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October 5, 2001

Mr. Kevin Lindquist
Trammell Crow Company
2049 Century Park East
Suite 2650
Los Angeles, California 90067

Subject: Methane Assessment Report,
ABC Entertainment Center
2020/2040 Avenue of the Stars
Los Angeles, California

Dear Mr. Lindquist:

Camp Dresser & McKee Inc. (CDM) has prepared this report for the Trammell Crow Company (TCC) that documents the methane assessment field activities in the lower level of the parking garage at the ABC Entertainment Center, 2020 and 2040 Avenue of the Stars, Los Angeles, California. The property is bounded by Avenue of the Stars, Constellation Boulevard, Century Park East, and Olympic Boulevard. This report provides a summary of the findings of the methane assessment studies conducted during June, July, and August 2001. The objective of this work was to evaluate the potential for gas accumulation beneath the concrete floor slab or within areas of the garage located below the ABC Entertainment Center. Gas samples were collected from areas within the lower garage level to assess the current methane gas conditions entering the garage. In addition, soil gas samples were collected from areas below the lower garage floor to assess the current and potential subsurface gas conditions at the property. These data assist in evaluating the risk associated with demolition and planned construction and operations at the project site. Construction at the site will involve the installation of approximately 68 new concrete pilings through the existing parking garage and concrete floor slab to a minimum of 5 feet below the existing grade. Because methane gas may accumulate beneath the concrete floor, potential risks include health and safety concerns during construction and long-term subsurface gas emissions. This evaluation assists in estimating the extent of subsurface gas emissions and allows for recommendations regarding the need for potential mitigation measures.

1.0 Introduction

1.1 Scope of Work

The building site is located in an area of the former "Wolfskill" gas/oil production field. Abandoned gas and oil wells are located at the property. As a result, it is possible that some methane gas may be present in the subsurface. CDM has reviewed the documents entitled *"Phase I Environmental Site Assessment and Soil Condition Evaluation"* prepared by

Law / Crandall (1997), *"Environmental Assessment of the Century City Acquisition"* prepared by Geraghty & Miller (1987), *and "Recommendations to Mitigate Subsurface Natural Gas Seepage into the Basement Levels of 2029 and 2049 Century Park East Buildings"* prepared by Engineering-Science (1988), prior to initiating this work. These documents provided an initial assessment of the site conditions with particular reference to the location of three abandoned oil wells and some subsurface gas analyses. The 1997 Law / Crandall assessment noted that the California Division of Oil and Gas determined that all three wells were abandoned properly. Methane gas was detected at concrete cracks within the garage during the last gas survey in 1987. Although the methane gas concentrations detected were well below the lower explosive level (LEL) (5 percent by volume [% (V)] or 50,000 parts per million volume [ppmv]), the exact methods used to collect and analyze the gas are not well documented and may not be consistent with current practices.

Based on this document review, CDM conducted a field investigation to determine the presence / absence and extent of subsurface methane gas immediately below the concrete floor slab or within the parking garage at the property. In addition, soil gas at depth was measured to determine if methane gas exists within the sub-soils even if not accumulated immediately below the concrete. The field investigation conducted by CDM included both soil gas measurements below the building slab and a gas survey within the existing parking garage. Gas measurements were conducted using both field instruments and a field laboratory consistent with current guidelines and procedures known to be acceptable to the Los Angeles Department of Building and Safety (LADBS). The field activities were completed in general accordance with the attached protocol developed by Exploratory Technologies Inc. (ETI), a methane consultant for LADBS.

1.2 Brief History of Project Area

The subject site consists of the entire block bounded by Century Park East, Constellation Boulevard, Avenue of the Stars, and Olympic Boulevard. The project was constructed in two phases, with the western portion of the site, the current ABC Entertainment Center, comprising the first phase and the eastern portion of the site, the twin 44-story Century Plaza Towers, comprising the second phase. The ABC Entertainment Center, completed in 1972, is comprised of two 8-story office buildings, housing office uses, the Shubert Theatre and a multi-screen Cineplex, situated above a two level retail / restaurant arcade. The Center totals approximately 678,000 square feet of commercial space. The Towers, completed in early 1975 are comprised of approximately 2.4 million square feet of commercial office space. The entire development site sits above a 6-level subterranean parking structure housing approximately 6,000 parking stalls that serve the site. The project has been in operation for close to 30 years and remains the focal point of Century City. There is no record of a methane incident at this site.

Three former oil and gas wells located within the property were properly abandoned in the 1940's and re-abandoned in 1970 *(Law/Crandall 1997*). A property assessment conducted in 1987 concluded the "Abandoned wells beneath the existing structures were sealed in accordance with state standards. Although it was not possible to observe the conditions of these wells below the ground during the Geraghty & Miller investigation, there was no evidence to suggest that corrosion or leakage around the seals had occurred." Assessment of the potential for methane emissions below the building was also conducted in 1988 (*Engineering-Science 1988*). Some methane was determined to be present in the subsurface below the garage. A sub-drainage system that was installed beneath the building at the time of construction was identified as an area in which methane could potentially accumulate. No significant methane was detected within the building above the floor level (*Engineering-Science1988*). The ventilation system has been operated since the building was constructed and potentially problematic incursions of methane into the building have not been identified in the history of this property.

2.0 Methodology

2.1 Gas Survey Within Garage

On June 30, 2001, CDM performed a field evaluation of 92 separate locations of existing floor drains, subsurface vaults, and cracks in the concrete floor where gas seeps could potentially be present or have been previously detected. The locations in the garage surveyed for gas (designated "S-#") are shown in **Figure 1** and the results are tabulated on **Table 1**. Field gas meters were used to measure hydrogen sulfide and methane concentrations through an inverted funnel connected with tubing to the meter. It is important to note that field gas meters used throughout the site investigations do not measure methane concentrations directly. Rather, the meters measure specific responses to the presence of combustible gases, which are calibrated to gases of known methane concentration. Results obtained from field gas meters are presented as "methane" in this report and are typically considered conservatively high estimates of actual methane concentrations, because of potential interferences that result from the presence of other combustible gases (e.g., ethane, propane, butane).

Samples were pumped into the field gas meters to purge gas from the tubing prior to taking a measurement. A background air sample was taken at each location to determine the level of methane gas present in the garage at the breathing level, i.e.- 4-6 feet off the floor. A Gas Tech 402 meter was used to measure hydrogen sulfide between 0 % and 30 % (V) concentration and methane concentration between 0.03% and <1% (V). The Gas Tech meter reports 10 ppmv (0.001%) methane as the detection limit but the results are not considered accurate at this level. A hand-held Flame Ionization Detector (FID) was used to measure methane concentrations in a range of 100 ppmv to 10,000 ppmv (0.01 % to 1.0 % V). A LandTec GEM 2000 was available for quantifying methane concentrations between 1.0%(V) and 100% (V) methane. Although the FID and LandTec methane meters malfunctioned and could not be replaced on the weekend during the June 2001 sampling event, only two locations surveyed (June 2001) by the Gas Tech meter exhibited a methane concentration exceeding the meter (>10,000 ppmv; or >1.0 %[V]) capability. These two locations were re-surveyed with the LandTec meter during the August 2001 event to obtain a measured concentration.

On August 25, 2001, CDM completed the garage survey, including those areas of proposed construction. All instruments described above were available and functioning for this event. Floor seams, cracks, and floor drains were sampled using an FID meter and elevated readings were confirmed using a LandTec meter. The locations surveyed in August are shown in **Table 2** and **Figure 1**.

In addition, air samples were collected from enclosures and rooms with no obvious exhaust on the lower or "F" level of the garage. The air samples were analyzed using the same two instruments as the floor samples. These areas were sampled to determine if unventilated enclosures on the lower level (F) were accumulating methane gas at potentially problematic concentrations. The rooms and enclosed spaces surveyed for gas are shown in **Table 3**. All rooms and enclosed spaces surveyed for methane gas were designated by their respective number (F-#) from the building plans (Floor Plan, “F” Level, September 1971), and shown in **Figure 2**.

The ceiling in the lower level of the garage contains depressions similar to a "honeycomb" design that could potentially trap the lighter weight methane gas. Approximately 50 separate locations at the ceiling were checked to determine methane gas concentrations. The FID gas meter was used to determine concentrations of methane at these locations.

2.2 Subsurface Soil Vapor Screening with Field Meters

Three-inch diameter borings were cut in the 4-inch deep concrete floor using boring apparatus equipped with a spark suppressor. One boring was completed adjacent to each of the 68 proposed locations for the concrete pilings. In addition, nine other borings were advanced in alternate locations due to refusal encountered by subsurface concrete footings near the existing columns. The locations for concrete floor borings (designated SG-#) were identified during the initial gas investigation. All borings and subsurface locations sampled for methane in soil gas are shown on **Figure 3** (July 2001). The borings were continuously covered with flowing water to reduce the potential for spark ignition of any methane beneath the floor. Gas just below the concrete floor was checked immediately after breakthrough for both methane and hydrogen sulfide using field meters equipped with a funnel (described above). This allowed a check for immediate danger to the field workers from gas released from below the floor and an indication of the gas concentration that may have accumulated below the floor. These data were recorded in field notebooks and transferred to **Table 4** for this report. All borings and soil gas collection and analyses were conducted July 14-15, 2001.

2.3 Collection of Subsurface Soil Vapor Samples

Generally, the procedure for collecting soil gas from below the concrete floor for methane analysis involved attempting to insert a gas sampling probe approximately 5 feet into the subsurface using a slide hammer. If the probe could not be inserted due to dense soils, hydraulic equipment was used to push a pilot hole to a depth of approximately 5 feet before inserting the gas sample probe. Ten locations were completed and six samples collected with a pilot hole (**Table 5**); 12 locations were completed and seven samples collected using only the sampling rod. The Geoprobe™ method was used for the remainder of the sample collection once the slide hammer failed due to metal fatigue. Not all locations were sampled for soil gas because the sample probe could not be advanced below the concrete (refusal) due to subsurface obstacles. **Table 5** shows the locations and method used to sample the soil gas.

As described above, the collection of subsurface soil vapor samples initially involved completion of a pilot hole. The pilot holes were advanced using a steel-tipped probe driven to a depth of approximately 4 feet bgs. This probe was extracted and then a hollow sampling rod was attached and driven to the final depth of approximately 5 feet. The sampling rod had a slightly larger tip than the pilot probe and there was a flange approximately 1 foot above the sampling tip. The flange effectively sealed the sampling area, preventing sample dilution from atmospheric gas intrusion. A barbed tip was attached to the top of the sample rod and a soil gas sample extracted as described below.

For the Geoprobe™ method, a new sampling tube was inserted into the borehole once the appropriate depth was reached. Drive rods are hollow, flush threaded, 1-1/4-inch hardened steel fitted with expendable drive points at the bottom. When desired depth was achieved, the drive rod was slightly raised, allowing the drive point to fall out. New, 1/4-inch polyethylene tubing with a stainless steel adaptor was lowered into the hollow drive rods and threaded into an adaptor mounted in the drive point holder. An O-ring connection at the surface ensured a vacuum tight seal and the sample vapor was collected from the soil gas at depth.

The barbed tip (slide hammer) or sampling tube (Geoprobe™) was fitted with silicon tubing and a T-valve for exhausting or collecting soil gas. A large syringe was used to withdraw and exhaust soil vapor to the atmosphere until the desired three purge volumes were completed.

The soil gas sample was then collected by inserting a syringe needle through the silicon tubing attached to the aboveground end of the sample tubing. Two 10-cubic centimeter (cc) syringes were collected, per location, for onsite analysis in the mobile laboratory. Archived samples were also collected in 20-cc or 100-cc gas sample vials evacuated onsite. Archived samples were collected with new needles and disposable syringes using the same method. The sample vials were over-pressurized by injecting 40cc's of gas into the 20cc vials and 180cc's of gas into the 100cc vials. The latter bottles were archived for possible isotopic analyses of the gases.

To ensure that no cross-contamination occurred between locations, the rods were washed with soap and water between sampling locations. New drive tips and new polyethylene tubing were used at each location. The 10-cc glass syringes used by the mobile laboratory were baked in an oven at 300 degrees F for 10 minutes before each use.

2.4 Borehole Abandonment and Surface Cover

Each borehole was abandoned by backfilling with granular bentonite and hydrating prior to covering with new surface concrete. The top 6 to 8 inches of the borehole were filled with cement until flush with the concrete surface of the garage. All boreholes were backfilled and checked for neatness before CDM left the site.

2.5 Gas Sample Analyses (Analytical Laboratories)

Soil gas samples were analyzed for fixed gases including oxygen, carbon dioxide, nitrogen, and methane using a mobile laboratory. Soil gas samples were also analyzed for benzene, toluene, ethyl benzene, and xylenes (BTEX) as well as hydrogen sulfide using the same mobile laboratory. The fixed gases and methane were measured using a gas chromatograph equipped with a thermal conductivity detector (TCD); BTEX were analyzed using a gas chromatograph equipped with a photo-ionization detector (PID). Hydrogen sulfide was analyzed using a gas chromatograph equipped with a flame photometric detector (FPD). Background and air samples were periodically checked for quality assurance purposes. In addition, duplicate soil gas samples were checked on approximately 10 percent of the total samples (minimum).

Archived gas samples were shipped to Microseeps Inc., Pittsburgh, Pennsylvania, for light hydrocarbon analyses (C1 through C4), methane, ethane, propane, propene, normal butane, and isobutane. Only selected samples were analyzed for these gases. Gas samples from locations exhibiting methane concentrations greater than 30% (V) (300,000 ppmv) were analyzed for C1 – C4. Other samples remain archived for any future analyses.

3.0 Results of the Field Investigation

3.1 Gas Analyses within Enclosures, Rooms, and Ceiling Spaces

Air samples were screened from 43 individual rooms and enclosures throughout the lower garage, "F" level. The locations and results are presented in **Figure 2** with the designated room numbers (F-1 through F-45) in accordance with Floor Drawing Number P-1 & P-2, September 15, 1971. Some rooms or enclosures were given different numbers in this series if the identifiers could not be located on the map (**Table 3**). Gas measurements in the enclosed rooms throughout the F-level showed limited accumulation in these areas. Most enclosed spaces (29 of 39 locations) exhibited methane concentrations less than 100 ppmv. However, methane concentrations up to 8,000 ppmv (0.8% V) were detected at samples F-35 and F-37, which were collected within two enclosures with no obvious ventilation.

Additional air samples were screened from the "honeycomb" ceiling pockets to determine if methane gas had collected in the ceiling area without being evacuated by the ventilation system. Approximately 50 air samples were screened from the ceiling area (within the honeycomb structure) described on **Figure 3** ("cloud design"). In addition to random locations, gas samples from the ceiling spaces above any area of the garage exhibiting elevated concentrations at the floor survey points were analyzed with the field meters. No sample location checked exhibited any gas concentration over typical background concentrations of 50-100 ppmv (0.005% - 0.01% V).

3.2 Gas Screening Survey

Air within the garage at the floor level and in the breathing space area was screened using handheld meters for methane and hydrogen sulfide at 214 separate locations. Seams in the concrete floor, cracks in the concrete slab, and vaults or covered openings to the subsurface (storm drain clean-out plates, FCP) were screened for methane or H_2S gas entering the garage through these floor openings. Locations were sequentially numbered, as S-1 through S-214, but were randomly selected compared to the boring locations for soil gas.

No hydrogen sulfide gas was detected using the field meters at any survey location or in background air in the garage during either sampling event (June and August 2001). Therefore, hydrogen sulfide data are not reported in the gas analysis tables (**Table 1 & Table 2**).

Methane was detected with the field meters during the June 2001 sampling event at concentrations that ranged from 20 ppmv (0.02 %V) to greater than 10,000 ppmv (1.0 %V) (**Table 1**). Two locations near the northwestern driveway entry, of the 92 locations surveyed in June 2001, had methane readings above 1.0%V.

Methane was detected with the field meters during the August 2001 sampling event at concentrations ranging from several hundred ppmv (300 – 500 ppmv (0.03 –0.05%V) to 100%V (using the LandTec meter). One hundred twenty-two new locations were surveyed. Methane gas concentrations were detected above 1.0%V at twelve locations.

Concentrations ranged from 1.2%V to 100%V at these locations. Most locations with elevated methane concentrations were within the center of the garage (10) between the escalator lobbies and two additional locations near the northwestern driveway entry ramp. The latter locations were near the previously identified elevated gas levels noted during the June 2001 sample event. These previously identified locations (SG-31 & SG-90, >10,000ppmv) were analyzed and showed methane concentrations of 63.6%V and 17.6%V, respectively. The highest concentrations were detected in the west central portion of the garage between the two escalator lobbies (**Figure 1**). No methane gas was detected at any open floor drains. All methane seeps occurred at floor cleanout plates or concrete seams in the floor.

The background samples listed in **Tables 1 & 2** were measured at 4-6 feet off the concrete floor. Therefore, in addition to being background to the floor sample, they represent samples taken at the "breathing space" elevation of the garage. Background measurements were quite variable but ranged from approximately 20 to 500 ppmv (0.002 to 0.05%V). Most of the garage area recorded background concentrations in the range of 100 to 300 ppmv (0.01 to 0.03%V) using the FID meter.

The distribution of methane gas seeps from the surveyed floor points during both sample events is indicated in **Figure 1**.

3.3 Soil Gas Concentrations

<u>Concrete Core Surface Gas Survey</u>

Upon completing the concrete cores in the garage floor, the gas below the cores was immediately measured for both methane and hydrogen sulfide. The measurements were made to determine if gas had accumulated beneath the concrete and was released following the coring. The results are shown in **Table 4**.

No hydrogen sulfide was detected at any boring location in the garage. No hydrogen sulfide was detected in the garage air as background (**Table 4**).

Methane concentrations in existing gas were quite variable but only 14 of the 77 boring locations exhibited methane above 10,000 ppmv (>1.0%V) (**Table 4**). All elevated methane concentrations exiting the boring were detected in the southwestern corner (10 locations) or along the western wall (4 locations) of the garage area. No location gave any indication of accumulated gas below the garage floor that rapidly escaped during coring activities. This indicates that accumulated gas below the garage floor was not found to be under obvious positive pressures during the coring activities. Areas where methane was detected below the concrete floor correlated well with areas of high soil gas (see below).

Areas with elevated methane concentrations also showed elevated carbon dioxide and depressed oxygen levels (**Table 4**). Areas with no detectable methane had carbon dioxide and oxygen levels close to atmospheric (background) concentrations (i.e., oxygen ~ 21%V; carbon dioxide below detection limits). These findings suggest that partial aerobic biodegradation of methane to innocuous byproducts (e.g., carbon dioxide and water) is likely occurring.

Five-Foot Soil Gas Analytical Results

The locations of the proposed 68 new pilings were located on the garage floor. Coring locations were designated to coincide with the proposed piling locations but moved slightly when subsurface drains or footings were located in the same area. **Figure 2** shows the locations of the 77 borings penetrating the garage floor. Of these locations, soil gas was sampled at 61 locations (**Table 5**). A number of locations designated for coring were located over subsurface concrete structures that caused refusal of the sampling devices. Therefore, these locations were either abandoned or moved to alternate areas. Several additional boring locations were installed near the southwestern wall of the area where the highest concentration of methane gas was indicated during the initial garage survey. The results of the soil gas analyses are shown in **Table 6** for methane, nitrogen, carbon dioxide, oxygen, hydrogen sulfide, and BTEX.

No significant hydrogen sulfide concentration was detected at any sampling location. The highest level detected was only 3 ppmv, detected at SG-71 and SG-77 (**Table 6**). Most locations did not show detectable hydrogen sulfide (33 of 61 samples at ND).

BTEX compounds were not detected at any sample location above the detection limit of <1.0 µg/L, with the exception of toluene (1.7 µg/L) and xylene (1.3 µg/L), which were detected at low concentrations at SG-68. No other BTEX component was detected at any other location (**Table 6**).

Methane was detected above the LEL (5%V) at approximately 40 percent (25 of 61 samples) of the locations sampled while approximately 55 percent (34 of 61 samples) of the locations exhibited methane gas concentrations above 1%V (**Table 6**). Methane concentrations, above 1%V, in soil gas ranged from 1.1%V to 55.8%V. The highest concentrations of methane (>50% V) were at two locations designated SG-30 and SG-77. Methane concentrations in soil gas were above 1%V in three distinct zones within the proposed construction area. **Figure 2** shows all the locations where soil gas was sampled and distinguishes locations >1%V methane gas (purple) and >5%V methane (blue).

Methane concentrations above 5%V (LEL) were encountered at 10 locations in the southwest corner of the proposed construction area. The methane concentrations ranged from 7.3%V to 25.1%V in this area. In the central portion of the construction area, another 10 locations were encountered with soil gas methane concentrations ranging from 13.1%V to 50.3%V. The two highest concentrations encountered were in this area. A smaller area, or less frequent number of locations with elevated methane concentrations, was located in the northwestern corner. Four locations were identified with methane concentrations ranging form 7.6%V to 31.1%V. Similar to the initial gas survey, oxygen was depressed and carbon dioxide elevated wherever methane was elevated. These findings suggest that partial aerobic biodegradation of methane to innocuous byproducts (e.g., carbon dioxide and water) is likely occurring.

The distribution of methane in soil gas is shown in **Figure 2**.

Select gas samples were analyzed for light hydrocarbon including C1-C4 (i.e., methane, ethane, propane, butane, and isobutane). The results of these analyses are included as an attachment. The results indicate that significant levels of ethane, propane and butane were present in all six gas samples analyzed. The ratio of ethane to methane was relatively the same in all samples (0.02 - 0.03). The gas contains the chemical distribution expected from methane or natural gas of thermogenic origin.

4.0 Discussion of Results

4.1 Gas Concentrations - Garage Floor Level, Rooms and Enclosures, and Ceilings

Methane gas was detected at a number of concrete seams and drain lines within the garage floor. Methane gas concentrations in floor samples were generally low in most samples throughout the garage area, with only two locations showing greater than 1%V methane in June 2001. In August, the remaining area of the garage floor was surveyed for gas seeps into the garage from concrete seams, cracks, and drains. Twelve additional locations had measurements above 1%V. Methane gas detected in the building was always associated with seams in the concrete slab or with floor plates covering the storm drain cleanout lines; no methane was detected at any of the cracks in the garage floor or open drain lines (**Figure 4**).

While some methane gas was detected at cracks or breaks in the concrete floor within isolated areas of the garage, the methane concentrations in the garage breathing space were at insignificant levels (100 – 500 ppmv; 0.01% - 0.05% V). Anomalous concentrations of methane were not detected in any of the background air samples collected throughout the entire garage.

The ceiling area of the garage was checked for accumulated methane gas. Methane is lighter than air and if not removed could accumulate in these spaces. Of the 50 sample locations, no sample exhibited any methane concentration over background. No gas is collecting in the spaces of the garage ceiling.

Most of the enclosed spaces and rooms on the garage Level F were monitored for methane gas. Most locations exhibited concentrations lower than the general air space background. All rooms and enclosed areas showed methane at less than 1.0 %V, although two storage rooms exhibited anomalously elevated methane concentrations (0.7% – 0.8%V). These levels are well below the LEL (5%V) but sufficiently elevated above background levels to suggest some minimal accumulation of methane is occurring in these areas. Thus, with the exception of the two storage rooms, methane is not collecting in any of the enclosed spaces within the garage at potential concentrations of concern.

The data collected indicate that, in general, methane gas entering the garage Level F (enclosed spaces, rooms, or parking areas) is not accumulating to levels of concern and unlikely to reach explosive levels. The low concentrations of methane within these areas indicate the flow of methane into the garage is low such that it does not accumulate and is rapidly diluted by ambient air, or that the existing ventilation system is removing most or all of the methane gas that enters the garage, or both.

The existing ventilation system on Level F was designed to provide a minimum of four air exchanges per hour in accordance with the building code that was in effect at the time of construction. This ventilation system is required to remove hydrocarbon vapors emitted from automobile exhausts. The ventilation rate, with all supply and exhaust fans running, is 5.4 air changes per hour or 11.2 minutes per air exchange (*Personal Communication with TCC 2001*). The exhaust fans, but not the supply fans, are connected to emergency power. Therefore, the ventilation rate on Level F, with only the fans connected to emergency power running, would be expected to be in the range of 40 to 50% of capacity, i.e.- 2.1 to 2.7 air changes per hour.

4.2 Soil Gas Concentrations

Methane in soil gas below the concrete floor was detected above 5 %V (LEL) at 25 different locations of the 61 borings sampled. Elevated methane gas concentrations were detected in primarily three areas of the construction site—the southwest corner with concentrations ranging from 8 % - 50 %V; the central area near the escalator lobby with concentrations ranging from 6 % - 50 %V; and a smaller area in the northeastern corner with concentrations ranging from 8 % - 31 %V. Elevated methane concentration in soil gas detected in the northeastern portion of the project area was, generally, less frequent and at lower concentrations than the other areas. The most frequent detection and the highest concentrations of methane in soil gas were along the southwestern wall (Avenue of the Stars) of the project area and near the center of the building site.

The location of an abandoned gas well, Wolfskill-44, is reportedly under the southern end of the project area (*Geraghty & Miller, 1987*). It is not known if this well is at all related to the concentrations of methane detected in the soil gas or garage. Records show, however, that this well was properly abandoned first in 1940 in a manner acceptable to the LA Fire

Department guidelines at the time. Later, in 1970, the well was re-abandoned in a manner that complied with appropriate state specifications. It is not currently known whether vented gas collection "hoods" were installed on the abandoned well.

Each boring location was surveyed for methane gas immediately below the concrete floor. Most locations with elevated methane concentrations above 1%V at the time of coring coincided with locations that also showed elevated soil gas concentrations. Although several borehole locations with elevated methane concentrations (>1%V) at the time of coring showed only low levels of methane in the soil gas, these locations were always located near borings with elevated soil gas concentrations. Therefore, the gas detected when the garage slab was cored was likely associated with soil gas that had accumulated beneath the slab from nearby source areas.

The areas of elevated methane concentrations in soil gas, generally, are located in the same quadrants of the garage where elevated gas concentrations were detected above the slab. However, not all the elevated soil gas areas directly correspond to the elevated concentrations of gas in the garage floor. In the northeastern area of the project, elevated methane concentrations in soil gas correspond with those locations identified as seeps in the garage. The area of elevated methane in soil gas in the southwest area of the garage was not associated with identified locations of methane seeping into the garage. The area with elevated methane soil gas in the center of the project site is located to the west of the area with elevated methane concentrations inside the garage. The elevated floor concentrations were detected in areas that extended beyond the boundaries of the proposed 68 pile locations (i.e., further to the east). It should be noted that methane rising vertically from depths below the garage floor may accumulate in sub-drain pipelines, allowing lateral migration of methane into other areas prior to exiting at the floor seams or drains.

BTEX compounds were not detected at any sample locations above the detection limit of <1.0 μg/L, with the exception of toluene (1.7 μg/L) and xylene (1.3 μg/L), which were detected at low concentrations at SG-68. As such, BTEX is not considered a contaminant at this project. Although hydrogen sulfide was detected, the concentrations were low (3 ppmv max). Therefore, hydrogen sulfide gas is not considered a compound of concern at this project site.

The building plans (Drawing C-2, July 1970) with subsurface drain systems were reviewed to determine if drain lines could serve to spread methane gas in the subsurface. The design of the sub-drainage system is shown in **Figure 4** and the floor cleanout plates in **Figure 5**. The subsurface drain system consists of a 9-inch layer of gravel under the concrete floor connecting trenches containing 4- or 6-inch perforated asbestos cement piping embedded in 12 inches of gravel. These trenches are spaced approximately 60 to

80 feet apart throughout the garage Level F. The perforated piping is punctuated by 4 inch cleanout openings on the garage floor (**Figure 5**). Many of these floor cleanout openings were monitored for methane gas and several showed evidence of elevated concentrations (**Figure 1**).

Most of the elevated methane concentrations (>1%V) observed in the garage can be found near these sub-drainage piping systems. It is possible that some methane is collected in these gravel trenches and perforated pipes and migrates through the piping system. Although these drains may serve to collect methane gas, the volume of methane gas is considered low. This conclusion is based on the lack of any significant concentration of methane in the building air space. Also, it is important to note that there is an apparent cross-connection between the sub-drainage system and the positive pressure air ventilation shafts in the southwestern area of the garage where elevated methane concentrations were detected below the concrete floor. It is unknown if the sub-drainage system piping connections in this area are factors that contribute to elevated methane concentrations in this area.

5.0 Conclusions

The objective of this investigation was to determine the extent of methane within the garage structure and to assess the potential safety risks associated with construction within and below the existing garage and operation of the project. The following conclusions can be made based on the data included in this report:

1. Methane gas at concentrations of concern is found in localized areas within the subsurface of the garage.

2. Methane was found entering the garage floor at elevated concentrations but these concentrations rapidly attenuate within a short distance of entry.

3. Hydrogen sulfide and BTEX are insignificant in the soil gas below the garage. Although hydrogen sulfide is not problematic from an exposure perspective, low concentrations of this compound (3ppmv) suggest that the presence of hydrogen sulfide may present odor concerns during excavation.

4. Methane gas appears to be locally accumulating and migrating within the sub-drainage system below the garage floor. With minor modifications, it may be possible to utilize this system to remove subsurface gas in the vicinity of the building foundation.

5. Partial biodegradation of methane to innocuous byproducts (e.g., carbon dioxide and water) is likely occurring below the garage floor.

Details of these conclusions are given below:

- Methane concentrations within the building airspace and enclosures on Level F are generally insignificant and not substantially elevated above background methane concentrations. However, anomalously high methane concentrations were measured within two enclosures (0.7% to 0.8%V) with no obvious ventilation. These levels are well below the LEL but sufficiently elevated such that additional monitoring and evaluation is warranted. Methane has an LEL of 5%V and an upper explosive limit (UEL) of 15%V.

- Methane can be detected, at limited locations, seeping into the garage through existing drainpipe cleanout ports and seams in the concrete floor. Concentrations ranged from 4 % to 100 %V at these locations. However, no methane was detected at any open floor drain suggesting that methane does not accumulate to concentrations of concern at these locations.

- Methane concentrations in the garage rapidly attenuate within a few feet of the seams and cleanout ports. Concentrations in the "breathing space" were between 100 ppmv to 500 ppmv (maximum). This attenuation is likely a combination of natural dilution and dispersion, which is enhanced by the ventilation system.

- The existing ventilation system for Level F was designed to meet the building code to remove hydrocarbon vapors emitted from automobile exhausts. The ventilation rate, with all supply and exhaust fans running, is 5.4 air changes per hour or one air exchange every 11.2 minutes (*Personal Communication with TCC 2001*). This system, in conjunction with natural dilution and dispersion processes, appears to be effectively attenuating methane concentrations to non-problematic levels within the garage Level F. Methane concentrations within the breathing space of the garage were typically in the range of 300 – 500 ppmv.

- Methane, probably of thermogenic origin, is present below the garage floor in a number of locations within the proposed building project area.

- Some areas below the concrete floor in the proposed construction zone exhibited methane concentrations in soil gas that exceeded the lower explosive limit (LEL) (50,000 ppmv, 5% V). These concentrations pose a risk of explosion that will need to be addressed during future construction activity (e.g., piling installation).

- Elevated methane concentrations in soil gas appear to be somewhat localized in the subsurface in at least three areas within the proposed construction zone: the southwestern corner of the garage, the middle portion of the garage near the escalators, and in the northeastern corner of the garage.

- The highest concentrations of methane in soil gas are located near the exterior wall of the garage in the west southwestern corner and the western central areas near the escalator lobby. The locations of elevated methane in soil gas are slightly east of the areas of highest methane concentrations detected entering the building. An abandoned gas well, Wolfskill 44, is located beneath the parking facility in this area. In addition, there is an apparent cross-connection between the sub-drainage system and the positive pressure air ventilation shafts in this area of the garage. It is unknown if the abandoned well or the sub-drainage system piping connections in this area are factors that contribute to elevated methane concentrations in this area.

- Elevated methane concentrations were detected in the northeastern portion of the test site near the entry driveway and stairway #4. These soil gas locations are more closely related to the locations where elevated methane concentrations were detected within the building.

- The sub-drainage system beneath the garage floor, which includes a network of perforated horizontal pipes throughout a gravel base, is a potential collector of methane gas. This system may facilitate the migration of methane gas below the garage floor. This sub-drainage system is constructed in a manner similar to subsurface methane mitigation systems. In contrast, open floor drains in the garage are connected to non-perforated pipes below the garage floor. The open floor drains exhibited no evidence of methane during the garage surveys.

6.0 Recommendations

Based on the above information, CDM makes the following recommendations to TCC to reduce risks associated with the presence of subsurface gas during construction, and to mitigate subsurface methane migration into the garage during operation of the project. These recommendations include additional studies that should be performed to validate some of the assumptions made in these recommendations.

6.1 Risk Mitigation During Construction

TCC should advise all contractors and construction companies of the potential risk associated with subsurface methane in soil gas below the building project site. Methane is a flammable and potentially explosive substance when sufficient concentration (5%V – 15%V) is in contact with oxygen and an ignition source. This ignition source can be a spark generated during drilling or other construction activities. Although soil gas monitoring did not indicate that hydrogen sulfide is a potential problem at the project, this gas can be associated with natural gases and should be monitored during operations as a potential health threat and an odor concern.

The contractors and construction companies should be advised to develop a Health and Safety Plan that addresses these hazards and the plans they intend to institute to minimize potential danger from explosion or exposure in the event elevated concentrations are encountered. The Plan should include, at a minimum, the following items:

1. Precautions that will be taken to arrest any spark generation or ignition sources during construction procedures that penetrate the concrete floor. Such efforts may include water saturation during any drilling or pile driving process, and use of explosion proof tools and equipment as feasible. Non-explosion proof tools and equipment should only be used as necessary, and when determined safe by the on-site Site Safety Officer.

2. Monitoring equipment and specifications should be included for continuous monitoring of methane concentrations and comparison to levels of concern such as Permissible Exposure Levels (PELs), Threshold Limit Values (TLVs) (1,000 ppmv), or concentrations Immediately Dangerous to Life and Health (IDLH) (6,250 ppmv) in the breathing zone. In addition, methane concentrations should be regularly monitored and compared against the LEL. Contingency responses should be established for each scenario. Current LADBS practice is to establish an action level, or "trigger concentration", at 25% of the LEL (12,500 ppmv or 1.25%V). Note that the monitoring should include hydrogen sulfide, although it is not considered a compound of concern at the site. Hydrogen sulfide has a TLV of 10 ppmv, and IDLH concentration of 300 ppmv.

3. Specifications should be included for use of the garage ventilation system, and any additional systems, to assure maximum air exchange within the facility during construction operations. The operation of the garage ventilation system is expected to help reduce potentially hazardous gas mixtures to safe levels in the breathing zone during construction activities. However, additional mitigation measures (e.g., mobile air blowers) may be necessary to ensure adequate safety, and should be considered. Specifications for the ventilation system(s) should include monitoring procedures to verify performance and operation on a regular basis.

4. Operation of proposed methane mitigation measures (e.g., evacuation of the sub-drainage systems believed to collect methane; see Section 6.2) is intended to reduce methane concentrations in soil gas below the garage floor, and the discharge of methane gas into the garage through seams and other structures. Such mitigation measures should be evaluated for implementation during construction operations.

5. Methane concentrations in the subsurface are likely to be highly variable in the construction zone. From a health and safety standpoint, it is recommended that all areas be considered to represent a potential explosion hazard, thereby providing maximum caution and awareness to protect worker safety.

6.2 Building Mitigation Measures for Methane

Concentrations of methane gas were found to be elevated in soil gas below the garage floor and seeping into the garage through drains and floor seams at concentrations that exceeded 1%V. However, the building airspace did not exhibit any methane concentrations at concentrations of immediate concern. TCC intends to begin construction on the site and will need to obtain LADBS approval of measures designed to mitigate potential risks associated with subsurface methane. CDM, therefore, makes the following recommendations to assure that whatever existing hazard might exist is mitigated. Note that additional detail regarding proposed mitigation measures for methane are provided in the *"Assessment of Potential Methane Gas Mitigation Tasks"*, dated October 3, 2001 by GeoKinetics.

- Although rooms and enclosures on Level F did not indicate any significant methane gas collection, it is recommended that all rooms possess openings or vents that allow the building ventilation system to adequately exchange air from these enclosures to ensure safe air quality within these areas.

- Methane concentrations within the lower garage are approximately 100-500 ppmv (0.01 to 0.05%V). However, methane was detected at the floor elevation in small, localized areas (e.g., along floor seams and drains) at concentrations up to 100%V methane. The cracks in the floor and seams that open below the concrete floor should be sealed to minimize gas migration into the garage. Smoke testing of the sub-drainage system should be conducted to help locate cracks and seams in the floor where sealing would be beneficial.

- The exhaust fans, but not the supply fans, of the existing ventilation system for Level F are connected to emergency power. Therefore, in the event of a power outage, if the exhaust fans operate and the supply fans do not, there would be a tendency for reduced air pressure within the building interior. Such operation could potentially increase the gas flux into the building. The operation of the ventilation system should be modified (e.g., connect the supply fans to emergency power sources) to avoid the development of negative pressures within the building during power outages.

- The existing sub-floor gravel filled trenches installed during initial construction allow for collection and dissipation of shallow groundwater or surface water infiltration beneath the garage. These trenches, which are 12 inches deep, are connected by a continuous 9-inch layer of gravel beneath the floor. These systems appear to collect methane that has migrated up from the subsurface and they likely serve as conduits to other areas of the garage. It is possible that the existing sub-floor storm drain trenches could be configured into a gas collection system and connected to vent risers to allow removal of any methane gas rising to the floor of the garage. The potential modification and use of the sub-floor storm drain trenches as a methane mitigation system should be investigated further.

- Current monitoring data indicate that methane gas accumulates in the perforated sub-drainage system and gravel trenches below the floor. Some of this gas subsequently seeps around the floor cleanout plates and floor seams into the garage. Most elevated methane concentrations detected during the floor surveys indicated these concentrations were closely associated with sub-drains and trenches. In most cases when the plates are removed, the methane rapidly dissipated to background levels. The potential for using the sub-drainage system as a methane mitigation system should be investigated further. Specifically, the establishment of pressure gradients within the sub-drainage system (positive or negative) should be considered for reducing the potential for methane accumulation below the concrete floor. The following studies are recommended:

  - Investigations to evaluate whether the induction of pressure gradients in the sub-drainage system will decrease the concentrations of methane entering the garage through seams and other areas. Pressure gradients should be induced using vacuum extraction (negative pressures) and air injection (positive pressures) methods.

  - An evaluation of the zone of influence of the vacuum extraction and air injection systems on the sub-drainage system and gravel trenches. These tests should include pressure and methane measurements in floor cleanout plates and monitoring points installed in gravel areas to assure complete coverage of areas potentially contributing methane to the garage floor.

  - Smoke tests to define areas of sub-drainage system confluence and connection throughout the garage. Smoke tests may help to identify areas of the sub-drainage system that will need to be isolated during the above testing procedures and possible utilization of this system in the future as a methane mitigation system.

- Methane gas detection systems should be installed on Level F to allow warning if gas concentrations in the garage structure reach a predetermined value (e.g., 1.25% or 12,500 ppmv). Such systems would likely consist of a series of interconnected detectors mounted on the ceiling within the parking structure and enclosed spaces (e.g., storage halls, fan rooms, and sumps areas). The detector systems should be tied into the ventilation system to allow automatic start-up of the system to rapidly dissipate the methane gas in the event that methane concentrations were detected above some predetermined concentration.

- Sections of the garage floor in Level F may be replaced during construction. Floor sections around new pilings should be sealed at the completion of construction to prevent gas migration into the garage from the sub-surface. If the sub-drainage systems are damaged or interrupted during construction, these systems should be repaired to best serve as methane collection and removal conduits to the exterior of the garage.

- Additional data should be collected prior to the start of construction to better assess potential risks associated with subsurface gas, and to facilitate the development and implementation of appropriate mitigation measures.

  - Additional measurements of methane concentrations within the garage should be made in the southwest corner of the garage, where elevated concentrations of methane were found to exist below the garage floor.

  - Vertically discrete, multi-depth subsurface gas monitoring points should be installed within the proposed construction area to evaluate the distribution of methane below the garage floor. At a minimum, these probes should extend to a depth of 20 to 30 feet below the garage floor to the extent feasible. The monitoring points should be capable of evaluating gas concentrations and pressures at depth.

  - Additional information and data on the abandoned oil wells, including their approximate locations, should be obtained. One or more of the multi-depth subsurface gas monitoring points (as described above) should be placed in close proximity to the well head and monitored for gas concentrations and pressures at depth. If the abandoned wells are found to be leaking, then appropriate mitigative measures should be taken.

If you have any questions or comments on this report or our recommendations, please contact Al Bourquin at 303-383-2318 or Jay Accashian at 949-752-5452. We thank you for this opportunity to be of service to you and the Trammell Crow Company.

Sincerely,

CAMP DRESSER & McKEE INC

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Attachments:
ETI's Protocol for Soil Vapor Sampling
Interphase Chemical Analysis Report on Gas Samples
Microseeps, Light Hydrocarbon Analyses
Tables 1 through 6
Figures 1 through 5