and buried (so-called “blind”) thrust faults (e.g., Elysian Park, Norwalk). In the West Montebello Hills Project area, the thick sedimentary sequence of Cenozoic formations is folded into doubly plunging anticlines (domes or convex upward folded geologic structures; Figure 4.6-1) that are sometimes faulted. These anticlines form the traps for the oil and gas within the West Montebello Oil Field. Where faults are found they may form direct or indirect pathways for subsurface gas to move upward into shallower geological formations.

Geological Units

The West Montebello Hills Project area geologic units consist of (from youngest to oldest):

- Surface soils
- Younger alluvium (Qal)
- Older Quaternary (upper Cenozoic) alluvium (Lakewood and San Pedro Formations)
- Tertiary (lower Cenozoic) bedrock formations (Fernando / Pico and Puente Formations)

Only the deeper Tertiary bedrock formations contain the oil / gas producing Shallow Zones and the SCG gas Storage Zone (Figure 4.6-2). Little information is known regarding deeper (>8,000 ft) units. Unit thickness varies widely across the West Montebello Field, and average thickness is reported below as representative of the overall area.

At the surface, the San Pedro Formation (Qsp) is exposed in areas generally north of Lincoln Avenue, while south of Lincoln Avenue younger alluvium (Qal) is present. Pico Formation (Tp) is exposed in an east-west band crossing Montebello Boulevard north of Michael Collins Circle, stopping on the west at about Juarez Street (ARCS / WEST, 1994). An isolated outcrop of Pico Formation (Tp) is found west of Howard Avenue and north of Lincoln Avenue (Figure 4.6-3).

Soils. The MGSF contains minor remnants of the original soil zones of the Montebello area, although development has removed or disturbed much of the soil. The Project areas have been subjected to major earthmoving in the past with early development of the oil fields and subsequent development of sand and gravel aggregate quarries, and residential, commercial, and industrial developments. All individual lots are assumed to be without natural soils while some natural soils persist in the Main Facility, Monterey Park Lots, and the East Site. Natural soil profiles where observed are less than about two (2) feet thick, consisting of a clearly identifiable dark black A-horizon (probably clayey silt, clayey sand, and silty clay in composition) over a thin B-horizon overlying alluvial materials. Generally these soils are moderately dense and well compacted, with moderate porosity and permeability. Presence of natural soils indicates potential for the overlying remnant vegetation being “original” to the area.

Alluvium. The MGSF Project area is located largely on the lower southern slopes of the Montebello Hills, which separate the San Gabriel Valley on the north from the Los Angeles coastal plains to the south. Some Project sites (south of Lincoln Boulevard and south of Los Amigos Avenue / Marek Drive) are located on the alluvial terrace and outwash plains that cover underlying lower Cenozoic rock formations. These higher elevation stream terrace deposits and the younger (lower elevation) alluvial fan deposits consist of a mixture of sand, silt, and gravel. This material is derived from erosion of the late Pleistocene units of the Pico formation, which are exposed on the Montebello Hills beneath the Operating Industries Inc. (OII) landfill and east of the Montebello Blvd. In general these deposits are poorly consolidated and have a moderate to high permeability. Thickness varies in these deposits from several feet to a few hundred feet.

Older Alluvium - San Pedro Formation. The San Pedro Formation uncomfortably overlies the Pico Formation in the site vicinity. This geologic unit is found from near the ground surface to a depth of 200 to 500 feet (top of the Pico Formation). It consists of undifferentiated Lakewood and San Pedro Formations of Lower Pleistocene age. These two Pleistocene formations are not mapped separately at the surface or in the subsurface because their characteristics are very similar. Together they are referred to as San Pedro Formation (map symbol Qsp). The Qsp will be encountered during site grading activities (cut and fill) in most areas north of Lincoln Boulevard and west of Montebello Boulevard, and will be the supporting formation for building foundations and most of the Proposed project infrastructure.

The early Pleistocene San Pedro Formation consists of well-graded sand with gravel interbeds, and discontinuous layers of poorly graded sand. The well-graded sand with gravel deposits is very dense, containing 10-40% gravel. Several cobbles greater than 3 in (diameter) were also encountered. These well-graded sands with gravel contain varying amounts of silt and clay.

The San Pedro Formation has poorly developed bedding planes and is generally slightly cemented. Poorly graded sand layers are generally 1 to 10 ft thick, is very dense, and contains less than 5% fines. Some finer grained silty, clayey sand layers may be encountered in some areas. Discontinuous clay seams have been observed in the formation.

Bedrock - Pico Formation. The Pico Formation is exposed at the surface within the Project area boundary and extends to a depth of about 5,300 ft (Duke, 1997). The shallowest Pico unit (EPA, 1992d) beneath the site is a groundwater-bearing zone. The Pico Formation is expected to be encountered during the Proposed project activities, particularly in the East Site west of Montebello Blvd. just south of Jefferson Blvd. continuing west toward the cul-de-sac at Germain Drive (west of the Main Facility.

The Pliocene (2 to about 7 million years old) Pico oil producing zones are designated, from youngest to oldest (shallowest to deepest), as 1st, 2nd, 3rd, and 4th. The dominant Pico Formation rock types in the upper 2,000 ft of the Project area are “gray shale and sandy shale” (Stolz, 1939), consisting of clayey siltstone to very fine-grained sandy siltstone and silty fine-grained sandstone. Fractures and joints have been noted, both at the surface and at depth in areas adjacent to the Pomona Freeway the north of the Project area (EPA 1992d). The upper Pico is considered poorly cemented, but well consolidated. Within this fine-grained unit are scattered, bedded sandstone, conglomeratic sandstone and conglomerate layers. These rocks have relatively high strength and integrity.

About 3,300 ft of lower Pico Formation consists of a series of interbedded brown and sandy shale, sandstone, and conglomerate. Each of the thicker shale units within the sequence described forms a more impervious cap or barrier to upward movement of water, oil, and gas, trapping the hydrocarbon deposits within underlying more porous and permeable sandstone beds. Less dominant rock types consist of channel deposits (filled marine canyons) that are composed of various sandstone, gravel and cobble conglomerates. Channel deposits range in thickness from a few feet to over 250 ft in the proposed Project area. These deposits appear to be relatively narrow channels, which are confined laterally and terminate abruptly. Sandstone ranges from fine to coarse-grained and often contains rounded gravels and pebbles with occasional cobble-sized clasts. Gravel and pebble conglomerates are generally sandy and clean. These rocks are very dense and consolidated.

Bedrock - Puente Formation. Puente Formation (Tpu) is not exposed at the surface within the Project area. The top of this formation is generally over 5,300 ft deep and wells have generally penetrated about 2,000 feet of the upper portion of the formation. This Miocene age (older than about 7 million years) formation consists of oil and gas producing zones designated, from younger to oldest (shallowest to deepest), as 5^{th}, 6^{th}, 7^{th}, 8^{th}, and 9^{th}. The Storage Zone contains three sub-zones: 8-1, 8-2, and 8-3 used for gas storage, at depths ranging from about 5,000-7,500 ft. Each sub-zone is characterized by a stratigraphic sequence consisting of a “cap” (a relatively impermeable shale) underlain by sandstone (a relatively porous and permeable storage zone). Table 1 shows the cap and storage unit thickness for the 8^{th} sub-zones.

Table 4.6-1 – Average MGSF Cap and Storage Zone Thickness in Zone 8

Sub-Zone	Cap Thickness	Storage Zone Thickness
8-1	85 ft	90 ft
8-2	20 ft	124 ft
8-3	12 ft	12 ft

The cap material is generally composed of hard to medium hard, massive to platy shale, typically gray to dark gray and brown. Some thin sand lenses and pockets are present in the shale. The storage sands where the gas is stored a mainly fine- to medium-grained and often contain thin shale beds. Average porosity (essentially the percentage of the bedrock volume capable of storing gas) in the sub-zones 8-1, 8-2, and 8-3 is approximately 20-25%.

General geologic conditions overlying the MGSF zone, including structure and units present, are described above. In the project area, the probability of deep gas (storage gas) migration along specific natural features, such as fault planes and fracture systems, is considered limited due to the following conditions:

- Presence of a primary seal (caprock) immediately above the gas storage zone

- Presence of multiple, shallower, secondary seals, fine grained portions of the Upper Repetto and Pico Formations
- Pressures in the storage reservoir (1,745 psi) is low relative to original reservoir pressure (2,940 psi)
- Limited evidence for only a few inferred faults cutting through primary or secondary geologic seal layers

Structure and Seismicity

Tectonic forces in the region are created by compression between two tectonic plates, the North American and Pacific plates. Tectonic forces break the earth surface, creating faults and generating earthquakes. Several faults are located within the project vicinity.

Regional tectonic stresses also uplifted, tilted, and folded sedimentary rock units in the project area, creating hills and related geologic structures. A chain of hills formed by these tectonic forces extends from north of Los Angeles, southeast to the Santa Ana River. Geologic structures underlying these hills are often elongated domes or anticlines, similar to the one underlying West Montebello Oil Field.

West Montebello Dome. In the West Montebello Hills Project area, the thick sedimentary sequence of Cenozoic rock layers is folded into a doubly plunging anticline (dome or convex upward folded geologic structure). Some fault may be associated with this structure. The anticline forms a trap for oil and gas accumulation within the West Montebello Oil Field.

The anticline forming West Montebello Oil Field is an east-west trending oval-shaped dome. Based on the structure contour map for the gas storage zone (zone 8-1), this dome is approximately 9,000 ft long and 3,000 ft wide. The center of this dome rises about 200 ft higher than its surrounding flanks.

Faulting. Faults are fractures or lines 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. Sudden movement along a fault results in an earthquake. Faults that allow landmasses to move horizontally past each other are called strike-slip faults (e.g. San Andreas, San Jacinto, Elsinore, and Newport-Inglewood). In contrast, mainly vertical movement occurs along normal, reverse and thrust faults. Buried low angle thrust faults that do not rupture the surface are known as "blind thrusts", for example the Elysian Park Thrust Fault (also known as the Elysian Park Fold and Thrust Fault, the Elysian Park blind thrust fault) and Torrance-Wilmington Fold and Thrust Belt. Faults exhibiting both vertical and horizontal movement are oblique faults (e.g. Santa Monica-Hollywood, Cucamonga, Palos Verdes, and Raymond Faults and Fault Zones). Major fault zones in Southern California are summarized in Table 4.6-2.

In cases where earthquakes are large or hypocenters are shallow, surface rupture can occur. The California Division of Mines and Geology (CDMG) defines "active" faults as those offsetting Holocene materials (less than 10,000 to 12,000 years ago) or exhibiting significant seismic activity. "Potentially active" faults are those offsetting Pleistocene (between 12,000 and 1,600,000 years ago) materials. In general, the younger the last movement on a fault is the higher the potential for future movement. The potential for surface fault rupture at the site is considered very low.

With the exception of the low angle Elysian Park Thrust Fault, which lies at least 5 kilometers deep (8,000 to 10,000 feet beneath the storage zone), no known active faults lie under the Project area and the Area of Influence of the Storage Zone. Other faults were defined within a 5-mile radius of the site in previous OII Landfill studies. Shorter fault zones include the northwesterly to northeasterly-trending East Montebello, Rio Hondo, Pico, and Cemetery Faults, as well as the east-west trending Montebello Fault.

The Montebello Fault (Figure 4.6-3) trends east-northeast from Whittier Narrows Recreation Area and south of Montebello Town Center, across Montebello Blvd. south of Liberty Ave. Because this fault offsets Pleistocene San Pedro Formation (Qsp), the Montebello Fault is considered potentially active (ARCS/WEST, 1994). The fault apparently terminates its surface expression near the Bunker Hill Ave. and Iguala St. intersection and a few 100 ft northeast of the Monterey Park Lots (with projection between the Main Facility and East Site).

Within the MGSF area and the Area of Influence of the Storage Zone (within 1 mile of the Main Facility), three sets of minor faults have been reported in the following units:

- Alluvium and upper Pleistocene deposits north of Jefferson Ave. and between the Main Facility and the East Site at depths less than 1,000 ft below ground surface (this could correspond to a subsurface extension of the Montebello fault)
- Upper Shallow Zones, 1-2, east of Montebello Blvd./Lincoln Intersection 1,000 to 4,000 ft below ground surface
- Lower Shallow Zones, 3-5, between Second and Poplar Ave. from 4,500 to 5,500 ft below ground surface

The fault reported in the upper Shallow Zones near Lincoln and Montebello Blvd. is near the Michael Collins Circle gas venting area. These relatively minor faults are not reported to have reached the ground surface, and as yet no specific fault has been interpreted to penetrate the shale bedrock cap over the Storage Zone or the Storage Zone (sub-zones 8-1, 8-2, and 8-3) itself. However, if the depths below ground indicated above are correct, the faults are sufficiently high in the Pliocene section that they may affect the bedrock caps over the 8^{th} zone and its storage sub-zones.

Seismicity. During the past 230 years (1769 to 1999), about 20 notable earthquakes (Mw 6.0 or greater; where Mw is the moment magnitude) were recorded in Southern California. Six of these events equaled or exceeded M7.0. The two largest earthquakes that occurred within the Los Angeles Basin during recent time are the 17 January 1994 Mw 6.7 Northridge and 2 February 1971 Mw 6.6 San Fernando earthquakes. The shortest distance from the site to the zone of energy release (site-to-source distance) in these earthquakes is about 27 miles and 22 miles for the Northridge and San Fernando events, respectively. The closest earthquake of notable magnitude to the site was the 1 October 1987 Mw 6.0 Whittier-Narrows event. It had a site-to-source distance of approximately 9 miles.

The 1 October 1987 Whittier-Narrows event is generally considered to have occurred on the Elysian Park Thrust Fault. Cracking observed at the OII Landfill following the Whittier-Narrows event led to the installation of strong motion instrumentation in 1988.

GeoSyntec (1996) conducted a detailed fault investigation associated with their evaluation of the seismic stability of the South Parcel OII Landfill, which abuts the Proposed project area on the north. They screened faults to select those requiring more detailed analysis as seismic sources that would define the earthquake groundshaking parameters used to design of various landfill components. These same faults are also appropriate for assessing the groundshaking potential within the Project area. Potential earthquake-producing faults that would control groundshaking levels at the site as identified by GeoSyntec are:

a. Alhambra Wash
b. Whittier
c. Coyote Pass
d. Raymond
e. Elysian Park Thrust System
f. San Andreas (Central Segment)

GeoSyntec's (1996) peak horizontal ground acceleration (PHGA) estimates indicate that the earthquake-induced acceleration hazard at the OII site (and by extension, the Project area) is dominated by the maximum credible earthquake (MCE) Mw 6.9 event on the underlying Elysian Park Thrust Fault. Their analyses indicate that the expected (mean) value of PHGA from the MCE on this fault is 0.61 g on a hypothetical bedrock outcrop at the site. The Mw 7.9 MCE event on the San Andreas fault (the Central segment), would generate a PHGA of about 0.15g compared to 0.61g for the Elysian Park Thrust MCE. A San Andreas MCE, however, would contain more spectral energy, have a longer duration of strong shaking, and potentially generate more damaging long period motions than the Elysian Park Thrust MCE. These events would produce ground motions sufficiently large to potentially damage Project facilities, adjacent structures and residences.

Geologic Hazards

Fault Rupture. Presently, four fault offsets are documented within the Storage Zone. None of these three offsets are on known active faults, although at least one is considered potentially active. The Montebello Fault lies within the northern edge of the storage zone and may correspond to the alluvial fault noted in the OII Landfill sections. A large local earthquake could possibly cause minor offsets (probably < 1.0 ft) at depth within the Storage Zone, but such offset is unlikely to propagate to within several hundred feet of the surface.

Earthquake Groundshaking. Estimated PHGA generated by earthquakes (MCE) on the San Andreas Fault (0.15g) and Elysian Park Thrust Fault (0.61g) would contain enough energy and spectral content and have a sufficiently long duration to potentially damage Project facilities, adjacent structures and residences.

Induced Seismicity. Microseismic activity, with magnitude on the order of –1.0 to 1.0 Mw, often occurs during injection and extraction operations. Activity of this magnitude can be anticipated at Montebello during depletions operations, and is not significant relative to natural daily seismicity in the Los Angeles area. An upper bound for potential micro-seismicity would be about M2 (Terralog Technologies 2000). Earthquakes in this magnitude range would not cause subsurface fault offset of more than an inch and would not be felt at the surface.

Slope Stability. Steep slope angles (including near vertical), slope heights of more than 50 ft, and location of bedrock formations suggest that potential slope stability problems would be limited to the San Pedro and Pico Formations bedrock, north of Lincoln Ave., e.g., the west wall of the Main Facility and the west slope of the East Site. The alluvial slopes should be stable in their natural condition due to the low slope angle and the massive nature of the deposits.

The Pico Formation will be more susceptible due to the greater percentage of fine-grained clay-rich layers. Landslides are known to have formed on slopes with out-of-slope bedding (south-dipping on the south slope of the hills). These landslides can occur with or without Proposed project construction.

Subsidence. The Project site is located in an oil producing area known as the West Montebello Oil Field. Removal of oil and gas (or other fluids) from poorly consolidated geologic formations can cause surface subsidence. The same general process can occur when groundwater is withdrawn from unconsolidated aquifers. These fluid withdrawal processes can leave void spaces at depth. Unless refilled with fluids by re-pressurization techniques, poorly consolidated sediments may collapse causing subsidence in the shallower earth layers. There is no indication that groundwater withdrawal is taking place in the Proposed project area, therefore this process would not cause subsidence. Withdrawal of gas may cause two inches of subsidence distributed over a broad area (Terralog Technologies 2000). Damage to surface structures from this subsidence would be very unlikely.

Liquefaction and Other Secondary Earthquake Effects. The State Seismic Hazard Zone maps outline areas that are considered susceptible to liquefaction and earthquake-induced landslides. No liquefaction susceptible areas are mapped within the Project area. Limited slope areas in the Qsp area between Howard Ave. and Germain Dr. (between the Monterey Park Lots and the East Site) are classified as potential landslide hazards.

Gas Migration

Well Drilling in the West Montebello Oil Field and Natural Gas Storage Field. Oil exploration and development in the Project area began second third of the 20th Century. The “old” or “main” Montebello Oil Field was first discovered in 1917. West Montebello Oil Field was discovered in 1937 following re-completion of the Kern Oil Company Monterey No. 20 well originally drilled in 1936. Field development proceeded during 1937 and 1938. Production from the Shallow Zones in the main Field area had been established previously.

Numerous documented wells and dry holes were drilled in the main Montebello Field area beginning in 1917. Of the documented wells drilled in the West Field area since the late 1930s, over 200 have been abandoned. These wells penetrated and produced from various zones, including the Storage Zone (Zone 8). Operators plugged and abandoned their non-commercial wells in accordance with the “practices of the day” (SCG 1999). A complete list of known abandoned wells is provided in Appendix G.

In the West Montebello Field, the California Division of Oil and Gas (DOGGR) required installation of surface casing to protect local aquifers and prevent blow-outs (Stoltz 1939). Surface casing in West Montebello Field wells were “set” in shale, and the entire length of the casing was cemented into place (casing to surrounding natural materials from surface to total depth).

Production characteristics in two or more producing intervals within the same zone could differ greatly from one another. This diversity in production characteristics between intervals or zones, together with the progressive mode of early field development (deepening wells after higher zones were depleted), caused non-uniform completion practices with different zones open to production at different times in different wells. Stotz (1939) indicated that the lack of uniformity in producing zones completed in wells, along with possible ineffective cementing operations and probable mechanical failures, probably permitted inter-communication between intervals and zones, especially in the structurally higher part of the field.

Gas Responsibility and Rights. SCG owns most if not all mineral rights in the West Montebello Field and Storage Zone. As such, SCG is responsible for any gas leaks originating the MGSF area of influence and from thermogenic sources. Due to the nature of recent alluvial deposits, the generation of natural biogenic gas at the project site is unlikely. Biogenic gas in the area is probably related to decomposition of trash and organic material contained in the adjacent OII Landfill and lateral migration from the landfill area. SCG is not responsible for occurrences of biogenic gas at the project site.

Types of Gases. Three types of gas may be present within geological and soil units underlying the Project area: processed natural gas (or piped gas), biogenic (or swamp) gas, and thermogenic (field) gas. Biogenic gas is primarily methane with carbon dioxide and sulfide gases resulting from decomposition of organic material from the adjacent landfill or other sources. Thermogenic gas is generated at depth, when increased temperatures and pressures alter organic material and includes a broad range of gas components (methane, propane, butane, ethane, etc.). In contrast, processed natural gas is primarily methane remaining from thermogenic gas after most of the heavier gas components are removed (usually less than 0.1% heavy thermogenic hydrocarbons). These gas types exhibit distinct chemical characteristic, which permits “finger-printing” of gases or differentiation between gas types. In addition to lacking heavier gas components (propane, butane, ethane, etc.), the presence of helium in detectible amounts is a primary fingerprint for natural gas imported from the central US and previously stored in the deep Storage Zone.

Natural gas can exist in subsurface environments as various phases. Understanding gas phases is important because each phase exhibits specific physical properties, and thus posses different flow characteristics. These phases include free gas, liquefied petroleum gas, and dissolved gas in both water and oil depending on pressures and temperatures. When evaluating the potential for shallow gases reaching the surface, the primary phases of concern are free gas and dissolved gas in groundwater.

Migration Pathways. Natural gas has been detected at the surface in the Montebello area along with other oil fields, and surface gases can originate from biogenic, thermogenic, or storage sources, or a combination of these sources. Gas reaches the surface through various natural, man-made, or combination migration pathways.

In the 1970s, thermogenic gas with helium (=processed gas) was discovered in the soils of Michael Collins Circle during routine SCG leakage surveys. SCG (1999) indicated that no known active or abandoned wells occurred in the immediate vicinity and that the source of this gas migration could not determined. Similarly thermogenic gases without helium were found in monitoring of the OII Landfill. Thermogenic gases were also found during surveys of abandoned wells and were leaking to surface along the well casings.

Major Pathways. Man-made structures can convey gas to the surface from deep or shallow sources. A list of the most common man-made structures that could serve as vertical conduits is presented below:

- Recently plugged and abandoned oil and gas wells (abandoned in accordance with current DOGGR regulations)
- Old abandoned oil and gas wells or dry holes, (abandoned prior to current DOGGR regulations
- Previously undocumented wells and dry holes
- Existing water extraction or injection wells
- Old abandoned water wells
- Monitoring wells

Gas can also reach the surface through natural geologic features, which may facilitate vertical, lateral, or oblique migration. The geologic features most likely to serve as potential pathways are listed below:

- Surficial deposits
- Fault planes
- Fracture systems
- Porous and permeable formations
- Aquifers.
- Other geologic features and structures, such as unconformities

The greatest possibility for potential gas migration reaching the surface is considered to be through or along man-made structures. In general, geologic pathways are relatively “tight” in the Shallow and Storage Zones. Fractures, faults, and spaces between individual grains are minimized due to the tremendous overburden pressure (the weight of the rock materials) trying to close all spaces and on the contained fluids. Within the Project area, wells penetrate shallow and deep gas zones at various depths. Once penetrated, a poorly constructed or abandoned well can serve as a conduit for upward migration of natural gas, and conduits can occur over the 70 years of deterioration even when proper construction and abandonment methods have been applied more than 20 years ago.

Natural gas of biogenic, thermogenic, and storage sources can travel through a variety of man-made structures to migrate both vertically and laterally through the subsurface. In addition to oil and gas wells, both active and abandoned water wells can serve as vertical conduits especially in the upper 1,000 ft of geological section. Utility trenches, storm drain systems, and sewer lines provide for lateral migration and accumulation and near-surface openings for natural gas release.

Leaking Wells. Several factors contribute to possible gas migrations through abandoned and active wells: original drilling, development and completion, operations and redevelopment, and abandonment. The West Montebello Oil Field was discovered in 1937 and developed through the 1940s to be “abandoned” in the late 1950s with the turnover to gas storage operations. Many wells and dry holes were drilled during the exploration and early field development period, and dry or non-commercial wells were abandoned. Common practice by some operators in the 1940s-1940s was to abandon wells and dry holes by filling them with construction debris or other items, such as telephone poles or railroad ties, prior to surface cover with soil. These improperly abandoned wells have been unearthed during grading operations for construction sites located over old oil field in several areas of the Los Angeles Basin. Current requirements have developed since the 1950s to the more stringent current standards. Many of these wells and dry holes may not have been plugged, as they would be today. Old dry holes and non-commercial wells have a high potential to provide migrations pathways.

Early in the history of oil and gas development in California and the United States, non-commercial or dry holes were drilled and abandoned without proper documentation and storage, and some of these abandoned dry holes and wells may not have been recorded by the original drillers or DOGGR. Absence of unknown abandoned holes can not attested with certainty and such could serve as migration pathways.

Well construction, redevelopment, and abandonment deficiencies can contribute to gas migration problems. If cement bonds between the casing and surrounding natural formation do not form adequate storage seals, pressurized leakage is possible. Leakage through the annular space between casing and formation can occur under the following circumstances: lack of proper seals, inadequate seal or poor cement bonds with bore walls, channels within cement, deterioration of annular seals over time, and fracturing or cavitation of enclosing walls.

Structural integrity of well components and seals is not permanent over 20-100 years and eventually deteriorates over time. Both casings and seals are subject to corrosion caused by exposure to chemical and biochemical/bacterial attack, high and fluctuating pressures, high temperatures, and earthquakes. Steel casing is susceptible to rusting from saline and sour/sulfurous water produced along with the oil. Hydrogen sulfide of sour water and sour gas can corrode both steel and cement. Differential earth stresses (e.g., local earthquakes) can affect well integrity, even causing casing to collapse. Any deterioration of well integrity can lead to leaks.

Natural Pathways. SCG, US Geological Survey (USGS), and California Division of Mines and Geology (CDMG) have fault studies and evidence indicating faults in the MGSF area of influence. They publish maps showing documented faults and reports describing such faults. No through-going active surface faults have been documented by either the USGS or CDMG. None of the information or reports reviewed for this study present conclusive evidence of active surface faults in the immediate project vicinity. The Elysian “Blind” Thrust Fault passes beneath the Project site at much greater depths (>10,000 ft, but no related fault is as yet known to cut through the Storage Zone

Montebello Fault is considered potentially active and projects toward the north edge of the MGSF from the northeast. Smaller, shorter faults and fracture systems are known in various units of the Shallow Zones within the West Montebello Field but are not likely to transmit large volumes of crude oil or natural gas during short time intervals (days, weeks, or months). Naturally occurring (not influenced by human activities) subsurface migration of petroleum hydrocarbons typically takes place over extended periods of time, possibly tens or hundreds of thousands of years or more. Significant natural upward migration is unlikely during the productive life of West Montebello Field. Transmission of hydrocarbons through these systems is known within the oil and gas industry as “micro seeps”. Upward migration of oil and gas through micro-seeps allowed hydrocarbon emplacement in Shallow Zones.

The original reservoir pressure in West Montebello Field was 2,940 psi, which is within the range of normal pressure gradient for the Storage Zone depths. Significant volumes of storage gas would not be expected to migrate to the surface through natural geologic features. Operating pressures are about 40 percent lower than original reservoir pressures.

Past and proposed withdrawal of gas from the Storage Zone is not expected to cause downward movement of groundwater or other fluids from Shallow Zones. With decreased reservoir pressures, lithostatic forces (rock overburden pressures) become more dominant, further compaction sealing any open fractures or void spaces in the cap rock. Thus the probability of fluid or gas migration through geologic pathways either into or out of the Storage Zone is very unlikely.

“Shallow” gas may migrate through younger earth materials to reach the surface. Both Pleistocene and Holocene sedimentary deposits include many permeable horizons or zones. Both biogenic and thermogenic gas from “shallow” zones can migrate, both vertically and laterally, through these permeable layers. Gas migration would involve both free-phase and dissolved-phase gases (dissolved in water). The contact between Lower Pleistocene Lakewood and San Pedro Formation and overlying Holocene alluvium is immediately adjacent to Michael Collins Circle. This contact between Quaternary geologic units in some way could affect subsurface fluid or gas movement.

Faults affecting the project vicinity are discussed above under Structure and Seismicity. In the Project area, the east-west trending Montebello fault (potentially active) crosses through the main Montebello Field and projects toward the northern edge of the West Montebello Gas Storage Field. Information on the depth and subsurface inclination of this fault is not known, but it is assumed that the fault propagates downward and may intersect the gas storage zone horizons north of Lincoln Ave. Although it is possible that such a fault could contribute to upward gas migration, rates would not be significant compared to leaking wells.

During well drilling, a few faults were encountered in some boreholes. Stoltz (1939) noted evidence of minor faulting in the upper part of the 5-1 Shale. Minor faults could affect subsurface gas migration, by either acting as barriers to lateral movement or pathways for vertical migration. Gas movement rates associated with minor faulting would not be significant compared to leaking wells.

Michael Collins Circle and Other Area Leaks. During the 1970s, SCG detected soil gas in the area of Michael Collins Circle as part of their routine surveys. Michael Collins Circle is a small cul-del-sac opposite of the East Site along the east side of Montebello Blvd., north of Avenida de la Merced. The area overlies the northeasterly part of the West Montebello Field. Two wells have been abandoned along the south side of the cul-de-sac on one lot, although SCG (1999) indicated there were no known active or abandoned wells in the immediate vicinity. Presence of helium indicated that the gas was processed storage gas and probably had originated from the Storage Zone. Soil gas readings at all known nearby active and abandoned wells did not detect gas, and the pathway of this gas migration was not determined.

In order to mitigate high concentrations of soil gas in the Michael Collins Circle area, SCG installed seven extraction wells in the early 1980s. Each boring reached a depth of approximately 40 feet below the surface. Slotted casing was installed and a manifold system connected each well to a blower that extracted the soil gas. This system successfully reduced soil gas concentrations to undetectable levels and maintained these levels for the past 20 years (SCG, 1999).

DOGGR records the location of all reported wells and dry holes. An examination of the DOGGR (1986) map and those of SCG for the Montebello Field area (Figure 4.6-4) show 2 abandoned oil wells on lots in the Michael Collins Circle. Depths for these wells were not determined, but they could provide migration pathways for upward movement of natural gas where local geologic conditions could cause migration to the general area of Michael Collins Circle.

Similarly, review of geological sections for the area indicated that a Shallow Zone Fault occurred about 1,000 ft below surface and within 1,000 ft to the south of the Circle area. The surface Montebello Fault also lies 1,000 ft to the northwest of the Circle area. These fault zones could be involved along with the abandoned wells in the release of gas to the soil and surface in the Michael Collins Circle venting area.

OII Landfill. In 1999, SCG informed New Cure, operator of the adjacent OII Landfill, that gas was detected in New Cure’s gas probes near the border with the MGSF’s Main Facility site. SCG tested this gas and determined the gases were thermogenic, not biogenic, but were not originating from the Storage Zone, no helium and presence of higher levels of heavy hydrocarbons. The Montebello Fault lies to the east of the Landfill while at least 3 wells lie under or within the Landfill site.

Abandoned Wells. During a 1983 routine SCG survey of abandoned wells, several abandoned wells were identified to be leaking thermogenic, processed gas. These leaks were discovered shortly after withdrawal of the total working gas inventory. SCG (1999) speculates that the pressure differential between the Storage Zone and the Zones 6-7 immediately above. The pressure differential may have caused downward water migration along the casings which enlarged imperfections in the cement seals of the abandoned wells. When the Storage Zone was re-pressurized, processed gas migrated upward through these “channels” in the well cement seals to the surface. SCG mitigated the surface occurrences by purchasing several homes constructed over these abandoned wells in order to reseal the wells with cement. Several improvements and other facility and operating procedures were implemented to reduce the potential for storage gas leakage.

During the period (1984-1987), one leaking abandoned well was detected on an isolated parcel away from any structures. This well never penetrated the Storage Zone and had never been operated by SCG. SCG drilled a new well adjacent to the leaking abandoned well to determine the source and collect the gas. This measure and other improvements eliminated gas leaks from this well (SCG 1999).

In 1999, leaking gas was detected in another well abandoned in the 1990s, and the gas contained helium which indicated the presence of processed gas from the Storage Zone. The gas was considered to have been processed gas from the Storage Zone that had migrated into a shallow sand many years before and had reached the surface through this abandoned well (SCG 1999). Such a pathway would indicate lateral or horizontal migration through geological not man-made paths.

Gas Migration Summary. The information presented above provides some SCG's documentation of gas leaks, possibly from several different sources. Most leaks are directly related to abandoned wells, but some also have geologic components associated with them and serve only to illustrate the range of possible gas leak causes and the complexity of this issue.

In the case of gas leaking in the Michael Collins Circle area, known and undocumented abandoned wells may be present along with fault zones. Abandoned wells may leak gas to Shallow Zones in the San Pedro Formation sand, where the gas may migrate laterally beneath the Michael Collins Circle area before reaching the surface.

Thermogenic gas in the OII Landfill area may originate in the Shallow Zones above the Storage Zone and then move upward along wells or the nearby Montebello Fault zone before reaching nearby leaking wells.

Previously abandoned wells in 1983 had apparently lost integrity of their annular cement seals from the Storage Zone 7,000+ ft up to the surface. The 1999 leak also illustrates that processed gas from the Storage Zone can reach the surface through shallow properly abandoned wells by migrating through complex pathways including deeper wells and shallow geologic units.

Migration pathways from the gas storage reservoir to the ground surface have existed and probably exist based on SCG reported incidents and indicate that they may exist elsewhere in the area of influence of the MGSF. Those pathways of greatest immediate concern are man-made: abandoned wells which provide conduits for rapid vertical migration of gas to the surface. Natural (geologic) pathways may also transmit gas but more slowly with the possibility of creating more regional surface gas problems.

REGULATORY SETTING

With a long history of oil production in southern California, dating back to the late 1800s and early 1900s, regulations were needed to protect people and the environment from various potential impacts associated with oil and gas operations. Today, operators must comply with numerous safety and environmental laws, regulations and guidelines. Thus, the oil and gas industry, including the SCG gas storage facilities, is highly regulated. Government agencies regulations issues relevant to this project are discussed below.

California Division of Oil, Gas and Geothermal Resources

The California Division of Oil, Gas and Geothermal Resources (DOGGR) regulates production of oil and gas, as well as geothermal resources, within the state of California. DOGGR regulations define well design and construction standards, surface production equipment and pipeline requirements, and well abandonment procedures and guidelines.

- DOGGR regulates well abandonment procedures to ensure they are conducted safely and are effective. These regulations require procedures designed to prevent future migration of oil and gas from a producing zone to shallower zones, and to protect groundwater
- DOGGR oversees operations. When an operator ceases well operation or production, state law requires the well is abandoned within a reasonable period of time
- Regulations require operators to maintain detailed records of abandonment operations and file copies with DOGGR
- DOGGR also regulates environmentally sensitive pipelines within 300 feet of any public recreational area, or a building intended for human occupancy (residences, schools, hospitals, and businesses) that is not necessary to the production operation

DOGGR regulations are defined in the California Code of Regulations (CCR), Title 14, Chapter 4.

California Environmental Protection Agency (Cal EPA), Department of Toxic Substance Control (DTSC)

The California Department of Toxic Substance Control (DTSC) oversees the identification, cleanup and removal of hazardous or potentially hazardous materials that may be present on project parcels. DTSC oversight would include remediation of hazardous or potentially hazardous soil contamination caused by past oil field activities.

County of Los Angeles, Department of Public Works

For projects involving site grading and earthmoving, the County of Los Angeles, Department of Public Works (DPW), Building and Safety Division, has jurisdiction to ensure the safety of workers during construction and the public once the project is constructed. DPW, City of Montebello and City of Monterey Park grading and earthmoving requirements are specified in the County Building Code (including the latest version of the Uniform Building Code) and the procedures outlined in the County Hydrology Manual.

Local

City of Montebello

Upon completion of well abandonment procedures, the Montebello Fire Department conducts a final inspection of the well site.

Along with the DPW, the City will issue permits for project related grading activities within the City, monitor project related construction activities if applicable, and ensure permit requirements are met. The City will issue final project approvals and a certificate of occupancy (if applicable) when all inspections and requirements have been met.

City of Monterey Park

Along with the DPW, the City will issue permits for project related grading activities within the City, monitor project related construction activities if applicable, and ensure permit requirements are met. The City will issue final project approvals and a certificate of occupancy (if applicable) when all inspections and requirements have been met.

IMPACTS

The proposed Project includes direct and indirect actions and effects along with connected actions and their effects both of which are related to the geological conditions affecting the MGSF area. The most important Project-related effect involves the continuing potential for gas migration from either the Storage Zone or Shallow Zones to the surface, as has been reported in the Project area in the past. Past experiences and lack of certainty in the gas migration pathways allows continuing potential of future significant impact without mitigation.

Lesser effects relate to potential for exposure of new developments and populations to possibly severe general area seismicity. Some increased soil erosion and potential slope instability is possible from the larger MGSF sites and around the Main Facility.

Significance Criteria

Significant impacts are herein defined as those derived from the checklist above and from previous criteria established under the CEQA process and can be summarized as follows:

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

  Encountering subsurface natural gas or petroleum at the surface
  Rupture of a known active earthquake fault
  Strong seismic ground shaking and seismic-related ground failures
  Landslides
- Result in substantial soil erosion or the loss of topsoil
- 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 on- or off-site landslide, lateral spreading, subsidence, liquefaction or collapse
- Expose life and property to damages resulting from known or suspected expansive soil
- Locate or use of soils inadequate for use of septic tanks or alternative wastewater disposal systems where sewers are not available for the disposal of wastewater

Impacts on the commercially valuable geological resources are discussed in the Mineral Resources section (see Section 4.10).

Gas Recovery and Decommissioning

The proposed Project is assessed for impacts due to, and on, geological, seismic, and soil conditions. Sale of the MGSF would not, in and of itself, result in significant physical changes in the subsurface of surface geologic conditions, and therefore would not result in significant impacts to, or from, the geology or soils of the Project area.

Gas recovery or withdrawal is a typical operation of the MGSF and as such does not require specific approvals by the CPUC. Separation of working and cushion gases is physically impossible and is related to efficiency in injection and withdrawal rates. Withdrawal of some or even a large part of the cushion gas does not cause irreversible changes to the field.

At present, recovery of cushion gas may change pressure and liquid conditions in the Storage Zone and above and along the as yet undetermined pathways for gas migration.

The only important impact would result from changes in gas migration and since so little is known about the sources and the pathways for migrating gas this can remain a potential significant impact requiring mitigation during the decommissioning and perhaps extending well beyond the decommissioning period.

Migration of Subsurface Gas to the Surface

Migration pathways from the gas Storage Zone and other producing zones exist in certain areas of the MGSF. As discussed above, these include both natural and man-made pathways. Therefore, uncertainty exists as to potential adverse impacts associated with leaking subsurface gas reaching the surface.

Storage Zone gas could travel to the surface through geologic pathways (e.g., faults, fractures, porous near-surface formations, etc.) and, more likely, leaking wells. This possibility or its absence can not be conclusively and thoroughly addressed with the available data for review. Even if no leaks are detected from all known wells, leaks could still develop at an undetermined future time; no certainty exists that such leaks would not occur. In addition, the possibility exists for undocumented abandoned wells or dry holes in the Project vicinity that would provide potential vertical gas migration pathways. If leaking wells are located near buildings or residences, soil gas could accumulate under or inside structures, leading to the threat of fire or explosion. Without mitigation, migration of gas to the surface through geologic pathways or future leaking wells represents potentially significant adverse impacts.

Removal of the working and a large part of the cushion gas would lower zone pressures to those similar to the initial conditions when gas storage operations began. Although depressurizing the Storage Zone would cause a downward pressure gradient between the Shallow Zone and Storage Zone, the storage zone pressures would remain well above ambient and equivalent to about 1500 ft (500-600 psi) below surface and groundwater levels. Any pathway connecting with zones above the “Shallow Zone” (producing levels of 3500-4500 ft) would continue to experience differentials and migration, although at diminished rates.

Field re-pressurization does occur due to inflow of liquids and other gases outside the storage zone. As indicated above, the greater differential caused by the reduced pressures in the Storage Zone would greatly increase the rates of inflow of liquids and gases from other zones once the withdrawal reduced pressures in the Storage Zone to less than 1200 psi (equivalent to those in the Shallow Zone). Liquid inflows at a rate of 1000 barrels per day would fill about 10 M cu ft (365 x 28,200 cu ft; 240 ac ft) of formation each year. At this average rate a field of 50 ft thick and 200 acres would require about 40 years to re-pressurize.

Ground Subsidence Over Storage Zone

Due to the following conditions, subsidence of less than an inch may occur and would will have no impact on surface structures within the Project area.

- Significant depth of the storage zones from which the cushion and inventory gas will be removed
- Lithified, compact nature of the Pliocene Pico Formation and Miocene Puente Formation bedrock

- Anticlinal (domal) geologic structure forming the oil field and gas storage zone
- Broad area underlain by the storage zone

Induced Seismicity

Due to the conditions listed below, a few very small (Mw=1 or less) magnitudes events are expected resulting from a few inches of rock movement at more than 5,000 ft depth. This will have no impact on surface structures within the Project area.

- Relatively shallow depth (for tectonically-induced earthquakes) of the storage zones from which the cushion and inventory gas will be removed
- Relatively small volume changes and limited thickness of the storage zone
- Relatively low overburden pressures
- Lack of a large source fault

Soils/Geologic Hazards

As explained above in fault ruptures, slope instability, secondary induced seismic effects, expansive soils, only very small movements in the earth materials under the Project area are likely to result from removal of the stored gas. Therefore, these effects would not be translated into surface movements, such as fault rupture, slope instability, liquefaction, settlement, ground cracking, etc.

Decommissioning

Decommissioning in general involves few actions related to the geological conditions of the Main Facility sites or East Site assuming activities are largely kept to existing disturbed or developed areas and no substantial earthworks are undertaken.

Erosion and Loss of Soil

The gas recovery process would have no impact on surface erosion. Decommissioning over the 5-7 year phase would expose uncovered soils and geological formations to increased surface runoff and increase potential erosion from uncontrolled area, primarily on the Main Facility site, East Site, and perhaps on the Monterey Park Lots.

Future Development

The proposed Project and the reasonably foreseeable future development are assessed for impacts on geological and soil conditions of the various sites and MGSF area. Decommissioning in itself would not generate major development; based on existing zoning about 16-24 dwellings could be built immediately primarily on the Townsite Lots.

Anticipated future development of the MGFS Project sites for their highest and best uses would eventually add housing (150+ dwelling over the existing allowed), other supporting development, and infrastructure systems to the area. Such development could result in increased human occupancy and exposure to potentially adverse geological conditions and is discussed in Section 3.

Migration of Subsurface Gas to the Surface

Storage gas could travel to the surface through leaking wells or geologic pathways as discussed above; evidence exists for past conditions and no evidence exists to exclude such in the future with absolute certainty. Even if no leaks are detected from all known wells, no evidence exists that leaks could not develop at an undetermined future time, life of the actions being more than 100 years. In addition, undocumented abandoned wells or dry holes and as-yet unknown pathways to Michael Collins Circle in the Project vicinity could provide potential vertical gas migration pathways to the ground surface and structures. As re-pressurizing of the Storage Zone and Shallow Zone occurs over a 20-40 year period, potential impacts from migrating gases could cause significant risk in the future based on actions taken during the Decommissioning period.

Potential impacts are associated with exposure of populations and structures to accumulation of soil gas in residential areas. If soil gas accumulates inside or under buildings or infrastructure systems, the threat of fire or explosion exists. Various methods exist for detection and removal of soil gas, thus minimizing the potential for accumulation inside structures. Without mitigation, this gas accumulation would result in a significant adverse impact. Since the CPUC and SCG actions would take place before realization of risks in the future, measures shall be taken during the Decommissioning period, before transfer to subsequent owners.

Geological Hazards

The central Los Angeles Basin has been and will continue being subjected to strong seismic shaking generated by large earthquakes on numerous active earthquake faults with 100 mi of the Project area. Future development of the Project lands would require considerable earthwork and geotechnical studies to assure adequate protection against seismic shaking. Critical or high occupancy facilities may require specific design standards due to high level of groundshaking expected from local severe earthquakes. Residential construction will be governed by the current Uniform Building Code regulations that require that all structural designs account for these earthquake forces. Therefore impacts from seismic events can be mitigated to less than significant.

As indicated above, the future connected actions for this Project would include eventual complete development of the Main Facility and East Site, and such development could encounter passively or actively unstable ground along the west or north sides of the Main Facility.

Slope stability concerns for the high slopes along the west side of the Main Site (>50 ft) are warranted since support against failure, with or without a severe seismic shaking event, is required for adjacent residential developments. Without this protection, a potentially significant impact is possible. Proper geotechnical investigations and analysis using standard geotechnical and geologic techniques specified in the Uniform Building Code would reduce potential for slope failures and reduce the impacts to less than significant, code-required measures are not considered mitigation.

Ground Subsidence Over the Storage Facility. As indicated above, no significant ground subsidence is anticipated. Therefore, impacts to future development from ground subsidence are considered unlikely.

Induced Seismicity. As indicated above, no significant induced seismicity is anticipated. Therefore, impacts to future development from induced seismicity are considered unlikely.

Initiation of Soils or Geologic Hazards. Some limited potential exists for slope instability in natural slopes (static or earthquake-induced) and in new cut slopes for development. Depending upon the condition of underlying materials, soil in the area may be moderately - highly expansive. Certain alluvial soils may be porous and subject to consolidation under building loads. Standard geotechnical design measures outlined in the Uniform Building Code can be used to compensate for these conditions. Therefore, no impacts are expected from expansive or collapsible soils.

Erosion and Loss of Soil. Recovery of gas and decommissioning of the MGSF would result in removal of most surface facilities and could leave the remaining ground surface exposed to erosion for a period of time before residential development is completed. Remnants of original soils are so small (less than 2 ac) as to eliminate any importance for their losses other than yielding runoff sediment. From such construction or demolition sites (Main Facility, East Site, and perhaps Monterey Park parcel), erosion of ground surface could yield considerable sediment to the local storm drain system. There are specific City and County requirements to control and prevent surface runoff to storm drains during grading and construction activities. These regulatory controls would be exercised for projects developed in the Proposed project area and therefore impacts would be less than significant.

The soil, alluvium, and bedrock formations will have variable susceptibility to extreme erosion due to their general lack of cementation and/or lack of density (compaction) within several feet of the ground surface. Water and gravity are the primary causes for erosion of unprotected surfaces, particularly slopes. Because the southern portion of the Project area has relatively low relief, and is relatively flat and level, only minor erosion is expected. In the northeastern hilly areas severe erosion potential is exists if runoff is concentrated on unprotected surfaces. Compliance with standard grading codes and hydrology analyses for residential, commercial, and industrial development (including Best Management Practices) will minimize erosion to less than significant.

MITIGATION MEASURES

No new mitigation measures are necessary for the development of new construction on the MGSF sites. Existing regulations will govern the preparation, submittal, and approval of development plans, grading plans, and tract maps. Prior to the sale and transfer of the MGSF, the primary goal shall be to demonstrate that each site is free of surface and shallow gas. The primary means to accomplish this shall be field ground gas and well testing, and if gas is present, safe removal and disposition of the vented gas in perpetuity.

Activities during decommissioning may generate some adverse effects on the geological resources and indirectly on the related context of the West Montebello Field, and these potentially significant effects shall be monitored and, if necessary, mitigated, and compensated for. Prior to the sale and transfer of the MGSF, the primary goal shall be to demonstrate that each site is free of surface and shallow gas and does not represent a risk to existing and future residents. The dominant means to accomplish this goal shall be field testing and documentation for gases on the sites and at all wells, and, if gas is present, safe removal and disposition of the vented gas in perpetuity.

Mitigation shall be undertaken during, and perhaps after the storage gas recovery, decommissioning, and transfer of MGSF assets. Mitigation measure shall fall into the following categories.

- Immediate Measures (2001-2003)
- Pre-Transfer Measures (2003-2006)
- Transfer Measures (2005-2008)
- Ongoing / Post-Transfer Measures (Post-2008)

SCG shall be responsible for measures during the former three phases (unless the facility is sold after the easily removed gas has been retrieved), while the subsequent owner(s) shall be responsible for those measures during the last phase. Reported results of each measure shall be used in subsequent phases for greater focus and specificity over the 5-7 year period of the Project implementation.

SCG shall be responsible for improved and continued upgrading monitoring and remediation training of SCG staff, staff used during decommissioning, new owners' staffs, and staff of the City of Montebello. SCG shall provide all monitoring and other documentation to the subsequent owner(s) and the City of Montebello throughout the decommissioning. SCG shall provide all petroleum and gas related-monitoring and other production and field-related documentation to DOGGR.

Immediate Mitigation-Gas and Wells

Measures are proposed for mitigation and recommended for all existing wells, including existing abandoned, operating, monitoring, inoperative, and venting in order to assure the future owner(s), occupants, and residents of continued safety for the area above the gas storage zone. Thorough documentation of previous and Project works related to the wells shall be provided for the current and future owners and the City of Montebello.

SCG has well files that contain information for all active wells that engineers refer to whenever problems occur with a well. Regular monitoring of the existing wells, as detailed below, will provide the highest and best method for detecting potential leaks and safety issues. SCG shall assemble a well-organized file for all wells and make available such files to the City of Montebello within two weeks of their request during the project, shall quarterly update the well / facility file, and shall deliver the complete file to the City or a designated representative 90 days before formal transfer of any property to a subsequent owner.

Immediate Field Monitoring

Current low-level operations and relatively stable storage conditions should have allowed the Storage Zone and related pathways to stabilized and should form a good baseline condition. Immediate field testing of the baseline conditions is vital for understanding any subsequent changes with regard to gas recovery and decommissioning. SCG shall undertake an immediate detailed monitoring task to establish the baseline conditions prior to initiation of gas recovery. The monitoring shall ascertain compositions, pressures, and origins of surface gas releases, determine the most probable pathways for releases to the surface, and changes for current and future near-surface gas releases.

Mitigation Measure 4.4-1 - Monitoring Procedures and Methods

SCG shall review well and ground monitoring requirements within an urban environment as required or practiced by other agencies and states and shall develop and implement an improved monitoring program and training of staff for monitoring of the near-surface ground and wells for existing wells and foundations over abandoned wells. SCG shall review the findings with DOGGR and jointly determine if revisions to SCG's monitoring program are required based on the best practices found in other areas. SCG and DOGGR shall provide their findings and determinations to the CPUC. SCG shall monitor all existing active, inactive, and abandoned wells at intervals as determined by the above study throughout the decommissioning period and until transfers to the new owner(s) are completed.

SCG in concert with DOGGR and the City of Montebello shall develop a more aggressive monitoring systems for abandoned well gas for the period of decommissioning; the systems shall use some means of concentrating gases released from with 3 ft of the casing and shall be installed at the time of the abandonment of all wells to be abandoned following approval of the proposed actions. SCG shall continue to conduct monitoring with qualified and trained staff on all wells at current intervals with provisions for additional and reduced monitoring depending on monitoring results.

Mitigation Measure 4.6-2 - Active Well Monitoring

All isolated wells passing through the Storage Zone and Shallow Zones shall be re-inspected and documented to assure proper documentation of facilities, locations, surrounding land uses, operating capability, and usefulness during the decommissioning period.

Mitigation Measure 4.6-3 - Monitoring of Main Facility Site Cluster

SCG shall provide special monitoring measures for the cluster of slant-drilled wells within the Main Facility site. The cluster of slant-drilled wells in the Main Facility site shall require prolonged abandonment and monitoring in close proximity. SCG shall prepare a special process and aggressive monitoring program for the cluster abandonment. Consideration shall be given for automated monitoring of wells before and after abandonment of individual wells during the overall decommissioning period.

Mitigation Measure 4.6-4 - Michael Collins Circle Venting System

The venting system has been operating successfully for more than a decade. SCG shall provide monitoring of the gas venting system in concert with abandoned wells in the Circle area as well as the nearest wells within or adjacent to the Circle area. Consideration shall be given to automated monitoring within the venting exhaust system. Exhaust gases from and the operations of the venting system shall be monitored, documented, and reported on a frequent basis during the degassing. Quarterly reports shall be provided to relevant agencies.

Mitigation Measure 4.6-5 - OII Wells

Many OII wells are located outside of the main landfill parcel and are monitored by OII under the guidance of the EPA. SCG shall also monitor the existing OII wells within the Main Facility site during the degassing and decommissioning period. SCG shall seek to acquire OII Landfill information on the same wells and other gas-related information for any OII wells. Conditions in the OII wells shall be correlated with degassing and other related decommissioning activities and reported to the DOGGR, operators at OII Landfill, City of Montebello, and CPUC.

Mitigation Measure 4.6-6 - Previously Abandoned and Leaking Wells

Some abandoned wells have leaked gases from various zones including the Storage Zone. SCG shall conducted a more intensive documentation and monitoring program for all wells previously reported with detectable gas levels and foundation margins over previously abandoned and now covered wells. Monitoring may be reduced or intervals increased when sufficient results indicate no further gas releases have occurred.

Mitigation Measure 4.6-7 - Specialized Monitoring of Wells

As indicated above, SCG shall develop gas monitoring probes and portable hoods and monitor selected representative abandoned wells during the Immediate and later phases. Monitoring shall provide means of direct testing of gases, sampling of gases, and pressure measuring of gases in inches of water column. This monitoring shall be continued and upgraded based on monitoring results throughout the decommissioning period and use the same for monitoring of newly abandoned wells until lands are transferred to the new owner(s).

Mitigation Measure 4.6-8 - Ground Gases

SCG shall develop and implement a soil gas survey on a 1000ft-grid (or shorter intervals) over the entire Storage Zone and individually for each parcel in the proposed Project area to determine the presence or absence of soil gas. If gas is identified from the Storage Zone, a supplemental monitoring program shall be established, and the pathway for release of the gas shall be established. An independent specialist shall review the monitoring program procedures in advance to determine the adequacy of the program and any supplements. In addition, all monitoring records should be reviewed to delineate any possible gas leaks in the area identified by the testing program.

Mitigation Measure 4.6-9 - Storm Drain Monitoring

Storm drains may act as collectors for near-surface gas migration due to their shallow embedment and open construction. SCG shall establish and implement a monitoring process and technique for at least four storm drains (e.g., one under Howard and one under Jefferson). Considerations shall be given for automated monitoring of the storm drains if manual system (i.e., a suitable flame or photo ionization detector [FID / PID]) detect thermogenic gases in storm drains.

Mitigation Measure 4.6-10 - Gas Controls and Remediation

For well sites where significant processed gas is detected (>100 ppm), SCG shall immediately undertake additional monitoring and with confirmation shall develop and implement a gas recovery and venting system. All venting shall be thoroughly monitored and documented for future use.

Mitigation Measure 4.6-11 - Pre-Transfer Measures

Prior to transfer of any MGSF lands and after at least 50% of the available cushion gas has been recovered, SCG shall compile, review, and evaluate all documentation, reviews, and monitoring results. During this later phase of gas recovery (2003-2006), modifications of training, monitoring, surface gas programs, and needs for near-surface gas venting systems may be required and useful for the remainder of the Project period. During this phase, currently active wells may be abandoned as unneeded for final gas recovery.

Mitigation Measure 4.6-12 - Monitoring Upgrading

After at least two years of monitoring and documentation and the review of initial monitoring and other gas-related decommissioning activities, SCG, City of Montebello, and DOGGR staff or representatives shall review and evaluate the immediate monitoring program and any upgrades and develop improvements as needed for the remainder of the Project period and prior to Transfer of MGSF lands. Monitoring frequency may be changed to reflect at least two years of monitoring results. Results of the evaluation shall be provided to the CPUC.

Mitigation Measure 4.6-13 - Later Monitoring

SCG shall continue monitoring of wells, ground gas probes, storm drains, and foundations. SCG shall collect representative gas samples from sources with>100 ppm of methane gas and with pressures of >1 in (water).

Ground gases have risen to the surface over the gas storage area. Measures are recommended for existing ground gas systems and continued operating, monitoring, and venting of existing and supplemental ground gas systems over the West Montebello Field. These measures shall assure the future owner(s), occupants, and residents of continued safety for the area above the gas storage zone.

SCG shall review requirements for wells in urban environments as practiced in other cities and states and develop if necessary an improved monitoring and venting design and process to reflect the greater reduction of risk of ground gases. The urban venting requirements shall be independently reviewed by specialists under contract to the CPUC or its representative without any past, existing, or anticipated relationship with SCG or its affiliates.

SCG shall assure easy access to monitoring wells and probes, assess at least three different depths of vadose gases down to 50 ft, and allow sampling and monitoring of gas composition and pressures (in inches of water, not 10s, 100s, or 1000s of psi) and of regional groundwater levels if within 50 ft of the surface. Additional monitoring shall be required below any perched water table found during drilling for monitoring wells or probes.

The venting and monitoring well designs shall provide for monitoring systems within the vicinity of wells and sites for optional venting wells if required in the future which shall be accessible for additional monitoring and installation of venting systems.

SCG shall document existing venting systems, installation of new ground gas monitoring systems, and if needed venting of ground gases during the decommissioning period and for two years thereafter. Documentation shall be provided to the new owner(s), the City of Montebello, and CPUC.

SCG shall install and operate ground gas monitoring and venting, if required, systems for all sites of more than 10,000 sq. ft throughout the decommissioning period. SCG shall monitor and provide for monitoring of ground gases at all wells and ground gas systems throughout the decommissioning period and two years after the transfer to new owner(s).

Monitoring wells and probes shall be installed for every area of more than 10,000 sq. ft or within 100 ft of an operating well. Larger areas may require more monitoring wells, and SCG shall install sufficient wells to provide adequate monitoring of the larger areas (e.g., >1 per acre). Initial monitoring wells shall be thoroughly documented and then updated as to geological units, ground water levels and other important characteristics for locating and design of additional wells, and perhaps for venting wells if required.

New ground gas monitoring may indicate changes in ground gas monitoring or venting. In the event of gas levels are detected at more than 100 ppm of methane and or pressures of more than 1 inch of water, additional monitoring wells shall be immediately installed. If pressures continue for more than 72 hours or are recorded within 100ft of an existing occupied structure, venting wells shall be installed immediately. All monitoring and venting activities during decommissioning and two years thereafter shall be thoroughly documented, and periodic reports shall be provided by SCG to the new owner(s), CPUC, DOGGR (if appropriate), and the City of Montebello.

Monitoring and Documentation of Project Abandonment

During this phase, currently active wells may be abandoned. Such abandonment requires adequate documentation and characterization and will be supervised by DOGGR and reported quarterly to the City of Montebello and the CPUC.

Mitigation Measure 4.6-14 - Well Abandonment Documentation

As part of the later gas recovery and well abandonment phase, SCG shall develop and implement an adequate documentation and monitoring program for all new well abandonment. Abandonment shall be graphically documented at critical points.

Mitigation Measure 4.6-15 - Gas Characterization

During abandonment, SCG shall conduct or require monitoring of casing gas levels and pressures at three evenly spaced intervals. Within one week of completion of abandonment, SCG shall begin aggressive monitoring of casing.

Mitigation Measure 4.6-16 - External Training

After the experiences and upgrading of programs from the initial monitoring phase, training of the future owner(s) and City of Montebello staff shall be undertaken.

SCG shall develop a standardized training program for gas monitoring, gas venting, documentation, and well abandonment suitable for the subsequent owner(s) and City staff, and others related to the west and main Montebello Oil Fields. Materials developed during monitoring and current abandonment operations shall be used to demonstrate and train staff.

Mitigation Measure 4.6-17 - Later Gas Controls Training

SCG shall review all documentation and monitoring of the then-current gas control systems and shall develop a training program for continuing and future operations during the remainder of the Project period.

Mitigation Measure 4.6-18 - Later Gas Remediation

Adequate documentation of existing or new gas control venting systems will provide an excellent training base, which shall be required for the future owner(s).

Gas remediation is currently required and during the initial phase of the Project additional areas of gas release could be added. If required, SCG shall develop trained staff, training programs, and improved venting systems for gas releases in the Montebello area. SCG shall develop and implement measures are required to remove escaping near-surface or well gases from the MGSF lands for sale. SCG shall use the Michael Collins Circle venting system and any other available systems at that time for demonstration and training for removal of gas (e.g., wells versus trenches). All systems shall be approved by the City of Montebello and by DOGGR in order that building permits and approvals can be issued before construction and with transfer(s) of ownership.

If required, SCG shall review and develop adequate passive and positive extraction-collection-venting systems. For large areas, such as neighborhoods like Michael Collins Circle, extraction systems may require collection manifolds, extensive piping, and other equipment, including blowers or compressors.

SCG installed and operated a ground gas venting system in the Michael Collins Circle east of Montebello Blvd. and shall continue to operate and monitor the system and gas composition and flows from the system. Before transfer of the East Site and wells east of Montebello Blvd., SCG shall fully document the existing system and update its performance to demonstrate its need and efficiency for the new owner(s) and City of Montebello.

SCG shall annually or more frequently, if repairs, damages, or deterioration have occurred, re-inspect and document all existing ground gas venting wells to assure proper operating capability and usefulness during the first half of the decommissioning period.

Potential air quality issues may be associated with venting soil gas may require SCAQMD permits, depending on concentrations of heavy hydrocarbon gases. SCG shall document previous City and SCAQMD permits and applications for venting equipment and shall prepare and submit appropriate permits for new venting systems, if required (e.g., >500 ppm of non-methane hydrocarbons).

Transfer Measures

Transfer mitigation measures are required to legally document the responsibilities of and assist the parties during and following the transfer. Such documentation shall also provide the cities of Montebello and Monterey Park with periodic (quarterly or more frequent as requested by the cities) updates and changes in responsibilities and obligations of SCG and the subsequent owner(s).

Mitigation Measure 4.6-19 - Responsibilities

In particular, documents shall define who retains responsibility for continued mitigation measures and, in particular, maintaining and operating the field-testing, monitoring, and remediation sites and equipment, wells, and probes.

The City of Montebello and City of Monterey Park shall not bear responsibilities, unless they are owners of any former SCG property.

Mitigation Measure 4.6-20 - Transfer Conditions

SCG shall assure that any prospective new owner(s) shall have adequate financial and technical resources to maintain responsibilities for the geological zones, field, wells, and gas monitoring and venting systems.

Transfer documents shall specify conditions and criteria for suspension, cancellation, or abandonment of gas monitoring and venting systems and concurrence by the cities of Montebello or Monterey Park for such suspension, cancellation, or abandonment

The transfer documents shall also prescribe necessary indemnification and insurance requirements (if any) for the buyers and sellers.

On-Going/Post-Transfer Measures

Based on terms and condition set for in the property transfer documents, the responsibilities of the parties shall be defined upon execution of sales contracts and conditions shall apply for a period of two (2) years from the date of transfer. The responsible parties (new owner(s), City of Montebello and City of Monterey Park, and DOGGR) shall maintain and operate field test stations, monitoring stations, and remediation site equipment. The transfer documents will also prescribe necessary indemnification and insurance requirements for the future buyers and owners. All future revisions and changes in conditions shall be approved by the cities of Montebello or Monterey Park.