Landfill Gas Investigation and Characterization Study
Sacramento Landfill

Prepared for **City of Albuquerque**
Albuquerque, New Mexico

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Acronyms and Technical Terms

AEHD	Albuquerque Environmental Health Department
AP-42	1995 EPA publication entitled *Compilation of Air Pollutant Emission Factors,* which provides default values for k and L_0.
bgs	below ground surface
Campbell 21X	self-contained datalogger
cf/lb-yr	cubic feet per pound per year
CH_4	methane
City	City of Albuquerque
CO_2	carbon dioxide
DBS&A	Daniel B. Stephens & Associates, Inc.
EPA	U.S. Environmental Protection Agency
ft^3/lb	cubic feet per pound
ft^3/min	cubic feet per minute
ft^3/ton	cubic feet per ton
GasTech monitor	gas monitor with built-in datalogging capability that allows for short-term, stand alone monitoring
GPS	global positioning system
H_2S	hydrogen sulfide
IDLH	immediately dangerous to life and health
k	methane generation rate constant (estimated fraction of waste that decays annually and produces methane to project annual landfill gas generation at 50 percent methane equivalent)
LandGEM	U.S. Environmental Protection Agency Landfill Gas Emissions Model
Landtec GA™-90	portable datalogging field analyzer designed to monitor methane, carbon dioxide, and oxygen.
Landtec GEM™ 500	portable datalogging field analyzer designed to analyze gas content and determine flow from LFG collection wellheads using an on-board computer to integrate nine LFG instruments
lbs/ft^3	pounds per cubic feet
lbs/yd^3	pounds per cubic yard
LEL	lower explosive limit
LFG	landfill gas

Acronyms and Technical Terms (continued)

LFG generation rate	rate at which a given landfill will produce landfill gas (influenced by the volume of waste, the percentage of degradable materials in the waste, the age of the waste, and the amount of moisture in the waste)
L_0	ultimate methane generation rate (ultimate amount of methane which a ton of refuse produces over time)
Mcf	millions of cubic feet
Mg	megagrams
NFRAP	no further response action planned (EPA designation)
NIOSH	National Institute for Occupational Safety and Health
NSPS	New Source Performance Standards
PID	photoionization detector
ppm	parts per million
ppbv	parts per billion by volume
psi	pounds per square inch
PVC	polyvinyl chloride
QA/QC	quality assurance/quality control
RFP	request for proposal
scfm	standard cubic feet per minute
SCS	SCS Engineers
Summa canister	1-liter stainless steel vessel with chemically inert internal surfaces.
TO-14	EPA-approved method for determining VOCs in ambient air using a Summa canister for sampling and gas chromatography or gas chromatography/mass spectroscopy.
Usft.	U.S. survey foot (equals 0.3048006096 meters)
VOC	volatile organic compound

Executive Summary

Executive Summary – Sacramento Landfill
Landfill Gas Investigation and Characterization Study

This report presents the findings of a study conducted for the City of Albuquerque Environmental Health Department (City) by the engineering firms of Daniel B. Stephens & Associates, Inc. and SCS Engineers (study team) between July 2001 and March 2002. The study assessed whether landfill gas is present in seven closed landfills formerly owned and/or operated by the City. The study is part of the City's effort to prevent current and future risks related to landfill gas.

The study was conducted with the primary goal of providing new information to assist future land use plans regarding properties in close proximity to the former landfills. The City has established *Interim Guidelines for Development Within 1,000 Feet of Landfills* (Interim Guidelines), which provides for City review of development plans to ensure protection of public health and safety.

The former City owned and/or operated landfills covered by this report are:

- Atrisco Landfill
- Coronado Landfill
- Eubank Landfill
- Nazareth Landfill
- Sacramento Landfill
- San Antonio Landfill
- Yale Landfill

This Executive Summary provides (1) an overview of the investigation methods used in the landfill gas study and (2) presents the results and recommendations specific to the Sacramento Landfill.

1. Overview of the Study

1.1 Landfill Gas Characteristics

Landfills have the potential to emit gases as a result of natural decomposition of the materials they contain. Landfill gas is typically composed of methane (about 50 to 60 percent) and carbon dioxide (about 40 to 50 percent). Neither methane nor carbon dioxide is toxic to humans in small amounts. However, methane concentrations between 5 and 15 percent (of the total gas in air) can create a risk of explosion. The minimum concentration that can be explosive (5 percent) is called the lower explosive limit.

Landfill gas may also contain trace amounts of toxic substances such as volatile organic compounds (VOCs), some of which are classified by the U.S. Environmental Protection Agency (EPA) as carcinogens. Hydrogen sulfide, an inorganic gas that is toxic at relatively low concentrations, can be produced in landfills from the degradation of gypsum wallboard.

The rate of landfill gas generation is influenced by the percentage of degradable materials in the waste (i.e. food, paper, lawn clippings, textiles, wood, etc.) and the amount of moisture in the waste (increased moisture causes more rapid degradation). Larger landfills with more waste have a greater potential to generate gas and present a more significant likelihood of landfill gas migrating off-site.

The study team measured gas concentrations underground at the seven former landfills to identify the potential for present and future problems. Landfill gas detected underground may never reach the surface and pose a public health threat. However, landfill gas can migrate underground, through soils or along utility corridors, and therefore can present a concern for nearby properties.

1.2 Study Methods

The study team reviewed existing documents and records about each landfill, then performed field investigations to determine landfill gas concentrations and waste characteristics. Using the data obtained, modeling was performed for each landfill to estimate current and future landfill gas generation rates.

Site History and Access

Site histories were compiled that summarize the types of materials that may have been disposed of at each landfill and the time periods during which disposal occurred. General background information was also collected on landfill boundaries, site hydrogeology, and existing development in the area.

The landfill properties have numerous public and private owners. The study team obtained formal access agreements with property owners at each site for permission to conduct field investigations.

Field Investigations

Several methods were used to determine the current and future behavior of landfill gas at each of the seven landfills studied. These methods include:

1) Landfill gas surveys using underground sampling with field and laboratory gas testing
2) Waste characterization to sample and describe waste types
3) Landfill gas pumping tests to establish site-specific gas generation rate parameters
4) Gas generation modeling to estimate the long-term gas generation potential.

The study was performed according to customary engineering practices and industry standards.

- *Landfill gas survey.* The study team performed a landfill gas survey at each site between September 10 and October 5, 2001 to establish concentrations of landfill gas. Boreholes were driven 10 feet below ground surface to collect gas samples in the underlying waste. Temporary and/or permanent monitoring probes were drilled on a grid pattern across the surface of each landfill.

  Landfill gas samples were tested in the field for methane, carbon dioxide, oxygen, and hydrogen sulfide using portable instruments. Gas samples were also submitted to a laboratory for additional testing of volatile organic compounds. A total of 163 gas sampling points were field tested during the study, and samples for laboratory testing were collected at approximately half of these sampling points. All samples were carefully collected, labeled, and transported to the laboratory for testing following established procedures.

- *Waste characterization.* A bucket auger drill rig or a backhoe was used to sample landfill materials at 12 locations. The study team maintained logs of waste composition and samples were collected for moisture content testing. Waste material decomposition rates were categorized as follows:

- Rapidly degradable – food waste
- Moderately degradable – green waste, paper, and cardboard
- Slowly degradable – wood and textiles
- Inert/inorganic – rubber, glass, metal, plastics, concrete, soil, and construction debris
- Fines/unknown – fines

- *Landfill gas pumping tests.* Multi-day landfill gas pumping tests were conducted at the two largest landfills studied (Eubank and Yale Landfills) where the gas surveys indicated relatively high landfill gas concentrations. These tests established site-specific data related to gas generation rates.

  Pumping tests indicate whether accumulated gases within a landfill consist of a limited reservoir of gas (i.e. one that can be extracted and depleted in a short time), or if gas is continually generated at a sustainable rate. The gas generation rate affects the likelihood of potential gas migration and provides information for the design of venting or containment systems, if needed.

- *Landfill gas generation modeling.* The study team estimated how much gas may be generated at each site using the EPA's LandGEM computer model. The model used various input parameters based on industry standards and site-specific data from the field investigation. Model calculations consider the volume and age of waste at each landfill as key factors in potential gas generation.

2. Sacramento Landfill Study Results and Recommendations

2.1 Landfill History

The Sacramento Landfill is located in northeast Albuquerque in the northeast quadrant of the intersection of Paseo del Norte Boulevard and I-25, bounded by Holly Avenue on the north. Currently, there is a moderate amount of development around the perimeter of the landfill. The closest building is Caliber's National Sports Shooting Center, approximately 100 feet to the east.

The site was operated as a landfill by the City in 1962, receiving mostly residential and commercial waste. The landfill is unlined and covers approximately 5 acres, with a waste depth of approximately 25 feet. Sacramento Landfill has poor drainage, and storm water from surrounding areas ponds on top of the landfill cover.

2.2 Landfill Gas Survey

The landfill gas survey at the Sacramento Landfill consisted of (1) installing 9 temporary sampling probes across the landfill, (2) testing gas samples for methane, carbon dioxide, oxygen, and hydrogen sulfide using field instruments, and (3) conducting laboratory analysis on 5 gas samples for 35 volatile organic compounds commonly found in landfill gas. The findings of this investigation included:

- *Methane concentrations ranged from 0 to 4.2 percent*. The highest concentration was slightly below the explosive limit (5 percent methane). These relatively low methane levels indicate a low potential for off-site gas migration.

- *Low levels of 13 volatile organic compounds* were detected in the gas samples taken beneath the ground surface. This volatile organic compound data will be used in further studies.

2.3 Waste Characterization

The waste characterization program was not implemented at the Sacramento Landfill due primarily to its relatively small size in comparison to the six other former landfills studied. The waste characterization results from other landfills provide useful data on typical conditions at all the former landfills.

2.4 Landfill Gas Generation Modeling

The landfill gas generation rate at the Sacramento Landfill was estimated with the EPA computer model, LandGEM, using input values based on site-specific data from the study. A range of projections were modeled using a combination of site-calibrated and “typical” landfill values. The modeling results indicate that:

- The peak year for landfill gas generation was 1963, which was one year after the landfill closed. The model indicates that landfill gas generation will continue to steadily decline as long as conditions do not change.

- The projected landfill gas generation rate in 2002 ranges from 8 to 9 standard cubic feet per minute. This is a relatively low gas generation rate for this small landfill, which indicates there is a low potential for off-site gas migration.

2.5 Recommendations

This report makes a number of recommendations as to actions that should be taken by the City. These recommendations are worded in terms of actions that should be taken by the City because the City is the party that requested recommendations. It is the City that has taken the lead in dealing with landfill gas problems. This report takes no position on whether it is properly the City's role or responsibility to deal with the concerns raised by these recommendations.

Reduce the Buffer Zone in the City's Interim Guidelines

The City could reduce the buffer zone in the Interim Guidelines provided a landfill gas monitoring plan is implemented (see recommendation below). The buffer zone can be reduced to 500 feet at the Sacramento Landfill because low levels of methane were found. Maintaining a minimum 500-foot setback distance is recommended, because the landfill is expected to continue to generate gas and pose a potential risk for the long term.

Develop a Comprehensive Landfill Management Plan

The City should consider developing a landfill management plan for the Sacramento Landfill to include:

- *Implement a landfill gas monitoring plan.* This monitoring plan should include the installation of perimeter monitoring probes spaced approximately 250 feet apart along the north, east, and south sides of the Sacramento Landfill to verify the limits of gas migration. An increased spacing of between 250 and 500 feet is appropriate on the west side of the landfill, adjacent to I-25. Methane should be monitored quarterly for at least two consecutive years at probes and selected underground utilities. If methane is not detected above safe limits for two years, the monitoring period can be extended to every six months. If elevated levels are detected, the monitoring frequency should be increased. If impervious surfaces (e.g., pavement or structures) are developed on the landfill, increased monitoring may be necessary.

- *Maintain positive drainage* across the landfill to minimize water infiltration into the waste. A site drainage study is recommended to identify improvements that may minimize methane generation. Drainage patterns around the I-25 and Paseo del Norte intersection, along local roads, and on adjacent properties should be examined.

- *Continue to require design, monitoring, and/or landfill gas abatement* as stated in the Interim Guidelines, such as directing storm water away from the landfill, sealing off underground utilities, installing venting systems beneath structures, and/or installing interior monitors in buildings.

- *Implement a landfill gas control plan* if sustained, elevated methane levels are found. Install passive or active gas control systems capable of reducing methane to safe levels.

For further detail on study methods, findings, and recommendations, please refer to the full report.

Part 1

General Section

1. Introduction

This report details the approach used to perform a landfill gas (LFG) investigation to characterize the gas generation potential of former City of Albuquerque (City) owned and/or operated landfills being studied as part of the City's Landfill Gas Investigation and Characterization study. The study is being conducted under the direction of the Albuquerque Environmental Health Department (AEHD) by Daniel B. Stephens & Associates, Inc. (DBS&A) and SCS Engineers (SCS). The purpose of the study is to determine if LFG currently exists or could be generated at former City owned and/or operated landfill sites and how LFG might impact development and the public.

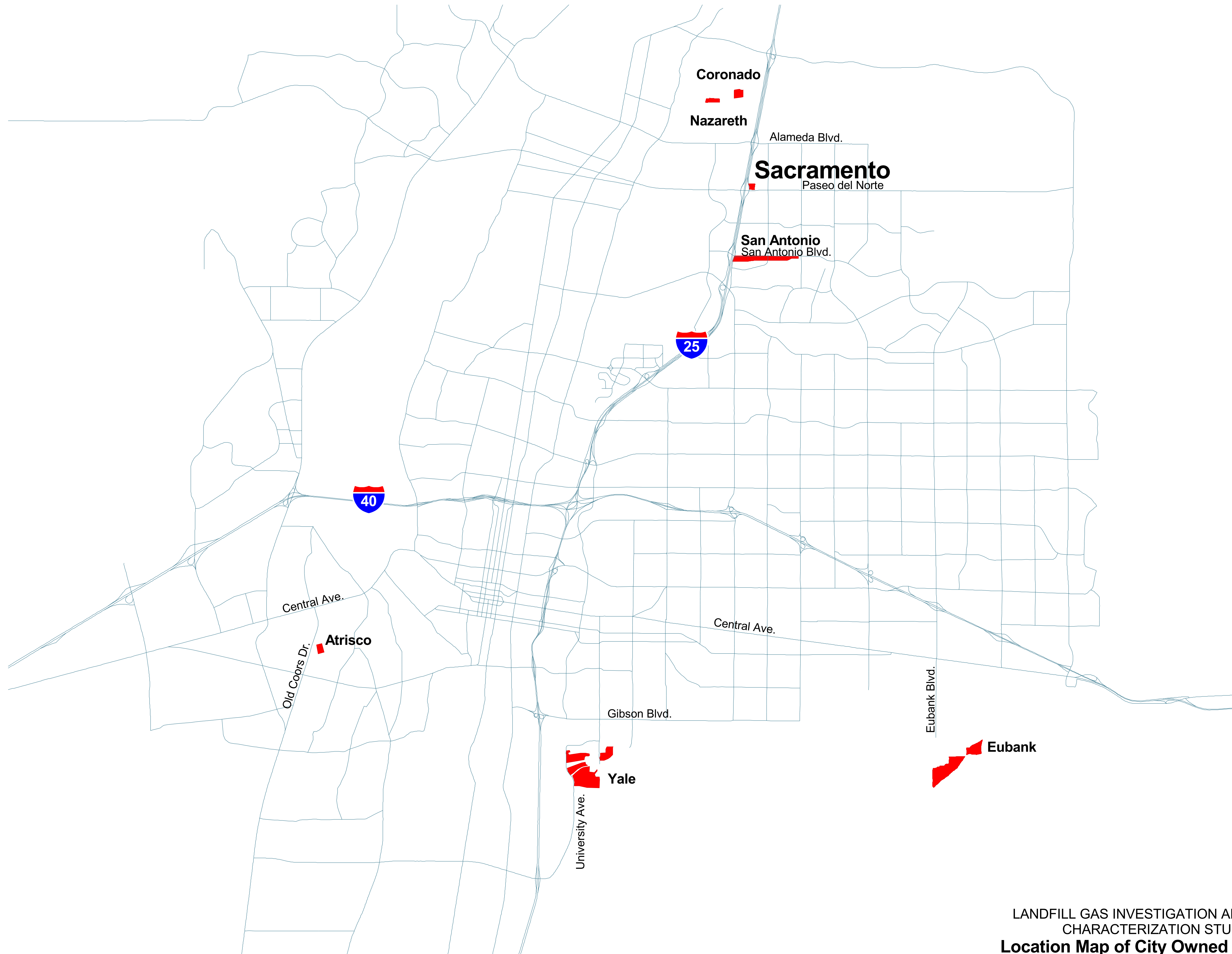
The City of Albuquerque currently has issued *Interim Guidelines for Development within 1,000 feet of Landfills.* The City's guidelines provide for review of development plans for public and private properties on or within a 1,000-foot buffer around former landfills. This includes not only City owned and/or operated landfills, but also permitted private landfills. This review is intended to ensure that appropriate landfill gas abatement measures are taken, based on the site-specific LFG conditions for a particular development. This LFG investigation and characterization study, as well as future studies, will assist the City in revising these Interim Guidelines, if needed, for each individual former City owned and/or operated landfill, and will provide planning and development guidance for future and existing development on and/or near the former City owned and/or operated landfills.

Part 1 of this report, which contains the first two sections, presents information on the overall Landfill Gas Investigation and Characterization study, which includes seven former City owned and/or operated landfill sites located within the City and Bernalillo County (Figure 1). These seven sites include:

- Atrisco Landfill
- Coronado Landfill (north cell only)
- Eubank Landfill
- Nazareth Landfill
- Sacramento Landfill

City of Albuquerque Zone Atlas Map

Landfill	Page
Atrisco	K-11
Coronado	B-18
Eubank	M-12
Nazareth	B-17
San Antonio	E-18
Sacramento	C-18
Yale	M-15



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Explanation

Landfill

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LANDFILL GAS INVESTIGATION AND
CHARACTERIZATION STUDY

Location Map of City Owned or Operated Landfills Studied

Figure 1

- San Antonio Landfill
- Yale Landfill

Components of the investigation include a LFG survey, waste characterization study, and LFG gas pump tests. Part 2 of this report presents the landfill-specific field investigation methods and results for the Sacramento Landfill. Results from individual landfill investigations were combined with modeling results and formed the basis for the conclusions and recommendations presented at the end of this report.

1.1 Composition and Measurement of Landfill Gas

LFG is composed primarily of methane (CH_4) and carbon dioxide (CO_2), naturally occurring byproducts of waste degradation that are not considered toxic to humans. Waste degradation occurs when organic landfill materials are exposed to moisture. The amount of methane generated by waste degradation depends on a number of factors, but primarily on the amount of water exposed to the organic waste under anaerobic (no oxygen) conditions.

Methane is a concern because concentrated accumulations of methane can be explosive and can displace oxygen, which may lead to asphyxiation. LFG can also carry trace concentrations of other gases with potential toxicity concerns. The most significant trace gases carried by LFG are volatile organic compounds (VOCs), some of which are classified by the U.S. Environmental Protection Agency (EPA) and other national public health organizations as carcinogens. In addition, LFG may include hydrogen sulfide (H_2S), an inorganic gas that can be toxic at relatively low concentrations, and is produced in landfills primarily from the degradation of gypsum wallboard.

Pure LFG within waste disposal cells typically contains approximately 50 to 60 percent methane and 40 to 50 percent carbon dioxide. LFG may also be diluted with air in the subsurface, which reduces methane and carbon dioxide concentrations and adds oxygen and nitrogen. Natural atmospheric barometric pressure changes, otherwise known as barometric pumping, mix air into the soil, and closed landfills that are covered with relatively permeable soil may have significant gas exchange with the atmosphere. This barometric pumping both dilutes the LFG deeper in the subsurface and oxygenates the soil gas. Through this process, methane breaks down in the subsurface and is prevented from reaching the shallow soils or the atmosphere.

Methane gas concentrations are measured using one of two reporting scales: (1) as a percentage of methane gas in the total gas or simply "percent", or (2) as a percentage of the lower explosive limit (LEL). The LEL for methane is equivalent to 5 percent methane gas in atmospheric air, which contains approximately 20 percent oxygen. The upper explosive limit is 15 percent methane in air. Methane is explosive only in the range of 5 to 15 percent and is not explosive if methane concentrations exceed 15 percent or if oxygen is depleted. In this report, methane and other gas constituents are reported as percent of total gas, and the methane concentration is referred to as being above or below the LEL, depending upon whether the methane concentration exceeds 5 percent total gas. A methane concentration of 100 percent of the LEL is the lower range of methane that will explode.

1.2 Landfill Gas Standards

Standards for allowable levels of LFG have been established to avoid explosion hazards. LFG can accumulate in enclosed structures and migrate away from the landfill through soils and along subsurface utility corridors. The rate of LFG generation is influenced by the percentage of degradable materials in the waste (i.e. food, paper, lawn clippings, textiles, wood, etc.) and the amount of moisture in the waste. Larger landfills with more waste have a greater potential to produce LFG and present a more significant likelihood of off-site LFG migration. The City of Albuquerque Fire Marshall's standard requires that methane concentrations must not exceed 10 percent of the LEL (0.5 percent) in an occupied structure.

Additional standards address the potential toxic hazard associated with VOCs and H_2S that may be present in LFG. Relatively low concentrations of certain gases, in the parts per million (ppm) range, may be a concern for human exposure. Allowable exposure limits for workers are published in a guide sponsored the National Institute for Occupational Safety and Health (NIOSH). These standards are not intended to protect non-workers against short- or long-term exposure, but may be used as an available guideline to evaluate potential hazards posed by trace gases in LFG.

The NIOSH guide provides standards for exposure limits to many VOCs that can be present in LFG. The NIOSH guide indicates a long-term permissible exposure limit for hydrogen sulfide of 10 ppm for workers. The guide also indicates that a hydrogen sulfide concentration of 300 ppm is immediately dangerous to life and health (IDLH). These NIOSH standards may be used as a guide to consider the relative toxicity of various trace gases that can be carried with LFG.

The results of the VOC sampling at each of the landfills indicate whether or not these trace gases exist below the ground surface of the landfills. However, the results obtained do not provide a basis to determine whether these values are toxic to the public, since it is unknown how these gases will migrate to the surface or how they may degrade and become diluted as they migrate up to the surface.

1.3 Future Land Use Considerations

Final land use plans are an integral part of landfill closures, and considerable work has been done across the country to complete landfill closures in a manner that provides for safe development of closed landfill sites. Development of closed landfills has included parks, industrial development, golf courses, and open space. The solid waste management industry in the United States has devised technologies to develop closed landfill sites in a manner that is protective of human health and safety and the environment.

Many of the significant issues concerning the development of a closed landfill are related to structures and facilities that are built directly on the closed landfill disposal cells. The following issues are generally addressed in developing a closed landfill:

- *LFG accumulation in enclosed structures*. LFG consists primarily of methane and carbon dioxide. If allowed to accumulate within a confined area in the presence of an ignition source, methane can explode if the concentration exceeds 100 percent of the LEL (5 percent). Development must prevent the potential for accumulation of explosive methane concentrations within buildings and smaller enclosures such as light poles, fence posts, and utility corridors and vaults.

- *Settlement of waste that affects structures built on the landfill*. Permanent structures and utilities must be designed in a manner to account for differential settlement that occurs as landfill waste degrades and consolidates over many years.

- *Infiltration of water into the landfill as a result of precipitation and irrigation*. The infiltration of water into a landfill from irrigation or precipitation must be minimized to prevent generation of leachate that can contribute to groundwater contamination. An increase in moisture content of the waste can also cause accelerated generation of LFG. Synthetic membranes or earthen covers are often used to cover landfills to prevent infiltration of precipitation/irrigation water into the waste. Landfill covers should also be graded to maintain positive drainage at all times.

By ensuring that these issues are addressed, development has been completed safely at many closed landfill sites.

2. Technical Approach

The technical approach for the landfill gas investigation and characterization project is described in this section. Several tasks were conducted including:

- Review of records on site history
- Obtaining permission for site access to landfill property
- LFG survey using push-probe sampling with field and laboratory gas testing
- Drilling waste characterization borings to characterize waste types
- LFG pumping tests to establish site-specific gas generation rate parameters
- LFG generation modeling to estimate the long-term gas generation potential

This section presents the methodology used for these tasks. Field investigation methods to implement the technical approach are provided in Section 4, and results are provided in Section 5.

2.1 Site History Records Review

The site history of each former landfill was obtained through a review of available records related to the landfill's operating history and previously completed investigations. Sources of data for this section were compiled by AEHD and include reports and files prepared by various organizations. A primary source of data was a report entitled *Past and Present Solid Waste Landfills in Bernalillo County, New Mexico* (Nelson, 1997), which focused on all seven landfills covered in the present study, as well as other private landfills not owned or operated by the City. Nelson's report provided details on the general backgrounds of the landfills including site history, landfill operational data, and site hydrogeology. Most importantly, Nelson (1997) carefully considered the landfill boundaries using past records such as aerial photographs and more recent on-site observations. These boundaries were used in the current investigation and are presented in the site maps included in this report.

2.2 Site Access

The seven former landfills being investigated have numerous landowners, and most are subdivided into several parcels under different ownership. The majority of properties are privately owned, with some public owners including the City of Albuquerque and the New Mexico State Land Office. The first task in arranging the LFG survey was to establish formal access agreements with property owners at each landfill to ensure access for field investigation.

Site access activities were initiated by obtaining zone atlas pages and identifying lots within the boundaries of the seven landfills. Property owners were identified using the Bernalillo County Tax Assessor's website in conjunction with the City of Albuquerque website. Information gathered from these websites was confirmed at the Bernalillo County Tax Assessor's office because the websites are updated only on an annual basis. Therefore, any changes in property ownership that had occurred during 2001 could be found only in the tax assessor's database at the County Assessor's office.

Once ownership was determined, formal access agreements were requested from property owners at each landfill to allow access for field investigation. Information gathered from the tax assessor's records was entered into a database and written access agreements were sent to each property owner for signature.

2.3 Landfill Gas Survey

A LFG survey was performed to establish the existing concentration of LFG at each of the seven former landfills. The survey fieldwork was conducted during September 10 to October 5, 2001. The LFG survey involved collection of LFG samples using a probe driven 10 feet below ground surface (bgs), through the landfill cover and into the underlying waste. The survey was performed using temporary and/or permanent probe installations distributed across each landfill and in selected off-site locations. LFG samples were tested in the field using portable instruments, and samples were also collected and submitted to a laboratory for additional testing.

Sampling was performed on a grid pattern submitted to and approved by the City prior to sampling. Sampling locations were staked/marked using global positioning system (GPS) survey equipment. This survey method allowed for efficient sampling point identification during the LFG survey and provided the ability to make adjustments in the field. The sampling grids at the landfills were based on the following general spacing and adjusted to fit the landfill configuration.

• Atrisco Landfill	200 x 200-foot grid
• Coronado Landfill	200 x 200-foot grid
• Eubank Landfill	400 x 400-foot grid
• Nazareth Landfill	200 x 200-foot grid
• Sacramento Landfill	200 x 200-foot grid
• San Antonio Landfill	200 x 200-foot grid
• Yale Landfill (northern, central, and hotel areas)	200 x 200-foot grid
(southern area)	400 x 400-foot grid

LFG samples were collected at each landfill location using a hydraulically driven, truck-mounted geoprobe. ESN Rocky Mountain, of Golden, Colorado was retained by DBS&A to perform the gas probe drilling at all of the landfills. In addition, Geo-Test, Inc. of Albuquerque was retained to provide a four-wheel drive drill rig to access steep terrain at the Yale Landfill for installation of seven gas probes. Temporary gas probe installations used a small-diameter drive probe to penetrate the landfill cover and allow LFG extraction and sampling from the underlying waste. At certain locations, where the City intends to conduct additional monitoring, permanent monitoring probes were installed. Details of the gas probe installation methods are provided in Section 4.3.

At each probe installation, several field instruments were connected in a sampling train to test for LFG constituents. The sampling train (Figure 2) consisted of a Landtec GA™-90 infrared gas analyzer, a hydrogen sulfide meter, and a Summa canister connection valve to facilitate the collection of VOC samples for laboratory analysis. The Landtec GA™-90 was used to measure concentrations of methane, carbon dioxide, and oxygen as well as LFG pressure and

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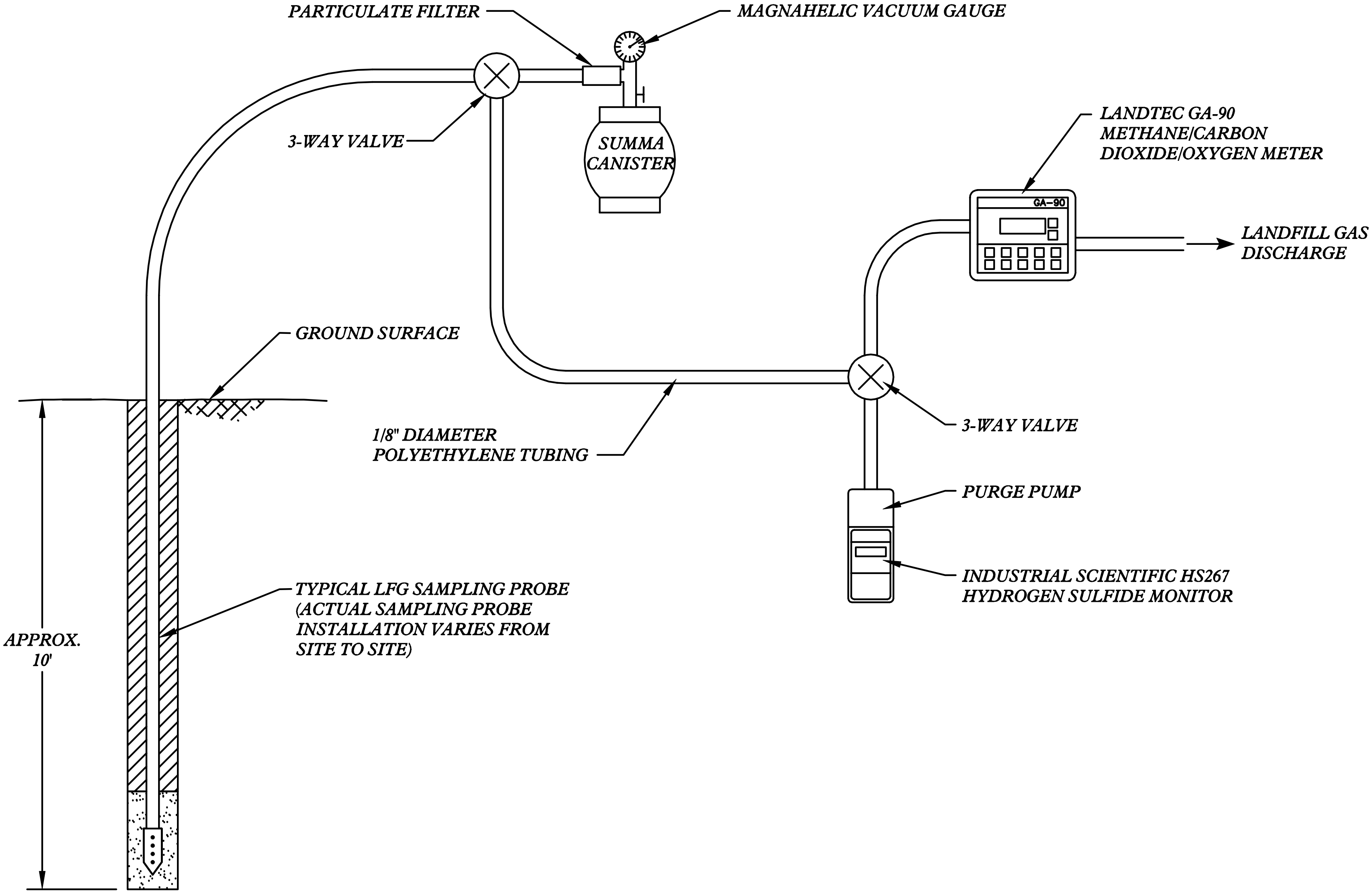

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Figure 2

LANDFILL GAS INVESTIGATION AND CHARACTERIZATION STUDY

Landfill Gas Survey Sampling Train Detail

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atmospheric pressure. Calibration of field instruments was performed daily during the survey, using bottled calibration gas with standard gas concentrations.

The LFG static pressure is measured relative to atmospheric pressure; negative readings indicate a pressure lower than atmospheric and positive readings indicate a pressure greater than atmospheric. These pressure measurements show the influence of barometric pumping (Section 1.1). At the time a given sample is collected, negative LFG pressure indicates that atmospheric air has a tendency to move downward through the landfill cover. Positive LFG pressure indicates that LFG has a tendency to move upward through the landfill cover. LFG static pressures tend to be negative in the morning hours when atmospheric pressure is rising and neutral or positive in the mid to late afternoon when atmospheric pressure is falling.

LFG samples were collected for laboratory analysis in accordance with AEHD's guidance regarding the number, and for some landfills, the location of sampling sites. Samples for VOC analysis were collected from all seven landfills studied. Additional samples were collected for laboratory analysis of methane, carbon dioxide, oxygen, and nitrogen for quality assurance/quality control (QA/QC) purposes. These QA/QC samples were collected in duplicate on 5 percent of the samples tested with field instruments.

Samples for laboratory analysis were collected by attaching a Summa canister to the sampling train ahead of the field instruments (Figure 2). The entire sampling train was then purged while the field parameters were measured. Once the purge was complete and stable readings were measured, the valve on the Summa canister was opened, allowing the canister to fill with LFG. Samples were sent to Air Toxics Ltd. in Folsom, California, where they were analyzed for 35 of the most commonly found LFG constituents using a modified version of the standard test for toxic organics at ambient air temperature (TO-14 test). Samples for QA/QC purposes were analyzed by U.S. EPA Method 3C. Chain-of-custody forms provided by the laboratory were filled out and signed by DBS&A's field technician and submitted with the samples.

2.4 Waste Characterization Analysis

A waste characterization program was implemented to determine whether the former landfills contain decomposable materials that may continue to produce LFG in the future. Waste characterization describes the type of waste present, its current state of decomposition, and its moisture content. These waste characteristics identify both the degree of degradation that has occurred since waste deposition and the potential for further waste degradation.

2.4.1 Waste Sampling, Testing, and Monitoring

Waste characterization exploration was conducted by drilling with a large-diameter bucket auger or excavating a test pit with a backhoe. Koda Drilling, Inc., of Grapevine, Texas, was retained by DBS&A to drill bucket auger borings at four of the landfills in the study (Coronado, Eubank, San Antonio, and Yale). Rodgers Environmental, Inc., of Albuquerque, was retained to excavate a test pit at the Atrisco Landfill. Waste characterization was not performed at the Nazareth Landfill, which is under City ownership, or at the Sacramento Landfill, which is the smallest landfill in the study.

Key elements conducted during the waste sampling task were:

- Documentation of drilling and excavation
- Preparation of waste logs
- Gas monitoring for health and safety
- Collection of waste samples for moisture content analysis
- Characterization of waste into waste types and degradability categories

All sampling activities were observed and logs were prepared that contained specific waste data such as odor, color, temperature (when available), organic content, and general material description of the waste samples. The temperature of the debris retrieved from the borehole was recorded by inserting either a standard thermometer or a probe-mounted thermocouple connected to a Campbell 21X datalogger.

A GasTech gas monitor (Model 90) was used to monitor levels of hydrogen sulfide and methane for health and safety purposes of the drill crew and field staff. All air monitoring results were below the short-term health and safety thresholds of 15 ppm for hydrogen sulfide and 5 percent for methane. A photoionization detector (PID) was also used to monitor for the presence of VOCs. All readings were collected from the breathing zone.

2.4.2 Degradation Rates

Waste material from each waste characterization boring was observed, categorized, and percentages assigned. Examples of the waste categories used include:

- Food waste
- Wood
- Metal
- Green waste
- Rubber
- Plastics
- Paper
- Textiles
- Concrete
- Cardboard
- Glass
- Soil

Percentages were assigned to each waste category by volume, according to what was observed during the removal of the waste from the borehole or excavation pit. The percent volume was then converted to percent weight using the average densities provided by Peavy, et al. (1985) After the weight percentages were calculated, decomposability ratings were estimated. The waste types listed above were divided into the following subjective categories:

- Rapidly degradable – food waste
- Moderately degradable – green waste, paper, and cardboard
- Slowly degradable – wood and textiles
- Inert/inorganic – rubber, glass, metal, plastics, concrete, and construction debris
- Fines/unknown – soil and fines

2.4.3 Moisture Content Analysis

Samples were collected for moisture content testing from the waste characterization borings that recovered substantial waste (Yale, Eubank, Atrisco, and San Antonio). Soil and other inert materials such as concrete encountered during drilling were not sampled for moisture content. Moisture content samples were collected only from the degradable portion of waste, since this is the only component of the waste stream that will have the potential to generate landfill gas.

Samples were selected at varying depths in the upper, middle, and bottom of each waste boring. The samples were placed in 5-gallon buckets with sealed lids and transported to the DBS&A Hydrologic Testing Laboratory in Albuquerque for moisture content analysis. The samples were labeled with a unique identification number indicating the date, time, and depth of each sample. Chain-of-custody was maintained and documented from the time of sample collection to completion of analyses.

2.5 Landfill Gas Pumping Tests

The purpose of pumping tests is to indicate whether the accumulated LFG within a landfill is a limited reservoir of gas (i.e., one that can be extracted and depleted in a short time) or whether high rates of gas generation will continue to replenish the gas extracted by pumping. The gas generation rate affects the likelihood of off-site LFG migration. During the multi-day pumping test, the rate of gas generation was estimated by observing whether LFG concentrations and flow rates were sustained during long-term extraction or whether LFG concentrations declined substantially after the initial reservoir of accumulated LFG was removed.

As part of this study, LFG pumping tests were conducted only at the two largest landfills studied (Yale and Eubank), in portions of the landfills where the LFG survey indicated relatively high LFG concentrations. For the Yale Landfill, the pump test was conducted from December 27, 2001 through December 30, 2002. For the Eubank Landfill, the pump test was conducted from January 4, 2002 through January 8, 2002. These tests were conducted to establish site-specific data pertaining to LFG generation for these two Albuquerque landfills. The data was used as a check on the validity of the LFG generation model used to estimate LFG generation for all seven landfills studied.

The LFG pumping tests were conducted by installing a LFG extraction well and three pressure monitoring probes at both the Eubank and Yale Landfills. Koda Drilling, Inc., of Grapevine, Texas, installed the extraction wells at the Eubank and Yale Landfills within one of the bucket auger borings drilled for waste characterization sampling. Rodgers Environmental, Inc. was retained by DBS&A to drill and construct three monitoring probes at each landfill using a hollow-stem auger drill rig.

LFG was pumped from the extraction well with a blower powered by an electric generator. Vacuum was measured in the three pressure probes installed at distances of 50, 100, and 200 feet from the extraction well. By monitoring the pressure drop resulting from LFG pumping, the radius of influence of the pumping well can be determined. Based on the LFG extraction rate and radius of influence, site-calibrated LFG generation input parameters were calculated for use in modeling LFG generation rates, as discussed in Section 2.6.

2.6 Landfill Gas Generation Modeling

Landfill gas generation projections were performed for each landfill evaluated in this study. Several input variables were assessed and used in the LFG generation estimations. The volume of in place waste at each landfill is a primary input variable and varying this number greatly influences the projected LFG generation rate. Another key factor in the estimation of LFG generation is the age of the in-place waste. Numerous information sources were used to determine the modeling input parameters, to provide for valid estimates of the expected range of LFG generation rates. Landfill gas generation projections were performed up to year 2020. Beyond 2020, the accuracy of the model declines without more recent site-specific data. The site-specific LFG generation model input and results are described in Section 5.

LFG generation was estimated using SCS's spreadsheet version of the EPA's Landfill Gas Emissions Model (LandGEM). LandGEM is a first-order decay model required by the EPA to be used for New Source Performance Standards (NSPS) evaluations, Title V permitting, and other

Clean Air Act permitting projects. This model is the industry recognized standard for predicting LFG generation rates. SCS has converted the LandGEM model to an Excel spreadsheet format for ease of use. LandGEM uses (1) annual waste disposal rates, (2) the ultimate amount of methane which a ton of refuse produces over time (ultimate methane generation rate or "L_0" value), and (3) the estimated fraction of waste that decays annually and produces methane (the methane generation rate constant or "k" value) to project annual LFG generation at 50 percent methane equivalent.

2.6.1 LFG Model Inputs: Annual Waste Disposal Rates

Information used to establish the waste disposal history needed as input for LFG models was obtained from the following sources:

- Information provided by the City of Albuquerque in Appendix C of the Request for Proposals (RFP) for the current project, including site acreage, refuse depths, and years that the landfill was open for disposal.
- Historical documents provided by the City of Albuquerque, which include reports documenting the results of field investigations and other prior studies with information relevant to waste disposal at the landfills.
- The present study, including drawings that define landfill areas, and field investigations to determine the locations, composition, and moisture content of refuse.

Based on data from previous studies and this field investigation, certain assumptions were made regarding the size, average soil cover thickness, average refuse thickness, and estimated volume and weight of refuse at the landfill.

Some of the landfills studied contain more than one disposal cell. In particular, the Yale Landfill is divided into four cells and the Eubank Landfill is divided into two cells. Other landfills may be divided into individual cells, although the configuration of cells is unknown. Detailed information on the age, acreage, and depth of the waste in individual waste cells is unavailable for the landfills studied. As a result, each landfill was modeled to estimate the total LFG production from the entire waste mass.

2.6.2 LFG Model Inputs: Ultimate Methane Generation Rate (L_0)

The L_0 value is estimated based on information from the following sources:

- U.S. EPA's estimated default (AP-42) L_0 value for dry landfills (EPA, 1995).

- The SCS default L_0 value, which is based on the SCS LFG database. This database includes actual LFG recovery data from over 100 U.S. landfills, representing over 300 years of flow data. The data indicate that the L_0 value is influenced by moisture and provide a correlation between average annual precipitation and the L_0 value.

- Waste characterization data, which include information on degradability categories (percentage of waste that is rapidly degradable, moderately degradable, etc.) and moisture content. The characteristics of wastes at each landfill were compared to the typical waste characteristics of landfills in the U.S. to estimate the likely effects of any deviation from average landfill conditions on the L_0 value.

Waste characterization data were generated for the landfills where waste borings and test pits were excavated (Atrisco, Coronado, Eubank, San Antonio, and Yale Landfills). At the Nazareth and Sacramento Landfills, where waste characterization was not studied, only default values were available.

2.6.3 LFG Model Inputs: Methane Generation Rate Constant (k)

The k value was estimated based on the following information sources:

- U.S. EPA's estimated default (AP-42) k value for dry landfills (EPA, 1995).

- The SCS default k value, which is based on the SCS LFG database. Data in this database indicate that the k value is strongly influenced by moisture, and provide a correlation between average annual precipitation and the k value.

- Results of the field evaluation of the moisture content of waste samples from the landfill under investigation. The moisture content of the sampled waste was compared to the moisture content of typical U.S. waste to estimate the likely effects of a significant variation from average refuse moisture content on the k value.

Waste moisture content data were generated from waste characterization sampling at the Atrisco, Eubank, San Antonio, and Yale Landfills. At the Coronado, Nazareth, and Sacramento Landfills, waste moisture was not studied through field testing, and only default values were available.

2.6.4 LFG Generation Projections

Multiple LFG model runs and resulting LFG generation projections were prepared for each landfill to cover the range of possible LFG generation rates. These included projections to delineate potential minimum and maximum LFG generation, and to estimate the effect of increasing moisture at selected landfills. The LFG generation projections used the following variables:

- EPA default (AP-42) projection using the default values for L_0 and k (EPA, 1995).

- The SCS default projection using the SCS precipitation-based values for L_0 and k.

- Site-calibrated projection(s) using the L_0 and/or k values derived from analyses of field data.

- Modified site-specific projection that uses the L_0 and k values derived from analyses of field data, but also shows the potential effects of adding moisture on LFG generation.

LandGEM simulates increased LFG generation rates when the waste moisture is increased. A projection with added moisture was modeled for the larger landfills in the study (Yale, Eubank, and San Antonio), where relatively high overall LFG generation rates are expected because of the large amounts of solid waste. A projection with added moisture was also modeled for the Sacramento Landfill, because this landfill has very poor drainage and is at a low topographic level that collects storm water runoff from surrounding areas. The added moisture scenario was not examined for the smaller landfills with positive drainage and/or no detection of methane during the LFG survey (Atrisco, Coronado, and Nazareth), because the added moisture would simulate a relatively small change in LFG generation.

LFG generation rates are adjusted to 50 percent methane content (standard normalization procedure) to reflect the typical methane content of LFG as it is generated.

2.6.5 Model Validation

Model validation of LandGEM is provided by the results of the LFG pumping tests conducted at the Eubank and Yale Landfills. These tests provided site-calibrated k values based on actual measurements of LFG production. The calibrated k values for Eubank and Yale were found to be consistent with k input parameters assigned through default values for the Albuquerque region. The consistency between pumping test results and regional default values for these two Albuquerque landfills support the application of the model to other landfills investigated in this study where no pumping tests were conducted. Adjusting LandGEM input parameters to reflect site-specific conditions for the remainder of the landfills should then provide reasonable estimates of the LFG generation rate.

The pumping test results for Eubank and Yale indicated the range of k values appropriate for the Albuquerque region and guided the adjustment to the k values made for these landfills based on waste moisture content. At the Atrisco and San Antonio Landfills, where no pumping tests were conducted, site-calibrated k values were assigned based on site-specific testing for the waste moisture content. At the Sacramento Landfill, which is characterized by storm water ponding and poor site drainage, a modeling scenario was analyzed using a k value adjusted upward from the default value to reflect a probable elevated waste moisture. For Coronado and

Nazareth Landfills, where neither pumping test nor waste moisture content results were obtained, the default k input values are expected to provide for reasonable estimates of the LFG generation rate using LandGEM.

Site-calibrated L_0 values were assigned by adjusting the regional default L_0 based on the percentage of degradable waste determined from waste characterization studies (Atrisco, Coronado, Eubank, San Antonio, and Yale). At the Nazareth and Sacramento Landfills, where waste characterization was not conducted, the default L_0 values were used to provide reasonable estimates of the LFG generation rate using LandGEM.

Part 2

Landfill-Specific Section

3. Site Background and Previous Investigations

The Sacramento Landfill is located in northeast Albuquerque in Zone C-18 at the northeast intersection of Paseo del Norte Boulevard and I-25 (Figure 1). Holly Avenue forms the northern boundary of the landfill. Currently, there is a moderate amount of development around the perimeter of the landfill. The closest building to the Sacramento Landfill is Caliber's National Sports Shooting Center approximately 100 feet east of the landfill (Figure 3).

The site was a borrow pit that was filled in as a landfill by the City in 1962. The site is unlined and covers approximately 5 acres, with a waste depth of approximately 25 feet. Maximum waste depth is reported to be 26 feet based on waste borings performed by AGRA Environmental, Inc. (Nelson, 1997). Waste appears to be deeper on the western two-thirds of the site. The material placed at the site was mainly residential and commercial waste (Nelson, 1997).

Cover material at the landfill consists mainly of silty sands up to several feet thick. During visual inspection of the site, waste was seen protruding through the cover in some areas. This is likely due to thin cover in those areas, as illegal dumping does not appear to be occurring at this landfill. Cover vegetation appears to be moderate and relatively healthy.

The landfill is currently a low spot that collects storm water from surrounding land and drains west through a culvert that runs under I-25. Because of the extensive depressions resulting from waste settlement and the permeability of the cover material, it is assumed that a significant quantity of water flowing across the site ponds and infiltrates into the waste below.

The Sacramento Landfill is located in the alluvial sediments of the Rio Grande. These terrace deposits consist of medium- to fine-grained sand and are underlain by a thick sequence of river sediments that grade from fine sand to gravel and boulders. Depth to groundwater is approximately 250 to 300 feet bgs, and groundwater flow is primarily southeast (COA, 2002).

Several geotechnical and LFG studies have been performed in and around the landfill. Waste boring activities and landfill gas testing at the Sacramento Landfill were conducted by Fox &

Source:
1999 Aerial photograph provided by Bernalillo County

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Explanation

- Sampling probe locations
- Sampling probe/lab sample locations
- Parcels
- Landfill boundary

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LANDFILL GAS INVESTIGATION AND CHARACTERIZATION STUDY
Sacramento Landfill Test Locations

Figure 3

Associates of New Mexico, Inc. in 1984. Methane concentrations were measured in the range of 1 to 10 percent (Fox, 1985). Fluor Daniel completed a site inspection report for the EPA in 1992. Subsequently in 1993, a Superfund Site Strategy Recommendation report was issued by the EPA awarding the site a “Site Evaluation Accomplished” status. This means the landfill was given the designation of “No Further Response Action Planned” (NFRAP) under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (Terracon, 1995).

In 1994, AGRA Earth and Environmental, Inc. performed exploratory borings for the purposes of developing a commercial building on the landfill. Four of the borings encountered waste (paper, plastic, and glass) to depths of 10 to 20 feet below existing grade with silty sand cover soils overlying the waste (AGRA, 1994). In 1995, Terracon Consultants Western, Inc. also performed geotechnical borings and prepared a site characterization report for the Sacramento Landfill. Terracon found that the cover ranged in thickness of approximately 1.5 to 5 feet and was composed of silty to clayey sands. Maximum depth of waste at the landfill was approximately 27 feet and typical waste encountered was metal, plastic, paper, wood, and miscellaneous debris (Terracon, 1995).

4. Field Investigation Methods

The field investigation methods used at the Sacramento Landfill are described in this section. The field investigation tasks included:

- Obtaining permission for site access to landfill property
- Clearing underground utilities prior to subsurface investigation activities
- LFG survey using push-probe sampling with field and laboratory gas testing

Sections 4.1 through 4.3 present the detailed methodology used for these tasks at the Sacramento Landfill.

4.1 Site Access

Based on records from the City of Albuquerque and the Bernalillo County Tax Assessor's Office, the property owner at the Sacramento Landfill was identified. An access agreement was obtained from the property owner to allow access for the LFG investigation and characterization field activities.

4.2 Utility Survey

Before the investigation commenced, New Mexico One Call was contacted to ensure that no utilities would be encountered during subsurface work. Information provided by New Mexico One Call indicated that no utilities would be encountered during subsurface activities within the landfill boundaries. Existing utilities in the area appear to be outside the landfill boundaries, along the shoulders of Paseo del Norte and the I-25 access road.

4.3 Landfill Gas Survey

LFG sampling locations at the Sacramento Landfill are shown in Figure 3. The sampling grid at the Sacramento Landfill was established at approximately 200 x 200-foot spacings, with adjustments made to fit the specific configuration of the landfill. Nine sampling locations were established across the landfill surface.

At the Sacramento Landfill, a geoprobe drill rig was used to drive a 1-inch-diameter, hollow drive probe to a depth of approximately 10 feet bgs (see photographs, Appendix C). Probe installations involved driving a sacrificial tip to the specified depth, followed by retracting the probe a few inches. The upward pull allowed the sacrificial tip to drop off the probe and enabled gas to enter the end of the probe. The gas was then drawn into the sampling train through polyethylene tubing (⅛-inch diameter) attached to the end of the drive probe. LFG samples were collected and analyzed as discussed in Section 2.3.

4.4 Waste Characterization Analysis

At the Sacramento Landfill, the waste characterization program was not implemented, primarily because of the relatively small size of this landfill in comparison to the other six former landfills investigated under this study. The results from the waste characterization analyses completed at five other landfills as part of this project provided useful data on the typical conditions at all the former landfills. Therefore, the Sacramento Landfill was a relatively low priority for waste characterization sampling.

5. Results

Results of the LFG investigation and characterization study of the Sacramento Landfill are presented in this section. The results include the following:

- LFG survey results for methane, carbon dioxide, oxygen, VOCs, and hydrogen sulfide
- LFG generation modeling results

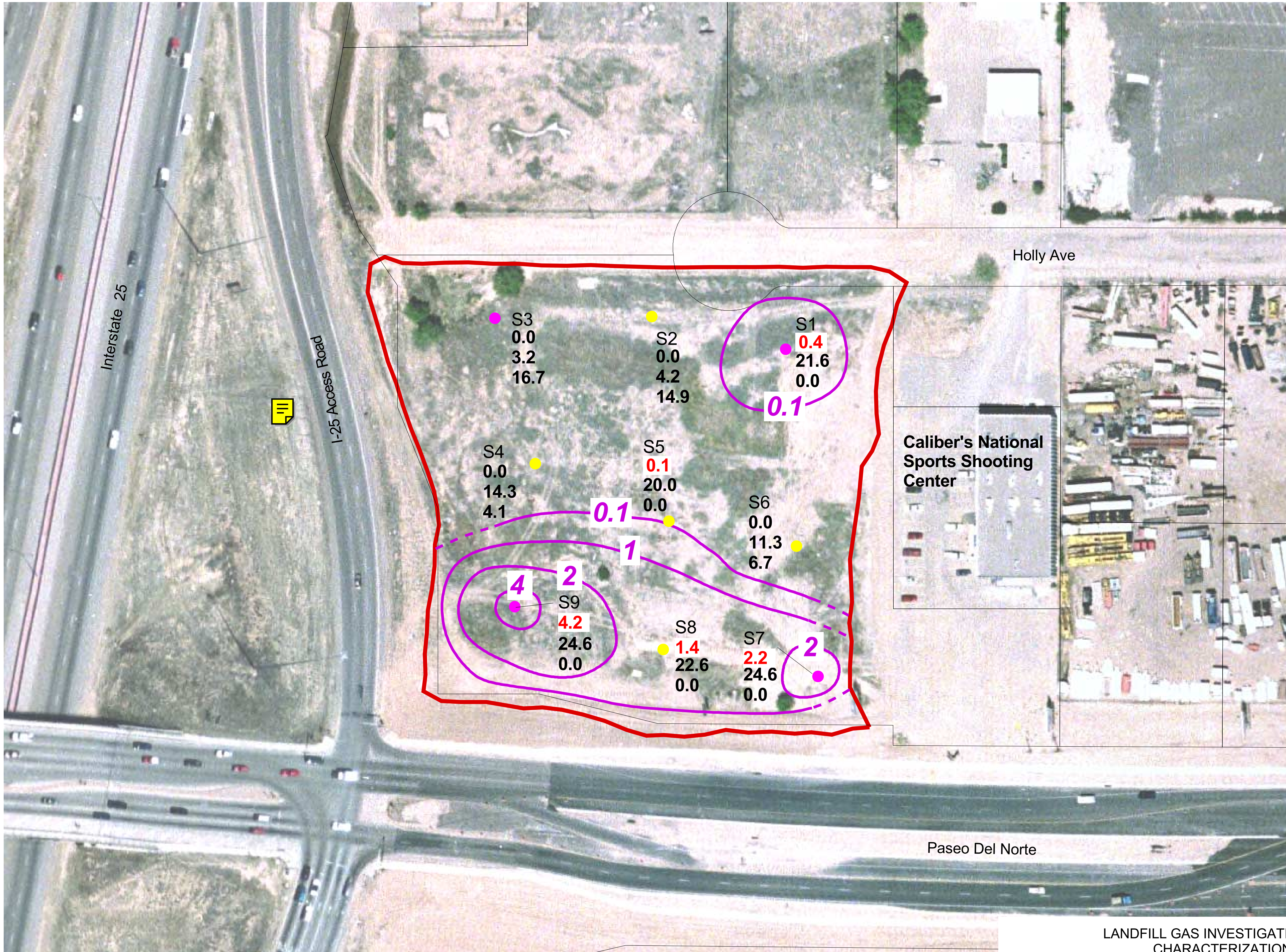
These items are addressed in Sections 5.1 through 5.3.

5.1 LFG Survey Field Analysis Results

A methane concentration map is presented in Figure 4 to graphically show the LFG concentrations at the Sacramento Landfill. The map displays numeric results for methane, carbon dioxide, and oxygen concentrations. Results of the LFG survey of the Sacramento Landfill are also summarized in Table 1.

Methane concentrations at the Sacramento Landfill were below the LEL, ranging from 0 to 4.2 percent (Table 1, Figure 4). The highest methane concentration detected was equivalent to 84 percent of the LEL. The highest concentrations of methane were detected in the southern portion of the landfill. Carbon dioxide was elevated and oxygen was depressed over most of the Sacramento Landfill, showing evidence of waste degradation.

The methane accumulation observed at the Sacramento Landfill may be caused in part by storm water run-on that flows onto the landfill from surrounding land. The southern portion of the landfill, where elevated methane concentrations were found, receives storm water runoff from the embankment along the north side of Paseo del Norte (culverts located on the western side of the landfill allow some of the storm water to drain off-site beneath I-25). The elevated methane concentrations appear to correspond to the drainage pathway of Paseo del Norte storm water run off to the culverts on the landfill. The remainder of the Sacramento Landfill appears to be relatively free of methane.



Source:
1999 Aerial photograph provided by Bernalillo County

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0 100 ft

Explanation

- Sampling probe locations
- Sampling probe/lab sample locations
- Parcels
- Landfill boundary
- –2– Methane concentration contour (%), dashed where inferred
- 0.4 Methane (%)
- 21.6 Carbon dioxide (%)
- 0.0 Oxygen (%)

Note:
Methane concentrations of 0.0 are shown in black text

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LANDFILL GAS INVESTIGATION AND CHARACTERIZATION STUDY
Sacramento Landfill Gas Survey Results

Figure 4

Table 1. Landfill Gas Survey Results
Sacramento Landfill

Sampling Point	Date	Time	Methane Concentration (%)	Carbon Dioxide Concentration (%)	Oxygen Concentration (%)	Hydrogen Sulfide Concentration (ppm)	Landfill Gas Temperature (°F)	Landfill Gas Static Pressure [a] (inches H_2O)	Atmospheric Pressure [a] (inches Hg)	Lab Sample Collected (Y or N)	Approximate Cover Thickness [b] (feet)
S1	09/13/01	1:41 PM	0.4	21.6	0.0	0.0	NM [c]	–0.40	24.7	N	0.5
S2	09/13/01	9:42 AM	0.0	4.2	14.9	0.0	73.9	–1.00	24.9	Y	S
S3	09/13/01	10:08 AM	0.0	3.2	16.7	0.0	NM [d]	–0.90	24.9	N	2.0
S4	09/13/01	10:28 AM	0.0	14.3	4.1	0.0	78.1	–0.80	24.9	Y	U
S5	09/13/01	2:02 PM	0.1	20.0	0.0	2.0	NM [c]	–0.10	24.7	Y	0.5
S6	09/13/01	1:19 PM	0.0	11.3	6.7	0.0	NM [c]	–0.20	24.9	Y	0.5
S7	09/13/01	1:02 PM	2.2	24.6	0.0	7.0	NM [c]	–0.30	24.9	N	0.5
S8	09/13/01	12:30 PM	1.4	22.6	0.0	0.0	NM [c]	–0.50	24.9	Y	0.5-1.0
S9	09/13/01	10:51 AM	4.2	24.6	0.0	0.0	82.6	–0.40	24.9	N	1.5

[a] Landfill gas static pressure and atmospheric pressure measurement was provided by the LandTec GA™-90.
[b] Approximate cover thickness is based on driller's "feel" of breakthrough from cover soil to waste; this data may be subjective and is not a scientific measurement.
[c] Broken landfill gas temperature probe.
[d] Hole collapsed.

ppm = Parts per million
°F = Degrees Fahrenheit
H_20 = Water
Hg =Mercury

NM = Not measured
S = Surface, no significant amount of cover present
U = Unknown, could not be determined by the driller

Hydrogen sulfide concentrations at the Sacramento Landfill ranged from 0 to 7 ppm (Table 1). These relatively low concentrations suggest that hydrogen sulfide is being generated only at low rates in the landfill and that hydrogen sulfide is not likely to present significant adverse impacts.

5.2 LFG Survey Laboratory Results

During the LFG survey (described in Section 2.4) five vapor samples were collected at the Sacramento Landfill for laboratory analysis of VOCs. Each sample was analyzed using a modified version of Method TO-14, which analyzes for the VOCs that occur most commonly in LFG. In addition, one sample (S8) was tested for quality control purposes by Method 3C for methane, carbon dioxide, oxygen, and nitrogen. The results of the quality control laboratory analysis show good agreement with the field measurements for methane, carbon dioxide, and oxygen.

Results of the laboratory analyses are summarized in Table 2. Sacramento Landfill VOC maps illustrating the concentrations measured for selected VOCs are included in Appendix B. The VOCs shown were specified by AEHD based on review of the VOC data to determine the significant parameters detected. Full laboratory reports and laboratory chain-of-custody forms are provided in Volume II.

5.3 Landfill Gas Generation Modeling Results

This section presents the model inputs used to estimate LFG generation at the Sacramento Landfill and summarizes the model results.

5.3.1 Input Parameters

As described in Section 2.6, LFG generation modeling requires setting model input parameters for (1) waste disposal history, (2) L_0 value, and (3) k value. The selected average waste volumes used as input to the LFG generation model are provided in Table 3. Information was gathered from field investigations, laboratory analyses of waste samples, historical documents,

Table 2. Laboratory Results
Sacramento Landfill

Compound Name	S2	S4	S5	S6	S8
Modified Method TO-14[a] (ppbv)					
1,1,1-Trichloroethane	---	---	---	---	---
1,1,2-Trichloroethane	---	---	---	---	---
1,1-Dichloroethane	---	---	---	---	---
1,1-Dichloroethene	---	---	---	---	---
1,2,4-Trimethylbenzene	---	---	94	---	150
1,2-Dichlorobenzene	---	---	---	---	---
1,2-Dichloroethane	---	---	---	---	---
1,2-Dichloropropane	---	---	---	---	---
1,3,5-Trimethylbenzene	---	---	24	---	52
1,3-Dichlorobenzene	---	---	---	---	---
1,4-Dichlorobenzene	---	---	23	---	87
2-Propanol	---	---	150	---	---
Benzene	---	---	---	---	---
Bromomethane	---	---	---	---	---
Carbon tetrachloride	---	---	---	---	---
Chlorobenzene	---	---	---	---	---
Chloroethane	---	---	---	---	---
Chloroform	---	22	---	---	---
Chloromethane	---	---	---	---	---
cis-1,2-Dichloroethene	---	---	---	---	---
Ethylbenzene	---	---	16	---	130
Ethylene dibromide	---	---	---	---	---
Freon 11	---	---	---	---	---
Freon 113	---	---	---	---	---
Freon 114	---	180	35	34	50
Freon 12	66	460	580	82	510
m,p-Xylene	---	---	24	---	560
Methyl tertiary-butyl ether	---	---	---	---	---
Methylene chloride	---	---	---	---	---
o-Xylene	---	---	---	---	230
Tetrachloroethene	---	13	45	30	51
Toluene	---	---	44	---	160
trans-1,2-Dichloroethene	---	---	---	---	---
Trichloroethene	---	---	---	---	34
Vinyl chloride	---	---	---	---	---
Method 3C[b] (% volume)					
Carbon dioxide	NS	NS	NS	NS	21
Methane	NS	NS	NS	NS	1.7
Nitrogen	NS	NS	NS	NS	70
Oxygen	NS	NS	NS	NS	1.2

[a] Detection limit for method is 5 ppbv; reporting limits vary depending on dilution factor (see laboratory results, Volume II).
[b] Detection limit for method is 0.10 percent of volume for all analytes.
--- = Not detected NS = Not sampled ppbv = Parts per billion by volume

Table 3. Available Information on Waste Disposal History and Volumes
Sacramento Landfill

Source of Information	Dates of Operation	Size (acres)	Average Soil Cover Thickness (feet)	Average Refuse Thickness (feet)	Estimated Refuse Volume (cubic yards)	Estimated Waste in Place [a] (tons)	Notes
City of Albuquerque RFP for this project	1968-1970	4.664	---	23.0	173,065	86,533	Reports a maximum refuse depth of 26 feet only. Subtracts an assumed cover soil depth of 3 feet.
Field investigation (present study)	---	4.665	---	---	147,189	73,595	No field investigation conducted at this site. Acreage is from drawings provided. Refuse volume calculated using average of RFP and historical reported refuse thickness.
Engineering Solutions and Design, Inc., 2000	1962	5.0	---	16.1	130,000	65,000	Reported refuse volume of 130,000 cubic yards. Refuse thickness is back-calculated from reported volume and acreage.
Values used for present study	1962	4.665	3.0	19.6	147,189	73,595	Years of operation are from historical reference. Acreage is from present study. Cover thickness is assumed to be 3 feet. Refuse thickness is average of RFP and historical values.

[a] Assumes an average in-place density equal to 1,000 pounds per cubic yard.

RFP = Request for proposal
--- = No data

and the RFP. Numerous information sources were used to provide reliable estimates of the expected range for LFG generation rates. The following model input parameters were chosen:

- Waste disposal history: 73,595 tons of refuse were disposed in 1962
- L_0 values ranging from 3,204 ft^3/ton to 3,550 ft^3/ton
- k values ranging from 0.019/yr to 0.025/yr

Development of the waste disposal history, L_0 values, and k values for LFG generation modeling for the Sacramento Landfill is described below.

5.3.1.1 Waste Disposal History

Annual waste volumes are a required input parameter for the LFG generation model. Since specific records do not exist for waste disposal at the Sacramento Landfill, three possible waste disposal histories were estimated for the Sacramento Landfill using the following data:

- Aerial extent of the landfill (4.66 acres) multiplied by waste thickness provided in the City's RFP for this project (23 feet), which yields 173,065 cubic yards.

- Aerial extent of the landfill (4.66 acres) multiplied by the average refuse thickness based on information obtained in the RFP (23 feet) and historical studies (16.1 feet), or 19.6 feet, which yields 147,189 cubic yards.

- Historical studies, which indicate the volume of in place waste is approximately 130,000 cubic feet (Engineering Solutions and Design, 2000).

Additional assumptions used for the study include:

- The reported years of active disposal as provided in the RFP are 1968 to 1970; however, the operational period reported in the historical studies is 1962 (Engineering Solutions and Design, 2000). Because the City reported that the years of operation provided in the RFP may be inaccurate, the operational period of 1962 as provided in historical reports was used.

- An estimated average refuse density of 1,000 lbs/yd^3.

Table 3 shows a range of in-place volume of waste based on the above information. For modeling the LFG generation for the Sacramento Landfill, a disposal volume of 147,189 cubic yards (73,595 tons) of refuse was used.

5.3.1.2 Ultimate Methane Generation Rate (L_0)

The ultimate methane generation rate, L_0 values used for LFG generation model runs for the Sacramento Landfill were assigned one of the following two values:

- EPA default value of 3,204 ft^3/ton, which is converted from the EPA (AP-42) value for of 100 cubic meters (m^3) of methane per Mg of waste (EPA, 1995).

- SCS default value of 3,550 ft^3/ton based on the precipitation for the Albuquerque region, (8.7 inches per year according to the Desert Research Institute [www.wrcc.dri.edu]).

5.3.1.3 Methane Generation Rate Constant (k)

The methane generation rate constant (k) values used for the LFG generation model runs for the Sacramento Landfill were as follows:

- EPA (AP-42) default k value of 0.02 per year for landfills experiencing less than 25 inches per year of precipitation (EPA, 1995).

- SCS default k value of 0.019 per year for the Albuquerque region.

- An elevated k value of 0.025 per year based on the estimated effect of adding moisture starting in 2002.

5.3.2 Model Validation Results

Validation of LandGEM's application to the Sacramento Landfill is provided by the site-calibrated k values, which are based on actual measurements of LFG production from pumping tests conducted at the Eubank and Yale Landfills. The calibrated k values of 0.01 and 0.023 for Eubank and Yale, respectively, provide a range of values that bracket the predicted k input parameters assigned through default values (0.019 and 0.020) used to model LFG generation at the Sacramento Landfill.

5.3.3 LFG Generation Model Results

Model results are provided in Table 4 and Figure 5, which show estimated LFG generation through 2020 for the Sacramento Landfill under three different projection scenarios, including the effect of adding moisture to the refuse mass. Table 4 also provides the estimated disposal rates and the k and L_0 values used for each projection. All LFG generation rates shown are adjusted to 50 percent methane content (standard normalization procedure) to reflect the typical methane content of LFG as it is generated.

Except for the projection showing the effect of adding moisture starting in 2002 (Projection 3), all projections show LFG generation reaching a peak in 1963, one year following landfill closure, and declining at a rate of approximately 2 percent annually thereafter. LFG generation in 2002 is estimated to range between 8 and 9 standard cubic feet per minute (scfm). Prior to 2003, the highest generation rates occur under the SCS default projection, which uses the highest L_0 value of any projection. LFG generation rates will continue to decline, as long as waste conditions are not significantly changed.

Projection 3 is a modified (moisture added) projection that uses the EPA default k and L_0 values through 2002, but which increases the k value to 0.025 for generation after 2002 to reflect the effect of adding moisture to the refuse mass. This projection shows LFG generation increasing from 9 scfm in 2002 to 11 scfm in 2003, the first year that the effects of added moisture are reflected in the model results. LFG generation is projected to decline at 2.5 percent annually after 2003 under the added moisture scenario (Projection 3).

Table 4. LFG Generation Projections
Sacramento Landfill
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Year	Disposal Rate (tons/yr)	Refuse In-Place (tons)	LFG Generation					
			scfm	Mcf/day	scfm	Mcf/day	scfm	Mcf/day
Methane content of LFG adjusted to:			*50%*		*50%*		*50%*	
Methane generation rate constant (k):			*0.020*		*0.019*		*0.019 and 0.025* [a]	
Ultimate methane generation rate (L_0):			*3,204* [b]		*3,550* [b]		*3,550* [b]	
1962	73,595	73,595	0	0.000	0	0.000	0	0.000
1963	0	73,595	18	0.025	19	0.027	19	0.027
1964	0	73,595	17	0.025	18	0.026	18	0.026
1965	0	73,595	17	0.024	18	0.026	18	0.026
1966	0	73,595	17	0.024	18	0.025	18	0.025
1967	0	73,595	16	0.023	17	0.025	17	0.025
1968	0	73,595	16	0.023	17	0.024	17	0.024
1969	0	73,595	16	0.022	17	0.024	17	0.024
1970	0	73,595	15	0.022	16	0.023	16	0.023
1971	0	73,595	15	0.022	16	0.023	16	0.023
1972	0	73,595	15	0.021	16	0.022	16	0.022
1973	0	73,595	14	0.021	15	0.022	15	0.022
1974	0	73,595	14	0.020	15	0.022	15	0.022
1975	0	73,595	14	0.020	15	0.021	15	0.021
1976	0	73,595	14	0.020	14	0.021	14	0.021
1977	0	73,595	13	0.019	14	0.020	14	0.020
1978	0	73,595	13	0.019	14	0.020	14	0.020
1979	0	73,595	13	0.018	14	0.020	14	0.020
1980	0	73,595	13	0.018	13	0.019	13	0.019
1981	0	73,595	12	0.018	13	0.019	13	0.019
1982	0	73,595	12	0.017	13	0.019	13	0.019
1983	0	73,595	12	0.017	13	0.018	13	0.018
1984	0	73,595	12	0.017	12	0.018	12	0.018
1985	0	73,595	11	0.016	12	0.018	12	0.018
1986	0	73,595	11	0.016	12	0.017	12	0.017
1987	0	73,595	11	0.016	12	0.017	12	0.017
1988	0	73,595	11	0.015	12	0.017	12	0.017
1989	0	73,595	10	0.015	11	0.016	11	0.016
1990	0	73,595	10	0.015	11	0.016	11	0.016
1991	0	73,595	10	0.014	11	0.016	11	0.016
1992	0	73,595	10	0.014	11	0.015	11	0.015
1993	0	73,595	10	0.014	10	0.015	10	0.015

[a] The k value changes from 0.019 to 0.025 after 2002 to reflect the addition of moisture.
[b] Cubic feet per ton.

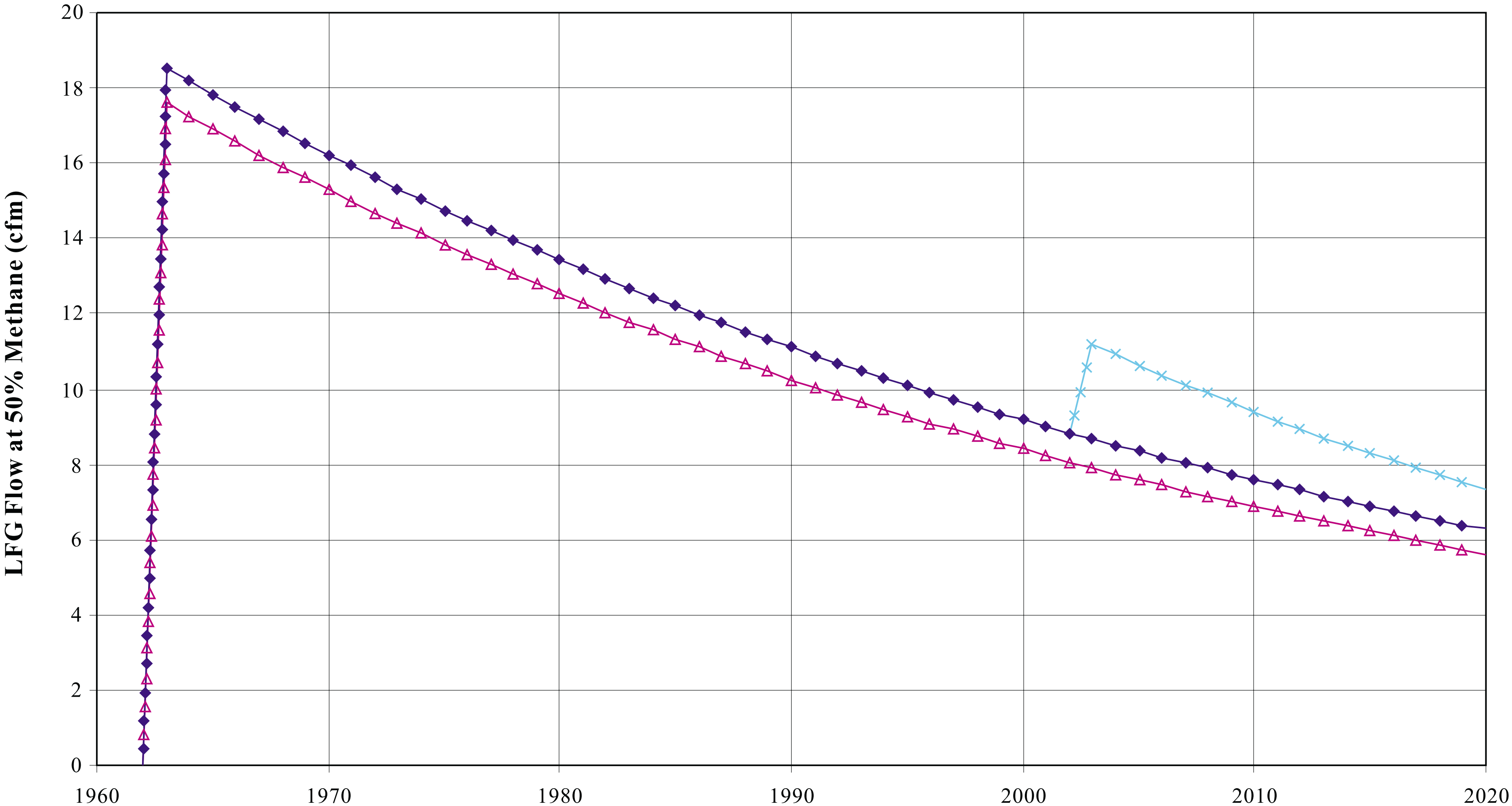
scfm = Standard cubic feet per minute
Mcf/day = Million cubic feet per day

Table 4. LFG Generation Projections
Sacramento Landfill
Page 2 of 2

Year	Disposal Rate (tons/yr)	Refuse In-Place (tons)	LFG Generation					
			scfm	Mcf/day	scfm	Mcf/day	scfm	Mcf/day
Methane content of LFG adjusted to:			*50%*		*50%*		*50%*	
Methane generation rate constant (k):			*0.020*		*0.019*		*0.019 and 0.025* [a]	
Ultimate methane generation rate (L_0):			*3,204* [b]		*3,550* [b]		*3,550* [b]	
1994	0	73,595	9	0.014	10	0.015	10	0.015
1995	0	73,595	9	0.013	10	0.015	10	0.015
1996	0	73,595	9	0.013	10	0.014	10	0.014
1997	0	73,595	9	0.013	10	0.014	10	0.014
1998	0	73,595	9	0.013	10	0.014	10	0.014
1999	0	73,595	9	0.012	9	0.013	9	0.013
2000	0	73,595	8	0.012	9	0.013	9	0.013
2001	0	73,595	8	0.012	9	0.013	9	0.013
2002	0	73,595	8	0.012	9	0.013	9	0.013
2003	0	73,595	8	0.011	9	0.012	11	0.016
2004	0	73,595	8	0.011	9	0.012	11	0.016
2005	0	73,595	8	0.011	8	0.012	11	0.015
2006	0	73,595	7	0.011	8	0.012	10	0.015
2007	0	73,595	7	0.011	8	0.012	10	0.015
2008	0	73,595	7	0.010	8	0.011	10	0.014
2009	0	73,595	7	0.010	8	0.011	10	0.014
2010	0	73,595	7	0.010	8	0.011	9	0.014
2011	0	73,595	7	0.010	7	0.011	9	0.013
2012	0	73,595	7	0.010	7	0.011	9	0.013
2013	0	73,595	6	0.009	7	0.010	9	0.013
2014	0	73,595	6	0.009	7	0.010	8	0.012
2015	0	73,595	6	0.009	7	0.010	8	0.012
2016	0	73,595	6	0.009	7	0.010	8	0.012
2017	0	73,595	6	0.009	7	0.010	8	0.011
2018	0	73,595	6	0.008	7	0.009	8	0.011
2019	0	73,595	6	0.008	6	0.009	7	0.011
2020	0	73,595	6	0.008	6	0.009	7	0.011

[a] The k value changes from 0.019 to 0.025 after 2002 to reflect the addition of moisture.
[b] Cubic feet per ton.

scfm = Standard cubic feet per minute
Mcf/day = Million cubic feet per day



Explanation

EPA (AP-42) Default Values k = 0.020 Lo = 3,204 cu.ft./ton

SCS Default Values k = 0.019 Lo = 3,550 cu.ft./ton

Site-Calibrated Values w/Added Moisture k = 0.025 Lo = 3,550 cu.ft./ton

Source: SCS Engineers

LANDFILL GAS INVESTIGATION AND CHARACTERIZATION STUDY

Sacramento Landfill
LFG Generation Projection

Daniel B. Stephens & Associates, Inc.
4-01-02 JN 9398

Figure 5

6. Conclusions and Recommendations

The landfill gas investigation and characterization study was conducted with the primary goal of providing new information to determine appropriate measures to address LFG issues related to the use of properties on and within close proximity to the former landfills. The following conclusions and recommendations related to the Sacramento Landfill have been made based on available information and the data collected during this investigation. Though it is impossible to precisely predict future landfill gas generation and migration, careful analysis of data can provide a tool for making an educated prediction of future landfill gas behavior. These assumptions of future landfill gas behavior combined with past landfill gas experience have allowed us to determine the possible effects of landfill gas on current and future development at or near the former landfills.

This report makes a number of recommendations as to actions that should be taken by the City. These recommendations are worded in terms of actions that should be taken by the City because the City is the party that requested recommendations. It is the City that has taken the lead in dealing with landfill gas problems. This report takes no position on whether it is properly the City's role or responsibility to deal with the concerns raised by these recommendations.

6.1 Conclusions

Based on the data and analysis discussed, the following conclusions can be made regarding LFG generation at the Sacramento Landfill:

- Based on the modeling results, the peak year for LFG generation at the Sacramento Landfill was 1963.

- The estimated LFG generation rate for the Sacramento Landfill indicates that the production of LFG is steadily declining in its current state. The projected LFG generation rate for 2002 for the Sacramento Landfill ranges from 8 to 9 scfm.

- Due to the small volumes of LFG predicted to be generated at both the Sacramento Landfill, the potential for significant volumes of LFG to migrate off-site is low.

- The LFG survey detected relatively low methane concentrations at the Sacramento Landfill. Methane concentrations ranging from 0 to 4.2 percent were measured in nine gas probes. The highest methane concentration of 4.2 percent is at 84 percent of the LEL, indicating significant methane accumulation approaching the LEL.

- VOCs were detected in soil gas samples collected at the Sacramento Landfill; however, at this time insufficient data exist to form conclusions concerning potential impacts to public health.

6.2 Recommendations

Based on the data and analyses discussed, the following recommendations are provided to address LFG issues relevant to the Sacramento Landfill.

6.2.1 Buffer Zone Reduction

The basic requirements of the City's *Interim Guidelines for Development within 1,000 feet of Landfills* should remain in place; however, reductions in the buffer zone distance are recommended contingent on implementing a LFG monitoring plan, as described below.

- *LFG monitoring plan.* The City should consider developing a LFG monitoring plan for the Sacramento Landfill to assess potential off-site migration of LFG. The plan should address the following:

  – *Installation of perimeter LFG monitoring probes.* These probes should be installed outside the waste disposal areas to confirm the limits of LFG migration. The probes should extend at least 10 feet below the depth of waste, or to approximately 30 to 40 feet bgs (typical). The monitoring probes should be spaced at approximate 250-foot intervals to form a monitoring perimeter that verifies the limits of LFG migration. On the west side of the landfill, where development is set back from the landfill adjacent to I-25, a greater monitoring probe spacing between approximately 250 and 500 feet is recommended. Suitable and accessible locations for the monitoring probes will need to be identified. The final number, spacing, and locations of monitoring probes will need to be determined during development of the LFG monitoring plan.

– *Quarterly monitoring.* The perimeter monitoring probes and selected subsurface utility vaults should be monitored for methane gas on a quarterly basis for at least two consecutive years. The utility investigation recommended in Section 6.2.2 should specify which subsurface utility vaults will be monitored on a regular basis. If methane is not detected during the two years of monitoring, the monitoring frequency may be reduced to once every six months.

– *Change in frequency of monitoring.* If at any time methane gas concentrations are detected that exceed 25 percent of the LEL in selected subsurface utility vaults or 50 percent of the LEL in perimeter LFG monitoring probes, the frequency of monitoring should be increased to monthly for at least six months. Subsequently, if the methane gas content stays below these limits for six months of monthly monitoring, the frequency can be decreased to quarterly.

– *Long-term monitoring and care*. Monitoring of perimeter probes and selected subsurface utility vaults should continue indefinitely, because LFG conditions in and around the landfill can change and may be affected by future development.

- *Development of property outside landfill perimeter.* Based on the results of the LFG investigation and characterization study, changes are recommended for the Sacramento Landfill in the City's Interim Guidelines.

– *Reduction of setbacks*. A reduction in the setback distance for applicability of the Interim Guidelines is recommended for the Sacramento Landfill. This recommendation is contingent on implementing the LFG monitoring plan described above. It is recommended that the setback distance be reduced to a provisional limit of 500 feet, based on the relatively low levels of methane found during the LFG survey. However, since one gas probe had a methane concentration of 84 percent of the LEL, maintaining a reasonable setback distance is appropriate.

Maintaining a minimum 500-foot setback distance is recommended because the landfill will continue to pose a potential risk, and the City may still consider some design, monitoring, and/or LFG abatement measures suitable under the Interim Guidelines. Examples of requirements that could be needed, even with a setback distance from the landfill, include directing storm water away from the landfill, sealing off subgrade utilities to prevent possible LFG migration, installing subsurface venting systems beneath structures, and/or installing building interior monitors in buildings (particularly in basements). Any requirements will depend on the site-specific development plans.

- *Monitoring conditions for reduction of setbacks.* The recommended setback distance reduction is contingent on the results of continued LFG monitoring. The detection of methane above 25 percent of the LEL in selected utility vaults or above 50 percent of LEL in any perimeter monitoring probe will result in this recommendation being rescinded and reinstatement of a setback distance of 1,000 feet (or other setback distance appropriate for the conditions observed).

6.2.2 Landfill Management Plan

The City should consider developing a comprehensive landfill management plan for the Sacramento Landfill, to address several items that play a significant role in reducing LFG generation and preventing adverse LFG impacts. The LFG monitoring plan, described above, is a component of the overall landfill management plan. The landfill management plan should include the recommended components described below.

- *LFG control plan.* If the methane content exceeds 25 percent of the LEL in selected subsurface utility vaults or 50 percent of the LEL in perimeter monitoring probes, the City should consider developing a LFG control plan. If the methane content exceeds the specified limits for three consecutive months, the City should immediately develop and implement a LFG control plan. The LFG control plan should consist of either passive or active LFG control systems capable of reducing the methane content to levels protective of public health and safety.

- *Utility investigation.* Selected subsurface utilities should be monitored for the presence of LFG and included with the quarterly monitoring program discussed above. Utilities should be investigated on and around the Sacramento Landfill to determine if existing utility corridors pose a risk by acting as conduits for the migration of LFG. Utility locations should be examined to the fullest extent possible, using all available records and possible on-site investigation. A utility monitoring plan should be developed to select utility monitoring locations where LFG may be detected and monitoring can minimize the risk for utility conduits to transmit LFG. As long as methane concentrations remain below 25 percent of LEL in selected subsurface utilities, no further utility investigation is needed. However, if methane concentrations increase above 25 percent of LEL, additional investigation of utilities should commence.

- *Development of landfill property*. If development occurs on the Sacramento Landfill, the developer should meet all applicable requirements of the City's Interim Guidelines. If development occurs on the landfill that may increase the potential for off-site LFG migration by sealing the landfill cover surface (e.g. buildings, paved parking areas, and densely vegetated areas), the perimeter probe monitoring frequency may need to be increased and/or additional monitoring probes added.

- *Drainage control.* Current drainage at the Sacramento Landfill is very poor, and the landfill is at a low point that collects storm water runoff. This storm water may contribute to LFG generation that has caused the elevated methane concentrations observed. It is recommended that the City consider undertaking a site drainage study to determine existing drainage patterns and identify needs for possible improvements. Drainage patterns around the I-25 and Paseo del Norte intersection, along local roads, and on adjacent properties in the vicinity of the Sacramento Landfill should be examined.

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