Landfill Gas Investigation and Characterization Study
Atrisco Landfill

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

April 5, 2002

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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/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
lbs/ft^3	pounds per cubic feet
lbs/yd^3	pounds per cubic yard
LEL	lower explosive limit
LFG	landfill gas
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)

Acronyms and Technical Terms (continued)

m^3	cubic meters
Mcf	millions of cubic feet
Mg	megagrams
MSW	municipal solid waste
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 – Atrisco 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 Atrisco 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, and construction debris
  - Fines/unknown – soil and 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. Atrisco Landfill Study Results and Recommendations

2.1 Landfill History

The Atrisco Landfill is located in southwest Albuquerque, south of Central Avenue and east of Old Coors Boulevard. The landfill is between Sunset Garden Road, Corregidor Road, City View Drive, and Salvador Road. The City View Mobile Home Park, developed on the landfill site in 1981, currently contains occupied homes on 66 lots.

The City operated the landfill from 1968 to 1969 to dispose of residential and commercial waste. Thereafter, the site changed ownership several times and was presumably used for disposal of construction and demolition until 1979. The landfill is unlined and covers about 7.6 acres with an average waste depth of about 8 feet.

2.2 Landfill Gas Survey

The landfill gas survey at the Atrisco Landfill consisted of (1) installing 9 permanent gas sampling probes to allow for long-term gas monitoring within the mobile home park, (2) testing gas samples for methane, carbon dioxide, oxygen, and hydrogen sulfide using field instruments, and (3) conducting laboratory analysis of all 9 samples for 35 volatile organic compounds commonly found in landfill gas. The findings of this investigation included:

- *Methane was not detected* at measurable levels in any of the gas probes installed at the Atrisco Landfill. This indicates there is little potential for off-site gas migration.

- *Low concentrations of four volatile organic compounds* were detected in landfill gas samples taken beneath the ground surface. The volatile organic compound data will be used in further studies.

2.3 Waste Characterization

The waste characterization study for the Atrisco Landfill consisted of (1) excavating landfill materials using a backhoe in the mobile home park detention pond and (2) collecting and analyzing the waste samples to establish their composition, percentage of degradable material, and moisture content. Results of the waste characterization study included:

- *Waste was encountered from 1 to 13.5 feet below ground surface.* Primarily concrete and other construction debris was encountered. Also, very small quantities of metal, green waste, rubber, and paper were found. Most of this waste decomposes at a slow rate.

- *Moisture content ranged from 7.4 to 10.0 percent by weight.* This level of moisture indicates slow waste decomposition and low gas generation rates.

2.4 Landfill Gas Generation Modeling

The landfill gas generation rate at the Atrisco 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 1970, one year after the municipal landfill operation ended (assuming additional degradable waste was not disposed of later). 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 0.5 to 10 standard cubic feet per minute. These methane levels are considered very low and create little 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 to 250 feet, provided a landfill gas monitoring plan is implemented (see recommendation below). Maintaining a minimum 250-foot setback distance for City review under the Interim Guidelines 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 Atrisco 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 to verify the limits of gas migration. 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.

- *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. Special attention is needed at the storm water detention basin.

- *Test air samples beneath mobile homes.* Because the Atrisco Landfill has been developed as a mobile home park, testing of surface emissions is recommended. This can be accomplished by collecting samples beneath three of more typical mobile homes.

- *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

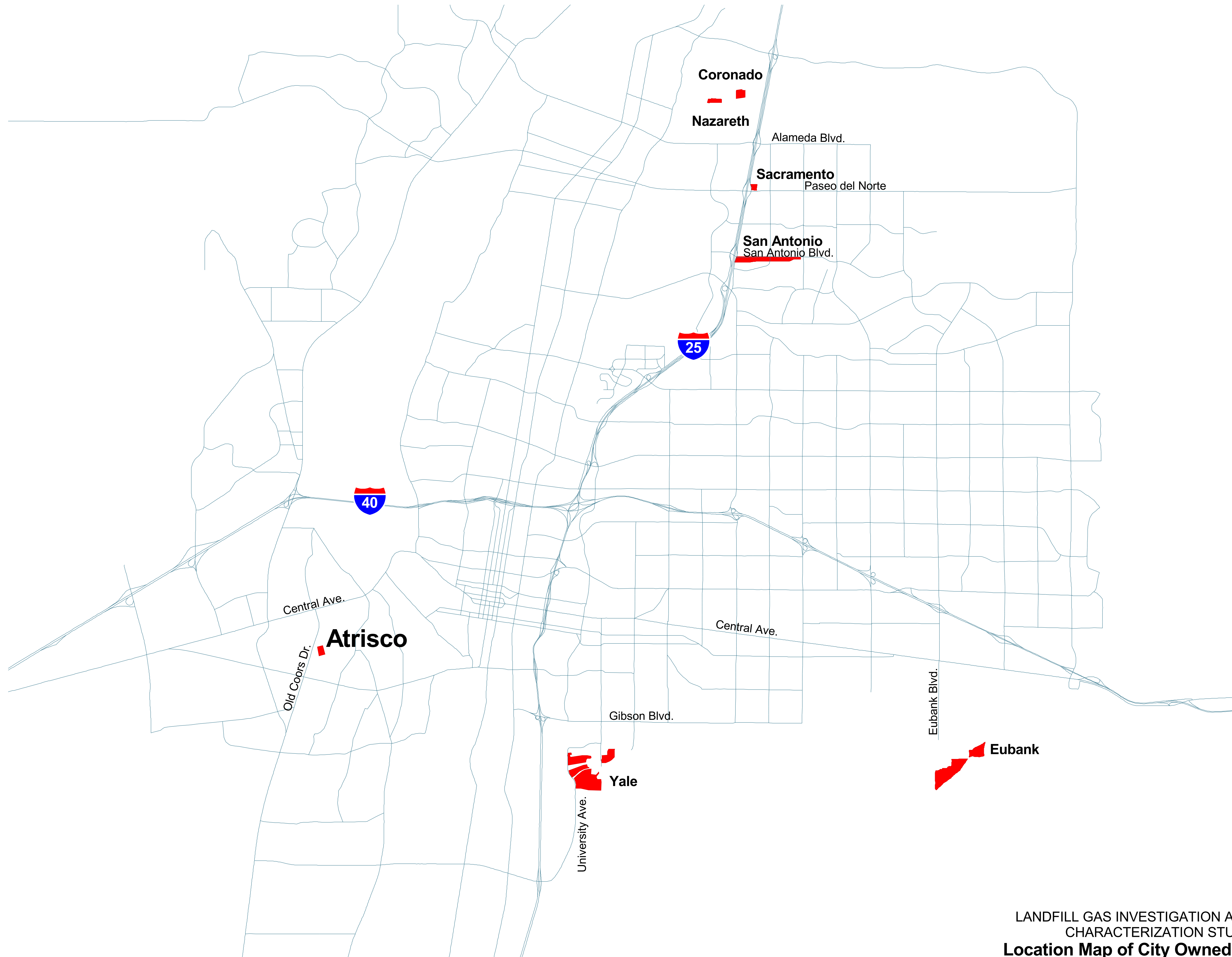
1. Introduction

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

N

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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 Atrisco 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

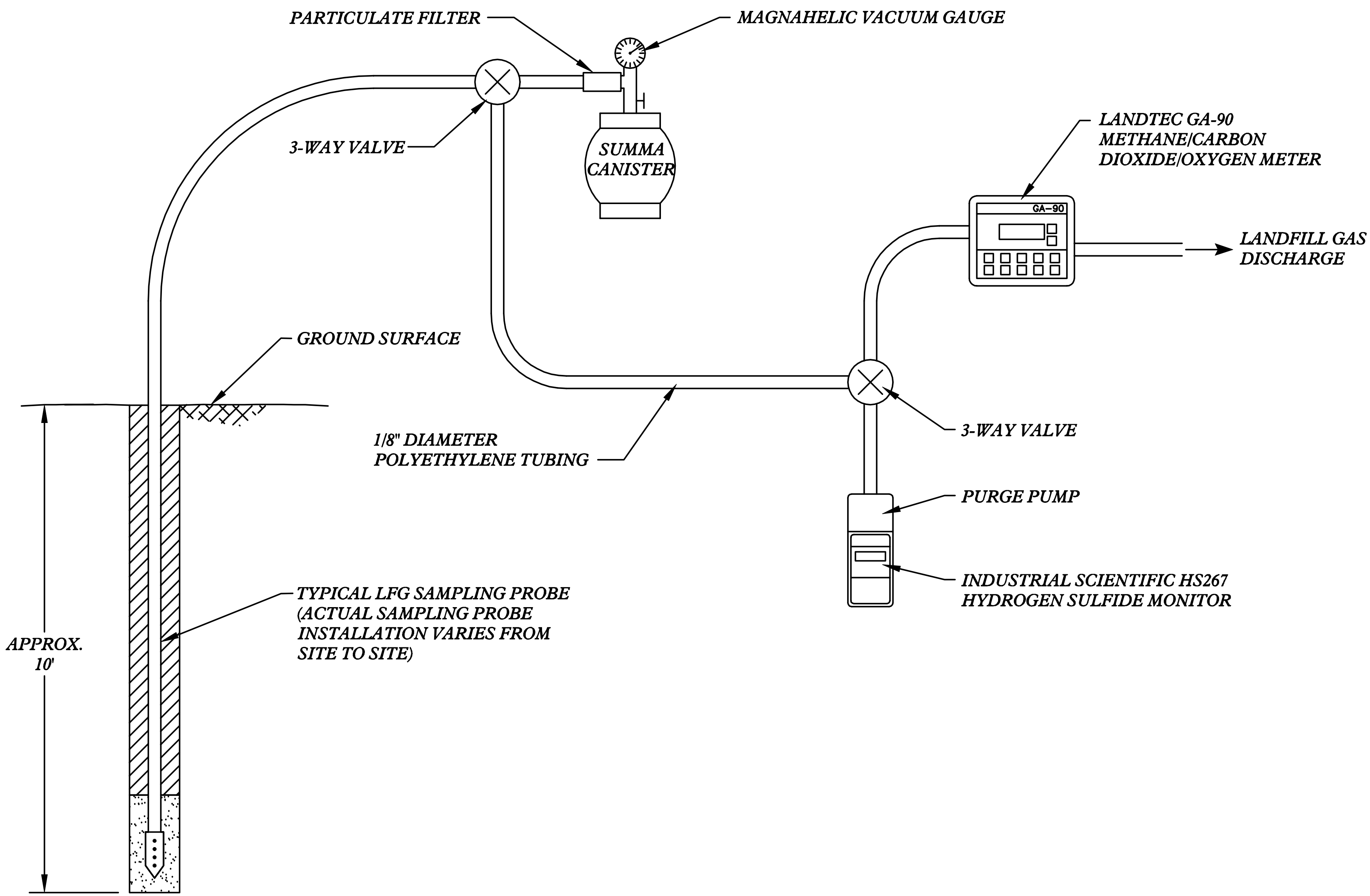
A LFG survey was performed to establish the existing concentration of LFG at each of the seven former landfills. The survey fieldwork was conducted during September 10 to October 5, 2001. The LFG survey involved collection of LFG samples using a probe driven 10 feet below ground surface (bgs), through 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 static pressure and atmospheric pressure. Calibration of field instruments was performed daily during the survey, using bottled calibration gas with standard gas concentrations.



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Landfill Gas Survey Sampling Train Detail

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Figure 2

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. Temperature measurements, odor, color, and organic content of the waste are included in the boring logs (Appendix A).

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) (Appendix B). 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 – soils 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

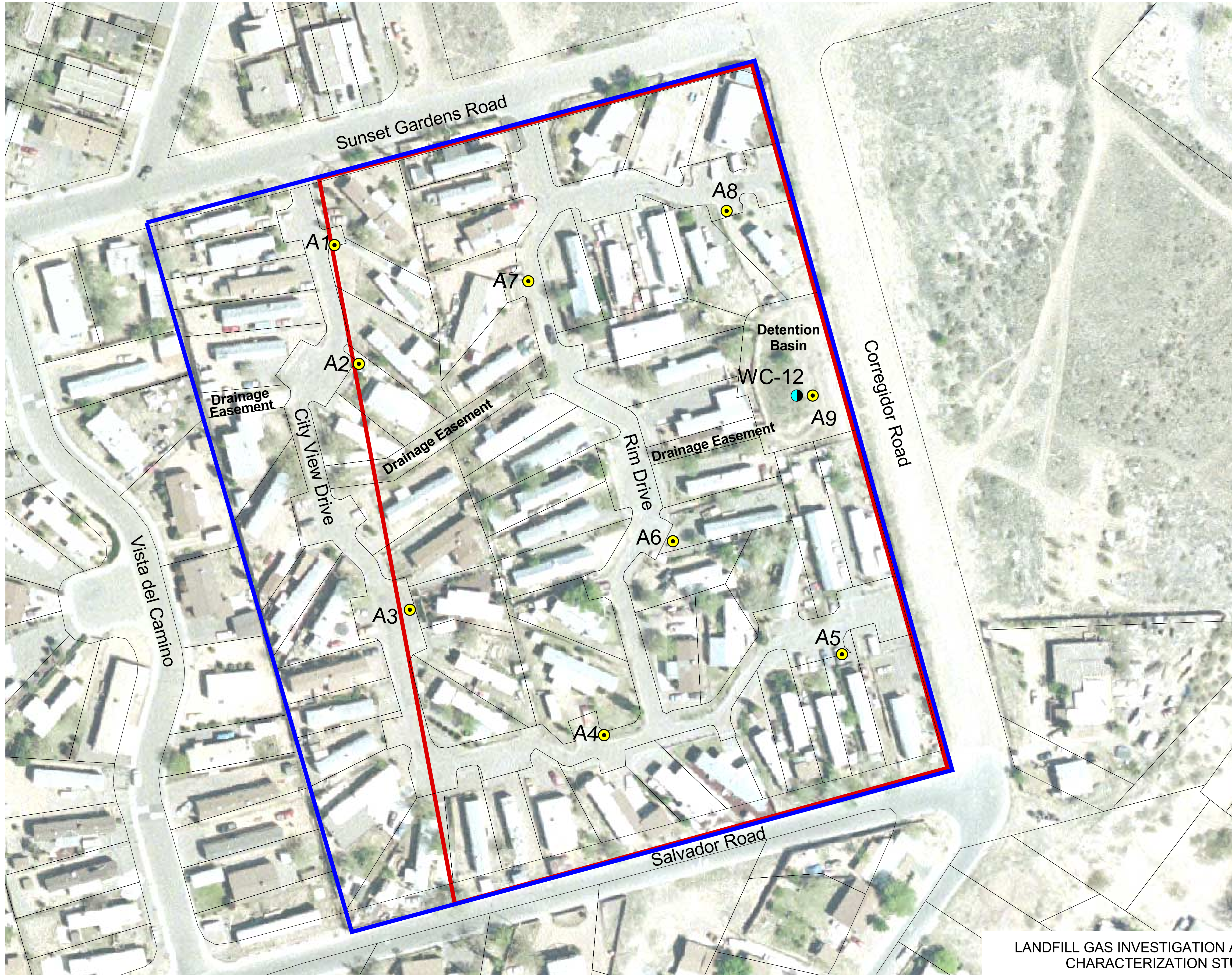
3. Site Background and Previous Investigations

The Atrisco Landfill is located in southwest Albuquerque in Zone K-11, south of Central Avenue, and east of Old Coors Boulevard (Figure 1). The landfill is bounded on the north by Sunset Gardens Road, on the east by Corregidor Road, on the west by City View Drive, and on the south by Salvador Road. The City View Mobile Home Park, developed on this site in 1981, currently contains occupied homes on a total of 66 lots (Figure 3).

The site was used as a City landfill from 1968 to 1969. Before this time it was operated as a gravel pit for a period of approximately one year. The landfill is unlined and covers approximately 7.6 acres with an average waste depth of approximately 8 feet.

Following its operation as a City landfill, the Atrisco Landfill property changed ownership several times (COA, 2001). In 1970, J.W. and Lola Hughes purchased the property. The land remained vacant and unused during the two years it was owned by the Hughes. In 1972, the property was sold to Dale Whale of Coronado Wrecking. Coronado Wrecking supposedly used the property to dispose of construction and demolition waste materials consisting of building materials, concrete, and asphalt (COA, 2001). The property was subsequently leveled with fill dirt, and in 1977 Dale Whale sold the property to Raymond Garcia of Ray's Print Shop. Raymond Garcia supposedly allowed construction and demolition waste (concrete, asphalt, etc.) to be disposed of on the property until 1979, when he sold the property to Granada Heights (COA, 2001). Granada Heights, owned by Don Keith, Bill Thompson, and John Halleck, purchased the property in order to build and develop the City View Mobile Home Park.

When the City View Mobile Home Park was constructed and began operating in 1981, a homeowners' association was set up to maintain the subdivision. Originally, all 66 lots of the mobile home park were serviced by one water meter. In 1987, the City took over operation of the main water system and individual meters were installed for each lot. Storm water is managed with drainage low points constructed for each lot (COA, 2001) and a larger detention pond on the east side of the mobile home park. These drainage controls were constructed by the developers of the mobile home park.



Source:
1999 Aerial photograph provided by Bernalillo County

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Explanation

- Sampling probe/lab sample locations
- Permanent probe locations
- Waste characterization sample point
- Parcels
- Landfill boundary
- City View Mobile Home Park boundary

LANDFILL GAS INVESTIGATION AND CHARACTERIZATION STUDY

Atrisco Landfill Test Locations

Figure 3

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There are conflicting reports about the type of waste that was disposed of at the Atrisco Landfill. A report prepared for the U.S. EPA entitled *Potential Hazardous Waste Site Identification and Preliminary Assessment* indicates the waste is mainly construction and demolition debris consisting of "concrete, asphalt, construction waste, lumber, tires, cardboard, etc." (Ecology and Environment, Inc., 1982). Another EPA report, *Superfund Site Strategy Recommendation,* states that the waste was "residential and commercial" (EPA, 1993). Finally, an equipment operator who worked at the landfill stated that only City garbage trucks deposited waste at the landfill (Nelson, 1997), which supports the waste being residential and commercial rather than construction and demolition waste. In actuality, it appears that all of the above-mentioned waste types were placed in the landfill over the years by many different owners.

Currently, the Atrisco Landfill is densely developed on all 66 lots in the City View Mobile Home Park. The site is relatively flat and drainage patterns to the storm water detention pond on the east side of the mobile home park are not immediately evident. Roadside areas show evidence of ponding where positive drainage is not provided. Roads in the neighborhood are privately owned by the mobile home park.

Surface sediments at the Atrisco Landfill consist of poorly consolidated deposits of sandy pebbles to cobbly gravel of the Upper Pleistocene Arenal Formation, which overlies the Arroyo Ojito Formation of the Upper Santa Fe Group. The Arenal Formation is approximately 10 to 20 feet thick (Kelley, 1977). The water table in the area of the Atrisco Landfill is approximately 70 to 80 feet bgs and the groundwater flow direction varies seasonally (COA, 2002). The direction of groundwater flow is influenced by local water supply wells (several production wells are located within 0.5 miles to the east of the landfill) and the Rio Grande.

In 1999, AEHD conducted a limited methane monitoring investigation at the Atrisco Landfill. This investigation used barhole probing to penetrate the landfill cover and measure subsurface gas concentrations on several different occasions. No significant methane was detected at depths of 1 to 5 feet bgs at any of the locations monitored (COA, 1999).

4. Field Investigation Methods

The field investigation methods used at the Atrisco 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
- Waste characterization test pit excavation to sample and categorize waste composition

Sections 4.1 through 4.4 present the detailed methodology used for these tasks at the Atrisco Landfill.

4.1 Site Access

Access agreements were established with the property owners at the Atrisco Landfill, to provide site access for the field investigation. A total of 66 individual property owners identified at the Atrisco Landfill, based on records from the City of Albuquerque and the Bernalillo County Tax Assessor's Office. Because the landfill boundaries are not precisely defined, property owners were identified for all properties within the City View Mobile Home Park, even though some properties may not be located directly on the landfill.

Due to the multitude of property owners at the Atrisco landfill, written access agreements were sent to only about one third of the owners, as these would provide sufficient access to complete the survey. The necessary access agreements were established with property owners to provide nine drilling sites for the LFG investigation and characterization study, suitably distributed across the mobile home park.

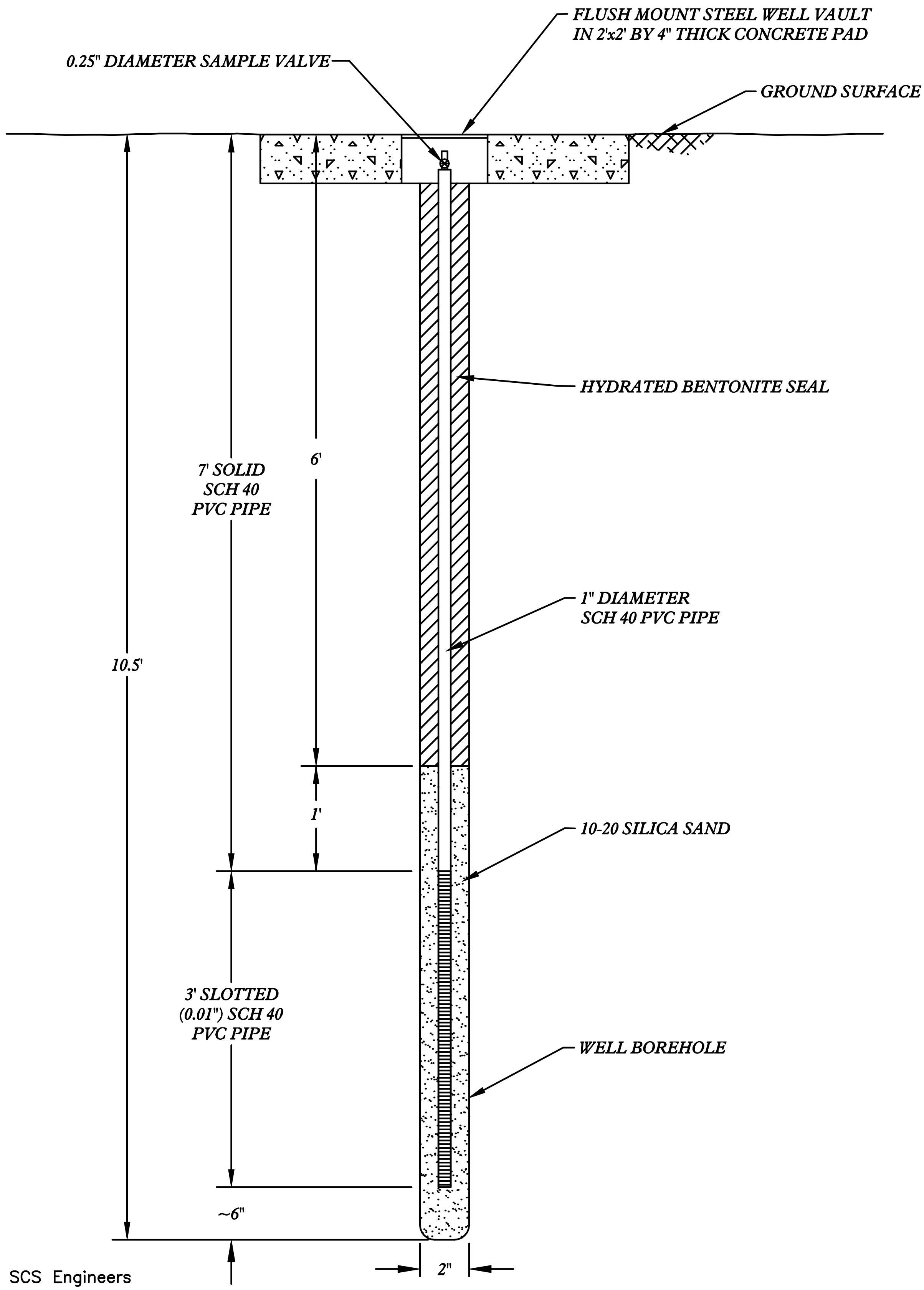
4.2 Utility Survey

Before the investigation commenced, New Mexico One Call was contacted to ensure that no utilities would be encountered during subsurface work. The presence of the mobile home park on top of the Atrisco Landfill has led to extensive utility lines at this site. Therefore, meetings were arranged with some utility locators to explain precisely where sampling was to occur. In addition to the utility-locating services provided by New Mexico One Call, added precautions were taken to check for utilities prior to sampling. Each sampling site at Atrisco was checked with a portable line locator (Schonstaedt Ga-72-Cd). This was followed by slowly inserting a ¼-inch rod approximately 4 feet into the ground as a precaution to ensure each survey location was free from utilities before the probe was installed.

4.3 Landfill Gas Survey

LFG sampling locations at the Atrisco Landfill are shown in Figure 3. The sampling grid at Atrisco Landfill was established at approximately 200 x 200-foot spacings with adjustments made to fit within areas that could be accessed at the mobile home park. Nine sampling locations were established across the landfill surface. Eight of the sampling locations were at the edge of roadways and parking areas, on properties where access agreements were established. One sampling location (A9) is within the storm water detention basin that receives runoff from the mobile home park. The storm water detention basin was of particular interest to determine if the addition of moisture was causing increased LFG generation in this area.

At the Atrisco Landfill, a geoprobe drill rig was used to install permanent gas probes at nine sampling locations. Permanent probes were selected for the Atrisco Landfill to provide for long-term monitoring within the mobile home park. The nine permanent monitoring probes were installed by hydraulically driving a 2-inch-diameter steel rod 10 feet into the soil and/or waste to create a pilot hole. The rod was then removed and 1-inch, Schedule 40 polyvinyl chloride (PVC) casing was installed in the borehole. The bottom 3 feet of casing were factory slotted well screen with 0.01-inch perforations to allow for transmission of LFG into the probe. The perforated section of well annulus was backfilled with 10-20 silica sand. The remaining annular space was sealed with hydrated bentonite. Sampling valves with a 0.25-inch barb for the sample hose connection were fitted to the top of the probes. Permanent wellhead completions consist of flush-mount steel well vaults installed in 2 x 2-foot by 4-inch-thick concrete pads to secure and protect the probes. Following installation of the probes, LFG samples were collected and analyzed as discussed in Section 2.3. A schematic diagram of the permanent monitoring probes is shown in Figure 4.



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Not to Scale

LANDFILL GAS INVESTIGATION AND CHARACTERIZATION STUDY

Atrisco Landfill

Permanent Monitoring Probe Detail

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Figure 4

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4.4 Waste Characterization Analysis

At the Atrisco Landfill, a test pit was excavated within the mobile home park's storm water detention basin to examine the waste characteristics. Waste characterization samples were taken from a test pit excavated by a backhoe. The test pit location (Figure 3) in the storm water detention basin was selected due to the potential for high moisture content in waste below the basin causing increased LFG generation. The test pit location also considered the results of the LFG survey and the access limitations within the mobile home park. The recommended test pit location was submitted to AEHD for approval prior to drilling. Test pit WC-12 was excavated to a depth of 13 feet bgs, the extent of the backhoe's reach. At this depth, waste was observed in the bottom of the pit, and the waste was not fully penetrated.

5. Results

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

- LFG survey results for methane, carbon dioxide, oxygen, VOCs, and hydrogen sulfide
- Waste characterization results that categorize the waste composition from borings
- LFG generation modeling results

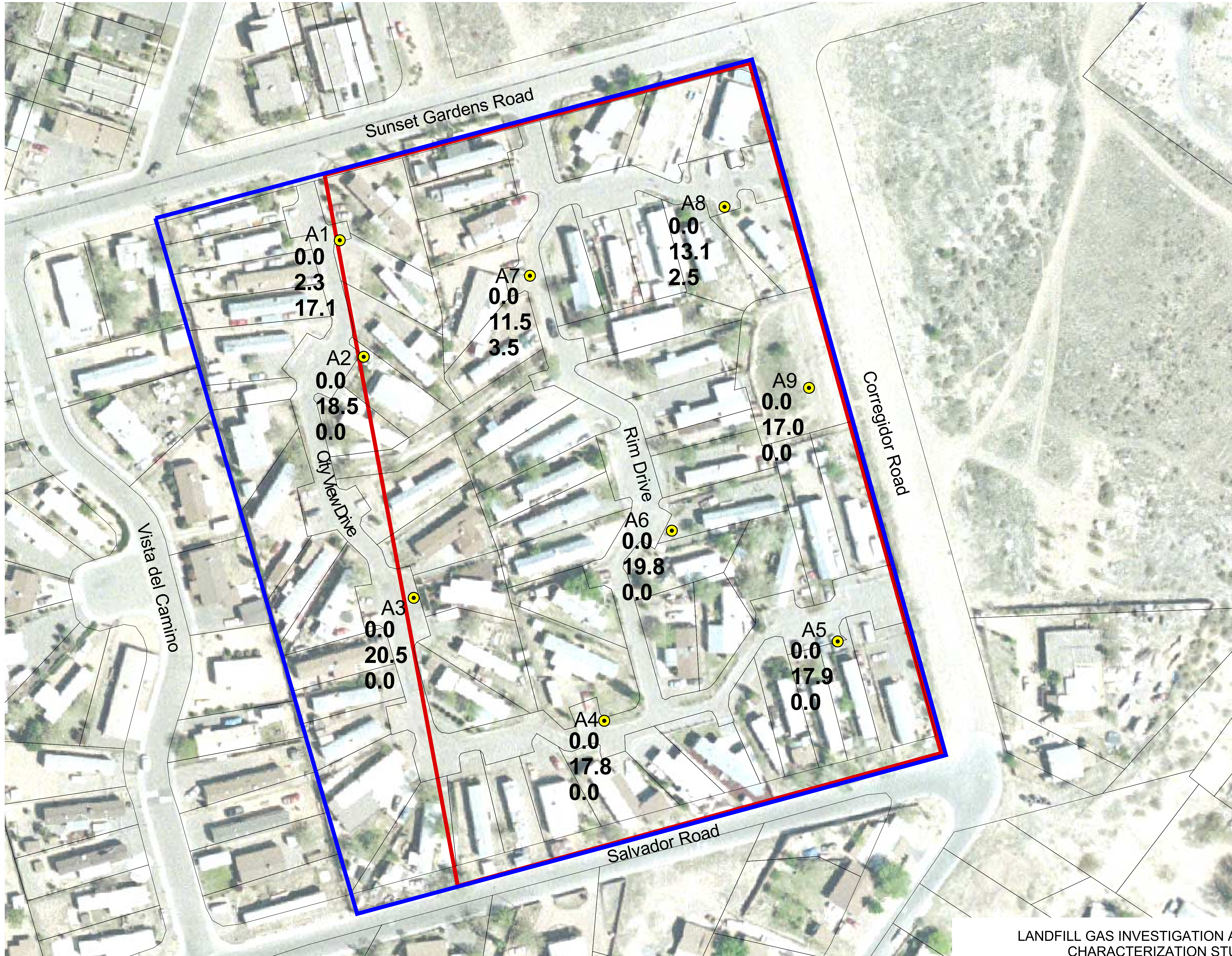
These items are addressed in Sections 5.1 through 5.4.

5.1 LFG Survey Field Analysis Results

A methane concentration map is presented in Figure 5 graphically show the LFG concentrations at the Atrisco Landfill. The map displays numeric results for methane, carbon dioxide, and oxygen concentrations. Results of the LFG survey of the Atrisco Landfill are also summarized in Table 1.

No methane was encountered at the Atrisco Landfill in any of the LFG samples collected from the nine permanent monitoring probes (Figure 5). Most sampling locations show evidence of waste degradation, which causes elevated levels of carbon dioxide and low concentrations of oxygen. The absence of methane may be due to a combination of factors including relatively thin waste, a possible predominance of non-degradable construction and demolition debris, and/or relatively dry waste conditions.

Surprisingly, even gas probe A9, which is located in the mobile home park's storm water detention basin, did not show a measurable methane concentration. This location is in an area where frequent ponding of water occurs. Gas concentrations at sampling point A1 were more consistent with atmospheric conditions, indicating that sample point was most likely not in waste. Therefore, it appears that A1 may be outside or at the edge of the landfill boundary. This seems to confirm the current boundary as drawn on Figure 3, which shows A1 located on the landfill boundary line.



Source:
1999 Aerial photograph provided by Bernalillo County

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Explanation

- Sampling probe/lab sample locations
- Permanent probe locations
- Parcels
- Landfill boundary
- City View Mobile Home Park boundary

0.0	Methane (%)
2.3	Carbon dioxide (%)
17.1	Oxygen (%)

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LANDFILL GAS INVESTIGATION AND CHARACTERIZATION STUDY
Atrisco Landfill Gas Survey Results

Figure 5

Table 1. Landfill Gas Survey Results
Atrisco 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)
A1	09/12/01	11:20 AM	0.0	2.3	17.1	2.0	87.1	–0.20	24.9	Y	3.0-4.0
A2	09/12/01	12:19 PM	0.0	18.5	0.0	0.0	88.7	–0.10	24.9	Y	3.0-4.0
A3	09/12/01	1:30 PM	0.0	20.5	0.0	0.0	89.2	–0.10	24.8	Y	3.0-4.0
A4	09/12/01	1:05 PM	0.0	17.8	0.0	0.0	88.7	0.00	24.8	Y	3.0-4.0
A5	09/12/01	2:02 PM	0.0	17.9	0.0	0.0	87.5	0.00	24.8	Y	3.0-4.0
A6	09/12/01	12:39 PM	0.0	19.8	0.0	12.0	89.2	0.00	24.8	Y	3.0-4.0
A7	09/12/01	2:36 PM	0.0	11.5	3.5	0.0	88.9	0.00	24.8	Y	3.0-4.0
A8	09/12/01	2:55 PM	0.0	13.1	2.5	0.0	90.4	0.00	24.8	Y	3.0-4.0
A9	09/12/01	3:10 PM	0.0	17.0	0.0	0.0	91.2	0.00	24.8	Y	3.0-4.0

[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.

ppm = Parts per million
°F = Degrees Fahrenheit

H_20 = Water
Hg = Mercury

Hydrogen sulfide concentrations at the Atrisco Landfill ranged from 0 to 12 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) samples were collected from all nine gas probes at the Atrisco Landfill for laboratory analysis of VOCs. Each sample was analyzed using a modified version of Method TO-14, which analyzes for the VOCs most commonly found in LFG. In addition, one sample (A5) was tested by Method 3C for methane, carbon dioxide, oxygen, and nitrogen. The results of the quality control laboratory analysis shows good agreement with the field measurements for methane, carbon dioxide, and oxygen.

Results of the laboratory analyses are summarized in Table 2. Atrisco Landfill VOC maps illustrating the concentrations measured for selected VOCs are included in Appendix C. 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 Waste Characterization Analysis

The waste characterization analysis from the test pit excavated at the Atrisco Landfill (WC-12) is presented in this section. A summary of the waste composition encountered is provided in Table 3, and additional details for each waste sample are provided in the boring logs (Appendix A) and field notes (Volume II).

The soil encountered at WC-12 generally consisted of dry, light brown, silty sand with large gravel. Waste was encountered from approximately 1 to 13.5 feet bgs. Slight odors were observed from WC-12. Methane and hydrogen sulfide gases were not detected during monitoring for worker health and safety purposes at the test pit location.

The primary types of waste encountered at WC-12 (along with the estimated percentage by weight) included concrete (44.7 percent) and other construction debris (44.7 percent). In

Table 2. Laboratory Results
Atrisco Landfill

Compound Name	A1	A2	A3	A4	A5	A6	A7	A8	A9
Modified Method TO-14 [a] (ppbv)									
1,1,1-Trichloroethane	---	---	---	---	---	---	---	---	---
1,1,2-Trichloroethane	---	---	---	---	---	---	---	---	---
1,1-Dichloroethane	---	---	---	---	---	---	---	---	---
1,1-Dichloroethene	---	---	---	---	---	---	---	---	---
1,2,4-Trimethylbenzene	---	---	75	46	260	120	48	43	250
1,2-Dichlorobenzene	---	---	---	---	---	---	---	---	---
1,2-Dichloroethane	---	---	---	---	---	---	---	---	---
1,2-Dichloropropane	---	---	---	---	---	---	---	---	---
1,3,5-Trimethylbenzene	---	---	---	---	---	---	---	---	---
1,3-Dichlorobenzene	---	---	---	---	---	---	---	---	---
1,4-Dichlorobenzene	---	---	---	---	---	---	---	---	---
2-Propanol	---	---	---	---	---	---	---	---	---
Benzene	---	---	---	---	---	---	---	---	---
Bromomethane	---	---	---	---	---	---	---	---	---
Carbon tetrachloride	---	---	---	---	---	---	---	---	---
Chlorobenzene	---	---	---	---	---	---	---	---	---
Chloroethane	---	---	---	---	---	---	---	---	---
Chloroform	---	---	---	---	---	---	---	20	---
Chloromethane	---	---	---	---	---	---	---	---	---
cis-1,2-Dichloroethene	---	---	---	---	---	---	---	---	---
Ethylbenzene	---	---	---	---	---	---	---	---	---
Ethylene dibromide	---	---	---	---	---	---	---	---	---
Freon 11	---	---	---	---	---	---	---	---	---
Freon 113	---	---	---	---	---	---	---	---	---
Freon 114	---	---	---	---	---	---	15	89	---
Freon 12	---	---	140	15	33	---	20	45	13
m,p-Xylene	---	---	---	---	---	---	---	---	---
Methyl tertiary-butyl ether	---	---	---	---	---	---	---	---	---
Methylene chloride	---	---	---	---	---	---	---	---	---
o-Xylene	---	---	---	---	---	---	---	---	---
Tetrachloroethene	---	---	---	---	---	---	---	---	---
Toluene	---	---	---	---	---	---	---	---	---
trans-1,2-Dichloroethene	---	---	---	---	---	---	---	---	---
Trichloroethene	---	---	---	---	---	---	---	---	---
Vinyl chloride	---	---	---	---	---	---	---	---	---
Method 3C [b] (% volume)									
Carbon dioxide	NS	NS	NS	NS	18	NS	NS	NS	NS
Methane	NS	NS	NS	NS	---	NS	NS	NS	NS
Nitrogen	NS	NS	NS	NS	75	NS	NS	NS	NS
Oxygen	NS	NS	NS	NS	4.1	NS	NS	NS	NS

[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

addition, minor quantities of metal (6.4 percent), green waste (2.8 percent), rubber (1.0 percent), and paper (0.4 percent) were encountered.

Table 3. Waste Characterization Boring Summary
Atrisco Landfill

Boring Number	Depth of Boring (feet)	Boring Location [a]	Depth Interval of Waste/Debris	Weight Percentages and Nature of Waste/Debris	Decomposability Rating
WC-12	13.5	• N 1482457 Usft. • E 1507200 Usft.	1.0 to 13.5 feet bgs	• 2.8% Green waste [b] • 44.7% Concrete • 1.0% Rubber • 44.7% Other construction debris • 0.4% Paper [b] • 6.4% Metal	Degradable fraction • 0% Rapid • 3.2% Moderate • 0% Slow Non-degradable fraction • 96.8% Inert

[a] New Mexico Planes Central Zone (NAD 83).
[b] Compose degradable fraction (see Table 6).
Usft. = U.S. survey foot (equals 0.3048006096 meters)
feet bgs = Feet below ground surface
NA = Not applicable

Three samples of waste materials were collected and analyzed for moisture content. The samples were obtained from 5 to 6 feet, 9 to 10 feet, and 12 to 13 feet bgs. The moisture content determined in the laboratory for the three waste samples ranged from 7.4 to 10.0 percent. A summary of moisture content data is included in Table 4. Complete laboratory moisture content results are contained in Appendix D.

The moisture content is low, considering the test pit's location in the storm water detention basin. The low moisture content may reflect the low moisture-holding capacity of the predominant concrete and construction debris that makes up most of the waste, although inert material was excluded from the moisture content samples.

Table 4. Waste Moisture Content Laboratory Results
Atrisco Landfill

Location	Depth (feet)	Sample Number	Moisture Content (%, g/g)
Boring WC-12	5-6	*5-6*	10.0
	9-10	*9-10*	7.4
	12-13	*12-13*	9.3

g/g = Gram per gram

5.4 Landfill Gas Generation Modeling Results

This section presents the model input variables used for estimating LFG generation at the Atrisco Landfill and summarizes the model results.

5.4.1 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 5. Information was gathered from field investigations, laboratory analyses of waste samples, historical documents, and the RFP. Numerous information sources were used to provide reliable estimates for the expected range LFG generation rates. The following model input parameters were chosen:

- Waste disposal history: 75,836 tons of refuse were disposed of between 1968 and 1969.
- L_0 values ranging from 226 cubic foot per ton (ft^3/ton) to 3,550 ft^3/ton.
- k values ranging from 0.010/yr to 0.020/yr.

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

5.4.1.1 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 Atrisco Landfill, three possible waste disposal histories were estimated for the Atrisco Landfill using the following data:

- Aerial extent of the landfill (7.52 acres) multiplied by average waste thickness provided in the City's RFP for this project (8 feet), which yields 97,058 cubic yards.

- Aerial extent of the landfill (7.52 acres) multiplied by average estimated refuse thickness based on information obtained from the waste characterization test pit (12.5 feet), which yields 151,672 cubic yards.

Table 5. Available Information on Waste Disposal History and Volumes
Atrisco 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	1968-1969	7.52	---	8.0	97,058	48,781	Reports a range of refuse depths of 4.5 to 23 feet. Subtracts an estimated cover soil depth of 5.75 feet (calculated below).
Field investigation (present study)	---	7.52	1.0	12.5	151,672	75,836	Soil cover and refuse thickness from WC-12. Refuse thickness is a minimum value since backhoe couldn't excavate below 13.5 feet (top foot consisted of soil). Acreage from existing landfill boundary.
U.S. EPA, 1993	---	---	6.0	42.0	55,556	27,778	Reported "a significant amount of top soil was spread over the mobile home park." Cover soil thickness estimated based on height above pit area where WC-12 drilled. Refuse thickness based on report that landfill located in a gravel pit with an average depth of 48 feet. Reported 1.5 million cubic feet in place, which is about 10 times too low for reported depth and known acreage.
Values used for present study	1968-1969	7.52	5.75	12.5	151,672	75,836	Dates of operation are during City operation and later disposal reported as primarily construction debris was excluded. Acreage is from present study. Cover thickness is area-weighted average of field-derived values and historical reported values. Refuse thickness is field-derived value. RFP reported refuse thickness appears low since field value is minimum value. Historical reference refuse thickness uncertain and inconsistent with reported refuse volume.

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

RFP = Request for proposal
--- = No data

- Historical studies, which indicate the volume of in place waste is approximately 55,556 cubic yards (EPA, 1993).

Additional assumptions used for the study include:

- The reported years of City landfill operation, as provided in the RFP, are 1968 and 1969. Later disposal at the landfill from 1972 to 1977 is reported as consisting primarily of inert construction debris. Assuming this information is correct, and since construction debris is typically inert and the amount of construction debris disposed of at Atrisco Landfill is unknown, only 1968 and 1969 were used for active waste disposal years.

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

Table 5 shows a range of in-place volumes of waste based on this information. For modeling the LFG generation for the Atrisco Landfill, a disposal volume of 151,672 cubic yards (75,836 tons) of refuse was used.

5.4.1.2 Ultimate Methane Generation Rate (L_0)

As outlined in Section 2.7.2, L_0 values used for LFG generation model runs for the Atrisco Landfill were assigned one of the following three values:

- EPA (AP-42) default value of 3,204 ft^3/ton, which is converted from the EPA (AP-42) value 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]).

- Site-calibrated value of 226 ft^3/ton based on the amount of degradable refuse found. This value was compared with the expected fraction of degradable waste remaining for a "typical" U.S. waste stream that had degraded the same number of years as the waste at the Atrisco Landfill. The ratio of degradable waste measured in the field to the expected value was multiplied by the SCS default value to estimate the site-specific value.

Table 6 summarizes the waste composition data and L_0 adjustments used for developing the site-calibrated L_0 value for the Atrisco Landfill. Because of the extremely low fraction of degradable refuse analyzed at Atrisco Landfill, the site-calibrated L_0 has been adjusted downward to 226 ft^3/ton.

Table 6. Derivation of a Site-Calibrated L_0 Value for Atrisco Landfill

Avg. Age of Landfill Refuse (years)	Typical MSW Degradable Fraction [a]	Site Sample Degradable Fraction [b]	Ratio of Site to Typical Degradable	SCS Default L_0 (ft^3/ton)	Site-Calibrated L_0 (Ratio x SCS L_0) (ft^3/ton)
39	50.3%	3.2%	0.064	3,550	226

[a] Derived from EPA's *Characterization of Waste in the United States: 1996 Update* (EPA, 1997) which shows that an average of 67.4 percent of MSW is decomposable as delivered to the landfill. Value shown is the expected fraction of decomposable refuse remaining as of the end of 2001 based on the age of waste in the landfill and the estimated rates of decomposition for waste components.

[b] Degradable fraction of sample from WC-12 (see Table 3).

MSW = Municipal solid waste L_0 = Ultimate methane generation rate ft^3/ton = Cubic feet per ton

5.4.1.3 Methane Generation Rate Constant (k)

As outlined in Section 3.6.4, k values used for the LFG generation model runs for the Atrisco Landfill were one of the following three values:

- 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.
- Site-calibrated k value of 0.01 per year, based on refuse moisture content. Although a numerical relationship between refuse moisture and the k value is not established, this relationship has been indirectly observed in the SCS database of LFG recovery data, which shows that k values tend to increase as annual precipitation increases. The effects of high or low refuse moisture on the k value can be approximated, and adjustments made as appropriate. To evaluate whether the Atrisco Landfill has high or low refuse moisture, the average refuse moisture derived from the field-testing program (8.9 percent) was compared to the moisture content for typical wastes (20 percent).

Because refuse moisture at the Atrisco Landfill was significantly lower than average, a lower k value than the SCS default is implied.

5.4.2 Model Validation Results

Validation of LandGEM's application to the Atrisco 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 Atrisco Landfill.

Use of site-calibrated k and L_0 values also supports the validity of LandGEM results. The site-calibrated k value of 0.010 (compared to default of 0.019) used at the Atrisco Landfill is based on a lower than typical waste moisture content of 8.9 percent (compared to the national average of 20 percent). The site-calibrated L_0 value of 226 ft^3/ton (compared to default of 3,550 ft^3/ton) is based on a lower than typical degradable waste content of 3.2 percent (compared to national average of 50.3 percent). Adjusting LandGEM input parameters in this manner to reflect site-specific conditions for the Atrisco Landfill should provide reasonable estimates of the LFG generation rate.

5.4.3 LFG Generation Model Results

Model results are provided in Table 7 and Figure 6, which show estimated LFG generation through 2020 for the Atrisco Landfill under four different projection scenarios. Table 7 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.

All projections show LFG generation reaching a peak in 1970, one year following closure of the City's municipal landfill operation, and declining at a rate of 1 to 2 percent annually thereafter. LFG generation in 2002 is estimated to range between 0.5 and 10 standard cubic feet per minute (scfm).

Table 7. LFG Generation Projections
Atrisco Landfill
Page 1 of 2

Year	Disposal Rate (tons/yr)	Refuse In-Place (tons)	LFG Generation: Projection 1 (EPA default values) scfm	Mcf/day	Projection 2 (SCS default values) scfm	Mcf/day	Projection 3 (site-calibrated values) scfm	Mcf/day	Projection 4 (site-calibrated values with no L_0 adjustment) scfm	Mcf/day
Methane content of LFG adjusted to:			*50%*		*50%*		*50%*		*50%*	
Methane generation rate constant (k):			*0.020*		*0.019*		*0.010*		*0.010*	
Ultimate methane generation rate (L_0):			*3,204* [a]		*3,550* [a]		*226* [a]		*3,550* [a]	
1968	37,918	37,918	0	0.000	0	0.000	0.0	0.000	0	0.000
1969	37,918	75,836	9	0.013	10	0.014	0.3	0.000	5	0.007
1970	0	75,836	18	0.026	19	0.027	0.6	0.001	10	0.015
1971	0	75,836	18	0.025	19	0.027	0.6	0.001	10	0.014
1972	0	75,836	17	0.025	18	0.026	0.6	0.001	10	0.014
1973	0	75,836	17	0.024	18	0.026	0.6	0.001	10	0.014
1974	0	75,836	17	0.024	18	0.025	0.6	0.001	10	0.014
1975	0	75,836	16	0.023	17	0.025	0.6	0.001	10	0.014
1976	0	75,836	16	0.023	17	0.024	0.6	0.001	10	0.014
1977	0	75,836	16	0.022	17	0.024	0.6	0.001	9	0.014
1978	0	75,836	15	0.022	16	0.023	0.6	0.001	9	0.013
1979	0	75,836	15	0.022	16	0.023	0.6	0.001	9	0.013
1980	0	75,836	15	0.021	16	0.023	0.6	0.001	9	0.013
1981	0	75,836	14	0.021	15	0.022	0.6	0.001	9	0.013
1982	0	75,836	14	0.020	15	0.022	0.6	0.001	9	0.013
1983	0	75,836	14	0.020	15	0.021	0.6	0.001	9	0.013
1984	0	75,836	14	0.020	14	0.021	0.6	0.001	9	0.013
1985	0	75,836	13	0.019	14	0.020	0.6	0.001	9	0.013
1986	0	75,836	13	0.019	14	0.020	0.5	0.001	9	0.012
1987	0	75,836	13	0.018	14	0.020	0.5	0.001	9	0.012
1988	0	75,836	13	0.018	13	0.019	0.5	0.001	8	0.012
1989	0	75,836	12	0.018	13	0.019	0.5	0.001	8	0.012
1990	0	75,836	12	0.017	13	0.019	0.5	0.001	8	0.012
1991	0	75,836	12	0.017	13	0.018	0.5	0.001	8	0.012
1992	0	75,836	12	0.017	12	0.018	0.5	0.001	8	0.012
1993	0	75,836	11	0.016	12	0.018	0.5	0.001	8	0.012
1994	0	75,836	11	0.016	12	0.017	0.5	0.001	8	0.011
1995	0	75,836	11	0.016	12	0.017	0.5	0.001	8	0.011
1996	0	75,836	11	0.015	12	0.017	0.5	0.001	8	0.011
1997	0	75,836	10	0.015	11	0.016	0.5	0.001	8	0.011

[a] Cubic feet per ton.

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

Table 7. LFG Generation Projections
Atrisco Landfill
Page 2 of 2

Year	Disposal Rate (tons/yr)	Refuse In-Place (tons)	LFG Generation: Projection 1 (EPA default values)		Projection 2 (SCS default values)		Projection 3 (site-calibrated values)		Projection 4 (site-calibrated values with no L_0 adjustment)	
			scfm	Mcf/day	scfm	Mcf/day	scfm	Mcf/day	scfm	Mcf/day
Methane content of LFG adjusted to:			*50%*		*50%*		*50%*		*50%*	
Methane generation rate constant (k):			*0.020*		*0.019*		*0.010*		*0.010*	
Ultimate methane generation rate (L_0):			*3,204* [a]		*3,550* [a]		*226* [a]		*3,550* [a]	
1998	0	75,836	10	0.015	11	0.016	0.5	0.001	8	0.011
1999	0	75,836	10	0.014	11	0.016	0.5	0.001	8	0.011
2000	0	75,836	10	0.014	11	0.015	0.5	0.001	7	0.011
2001	0	75,836	10	0.014	10	0.015	0.5	0.001	7	0.011
2002	0	75,836	9	0.014	10	0.015	0.5	0.001	7	0.011
2003	0	75,836	9	0.013	10	0.015	0.5	0.001	7	0.010
2004	0	75,836	9	0.013	10	0.014	0.5	0.001	7	0.010
2005	0	75,836	9	0.013	10	0.014	0.5	0.001	7	0.010
2006	0	75,836	9	0.013	10	0.014	0.4	0.001	7	0.010
2007	0	75,836	9	0.012	9	0.013	0.4	0.001	7	0.010
2008	0	75,836	8	0.012	9	0.013	0.4	0.001	7	0.010
2009	0	75,836	8	0.012	9	0.013	0.4	0.001	7	0.010
2010	0	75,836	8	0.012	9	0.013	0.4	0.001	7	0.010
2011	0	75,836	8	0.011	9	0.013	0.4	0.001	7	0.010
2012	0	75,836	8	0.011	9	0.012	0.4	0.001	7	0.010
2013	0	75,836	8	0.011	8	0.012	0.4	0.001	7	0.009
2014	0	75,836	7	0.011	8	0.012	0.4	0.001	6	0.009
2015	0	75,836	7	0.011	8	0.012	0.4	0.001	6	0.009
2016	0	75,836	7	0.010	8	0.011	0.4	0.001	6	0.009
2017	0	75,836	7	0.010	8	0.011	0.4	0.001	6	0.009
2018	0	75,836	7	0.010	8	0.011	0.4	0.001	6	0.009
2019	0	75,836	7	0.010	7	0.011	0.4	0.001	6	0.009
2020	0	75,836	7	0.010	7	0.011	0.4	0.001	6	0.009

[a] Cubic feet per ton.

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

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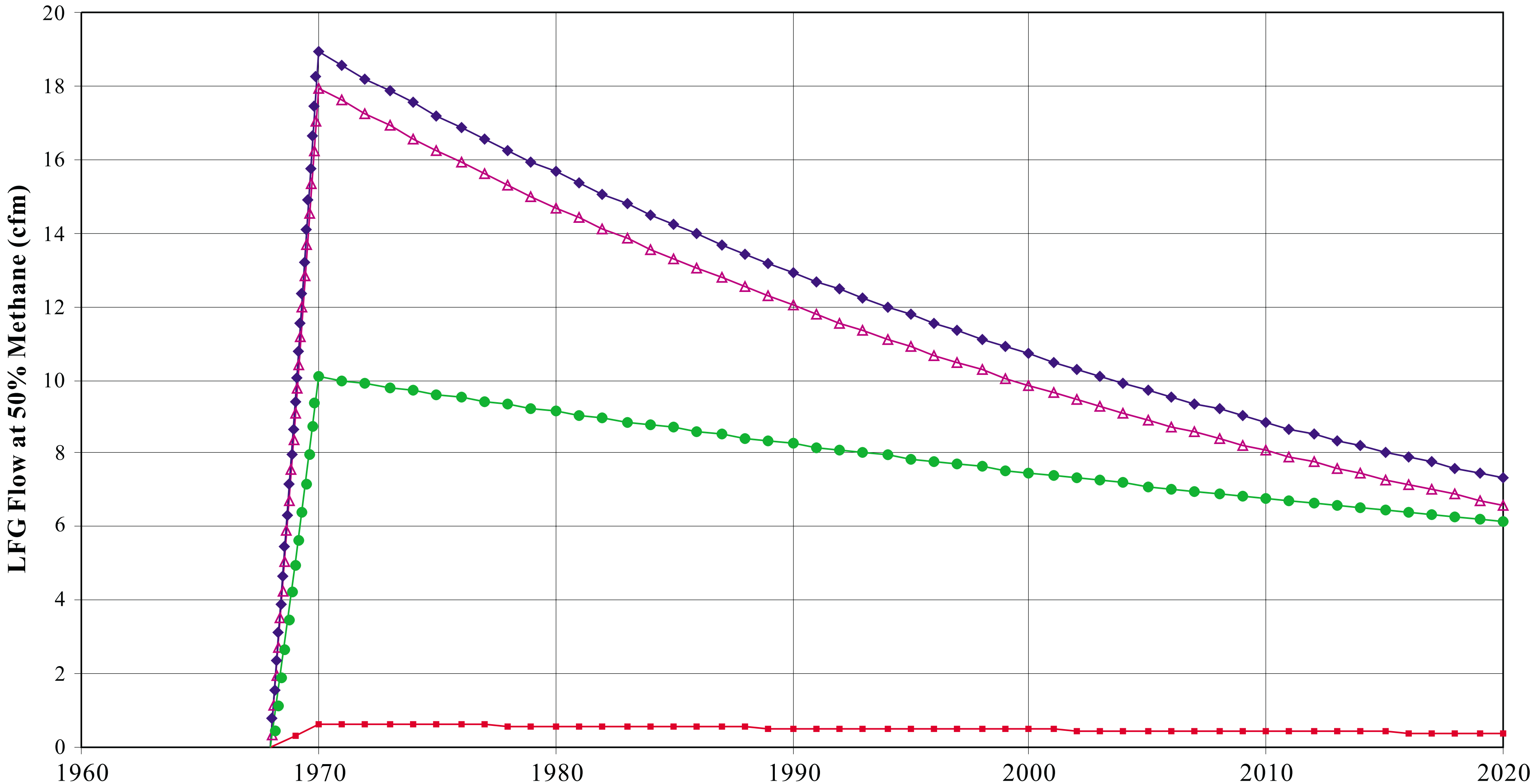

Explanation

- 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 k = 0.010 Lo = 226 cu.ft./ton
- Site-Calibrated k Value w/SCS Default Lo Value K = 0.010 Lo = 3,550 cu.ft./ton

Source: SCS Engineers

LANDFILL GAS INVESTIGATION AND CHARACTERIZATION STUDY

Atrisco Landfill
LFG Generation Projection

Daniel B. Stephens & Associates, Inc.
3-28-02 JN 9398

Figure 6

The highest generation rates occur under the SCS default projection (Projection 2), which uses the highest L_0 value of any projection. The lowest generation rates occur under the site-calibrated projection (Projection 3), which uses a k value of 0.01 that has been adjusted downward from the SCS default (0.019) due to the low moisture content of refuse at the landfill. Also, Projection 3 uses an L_0 value of 226 ft^3/ton, which has been discounted by 94 percent from the SCS default L_0 based on the near absence of degradable waste found in waste samples taken in the field. Overall LFG generation rates will continue to decline, as long as waste conditions are not significantly changed.

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 City owned and/or operated landfills. The following conclusions and recommendations related to the Atrisco Landfill have been made based on available information and the data collected during this investigation. Though it is impossible to precisely predict future LFG generation and migration, careful analysis of data can provide a tool for making an educated prediction of future LFG behavior. These assumptions of future LFG behavior combined with past LFG experience have allowed us to determine the possible effects of LFG on current and future development at and 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 Atrisco Landfill:

- Based on the modeling results, the peak year for LFG generation at the Atrisco Landfill was 1970.

- The estimated LFG generation rate for the Atrisco Landfill indicates that the production of LFG is steadily declining in its current state. The projected LFG generation rate for 2002 for the Atrisco Landfill ranges from 0.5 to 10 scfm.

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

- The LFG survey did not detect measurable methane in any of the nine gas probes installed at Atrisco Landfill.

- VOCs were detected in LFG samples collected at the Atrisco 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 Atrisco 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 Atrisco 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 20 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. 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 nine existing gas probes, selected subsurface utility vaults, and perimeter monitoring probes should be monitored for methane gas on a quarterly basis. The utility investigation recommended in Section 6.2.2 should specify which subsurface utility vaults will be monitored on a regular basis.

- *Change in frequency of monitoring.* If methane gas is detected at any time exceeding 25 percent of the LEL in selected subsurface utility vaults or on-site monitoring probes or exceeding 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.* Continued monitoring of the on-site and perimeter probes and selected subsurface utility vaults should be performed. Monitoring should continue indefinitely, as long as the property continues to be used for residences. The Atrisco Landfill is overlain by extensive water and sewer lines as well as many small storm water detention ponds constructed by the mobile home park developer on individual lots. Because of the potential for increases in waste moisture due to causes such as utility line leaks and poor surface water drainage, LFG generation rates could increase unexpectedly. Therefore, long-term monitoring is needed to detect any significant changes in LFG generation that may occur.

• *Development of property outside landfill perimeter.* Based on the results of the LFG investigation and characterization study, changes are recommended for the Atrisco 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 Atrisco 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 250 feet, based on the absence of methane during the LFG survey at the Atrisco Landfill and the verification of these results by AEHD during continued monitoring of the nine permanent gas probes.

Maintaining a minimum 250-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 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 a return to a greater setback distance of 1000 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 Atrisco 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 on-site monitoring probes, or if the methane content exceeds 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. 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 the LEL in selected subsurface utilities, no further investigation is needed. However, if methane concentrations increase above 25 percent of the LEL, additional investigation of utilities should commence.

- *Development of landfill property.* Additional development on the Atrisco Landfill within the mobile home park, should meet the general requirements of the City's Interim Guidelines. This will provide a notice between the property owner and City, so that the City is aware of construction plans and the property owner is informed of measures needed to address LFG and possible differential settlement. As long as methane is not detected above 25 percent of LEL in the on-site landfill monitoring probes, the requirements under the City's guidelines should not require any additional LFG abatement, monitoring, or certification requirements. If methane concentrations increase above 25 percent of LEL, additional LFG abatement requirements will be necessary.

- *Surface emissions testing.* Because the Atrisco Landfill has been developed as a mobile home park, surface emissions testing is recommended. This testing would involve collection and analysis of surface air samples from representative locations at the site. It is recommended to collect the samples from beneath three or more typical mobile homes (within the mobile home's skirts) using a Summa canister equipped with a 4-hour orifice. The collected gas would be representative of "surface emissions" and should be analyzed by Method TO-14 for VOCs (modified for LFG specific constituents). The results of the initial surface emissions testing should be used to evaluate the need for additional surface monitoring. Surface emissions testing may also be added if monitoring of selected utilities or gas probes indicates an increase in LFG.

- *Drainage control.* Current drainage at the Atrisco Landfill is poor, and positive drainage should be maintained over the landfill to prevent excess infiltration of water into the landfill waste. It is recommended that the City consider undertaking a site drainage study to determine existing drainage patterns and identify needs for possible improvements.

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