Appendix J

SCS Engineers Odor Studies

Review of Odor Management at Western Regional Sanitary Landfill

Evaluation of Incremental Odor Increase from Western Regional Sanitary Landfill

SCS ENGINEERS

Review of Odor Management at Western Regional Sanitary Landfill

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November 9, 2017
File No. 01217279.00

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INTRODUCTION

This Review of Odor Management (Review) at the Western Regional Sanitary Landfill (WRSL) has been completed at the request of Ascent Environmental, Inc. (Ascent) on behalf of Placer County (County) to assess potential changes to the existing one-mile buffer for residential land use around the WRSL (Buffer).

The County is proposing residential development as part of the Sunset Area Plan, a portion of which is in the current Buffer around the WRSL. The Buffer restricts residential development within one mile of the WRSL

1.0 LANDFILL BACKGROUND

WRSL is owned and operated by Western Placer Waste Management Authority (WPWMA). WRSL is located approximately one (1) mile north-northwest of the city of Roseville, and encompasses an area of 291 acres, of which 231 acres are permitted for disposal activities. WRSL has been operating as a Class II and Class III Waste Management Unit (WMU), and consists of 14 modules. The Class II WMU is comprised of Modules 5, 6, 7, 8, 9, 14, 15, and 16. The Class III WMU is comprised of Modules 1, 2, 10, 11, 12, and 13. Modules 1 and 2 were closed in 1998, and Modules 10 and 11 were closed in 1999. Modules 6 through 9 are undeveloped.

Solid waste collected in western Placer County is processed at the WPWMA’s Material Recovery Facility (MRF). The MRF receives, separates, processes and markets recyclable materials removed from the waste stream. The facility also processes source separated wood waste, green waste, and construction and demolition debris. Hazardous waste from households and Conditionally Exempt Small Quantity Generators is accepted at the Permanent Household Hazardous Waste Facility (PHHWCF), located next to the MRF.

Residual waste from the MRF is transported to the WRSL. WRSL is specified as a Class II/Class III non-hazardous site and a private firm, under contract with WPWMA, manages its operation.

The WRSL’s maximum permitted disposal is 1,900 tons per day and currently receives approximately 1,000 tons per day. Under current land use and development conditions, WRSL has a projected lifespan extending to 2058.

1.1 LANDFILL GAS COLLECTION AND CONTROL SYSTEM

The existing landfill gas (LFG) collection, control and monitoring system, as of this study, installed at WRSL consists of the following components:

- A system of vertical extraction wells installed in the existing waste mass;
- Test wells that are connected to the conveyance system to provide some additional coverage in Module 2;
- A system of vertical extraction wells installed in native soils outside the limit of fill (perimeter system);

- Horizontal collectors installed in the existing waste mass to help control surface emissions;
- A system of lateral piping which connects the vertical wells and horizontal collectors to a main header system;
- Three main collection headers (one for the perimeter extraction system and two for the infill extraction system) which transport LFG to the blower/flare station;
- Sumps for collection of condensate.
- A blower/flare station with a flare capacity of 2,500 standard cubic feet per minute (scfm), three blowers (two with a capacity of 1,200 scfm each and one with a 2,500 scfm capacity), and condensate separators;
- A network of perimeter LFG monitoring probes;
- A landfill gas to energy (LFGTE) plant (Energy 2001) which consists of the following components:
  - Six LFG fueled engines which can control approximately 1,800 scfm of LFG;
  - A small flare which can control from 50 to 450 scfm of LFG.

1.2 MATERIALS RECOVERY FACILITY (MRF) AND COMPOSTING FACILITY

The MRF is designed to recover recyclable materials (including newspaper, cardboard, metals, glass, plastics, green waste, and wood waste) from the trash to reduce the amount of material placed in WRSL. The MRF operates under the solid waste facility permit number 31-AA-0001. The permitted area of the MRF is 52.6 acres, which includes 18.3 acres located within the WRSL boundary adjacent to the MRF's southern boundary. The maximum tonnage allowed at the MRF is 1,750 tons per day, while the design capacity is 3,850 tons per day.

The MRF alone diverts approximately 28 percent of the solid waste received. Combined with the source-separated wood waste, green waste, and inert waste diversion programs, the facility as a whole diverts approximately 42 percent of the waste received.

The MRF operations include a composting facility to produce compost suitable for public use as topsoil amendment, and a chipping and grinding operation.

Feedstock for the composting and chipping and grinding operations consist of source-separated green waste from commercial and residential haulers and green waste recovered from the municipal solid waste (MSW) and construction and demolition (C&D) sorting processes. The composting process is a turned windrow process. The turning provides aeration which minimizes odors. The composting and chipping and grinding operations are conducted on concrete pads that were constructed to minimize ponding and graded to drain to a properly designed drainage containment pond. All existing finished product storage areas are concrete pads that also drain. Drainage facilities are designed so that all contact water is separated from storm water. The facilities were constructed with a capacity of 75,000 cubic yards for compost storage and processing and for finished product storage. Approximately 50,000 tons of feedstock per year are delivered to the composting facility.

2.0 ODOR CONTROL TECHNOLOGIES

Odor management practices at landfills, MRFs, and composting facilities exist to prevent excessive odor impacts from those facilities at nearby neighborhoods, which could rise to the levels of a public nuisance. This section will discuss some of the technologies each practice can employ to reduce odor impacts from each source.

2.1.1 LANDFILL ODOR CONTROL PRACTICE

LFG contains a variety of chemicals which can contribute to odor. Sulfurous chemicals are the primary odor drivers in LFG. Hydrogen sulfide is the dominant odor driver in LFG, with methyl and ethyl mercaptan the next biggest contributors. These reduced sulfur compounds are generated in the landfilled waste when sulfur-containing materials, such as drywall, decay. Other volatile organic compounds (VOCs) can also contribute to the overall odor, but they are unlikely to be the odor drivers. These odors are generated by anaerobic waste, typically placed more than one year ago. The odorous chemicals are then emitted through the landfill surface as fugitive gas.

Another contributor to odor from landfills is newly placed waste. This is the waste that is brought daily by trucks and is covered each night. The odor from this waste is distinct from the odor of LFG. Chemicals contributing to the odor are highly dependent on the waste stream, but can include ethyl acetate and limonene. These odors are generated by recently placed waste, which is undergoing anaerobic degradation.

Methods of controlling odor emissions from a landfill include LFG collection and control systems (GCCS) and cover management. Both these practices are regulated by the landfill New Source Performance Standard (NSPS). When the Buffer at WRSL was created, the NSPS was the standard for controlling odor from landfills.

The NSPS requires that landfills as large as WRSL install LFG collection and destruction. The NSPS was intended to reduce emissions of non-methane organic compounds (NMOCs) and VOCs from landfills. NMOCs and VOCs include odorous compounds. While the NSPS was not intended as a way to reduce odor from landfills, it has the effect of reducing odor emissions from landfills. Historically, the U.S. Environmental Protection Agency (EPA) has estimated that landfills collect and destroy 75 percent of the generated LFG, on the average.

The NSPS also requires that landfills install intermediate and final cover after waste placement in areas has ceased. These thicker covers serve to reduce odor emissions from landfills by restricting air flow through the surface and increasing LFG collection by the GCCS.

Since the creation of the Buffer around WRSL, two major regulations have passed which improve odor management practices at the WRSL.

In 2009, the California Air Resources Board (CARB) implemented the Landfill Methane Regulation (LMR) for solid waste landfills. The LMR also requires that landfills collect and destroy LFG, but requires additional monitoring and applies to smaller landfills in California. The LMR also has cover installation requirements which require the installation of cover on a faster timeline than the NSPS. LMR requires integrated surface monitoring of the landfill surface in addition to the instantaneous surface monitoring required by the NSPS. LMR also requires monitoring of landfill penetrations and pipelines with positive pressure, which are not required by the NSPS. In its assessment of the impact of LMR on emissions, CARB estimated that the LMR would increase LFG collection to 85 percent in California.

The second regulatory change that could change odor emissions from WRSL is the new landfill NSPS, passed in 2016 and effective as of September 2017. The new NSPS requires more monitoring of landfill emissions than the old NSPS. It is unlikely that the new NSPS will have much impact on the odor emissions from WRSL because the facility is not currently subject to the regulation, and the LMR is generally more stringent.

Technological improvements to landfill odor emissions have been incremental since the adoption of the Buffer. Both GCCS design and cover technologies for landfills have matured over the last 20 years. Examples to improvements to GCCS design include improved flares and engines used to destroy LFG and remote monitoring and control of GCCS operation. Improvements to landfill cover technologies include improvements in synthetic materials and practice. These technological improvements could potentially be implemented in areas where the GCCS is expanded or where final cover is implemented. Overall these technological improvements to reduce odor impacts are minor and would not be expected to contribute significantly to odor mitigation at WRSL.

2.1.2 MRF ODOR CONTROL PRACTICE

MRF odor control technology has not fundamentally changed since the creation of the Buffer, but the practice has changed to reduce odor from MRF operations. The MRF was not at the WRSL at the time of the adoption of the Buffer. Good housekeeping remains a key element of MRF odor management. MRF odor management has grown to include improved management of fines and dust control as well. MRF fines and dust can generate odor of they are left open to the air outside the MRF building, so covering MRF fines and using misters to control dust is an effective odor control measure. The technology and practice of covering fines and misting to reduce dust are not new, but there is better understanding in the industry of the effectiveness of these practices since the implementation of the Buffer.

MRF fines are a major contributor to odor from the MRF because they typically contain a high amount of sulfur-containing materials such as dry-wall dust as well as some residual organic materials. Because of the high surface area of the dust, it can decay rapidly and generate odorous chemicals.

2.1.3 COMPOST ODOR CONTROL PRACTICE

Odor from composting can include many of the same chemicals that are found in LFG, but composting odor is generally not driven by the sulfurous chemicals. Instead, compost odor is typically characterized by aldehydes, volatile fatty acids (VFA), and ammonia. The composition of the compost odor can change throughout the composting process. Compost odor can be generated from inside the windrow or pile, and then is emitted from the surface of the windrow or pile.

Prior to 2002, WRSL used a 3.1 acre pad for its composting operation. The current operation encompasses 25.4 acres and consists of receipt, processing, composting, finished product screening, and storage areas. There have been significant changes in the state of the practice for odor mitigation from compost facilities since the implementation of the Buffer. Windrow composting operations in California are still common practice, but aerated static piles (ASP) are becoming more common as a way to reduce VOC and odor emissions from composting operations. In some jurisdictions (e.g. Bay Area Air Quality Management District [BAAQMD]), covered ASP (CASP) is required as the Best Available Control Technology (BACT) for new or modified composting operations.

It is also possible for compost operations to be fully enclosed in structures to control odors. These structures and then aerated and the air is filtered before being exhausted outside the enclosed building. Enclosure of the composting operation is significantly more expensive than windrow or ASP composting operations, but offers an additional level of control of odor impacts.

Compost covers have also been required of compost facilities in several air quality districts (e.g. BAAQMD, South Coast Air Quality Management District [SCAQMD], San Joaquin Valley Air Pollution Control District [SJVAPCD]). Covering the composting materials during the active composting phase with a layer of finished compost has been shown to be effective at reducing VOC emissions, which will also serve to reduce odorous emissions.

2.1.4 GENERAL ODOR CONTROL STRATEGIES

General odor impact reduction technologies and practice have improved since the adoption of the Buffer in 1994. These technologies include the utilization of deodorizing or odor masking misters. These misters can be applied at a source-specific level, such as misters in the MRF, or as a site-wide odor reduction level where misters would be placed between odor sources and downwind receptors. In general, these site-wide odor-reducing misters are best applied as a last line of defense against odor impacts because their impact can be unreliable if misapplied. Target use of odor-reducing misters, such as at the MRF, is expected to be more reliably effective and would serve the secondary purpose of reducing dust.

3.0 BACKGROUND CONDITIONS

When the Buffer was implemented in 1994, WRSL contained approximately two (2) million tons of solid waste and recovered approximately 500 standard cubic feet per minute (scfm) of LFG. The landfill now contains approximately 8 million tons of waste and generates over 1,500 scfm of LFG. The composting has similarly expanded from a 3.1 acre operation to 25.4 acres for composting.

Surround land use is still primarily agricultural and industrial within one mile of the WRSL. Outside of the Buffer, there are residences approximately 1 (one) mile to the south of WRSL. These residences were not present when the Buffer was adopted and were constructed in the early 2000s. In the mid-2000s, the Settler’s Ridge development was constructed to the west of the Crocker Ranch development.

4.0 PREVIOUS ODOR STUDIES

Several odor studies and evaluations have been performed on behalf of the County and/or the Authority, including:

- Landfill Survey and Report (URS, 2005)
- Air Modeling Report (SCS Engineers, 2007)
- Odor Study Report (SCS Engineers, 2009)
- Compost Facility Odor Evaluation (Integrated Waste Management Consulting [IWMC], 2009)
- Evaluation of Current and Future Conditions at the WPWMA Facilities and Analysis of Odotech Odor Emission Monitoring System (CalRecovery, 2015)
- Odor Assessment (Environmental Management Consulting [EMC], 2015)

This section will provide a brief summary of each of the reports, including methodologies, methods, analytes, and results, where applicable.

4.1.1 LANDFILL SURVEY AND REPORT

The Landfill Survey and Report was prepared by URS in 2005. The report provides a summary of information related to landfills and other waste management facilities (MRFs, transfer stations, composting facilities) in an effort to provide the County with information about the Placer Ranch development, which was planned at the time the report was written.

The Landfill Survey and Report reviewed buffer requirements around comparable facilities, reviewed complaints related to those facilities, and reviewed odor mitigation strategies. The URS report did not conduct field sampling, analysis or surveys. The URS report is unique in that it included a phone survey of regulatory agencies, landfill operators, and elected officials. The survey asked whether officials were aware of complaints received about the landfill and whether they were familiar with the Buffer.

The Landfill Survey and Report concluded that buffer policies were not directly correlated to adjacent development and complaints (e.g. “sites with larger buffers had similar complaints to facilities with smaller buffer zones”). URS found that buffer zones could reduce complaints related to non-odor issues, such as aesthetics, litter, and dust, but URS found that other factors, including landfill and composting operational practice were more significant contributors to odor-related complains. The URS report did not specifically recommend odor management policies, but it did not several policies that could mitigate odor impacts, including:

- meteorological monitoring,
- adjusting hours of operation,
- improved litter control,
- improved community outreach,
- notice to homeowners,
- locating composting operations at a remote area of the facility,
- composting in ag-bags or enclosures,

- control of compost feedstock accepted.

The effectiveness of these recommendations will be discussed later in this evaluation.

4.1.2 AIR MODELING REPORT

SCS prepared an air dispersion modeling report for the WRSL in 2007. The Air Modeling Report provided a screening-level evaluation of the transport of odor from the facility to offsite receptors. The Air Modeling Report evaluated hydrogen sulfide, ammonia, and NMOC emissions from the WRSL operations and the potential of those emissions to impact receptors 1.52 to 2.78 miles away.

The Air Modeling Report determined that ammonia would not be expected to exceed the concentration at which humans can smell it (odor detection threshold) at any of the modeled residential locations. The report also concluded that individual NMOC species were also unlikely to exceed the odor detection threshold. However, the Air Modeling Report determined that hydrogen sulfide may be detectible at offsite locations.

The Air Modeling Report provided a preliminary evaluation of whether sources at WRSL could be the cause of odor complaints in the area and served to inform later sampling in the area. The Air Modeling Report confirmed that the landfill was a potential contributor to odor impacts but could not confirm or eliminate composting as a contributor. It did not make recommendations related to odor mitigation.

4.1.3 ODOR STUDY REPORT

In 2009, SCS prepared an Odor Study Report. The 2009 Odor Study Report was conducted to identify potential odor sources, review on-site odor management. The 2009 Odor Study Report also identified other potential sources of odor in the region and which conditions were most likely to lead to odor complaints.

The report included interviews with nearby residents who had complained about odor. Complaints were generally consistent about the characterization of odor as “decomposing or rotting vegetation” but the description of the wind conditions when odors were worst was inconsistent.

The 2009 Odor Study Report included field sampling for hydrogen sulfide with a portable Jerome Model 631X meter, sampling for VOCs with a photo ionization detector (PID) and sampling for total organic gases (TOG) with a flame ion detector (FID). The field sampling was conducted around the WRSL facility, residential neighborhoods, and near potential off-site sources of odor.

The 2009 Odor Report also included collection of overnight ambient air samples for analysis by a laboratory. The overnight samples were analyzed for 80 chemicals, including hydrogen sulfide, other reduced sulfur compounds, chemicals characteristic of composting, and chemicals characteristic of LFG.

The 2009 Odor Study Report concluded that composting was a likely source of off-site odor because it was the strongest source of odor observed during the site visit and changes to the composting operation occurred at the same time odor complaints from the neighborhood increased. The 2009 Odor Study Report also concluded that LFG was a likely source of off-site odor because field sampling confirmed the presence of hydrogen sulfide off-site and at the landfill. The report found that the MRF was not likely to be a major contributor to off-site odor impacts due to the lack of odor observed during the site visit.

The 2009 Odor Study Report made several recommendations for odor mitigation, including:

- continued documentation of odor complaints,
- correlate complaints with upset conditions,
- review and update the Odor Impact Minimization Plan (OIMP),
- conduct additional air monitoring,
- review and improve the LFG system design,
- review and improve the composting operation,
- add an on-site meteorology station and wind sock,
- acquire a specialized compost turner.

The effectiveness of these recommendations will be discussed later in this evaluation.

4.1.4 COMPOST FACILITY ODOR EVALUATION

IWMC conducted a Compost Facility Odor Evaluation in 2009. The evaluation was to identify factors contributing to odor emissions from the compost facility at WRSL. Unlike most other odor studies for the WRSL, the Compost Facility Odor Evaluation did not address the entire facility but focused on the compost operation.

IWMC conducted a review of the composting OIMP and performed a detailed evaluation of potential design and/or operational changes that could reduce odor emissions from the composting operation. The evaluation did not include sampling or analysis for chemicals or odor. The IWMC evaluation made several recommendations, including:

- self-monitoring for odor,
- correlating complaints with composting operations,
- OIMP document training,
- develop an OIMP mitigation matrix,
- develop a marketing plan for finished compost,
- reduce “off-peak” operations,
- visual screening of compost operations,
- identify off-site options for material handling during peak loading situations.

The effectiveness of these recommendations will be discussed later in this evaluation.

4.1.5 EVALUATION OF CURRENT AND FUTURE CONDITIONS AT THE WPWMA FACILITIES AND ANALYSIS OF ODOTECH ODOR EMISSION MONITORING SYSTEM

CalRecovery performed an evaluation of the Odotech odor emission monitoring system in 2015. The evaluation consisted of a series of three technical memorandums. The first memorandum assesses the current and future conditions of WRSL operations, including projections of future waste processing and placement rates. The memorandum also describes how a proprietary monitoring system (Odotech) would be used to predict odor impacts from the WRSL. The second memorandum provides a scope and cost for improving and additional monitoring and modeling of potential offsite impacts. The final memorandum provides potential emission and control measures for the WRSL.

The evaluation does not provide recommendations for odor control, but it does provide potential odor control measures that could be taken, including an estimated effectiveness and an estimated cost to implement the measure. The potential measures include ASP, ASP with enclosures, operating MRF in a building with negative pressure, cover modifications to the landfill, and enclosing grinding and trommel operations.

4.1.6 ODOR ASSESSMENT

EMC prepared an odor assessment report for the WRSL in 2015. The assessment included the collection of 97 flux samples from the landfill face, inactive landfill surfaces, the MRF, compost windrows, and the leachate pond. Samples were analyzed in the field for hydrogen sulfide and collected samples were shipped to a laboratory for odor analysis by an odor panel.

EMC found that the composting operation had comparatively low odor emissions for a windrow composting operation; however, the composting windrows made up the largest single source of odor sampled. EMC also found that odor emissions from the MRF were low compared to other MRFs. The assessment stated that the active face of the landfill had odor emissions typical of MSW landfills but that biosolids and the MSW derived fines used as alternative daily cover (ADC) had high odor compared to the MSW refuse. EMC believed that the inactive landfill samples may have been collected during upset conditions due to operational changes due to the energy plant operations. During the sampling period, the inactive areas of the landfill were the second largest odor source, but EMC recommended resampling the source during standard (non-upset) conditions.

The EMC Odor Assessment included a few recommendations on controlling odor emissions from WRSL. EMC did noted that ASP composting technology offers significant reductions in odor emissions from composting operations. EMC also noted that while not a major source of odor, the MRF could provide additional odor mitigation by closing doors would further reduce odors. EMC noted that engineering options may need to be considered to mitigate the high odor materials on the landfill active face.

5.0 CURRENT CONDITIONS

The Authority's current operation (MRF, landfill, composting, and supporting operations) takes in approximately 427,000 tons of waste per year, and that waste acceptance rate is expected to increase by more than 40 percent over the next 20 years. The facility has some waste streams/cover materials that are significant sources of odor. MSW and MRF fines used as ADC can be a significant source of odor due to the large amount of surface area, which leads to more volatilization of odorous chemicals and faster generation of odorous chemicals through decay. Wastewater sludge from the Roseville wastewater treatment plant (WWTP) is also a significant source of odor.

The composting operation is much larger than the historical operation. The current composting operation is 25.4 acres, more than eight times larger than the historic composting facility of only 3.1 acres. The EMC report indicates that odors from the windrow composting operation are managed well compared to comparable windrow facilities, but emissions from windrow composting operations are uncontrolled and even a well-managed composting facility can have significant odor emissions.

The MRF does not seem to be a significant contributor to odor emissions from the facility other than when MRF fines are used as ADC and left uncovered overnight.

5.1 ODOR COMPLAINT HISTORY

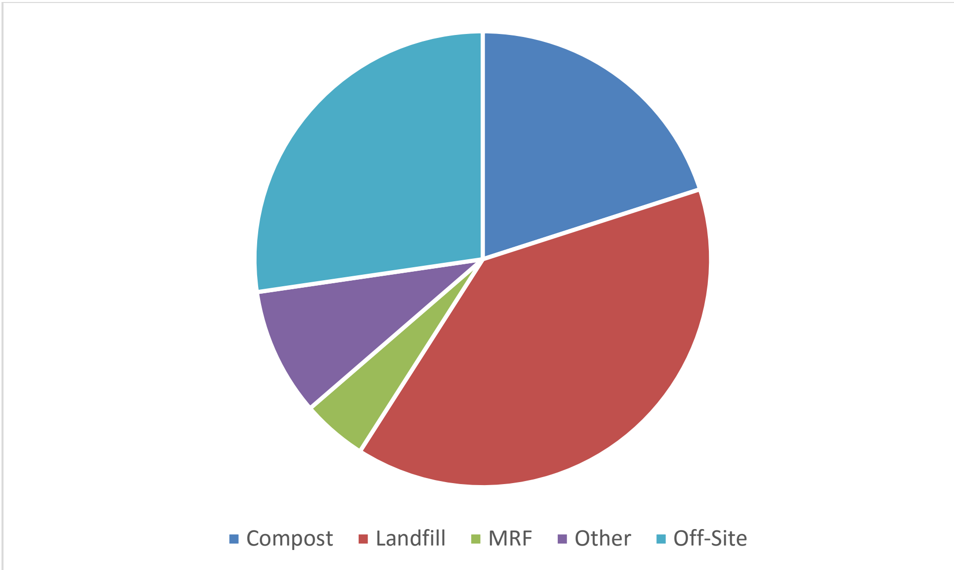
SCS reviewed the odor complaint log provided by the WRSL. ***Table 1*** provides a summary of the complaints by year.

Table 1 – Odor Complaints by Year

Year	Complaints
2012	148
2013	212
2014	93
2015	333
2016	88
2017*	162
*As of September	

A complaint was considered to be valid and attributable to the landfill if it was not attributed to livestock, the WWTP, or the nearby Rio Bravo facility. This methodology may over attribute odor complaints to the WRSL, but the complaints would be consistently over attributed for the years evaluated. The number of complaints does not show a significant trend and varies significantly from year to year. ***Figure 1*** shows the source of each complaint logged for 2012-2017. As seen in ***Figure 1***, the landfill itself is the most common identified source cited in the odor complaints. It is the experience of SCS that odors from sources co-located with the landfill can be misattributed to the landfill itself and it is possible that the compost operation and MRF may represent a greater proportion of odor complaints than shown in ***Figure 1***. However, it is clear that the landfill and the compost operation are the two sources most likely to result in odor complaints.

Figure 1 – Odor Sources 2012-2017



5.2 MITIGATION EFFECTIVENESS

WRSL has implemented many of the recommended odor mitigation measures from historical odor reports. Some of these measures do not directly reduce odor impacts but are intended to make tracking of odor sources more effective, including the maintenance of an odor monitoring log, monitoring local wind conditions, and outreach to the community. WRSL also conducts self-monitoring of odor per its OIMP. SCS notes that WRSL does not correlate odor complaints with weather/wind conditions or landfill operations in its odor complaint logs.

The WRSL OIMP integrates some of the previously suggested odor reduction measures, including good housekeeping practices, proper aeration, moisture management, and storage practiced. The OIMP does not call for moving operations that are likely to cause increased odor emissions (e.g. compost turning) to times that are less likely to have off-site impacts. The EMC sampling indicates that the windrows are generally well managed when not being turned. One observation that has been made in many of the odor reports is that composting in an aerated and/or enclosed operation would significantly reduce odor emissions; however, this modification would incur significant costs and its cost must be weighed against its effectiveness.

WRSL has implemented odor controls for the landfill through continued GCCS expansion and GCCS design review. The upset event during the EMC sampling of inactive areas of the landfill indicates that the GCCS may not be operated with odor control as the primary concern, but such operation may adversely impact the quality of the LFG available to the engine facility.

WRSL continues to receive odor complaints. The relatively large number of complaints received from year to year demonstrates that odor from WRSL is not completely under control. However, the EMC sampling event strongly suggests that emissions for each source are relative low for the type of operation WRSL is using.

6.0 SOLID WASTE FACILITY BUFFER AREAS

The Buffer around the WRSL prohibits residential development within one mile of the WRSL. Other jurisdictions use similar restrictions for similar waste management facilities, but the approach is not universal. California does not have a buffer requirement at the state level. A buffer distance of one mile (5,280 feet) is large compared to other buffer areas where such buffers exist. ***Table 2*** shows a summary of some jurisdictions of landfills in California and the buffer distances.

Table 2 – California Landfills and Buffers

Jurisdiction	Facility	Buffer Distance (ft)	Basis	Technology (current)
City of Chula Vista	Otay Landfill	700-1,000	Health and odor assessment, historical odor complaint data	LMR compliant landfill, windrow composting, odor monitoring
Contra Costa County	Keller Canyon	2,000	Not provided	LMR landfill, windrow composting
Contra Costa County	West Contra Costa Landfill	none	NA	LMR landfill
Fresno County	American Avenue	none	NA	LMR landfill
Kern County	Shafter-Wasco	660	Precautionary	LMR landfill
Kern County	Other facilities	None	Precautionary	LMR and NSPS landfills
Los Angeles County	Puente Hills	1,000	Precautionary	LMR landfill
Los Angeles County	Antelope Valley	None	NA	LMR landfill
Los Angeles County	Lancaster Landfill	None	NA	LMR landfill
Merced County	Highway 59	60-700	Precautionary	LMR landfill, windrow composting
Monterey County	County facilities Other facilities	2,500 1,000	Precautionary	LMR and NSPS landfills, windrow composting, food waste composting, anaerobic digestion
Sacramento County	Kiefer Landfill	2,000	Precautionary	LMR Landfill
San Joaquin County	Forward Landfill	None	NA	LMR Landfill, windrow composting, MRF
Sonoma County	Central Landfill	1,320	Precautionary	LMR Landfill, MRF
Tulare County	Visalia Disposal Site	None	NA	LMR Landfill
Yuba County	Ostrom Road	3,960	Odor and risk evaluation	LMR Landfill

Some of these buffers have been rigorously evaluated, but others are conservative approaches designed to create a separation between the receptor and landfill as a precaution against potential odor or health impacts. Jurisdictions taking a precautious approach have created buffers to prevent residential encroachment on landfills on the basis of potential odor, nuisance, health risk, or vapor intrusion. These policies have rarely been formed on the basis of a rigorous or site-specific evaluation of odor or risk. In most cases, the buffer policies were adopted prior to the implementation of the NSPS. The addition of new, potentially odor-emitting, processes such as composting, has not prompted revisitation of buffer distances. Similarly, tightening regulation on LFG emissions such as the NSPS and LMR has not impacted buffer distances. In general, buffer distances are independent of landfill practice, processes, and even size. For example, the Lewis Road Landfill in Monterey County holds approximately 22 million tons of waste and has a buffer of 2,000 feet, but the Puente Hills Landfill in Los Angeles holds more than 12 million tons of waste but has a buffer of only 1,000 feet.

Some counties have policies that create or result in unofficial buffers around landfills. Fresno County and Kern County are examples of this approach. Both counties have acquired land around county-owned landfills to create an informal buffer separating the landfills from other land use without official buffer policies for most sites. Other facilities have naturally occurring buffer zones, such as Central Disposal Site in Sonoma County. Some buffer area around the Central Disposal Site exists as a result of environmentally sensitive areas that cannot be developed residentially.

The one mile Buffer is significantly larger than most buffers around landfills in California.

6.1 OTAY LANDFILL

One notable exception to the non-specific evaluation of buffer policies is the Otay Landfill. The buffer at the Otay Landfill is an example of a facility that has undergone analysis of odor and health risk impact from the facility before an existing buffer moved from 1,000 feet to 700 feet from the landfill. Developers proposed residential development inside the 1,000 foot nuisance easement around the Otay Landfill. SCS provided a nuisance and health risk evaluation for the proposed development, assessing the potential impact the landfill would have on residences in the development.

Sources of odor at Otay Landfill were modeled using regional meteorology data. Odor impacts determined by the model were compared to complaint data provided by San Diego County. The assessment included odor emissions from major odor sources at the Otay Landfill, including the landfill itself and the greenwaste composting process. It factored in continued growth of the landfill under the existing regulatory environment, including continued waste placement and continued expansion of the GCCS. The model results were then used to determine whether residences within the original 1,000 foot buffer would be located in an area with odor impacts comparable to residential areas where odor impacts were deemed acceptable. The City of Chula Vista determined that nuisance impacts, including odor, and health impacts were allowable and the proposed development was allowed. The assessment resulted in a reduction of the buffer from 1,000 feet to 700 feet based on the odor results.

Additional development for residential use would require additional assessment of the specific proposed development plan as part of the California Environmental Quality Act (CEQA) process for such a development. Such assessment would include updating odor complaint information, odor emissions source information, and meteorology.

6.2 OSTROM ROAD LANDFILL

The Ostrom Road Landfill buffer represents a middle ground between these two approaches. A uniform buffer of 3,960 feet (three quarters of a mile) exists around the Ostrom Road Landfill. This buffer distance was determined based on site specific conductions such as wind speed and surrounding land use, but the uniform buffer distance does not account for variability in localized impacts by direction as was done in the case of Otay Landfill.

Land use surrounding the Ostrom Landfill is primarily agricultural, and residential developments are not encroaching on the buffer around the Otay Landfill. This surrounding land use makes additional refinement of the buffer area unnecessary. It has been established that the 3,960 foot buffer is protective for both health risk and odor, and there is no necessity to conduct a more refined analysis that might demonstrate that a smaller buffer could be adequate.

7.0 ODOR CONTROL STRATEGIES

There are several odor mitigation methods that are available to the WRSL. Not all these odor mitigation strategies will be viable due to conditions outside the landfill's control, and some strategies may not be feasible for financial reasons, but consideration should be given to all viable strategies.

7.1 CHANGES TO COMPOSTING METHODOLOGY

One recurring recommendation in previous odor evaluations is a fundamental change in the composting process at the WRSL. Recommendations have included utilization of an ASP system and/or partial or total cover or enclosure of the composting process. These changes would require significant and expensive modifications of the WRSL composting facility but we believe they are justified based on the EMC odor sampling results that indicate that composting is the largest source of odor at WRSL and other odor studies that identified composting as the primary source. EMC notes that odor emissions are low compared to other windrow composting facilities, which suggests that odor emissions from windrow composting are unlikely to be mitigated further without changing to a fundamentally different method such as CASP or negatively ASP with a biofilter.

CASP composting of the curing reduces VOC emissions from the overall composting process by 72 percent. Such a large decrease in the VOC emissions would result in a reduction in the odor emissions from composting by a similar amount. Modeling, such as that done for the Otay Landfill, shows that odor emissions from similar sources halves roughly every 250-350 meters. Based on this relationship, SCS predicts that utilizing a CASP system would allow the buffer to be reduced to a half-mile buffer and result in the same number of complaints resulting from compost emissions. Similarly, if the Buffer remained and CASP were implemented, the County could expect the number of complaints resulting from the composting operation to decrease.

Food waste composting has grown as a practice in California. This increase is partially driven by increased waste diversion goals. Food waste composting follows the same general practices as greenwaste composting, but emits significantly more VOCs and odors. If food waste composting is added to the WRSL operation, CASP or similar a similar level of control would be required to mitigate odors to a reasonable level.

Food waste composting increases VOC emissions from the composting process. Air districts have not formalized VOC emission factors, but some research suggests that foodwaste increases VOC emissions by approximately 50 percent. If WRSL adopted both foodwaste composting and CASP, VOC and odor emissions would decrease overall by approximately 50 percent. Based on this decrease in VOC emissions, a decrease in the buffer distance of 250 meters (0.15 miles) is expected to result in the same number of odor complaints from the composting process. It should be noted that the magnitude of the increase of odor and VOC emissions from foodwaste composting is not rigorously established.

Application of a layer of finished compost to unfinished active compost was found to significantly reduce VOC emissions from the active composting phase. This practice has become a regulatory requirement in several air districts in California. Reducing VOC emissions from the active composting phase can significantly reduce emissions of odorous chemicals from the composting process.

The application of a finished compost layer to a windrow composting process mitigates 40 percent of VOC emissions, per SCAQMD regulations.

7.2 MONITORING OF HYDROGEN SULFIDE TRENDS AND SULFUR CONTAINING WASTES

WRSL should track hydrogen sulfide concentrations both in the LFG header and at individual wells as part of its regular monitoring. Because hydrogen sulfide is the major contributor to LFG odor, it is critical for the facility to have an understanding of hydrogen sulfide trends and whether odor emissions may be increasing despite continued control of LFG at the same level.

Tracking waste streams that contain significant amounts of sulfur is another elements of improved hydrogen sulfide tracking. Some waste streams, most notably drywall, MRF fines, and sludge, contain significantly higher amounts of sulfur than other MSW. Tracking trends in these types of waste streams would allow WRSL to anticipate increases in hydrogen sulfide.

7.3 USE OF FINES AS ADC

As previously discussed in this report, MSW/MRF fines can generate much more odor than the normal MSW waste stream due to the large surface area and potential to quickly generate odorous gases. By using fines as ADC, WRSL is leaving one of the most odorous waste streams on the surface of the landfill overnight when conditions can increase the likelihood of significant odor impacts. WRSL may find that they can landfill can reduce odors if they reduce the use of fines and/or quickly cover them with MSW or other daily cover to reduce odor emissions from fines used overnight as ADC.

Drywall fines, which are often a major component of MRF fines, are suspected of creating larger amounts of hydrogen sulfide in LFG. Because of this hydrogen sulfide generation, MRF fines can lead to an increase in landfill odor emissions. Reducing the waste placement of MRF fines could lead to reduced hydrogen sulfide generation and related odorous emissions.

MRF fines should be covered as much as conditions allow. MRF fines should be covered while they are collected for later use to prevent odor emissions before they are landfilled at the working face. They should also be covered quickly with at least a small layer of soil when applied to the working face. Covering the fines will reduce emissions from the fine material, which is one of the major contributors to odor from the landfill itself.

7.4 IMMEDIATELY COVER SLUDGE WASTE

The other waste stream that is especially likely to generate odorous emissions is the sludge WRSL receives from the Roseville WWTP. Immediately covering sludge landfilled at WRSL will help reduce odor emitted by the stream than can migrate offsite and impact residential neighborhoods. It should be noted that there may be upcoming changes at the Roseville WWTP that reduce the quantity of sludge landfilled.

Some sites which accept sludge waste create holes or trenches specifically for the sludge. By pre-digging the holes or trenches, sites can quickly dispose of the waste and cover it, resulting in a location with less surface area for emissions. This practice prevents the sludge from off gassing for extended periods and reduces odorous emissions.

7.5 EARLY EXPANSION OF GCCS

WRSL should consider expanding the GCCS into areas at the earliest feasibly opportunity to expand into a new area. This expansion could be either vertical wells if the area has reached final grade or horizontal collectors if the area is still being filled. Horizontal collectors offer the advantage of providing some level of control to the active face area. This practice should be used more frequently when LFG data show increased levels of hydrogen sulfide in the raw gas in a new waste area or tracking of sulfurous waste streams indicates more sulfurous wastes may be present.

8.0 SCS RECOMMENDATIONS

The existing one-mile Buffer around the WRSL is among the biggest landfill buffers in California. The basis of that distance appears overly cautious and is not robustly justified by the County. The County should consider revision of the Buffer distance. However, the existing complaint log demonstrates that there are existing odor impacts from WRSL. Allowing development between the landfill and areas that are already being impacted by odor is likely to result in additional odor issues unless WRSL significantly reduces existing odor emissions. Changing from a windrow composting facility to a CASP or other controlled system offers the most potential to reduce odor emissions from the facility.

Any revised buffer distance should be consistent with expected and acceptable odor impacts for the proposed land use. The impacts of odor from the WRSL areas removed from the Buffer could be modeled based on current or expected odor mitigation strategies along with air dispersion modeling such as that used by SCS in the 2007 Air Modeling Report or as associated with the Odotech system evaluated by CalRecovery.

WRSL maintains an odor complaint log, and maintenance of a robust odor complaint log is critical to evaluating current odor impacts and in anticipating future odor impacts. Any robust evaluation of future odor impacts should be compared to current odor impacts as a baseline for expected odor levels in surrounding areas. SCS recommends matching complaints to meteorological conditions and operations that are likely to generate significant odor (e.g. compost turning, sludge waste disposal, application of MRF fines).

Evaluation of future odor conditions could be performed to assume certain odor mitigation strategies are adopted, such as the utilization of CASP composting processes or the reduced sludge acceptance at the landfill. This evaluation could provide WRSL with a cost effectiveness for odor impact reductions in a specific area rather than a cost effectiveness based on odor emission rates. This distinction is important because odor impacts are not proportional to emission rates for different sources.

Evaluation of Incremental Odor Increase from Western Regional Sanitary Landfill

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Appendices

Appendix A Baseline Scenario LandGEM Output
Appendix B Project Scenario LandGEM Output

1 INTRODUCTION

Placer County (County) has proposed reducing the buffer areas around Western Regional Sanitary Landfill (WRSL) to allow residential development closer to WRSL. The purpose of the existing policy is to protect the long-term viability of solid waste facilities and to ensure land use compatibility with uses surrounding such facilities. The buffer policy was enacted in 1994 with adoption of the Placer County General Plan. Since the policy was enacted, several odor studies have been conducted at WRSL. SCS conducted a review of the changes in operations, odor control technology, and landfill buffers in California. The County has decided to analyze the incremental increase in odor emissions from the waste generated by the Sunset Area Plan (SAP) and the Placer Ranch Specific Plan (PRSP) (Project).

2 METHODOLOGY

Both the magnitude and the extent of the odor increase from the incremental increase in emissions from WRSL resulting from the Project will be evaluated. This report evaluates only the incremental increase resulting from the Project.

This evaluation will review the incremental odor impact from the Project as a change in odor emissions, a change in odor impact, and a change in odor extent. Only the composting, landfill gas (LFG) odor, the landfill active face, and the material recovery facility (MRF) will be included in the evaluation, consistent with the odor sources believed to be the primary contributors to odor incidents.

The evaluation will also review odor monitoring and modeling data maintained by WRSL as part of its ongoing odor management program.

This evaluation of odor emission rates does not account for any change in odor management practices. It is based on odor emissions measured by Environmental Management Consulting (EMC) and by odor impacts modeled by Odotech. Any improvements to odor management practice (e.g. facility-wide adoption of aerated static pile [ASP] composting) would reduce odors from levels determined in this report.

Incremental waste disposal rates from the Project used in this evaluation are shown in Table 1 Based on current waste in place, the landfill capacity, and a closure date of 2058, it was determined that an annual waste placement growth rate of 1.5 percent was appropriate to assume as a result of the Project. This regional growth is considered independently of the Project for purposes of this evaluation.

Table 1. Waste Placement Rates

Source	Waste Disposed (cubic yards per year)	Waste Disposed (tons per year)
Baseline 2018	321,705	241,279
Baseline 2058	583,578	437,684
Total Project	50,226	37,670

3 ODOR EMISSION RATES

The Project could result in an incremental increase in the odor emissions from WRSL due to the waste stream from the Project that would be processed and disposed of at WRSL. For most sources, including the MRF, compost, and the active face, the increase in odor emissions is expected to be proportional to the increase in the waste processing or waste placement rate. The waste processing and waste placement rate from the Project is proportional, so further discussion will only refer to the waste placement rate. LFG generation is the result of slow decay of waste over time and is not directly proportional to the amount of waste processed in a given year, and this was calculated independently of other odor sources.

Landfill Gas Odor

The incremental increase in the odor from LFG was evaluated by modeling LFG emissions for the baseline conditions and the Project conditions. The United States Environmental Protection Agency's (EPA's) LFG Emission Model (LandGEM) was used to model LFG generation. LandGEM is a first order decay model developed by the EPA to estimate LFG generation using waste input mass and basic climate information.

To model baseline LFG generation, historical waste acceptance was obtained from publicly available waste placement tonnages in the EPA Facility Level Information on Greenhouse Gas Information Tool (FLIGHT) system then extrapolated until the anticipated closure year of 2058. The model output for the baseline scenario is shown in Appendix A.

To model the increase in the LFG emissions from the Project, the waste generation estimated from Phase I of the project was phased in even over the estimated duration of the Project construction of 20 years. As a conservative assumption, all waste generation from Phase II of the project was assumed to occur at year 20 as well. After Project completion, waste placement was assumed to continue at the maximum rate until the closure of WRSL in 2058. The model output for the Project increment is shown in Appendix B.

Because LFG generation increases at landfills until waste placement ceases or is dramatically decreased, the peak year for LFG generation would be 2059, the year after landfill closure. However, other odor sources are likely to have reduced odor emissions when the landfill closes, so 2058 was evaluated as the peak odor emission year except for the Project increment, which would be greatest in 2059. That year will be the peak year of LFG generation for both the baseline and the incremental increase from the Project. A summary of LFG generation in standard cubic feet per minute (scfm) for 2058 for each scenario is shown in Table 2. LFG generation for 2018 is also shown, so projected LFG generation can be compared to current LFG generation.

Table 2. Baseline and Incremental Project LFG Generation

Scenario	Year	LFG Generation (scfm)	% of Current LFG Generation	% of 2058 LFG Generation
Baseline	2018	1,312	100%	41%
Baseline	2058	3,109	237%	100%
Project Increment	2059	199	15%	6.4%

At full buildout and at the peak of LFG generation from the incremental increase in waste generation from the Project, the Project will increase LFG generation by 15 percent relative to current LFG generation, and 6.3 percent relative to the maximum LFG generation.

MRF, Compost, and Active Face Odor

Odor from all other sources is expected to be proportional to the amount of waste processed at the odor source, and the amount of waste processed at each source is proportional to the total amount of waste disposed. The percent increase in the strength of each source is shown in Table 3.

Table 3. Relative Odor Emission Rates from Project

Source	Waste Disposed (tons per year)	% of 2018 Waste	% of 2058 Waste
Baseline 2018	241,279	100%	55%
Baseline 2058	437,684	181%	100%
Total Project	37,670	16%	8.6%

Odor Emission Rates

A November 2015 Odor Assessment report prepared by EMC (Odor Assessment) measured the odor emission rate for most odor sources at WRSL. This data represents the most thorough and current odor emission measurement performed for the site, and the odor emission rates are used as the basis for the 2018 odor emission rates for this evaluation. The odor emission rates found in the Odor Assessment are shown in Table 4. Odor emission rates are shown in dilutions to threshold per minute (DT/min). The business-as-usual (BAU) emissions for 2058 and the Project odor emissions are shown in the table as well.

Table 4. Odor Emission Rates

Source	2015 Odor Emission Rate (DT/min)	2058 BAU Odor Emission Rate (DT/min)	Incremental Project Odor Emission Rate (DT/min)
LFG	2,105,365	4,989,009	319,335
Composting	5,158,143	9,356,955	805,321
Active Face	214,150	388,472	33,434
MRF	4,003	7,262	624
Total	7,481,661	14,741,697	1,158,716

0 shows the incremental increase in odor from the Project relative to current odor emissions and 2058 emissions. Individual odor sources are calculated using the increases shown for sources in Table 2 and Table 3. The change in total odor is calculated as the change in the sum of the odor emissions for all sources.

Table 5. Relative Odor Emission Rates

Source	Incremental Project Odor Emission Rate as a Fraction of 2018 Emissions	Incremental Project Odor Emission Rate as a Fraction of 2058 Emissions
LFG	15%	6.2%
Composting	16%	8.6%
Active Face	16%	8.6%
MRF	16%	8.6%
Total	16%	7.9%

4 MAGNITUDE AND EXTENT OF ODOR IMPACT

WRSL receives odor monitoring and modeling information as part of the OdoWatch system. To estimate the impact of the odor emissions increase, SCS reviewed the odor impact modeled by the OdoWatch system for the month of June, 2018. Odotech, the developers of OdoWatch, indicated that it would not be feasible to review a full year of data, and provided the June 2018 data for review.

The data provided for the OdoWatch system includes the modeled odor concentration at specified locations based on meteorological conditions and odor monitoring sensors. The data from Odotech also include a breakdown of the odor contribution by source. A summary of the number of times the modeled odor concentration exceeded the given threshold at specific location is shown in Table 6. Location descriptions are from the Odotech dataset.

Data are summarized by the number of exceedances of the threshold shown in dilutions to threshold (DT). One (1) DT is the weakest odor concentration that can be detected by half of the population. Generally, odor is frequently considered likely to be offensive when it exceeds 10 DT, may be considered offensive when it exceeds 8 DT, and is sometimes considered offensive when it exceeds 5 DT. These thresholds are sometimes used as regulatory odor nuisance thresholds and are illustrative of the range of odor concentrations that are considered a nuisance. St. Croix Sensory, a laboratory specializing in odor measurement and characterization, notes that 5 DT and 10 DT are common design values used in odor modeling. Illinois and other jurisdictions use an odor concentration of 8 DT as a threshold for residential.

The data reviewed included 10,542 odor calculations for each location. The WRSL parking lot is on the WRSL property and is not considered to be an offsite impact. The location is included because it is included in the OdoWatch data and provides a useful baseline for what odor at WRSL itself is like.

To consider the Project odor effects, the modeled impacts from Odotech were scaled up by source based on the changes in emission rates found in Section 3. The total future odor impact was calculated for each odor impact calculated by Odotech, and the number of exceedances for each threshold and location was determined again. Table 6 shows the results of the calculated impacts.

Finally, Table 6 shows the increase in the number of times the modeled odor impact would exceed each odor concentration threshold (10 DT, 8 DT, and 5 DT) with the incremental increase in odor impact from the Project.

Table 6. Summary of June 2018 Odor Modeling by Odotech

Location	June 2018 Results			June 2018 Plus Project			Increase in Exceedance from Project		
	10 DT	8 DT	5 DT	10 DT	8 DT	5 DT	10 DT	8 DT	5 DT
WRSL parking lot	195	259	485	234	311	578	39	52	93
Closest regional commercial	5	19	71	14	31	86	9	12	15
Mid North boundary of future Sac State	0	2	14	1	4	29	1	2	15
Roundabout at entry to future Sac State	0	0	2	0	0	5	0	0	3
Closest medium density residential	0	0	1	0	0	1	0	0	0
Closest high density residential	0	0	0	0	0	1	0	0	1
Closest low density residential	0	0	0	0	0	1	0	0	1

To determine the incremental odor impact in 2058, the peak odor emission year, impacts from the 2018 Odotech data were scaled up based on the anticipated increases in odor emission rates shown in Table 5. The results of that upscaling are shown in Table 7, as well as the results minus the Project increment and the number of exceedances of each threshold resulting from the Project increment.

Table 7. Future Odor Impacts

Location	Upscaled Impact in 2058			Upscaled Impact Minus Project			Increase in Exceedance from Project		
	10 DT	8 DT	5 DT	10 DT	8 DT	5 DT	10 DT	8 DT	5 DT
WRSL parking lot	434	566	1059	375	505	938	59	61	121
Closest regional commercial	73	102	178	59	93	164	14	9	14
Mid North boundary of future Sac State	14	40	113	9	28	96	5	12	17
Roundabout at entry to future Sac State	1	7	13	0	3	9	1	4	4
Closest medium density residential	1	1	9	0	1	7	1	0	2
Closest low density residential	0	1	7	0	0	6	0	1	1
William Hughes Park	0	0	5	0	0	4	0	0	1
Leopard Davis Park	0	0	5	0	0	3	0	0	2
Verrasona and Vignolia	0	0	5	0	0	4	0	0	1
Closest high density residential	0	1	4	0	0	4	0	1	0
Greywood Circle	0	0	4	0	0	3	0	0	1
Woodcreek Oaks Safeway	0	0	3	0	0	3	0	0	0
Rainbow Trout	0	0	2	0	0	2	0	0	0
Veterans Park	0	0	2	0	0	2	0	0	0
Settlers Ridge	0	0	2	0	0	2	0	0	0
Dugan Park	0	0	2	0	0	2	0	0	0
Amoruso	0	0	2	0	0	2	0	0	0
Fiddyment Farm Elementary	0	0	2	0	0	2	0	0	0
Mel Hamel Park	0	0	2	0	0	1	0	0	1

5 CONCLUSIONS

WRSL will continue to generate odor, and the rate of odor generation will increase until the facility closes. Assuming that no additional odor control is implemented, the odor intensity and footprint from the facility will increase.

The Project will generate waste that will be processed and disposed of at WRSL, and that waste will generate odor. At its peak, that incremental odor will be about approximately 16 percent of what current odor generation at the WRSL is. If the peak incremental increased odor, which will not occur until the full Project buildout is completed, is added to current odor generation, the number of times common odor thresholds are exceeded will increase. The number of locations impacted by the 10 DT and 5 DT plumes will increase as well.

The impact from the incremental increase in waste generation from the Project is much smaller than the increase in odor emissions and impact from the permitted and expected organic growth of the waste stream at WRSL. As seen in Table 2, Table 3, and Table 4, the incremental increase in odor emissions is less than nine (9) percent of the expected odor emissions from WRSL in 2058.

Both the frequency and the footprint of odor events in 2058 without the Project will be greater than the current odor emissions plus an incremental increase in odor from the Project, as seen in Tables 6 and 7.

The Placer County Air Pollution Control District (PCAPCD) does not have a published significance criterion of odor impacts, so these increased odor impacts cannot be compared to a numerical threshold of significance. However, this evaluation supports a conclusion that odor emissions and impact will increase through 2058 and that the incremental odor from the Project will increase odor emissions from WRSL. This evaluation also demonstrates that the increased odor emissions and footprint will not solely be caused by the Project.

Appendix A

Baseline Scenario LandGEM Output

Summary Report

Landfill Name or Identifier: Western Regional Sanitary Landfill

Date: Wednesday, September 26, 2018

Description/Comments:

1.015

About LandGEM:

First-Order Decomposition Rate Equation:

$$Q_{CH_4} = \sum_{i=1}^{n} \sum_{j=0.1}^{1} k L_o \left(\frac{M_i}{10} \right) e^{-k t_{ij}}$$

Where,

Q_{CH4} = annual methane generation in the year of the calculation (*m^3/year*)

i = 1-year time increment

n = (year of the calculation) - (initial year of waste acceptance)

j = 0.1-year time increment

k = methane generation rate (*$year^{-1}$*)

L_o = potential methane generation capacity (*m^3/Mg*)

M_i = mass of waste accepted in the i^{th} year (*Mg*)

t_{ij} = age of the j^{th} section of waste mass M_i accepted in the i^{th} year (*decimal years*, e.g., 3.2 years)

LandGEM is based on a first-order decomposition rate equation for quantifying emissions from the decomposition of landfilled waste in municipal solid waste (MSW) landfills. The software provides a relatively simple approach to estimating landfill gas emissions. Model defaults are based on empirical data from U.S. landfills. Field test data can also be used in place of model defaults when available. Further guidance on EPA test methods, Clean Air Act (CAA) regulations, and other guidance regarding landfill gas emissions and control technology requirements can be found at http://www.epa.gov/ttnatw01/landfill/landflpg.html.

LandGEM is considered a screening tool — the better the input data, the better the estimates. Often, there are limitations with the available data regarding waste quantity and composition, variation in design and operating practices over time, and changes occurring over time that impact the emissions potential. Changes to landfill operation, such as operating under wet conditions through leachate recirculation or other liquid additions, will result in generating more gas at a faster rate. Defaults for estimating emissions for this type of operation are being developed to include in LandGEM along with defaults for convential landfills (no leachate or liquid additions) for developing emission inventories and determining CAA applicability. Refer to the Web site identified above for future updates.

Input Review

The 80-year waste acceptance limit of the model has been exceeded before the Waste Design Capacity was reached. The model will assume the 80th year of waste acceptance as the final year to estimate emissions. See Section 2.6 of the User's Manual.

LANDFILL CHARACTERISTICS

Landfill Open Year	**1979**	
Landfill Closure Year (with 80-year limit)	**2058**	
Actual Closure Year (without limit)	***4298***	
Have Model Calculate Closure Year?	**Yes**	
Waste Design Capacity	**1,000,000,000**	*megagrams*

MODEL PARAMETERS

Methane Generation Rate, k	**0.020**	*$year^{-1}$*
Potential Methane Generation Capacity, L_o	**100**	*m^3/Mg*
NMOC Concentration	**4,000**	*ppmv as hexane*
Methane Content	**50**	*% by volume*

GASES / POLLUTANTS SELECTED

Gas / Pollutant #1:	**Total landfill gas**
Gas / Pollutant #2:	**Methane**
Gas / Pollutant #3:	**Carbon dioxide**
Gas / Pollutant #4:	**NMOC**

WASTE ACCEPTANCE RATES

Year	Waste Accepted		Waste-In-Place	
	(Mg/year)	*(short tons/year)*	*(Mg)*	*(short tons)*
1979	1,607	1,768	0	0
1980	36,130	39,743	1,607	1,768
1981	37,194	40,913	37,737	41,511
1982	38,945	42,840	74,931	82,424
1983	65,895	72,485	113,876	125,264
1984	99,586	109,545	179,771	197,748
1985	116,020	127,622	279,357	307,293
1986	132,267	145,494	395,377	434,915
1987	140,383	154,421	527,644	580,408
1988	186,250	204,875	668,027	734,830
1989	170,125	187,138	854,277	939,705
1990	169,685	186,654	1,024,402	1,126,842
1991	166,487	183,136	1,194,087	1,313,496
1992	167,797	184,577	1,360,574	1,496,631
1993	170,886	187,975	1,528,371	1,681,208
1994	158,105	173,916	1,699,257	1,869,183
1995	165,098	181,608	1,857,362	2,043,098
1996	164,800	181,280	2,022,460	2,224,706
1997	167,631	184,394	2,187,260	2,405,986
1998	181,043	199,147	2,354,891	2,590,380
1999	201,622	221,784	2,535,934	2,789,527
2000	234,530	257,983	2,737,556	3,011,312
2001	248,824	273,706	2,972,086	3,269,295
2002	265,666	292,233	3,220,910	3,543,001
2003	227,205	249,926	3,486,576	3,835,234
2004	234,087	257,496	3,713,781	4,085,159
2005	144,322	158,754	3,947,868	4,342,655
2006	256,788	282,467	4,092,190	4,501,409
2007	228,989	251,888	4,348,978	4,783,876
2008	207,504	228,254	4,577,967	5,035,764
2009	190,955	210,051	4,785,471	5,264,018
2010	188,934	207,827	4,976,426	5,474,069
2011	182,572	200,829	5,165,360	5,681,896
2012	183,652	202,017	5,347,932	5,882,725
2013	195,192	214,711	5,531,584	6,084,742
2014	201,304	221,434	5,726,776	6,299,454
2015	216,138	237,752	5,928,080	6,520,888
2016	234,200	257,620	6,144,218	6,758,640
2017	237,713	261,484	6,378,418	7,016,260
2018	241,279	265,407	6,616,131	7,277,744

WASTE ACCEPTANCE RATES (Continued)

Year	Waste Accepted		Waste-In-Place	
	(Mg/year)	*(short tons/year)*	*(Mg)*	*(short tons)*
2019	244,898	269,388	6,857,410	7,543,151
2020	248,571	273,428	7,102,308	7,812,538
2021	252,300	277,530	7,350,879	8,085,967
2022	256,084	281,693	7,603,179	8,363,497
2023	259,926	285,918	7,859,263	8,645,190
2024	263,825	290,207	8,119,189	8,931,108
2025	267,782	294,560	8,383,013	9,221,315
2026	271,799	298,979	8,650,795	9,515,875
2027	275,876	303,463	8,922,594	9,814,853
2028	280,014	308,015	9,198,470	10,118,317
2029	284,214	312,635	9,478,483	10,426,332
2030	288,477	317,325	9,762,697	10,738,967
2031	292,804	322,085	10,051,175	11,056,292
2032	297,196	326,916	10,343,979	11,378,377
2033	301,654	331,820	10,641,175	11,705,293
2034	306,179	336,797	10,942,830	12,037,113
2035	310,772	341,849	11,249,009	12,373,910
2036	315,433	346,977	11,559,781	12,715,759
2037	320,165	352,181	11,875,214	13,062,736
2038	324,967	357,464	12,195,379	13,414,917
2039	329,842	362,826	12,520,347	13,772,381
2040	334,790	368,269	12,850,189	14,135,207
2041	339,811	373,793	13,184,978	14,503,476
2042	344,909	379,399	13,524,790	14,877,268
2043	350,082	385,090	13,869,698	15,256,668
2044	355,333	390,867	14,219,780	15,641,758
2045	360,663	396,730	14,575,114	16,032,625
2046	366,073	402,681	14,935,777	16,429,355
2047	371,564	408,721	15,301,851	16,832,036
2048	377,138	414,852	15,673,415	17,240,757
2049	382,795	421,075	16,050,553	17,655,608
2050	388,537	427,391	16,433,348	18,076,683
2051	394,365	433,802	16,821,885	18,504,073
2052	400,280	440,309	17,216,250	18,937,875
2053	406,285	446,913	17,616,530	19,378,184
2054	412,379	453,617	18,022,815	19,825,097
2055	418,565	460,421	18,435,194	20,278,714
2056	424,843	467,327	18,853,759	20,739,135
2057	431,216	474,337	19,278,602	21,206,462
2058	437,684	481,452	19,709,818	21,680,799

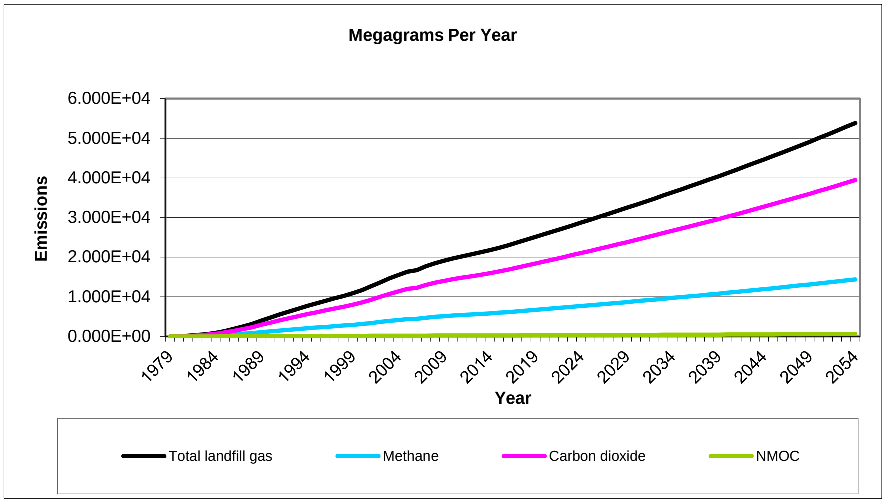
Pollutant Parameters

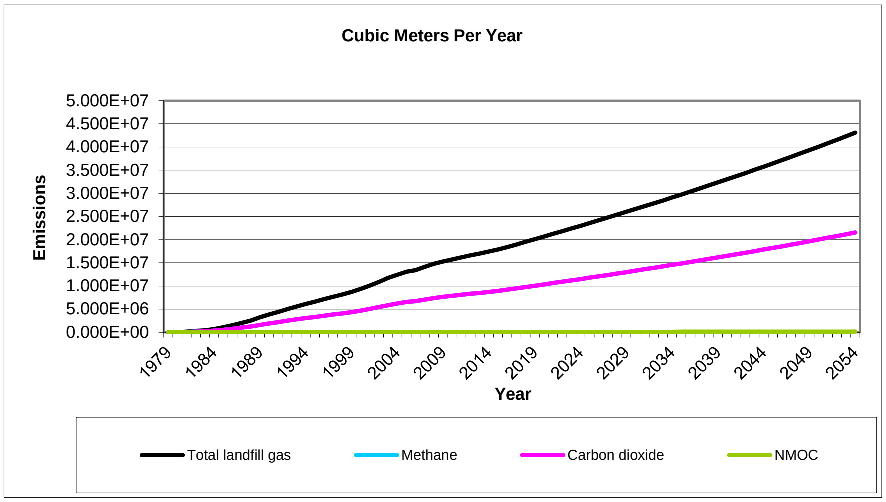
		Gas / Pollutant Default Parameters:		User-specified Pollutant Parameters:	
	Compound	Concentration (*ppmv*)	Molecular Weight	Concentration (*ppmv*)	Molecular Weight
Gases	Total landfill gas		0.00		
	Methane		16.04		
	Carbon dioxide		44.01		
	NMOC	4,000	86.18		
Pollutants	1,1,1-Trichloroethane (methyl chloroform) - HAP	0.48	133.41		
	1,1,2,2-Tetrachloroethane - HAP/VOC	1.1	167.85		
	1,1-Dichloroethane (ethylidene dichloride) - HAP/VOC	2.4	98.97		
	1,1-Dichloroethene (vinylidene chloride) - HAP/VOC	0.20	96.94		
	1,2-Dichloroethane (ethylene dichloride) - HAP/VOC	0.41	98.96		
	1,2-Dichloropropane (propylene dichloride) - HAP/VOC	0.18	112.99		
	2-Propanol (isopropyl alcohol) - VOC	50	60.11		
	Acetone	7.0	58.08		
	Acrylonitrile - HAP/VOC	6.3	53.06		
	Benzene - No or Unknown Co-disposal - HAP/VOC	1.9	78.11		
	Benzene - Co-disposal - HAP/VOC	11	78.11		
	Bromodichloromethane - VOC	3.1	163.83		
	Butane - VOC	5.0	58.12		
	Carbon disulfide - HAP/VOC	0.58	76.13		
	Carbon monoxide	140	28.01		
	Carbon tetrachloride - HAP/VOC	4.0E-03	153.84		
	Carbonyl sulfide - HAP/VOC	0.49	60.07		
	Chlorobenzene - HAP/VOC	0.25	112.56		
	Chlorodifluoromethane	1.3	86.47		
	Chloroethane (ethyl chloride) - HAP/VOC	1.3	64.52		
	Chloroform - HAP/VOC	0.03	119.39		
	Chloromethane - VOC	1.2	50.49		
	Dichlorobenzene - (HAP for para isomer/VOC)	0.21	147		
	Dichlorodifluoromethane	16	120.91		
	Dichlorofluoromethane - VOC	2.6	102.92		
	Dichloromethane (methylene chloride) - HAP	14	84.94		
	Dimethyl sulfide (methyl sulfide) - VOC	7.8	62.13		
	Ethane	890	30.07		
	Ethanol - VOC	27	46.08		

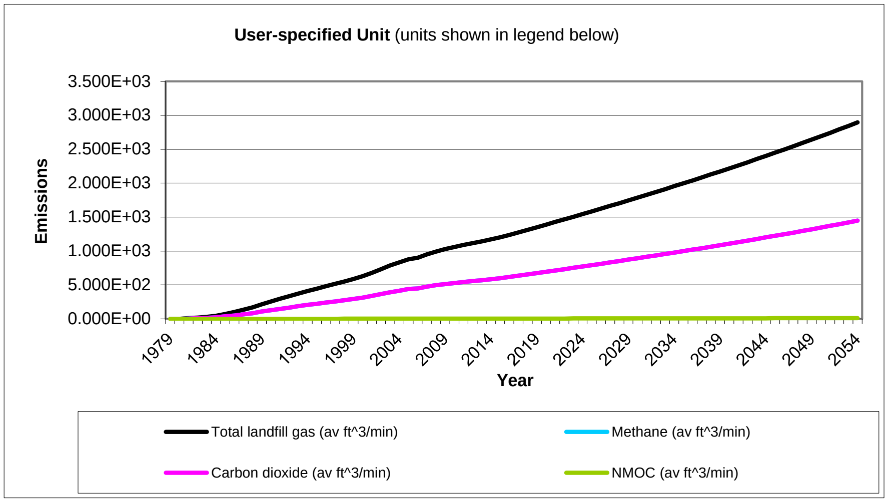
Pollutant Parameters (Continued)

	Gas / Pollutant Default Parameters:			User-specified Pollutant Parameters:	
	Compound	Concentration (*ppmv*)	Molecular Weight	Concentration (*ppmv*)	Molecular Weight
Pollutants	Ethyl mercaptan (ethanethiol) - VOC	2.3	62.13		
	Ethylbenzene - HAP/VOC	4.6	106.16		
	Ethylene dibromide - HAP/VOC	1.0E-03	187.88		
	Fluorotrichloromethane - VOC	0.76	137.38		
	Hexane - HAP/VOC	6.6	86.18		
	Hydrogen sulfide	36	34.08		
	Mercury (total) - HAP	2.9E-04	200.61		
	Methyl ethyl ketone - HAP/VOC	7.1	72.11		
	Methyl isobutyl ketone - HAP/VOC	1.9	100.16		
	Methyl mercaptan - VOC	2.5	48.11		
	Pentane - VOC	3.3	72.15		
	Perchloroethylene (tetrachloroethylene) - HAP	3.7	165.83		
	Propane - VOC	11	44.09		
	t-1,2-Dichloroethene - VOC	2.8	96.94		
	Toluene - No or Unknown Co-disposal - HAP/VOC	39	92.13		
	Toluene - Co-disposal - HAP/VOC	170	92.13		
	Trichloroethylene (trichloroethene) - HAP/VOC	2.8	131.40		
	Vinyl chloride - HAP/VOC	7.3	62.50		
	Xylenes - HAP/VOC	12	106.16		

Graphs


Megagrams Per Year
6.000E+04
5.000E+04
4.000E+04
3.000E+04
2.000E+04
1.000E+04
0.000E+00
Emissions
1979
1984
1989
1994
1999
2004
2009
2014
2019
2024
2029
2034
2039
2044
2049
2054
Year
Total landfill gas
Methane
Carbon dioxide
NMOC


Cubic Meters Per Year
5.000E+07
4.500E+07
4.000E+07
3.500E+07
3.000E+07
2.500E+07
2.000E+07
1.500E+07
1.000E+07
5.000E+06
0.000E+00
Emissions
1979
1984
1989
1994
1999
2004
2009
2014
2019
2024
2029
2034
2039
2044
2049
2054
Year
Total landfill gas
Methane
Carbon dioxide
NMOC


User-specified Unit (units shown in legend below)
3.500E+03
3.000E+03
2.500E+03
2.000E+03
1.500E+03
1.000E+03
5.000E+02
0.000E+00
Emissions
1979
1984
1989
1994
1999
2004
2009
2014
2019
2024
2029
2034
2039
2044
2049
2054
Year
Total landfill gas (av ft^3/min)
Methane (av ft^3/min)
Carbon dioxide (av ft^3/min)
NMOC (av ft^3/min)

Results

Year	Total landfill gas			Methane		
	(Mg/year)	*(m^3/year)*	*(av ft^3/min)*	*(Mg/year)*	*(m^3/year)*	*(av ft^3/min)*
1979	0	0	0	0	0	0
1980	7.956E+00	6.371E+03	4.280E-01	2.125E+00	3.185E+03	2.140E-01
1981	1.867E+02	1.495E+05	1.004E+01	4.986E+01	7.474E+04	5.021E+00
1982	3.671E+02	2.940E+05	1.975E+01	9.806E+01	1.470E+05	9.875E+00
1983	5.526E+02	4.425E+05	2.973E+01	1.476E+02	2.213E+05	1.487E+01
1984	8.679E+02	6.950E+05	4.670E+01	2.318E+02	3.475E+05	2.335E+01
1985	1.344E+03	1.076E+06	7.230E+01	3.589E+02	5.380E+05	3.615E+01
1986	1.892E+03	1.515E+06	1.018E+02	5.052E+02	7.573E+05	5.088E+01
1987	2.509E+03	2.009E+06	1.350E+02	6.701E+02	1.004E+06	6.749E+01
1988	3.154E+03	2.526E+06	1.697E+02	8.425E+02	1.263E+06	8.485E+01
1989	4.014E+03	3.214E+06	2.160E+02	1.072E+03	1.607E+06	1.080E+02
1990	4.776E+03	3.825E+06	2.570E+02	1.276E+03	1.912E+06	1.285E+02
1991	5.522E+03	4.422E+06	2.971E+02	1.475E+03	2.211E+06	1.485E+02
1992	6.237E+03	4.994E+06	3.356E+02	1.666E+03	2.497E+06	1.678E+02
1993	6.944E+03	5.560E+06	3.736E+02	1.855E+03	2.780E+06	1.868E+02
1994	7.653E+03	6.128E+06	4.117E+02	2.044E+03	3.064E+06	2.059E+02
1995	8.284E+03	6.633E+06	4.457E+02	2.213E+03	3.317E+06	2.228E+02
1996	8.937E+03	7.156E+06	4.808E+02	2.387E+03	3.578E+06	2.404E+02
1997	9.576E+03	7.668E+06	5.152E+02	2.558E+03	3.834E+06	2.576E+02
1998	1.022E+04	8.181E+06	5.497E+02	2.729E+03	4.090E+06	2.748E+02
1999	1.091E+04	8.736E+06	5.870E+02	2.914E+03	4.368E+06	2.935E+02
2000	1.169E+04	9.363E+06	6.291E+02	3.123E+03	4.681E+06	3.145E+02
2001	1.262E+04	1.011E+07	6.791E+02	3.371E+03	5.053E+06	3.395E+02
2002	1.360E+04	1.089E+07	7.319E+02	3.634E+03	5.447E+06	3.660E+02
2003	1.465E+04	1.173E+07	7.882E+02	3.913E+03	5.865E+06	3.941E+02
2004	1.548E+04	1.240E+07	8.331E+02	4.136E+03	6.200E+06	4.165E+02
2005	1.634E+04	1.308E+07	8.789E+02	4.364E+03	6.541E+06	4.395E+02
2006	1.673E+04	1.339E+07	9.000E+02	4.468E+03	6.697E+06	4.500E+02
2007	1.767E+04	1.415E+07	9.506E+02	4.719E+03	7.074E+06	4.753E+02
2008	1.845E+04	1.478E+07	9.927E+02	4.929E+03	7.388E+06	4.964E+02
2009	1.911E+04	1.531E+07	1.028E+03	5.105E+03	7.653E+06	5.142E+02
2010	1.968E+04	1.576E+07	1.059E+03	5.257E+03	7.879E+06	5.294E+02
2011	2.023E+04	1.620E+07	1.088E+03	5.403E+03	8.098E+06	5.441E+02
2012	2.073E+04	1.660E+07	1.115E+03	5.537E+03	8.299E+06	5.576E+02
2013	2.123E+04	1.700E+07	1.142E+03	5.670E+03	8.499E+06	5.711E+02
2014	2.177E+04	1.744E+07	1.171E+03	5.816E+03	8.718E+06	5.857E+02
2015	2.234E+04	1.789E+07	1.202E+03	5.967E+03	8.944E+06	6.010E+02
2016	2.297E+04	1.839E+07	1.236E+03	6.135E+03	9.195E+06	6.178E+02
2017	2.367E+04	1.896E+07	1.274E+03	6.323E+03	9.478E+06	6.368E+02
2018	2.438E+04	1.952E+07	1.312E+03	6.512E+03	9.761E+06	6.558E+02
2019	2.509E+04	2.009E+07	1.350E+03	6.702E+03	1.005E+07	6.750E+02
2020	2.581E+04	2.067E+07	1.388E+03	6.893E+03	1.033E+07	6.942E+02
2021	2.653E+04	2.124E+07	1.427E+03	7.086E+03	1.062E+07	7.136E+02
2022	2.725E+04	2.182E+07	1.466E+03	7.279E+03	1.091E+07	7.331E+02
2023	2.798E+04	2.240E+07	1.505E+03	7.473E+03	1.120E+07	7.527E+02
2024	2.871E+04	2.299E+07	1.545E+03	7.669E+03	1.150E+07	7.724E+02
2025	2.945E+04	2.358E+07	1.584E+03	7.866E+03	1.179E+07	7.922E+02
2026	3.019E+04	2.418E+07	1.624E+03	8.064E+03	1.209E+07	8.122E+02
2027	3.094E+04	2.477E+07	1.665E+03	8.264E+03	1.239E+07	8.323E+02
2028	3.169E+04	2.538E+07	1.705E+03	8.465E+03	1.269E+07	8.526E+02

Results (Continued)

Year	Total landfill gas			Methane		
	(Mg/year)	*(m^3/year)*	*(av ft^3/min)*	*(Mg/year)*	*(m^3/year)*	*(av ft^3/min)*
2029	3.245E+04	2.599E+07	1.746E+03	8.668E+03	1.299E+07	8.730E+02
2030	3.322E+04	2.660E+07	1.787E+03	8.872E+03	1.330E+07	8.935E+02
2031	3.399E+04	2.721E+07	1.829E+03	9.078E+03	1.361E+07	9.143E+02
2032	3.476E+04	2.784E+07	1.870E+03	9.285E+03	1.392E+07	9.352E+02
2033	3.555E+04	2.846E+07	1.912E+03	9.495E+03	1.423E+07	9.562E+02
2034	3.633E+04	2.910E+07	1.955E+03	9.705E+03	1.455E+07	9.775E+02
2035	3.713E+04	2.973E+07	1.998E+03	9.918E+03	1.487E+07	9.989E+02
2036	3.793E+04	3.038E+07	2.041E+03	1.013E+04	1.519E+07	1.020E+03
2037	3.874E+04	3.103E+07	2.085E+03	1.035E+04	1.551E+07	1.042E+03
2038	3.956E+04	3.168E+07	2.129E+03	1.057E+04	1.584E+07	1.064E+03
2039	4.039E+04	3.234E+07	2.173E+03	1.079E+04	1.617E+07	1.086E+03
2040	4.122E+04	3.301E+07	2.218E+03	1.101E+04	1.650E+07	1.109E+03
2041	4.206E+04	3.368E+07	2.263E+03	1.124E+04	1.684E+07	1.132E+03
2042	4.291E+04	3.436E+07	2.309E+03	1.146E+04	1.718E+07	1.154E+03
2043	4.377E+04	3.505E+07	2.355E+03	1.169E+04	1.752E+07	1.177E+03
2044	4.464E+04	3.574E+07	2.402E+03	1.192E+04	1.787E+07	1.201E+03
2045	4.551E+04	3.644E+07	2.449E+03	1.216E+04	1.822E+07	1.224E+03
2046	4.640E+04	3.715E+07	2.496E+03	1.239E+04	1.858E+07	1.248E+03
2047	4.729E+04	3.787E+07	2.544E+03	1.263E+04	1.893E+07	1.272E+03
2048	4.819E+04	3.859E+07	2.593E+03	1.287E+04	1.930E+07	1.296E+03
2049	4.911E+04	3.932E+07	2.642E+03	1.312E+04	1.966E+07	1.321E+03
2050	5.003E+04	4.006E+07	2.692E+03	1.336E+04	2.003E+07	1.346E+03
2051	5.096E+04	4.081E+07	2.742E+03	1.361E+04	2.040E+07	1.371E+03
2052	5.190E+04	4.156E+07	2.793E+03	1.386E+04	2.078E+07	1.396E+03
2053	5.286E+04	4.233E+07	2.844E+03	1.412E+04	2.116E+07	1.422E+03
2054	5.382E+04	4.310E+07	2.896E+03	1.438E+04	2.155E+07	1.448E+03
2055	5.480E+04	4.388E+07	2.948E+03	1.464E+04	2.194E+07	1.474E+03
2056	5.579E+04	4.467E+07	3.001E+03	1.490E+04	2.234E+07	1.501E+03
2057	5.678E+04	4.547E+07	3.055E+03	1.517E+04	2.274E+07	1.528E+03
2058	5.779E+04	4.628E+07	3.109E+03	1.544E+04	2.314E+07	1.555E+03
2059	5.882E+04	4.710E+07	3.164E+03	1.571E+04	2.355E+07	1.582E+03
2060	5.765E+04	4.617E+07	3.102E+03	1.540E+04	2.308E+07	1.551E+03
2061	5.651E+04	4.525E+07	3.040E+03	1.509E+04	2.263E+07	1.520E+03
2062	5.539E+04	4.436E+07	2.980E+03	1.480E+04	2.218E+07	1.490E+03
2063	5.429E+04	4.348E+07	2.921E+03	1.450E+04	2.174E+07	1.461E+03
2064	5.322E+04	4.262E+07	2.863E+03	1.422E+04	2.131E+07	1.432E+03
2065	5.217E+04	4.177E+07	2.807E+03	1.393E+04	2.089E+07	1.403E+03
2066	5.113E+04	4.094E+07	2.751E+03	1.366E+04	2.047E+07	1.376E+03
2067	5.012E+04	4.013E+07	2.697E+03	1.339E+04	2.007E+07	1.348E+03
2068	4.913E+04	3.934E+07	2.643E+03	1.312E+04	1.967E+07	1.322E+03
2069	4.816E+04	3.856E+07	2.591E+03	1.286E+04	1.928E+07	1.295E+03
2070	4.720E+04	3.780E+07	2.540E+03	1.261E+04	1.890E+07	1.270E+03
2071	4.627E+04	3.705E+07	2.489E+03	1.236E+04	1.852E+07	1.245E+03
2072	4.535E+04	3.631E+07	2.440E+03	1.211E+04	1.816E+07	1.220E+03
2073	4.445E+04	3.560E+07	2.392E+03	1.187E+04	1.780E+07	1.196E+03
2074	4.357E+04	3.489E+07	2.344E+03	1.164E+04	1.745E+07	1.172E+03
2075	4.271E+04	3.420E+07	2.298E+03	1.141E+04	1.710E+07	1.149E+03
2076	4.186E+04	3.352E+07	2.252E+03	1.118E+04	1.676E+07	1.126E+03
2077	4.104E+04	3.286E+07	2.208E+03	1.096E+04	1.643E+07	1.104E+03
2078	4.022E+04	3.221E+07	2.164E+03	1.074E+04	1.610E+07	1.082E+03
2079	3.943E+04	3.157E+07	2.121E+03	1.053E+04	1.579E+07	1.061E+03

Results (Continued)

Year	Total landfill gas			Methane		
	(Mg/year)	*(m^3/year)*	*(av ft^3/min)*	*(Mg/year)*	*(m^3/year)*	*(av ft^3/min)*
2080	3.865E+04	3.095E+07	2.079E+03	1.032E+04	1.547E+07	1.040E+03
2081	3.788E+04	3.033E+07	2.038E+03	1.012E+04	1.517E+07	1.019E+03
2082	3.713E+04	2.973E+07	1.998E+03	9.918E+03	1.487E+07	9.988E+02
2083	3.639E+04	2.914E+07	1.958E+03	9.721E+03	1.457E+07	9.791E+02
2084	3.567E+04	2.857E+07	1.919E+03	9.529E+03	1.428E+07	9.597E+02
2085	3.497E+04	2.800E+07	1.881E+03	9.340E+03	1.400E+07	9.407E+02
2086	3.428E+04	2.745E+07	1.844E+03	9.155E+03	1.372E+07	9.221E+02
2087	3.360E+04	2.690E+07	1.808E+03	8.974E+03	1.345E+07	9.038E+02
2088	3.293E+04	2.637E+07	1.772E+03	8.796E+03	1.319E+07	8.859E+02
2089	3.228E+04	2.585E+07	1.737E+03	8.622E+03	1.292E+07	8.684E+02
2090	3.164E+04	2.534E+07	1.702E+03	8.451E+03	1.267E+07	8.512E+02
2091	3.101E+04	2.483E+07	1.669E+03	8.284E+03	1.242E+07	8.343E+02
2092	3.040E+04	2.434E+07	1.636E+03	8.120E+03	1.217E+07	8.178E+02
2093	2.980E+04	2.386E+07	1.603E+03	7.959E+03	1.193E+07	8.016E+02
2094	2.921E+04	2.339E+07	1.571E+03	7.802E+03	1.169E+07	7.857E+02
2095	2.863E+04	2.292E+07	1.540E+03	7.647E+03	1.146E+07	7.702E+02
2096	2.806E+04	2.247E+07	1.510E+03	7.496E+03	1.124E+07	7.549E+02
2097	2.751E+04	2.203E+07	1.480E+03	7.347E+03	1.101E+07	7.400E+02
2098	2.696E+04	2.159E+07	1.451E+03	7.202E+03	1.079E+07	7.253E+02
2099	2.643E+04	2.116E+07	1.422E+03	7.059E+03	1.058E+07	7.110E+02
2100	2.590E+04	2.074E+07	1.394E+03	6.919E+03	1.037E+07	6.969E+02
2101	2.539E+04	2.033E+07	1.366E+03	6.782E+03	1.017E+07	6.831E+02
2102	2.489E+04	1.993E+07	1.339E+03	6.648E+03	9.965E+06	6.695E+02
2103	2.440E+04	1.954E+07	1.313E+03	6.516E+03	9.768E+06	6.563E+02
2104	2.391E+04	1.915E+07	1.287E+03	6.387E+03	9.574E+06	6.433E+02
2105	2.344E+04	1.877E+07	1.261E+03	6.261E+03	9.385E+06	6.306E+02
2106	2.298E+04	1.840E+07	1.236E+03	6.137E+03	9.199E+06	6.181E+02
2107	2.252E+04	1.803E+07	1.212E+03	6.015E+03	9.017E+06	6.058E+02
2108	2.207E+04	1.768E+07	1.188E+03	5.896E+03	8.838E+06	5.938E+02
2109	2.164E+04	1.733E+07	1.164E+03	5.780E+03	8.663E+06	5.821E+02
2110	2.121E+04	1.698E+07	1.141E+03	5.665E+03	8.492E+06	5.706E+02
2111	2.079E+04	1.665E+07	1.119E+03	5.553E+03	8.323E+06	5.593E+02
2112	2.038E+04	1.632E+07	1.096E+03	5.443E+03	8.159E+06	5.482E+02
2113	1.997E+04	1.599E+07	1.075E+03	5.335E+03	7.997E+06	5.373E+02
2114	1.958E+04	1.568E+07	1.053E+03	5.230E+03	7.839E+06	5.267E+02
2115	1.919E+04	1.537E+07	1.033E+03	5.126E+03	7.684E+06	5.163E+02
2116	1.881E+04	1.506E+07	1.012E+03	5.025E+03	7.531E+06	5.060E+02
2117	1.844E+04	1.476E+07	9.920E+02	4.925E+03	7.382E+06	4.960E+02
2118	1.807E+04	1.447E+07	9.724E+02	4.828E+03	7.236E+06	4.862E+02
2119	1.772E+04	1.419E+07	9.531E+02	4.732E+03	7.093E+06	4.766E+02

Results (Continued)

Year	Carbon dioxide			NMOC		
	(Mg/year)	*(m^3/year)*	*(av ft^3/min)*	*(Mg/year)*	*(m^3/year)*	*(av ft^3/min)*
1979	0	0	0	0	0	0
1980	5.831E+00	3.185E+03	2.140E-01	9.134E-02	2.548E+01	1.712E-03
1981	1.368E+02	7.474E+04	5.021E+00	2.143E+00	5.979E+02	4.017E-02
1982	2.690E+02	1.470E+05	9.875E+00	4.215E+00	1.176E+03	7.900E-02
1983	4.050E+02	2.213E+05	1.487E+01	6.345E+00	1.770E+03	1.189E-01
1984	6.361E+02	3.475E+05	2.335E+01	9.965E+00	2.780E+03	1.868E-01
1985	9.848E+02	5.380E+05	3.615E+01	1.543E+01	4.304E+03	2.892E-01
1986	1.386E+03	7.573E+05	5.088E+01	2.172E+01	6.059E+03	4.071E-01
1987	1.839E+03	1.004E+06	6.749E+01	2.880E+01	8.036E+03	5.399E-01
1988	2.312E+03	1.263E+06	8.485E+01	3.621E+01	1.010E+04	6.788E-01
1989	2.942E+03	1.607E+06	1.080E+02	4.608E+01	1.286E+04	8.638E-01
1990	3.501E+03	1.912E+06	1.285E+02	5.484E+01	1.530E+04	1.028E+00
1991	4.047E+03	2.211E+06	1.485E+02	6.340E+01	1.769E+04	1.188E+00
1992	4.571E+03	2.497E+06	1.678E+02	7.161E+01	1.998E+04	1.342E+00
1993	5.089E+03	2.780E+06	1.868E+02	7.973E+01	2.224E+04	1.494E+00
1994	5.608E+03	3.064E+06	2.059E+02	8.786E+01	2.451E+04	1.647E+00
1995	6.071E+03	3.317E+06	2.228E+02	9.511E+01	2.653E+04	1.783E+00
1996	6.550E+03	3.578E+06	2.404E+02	1.026E+02	2.863E+04	1.923E+00
1997	7.018E+03	3.834E+06	2.576E+02	1.099E+02	3.067E+04	2.061E+00
1998	7.487E+03	4.090E+06	2.748E+02	1.173E+02	3.272E+04	2.199E+00
1999	7.996E+03	4.368E+06	2.935E+02	1.253E+02	3.495E+04	2.348E+00
2000	8.569E+03	4.681E+06	3.145E+02	1.342E+02	3.745E+04	2.516E+00
2001	9.250E+03	5.053E+06	3.395E+02	1.449E+02	4.043E+04	2.716E+00
2002	9.970E+03	5.447E+06	3.660E+02	1.562E+02	4.357E+04	2.928E+00
2003	1.074E+04	5.865E+06	3.941E+02	1.682E+02	4.692E+04	3.153E+00
2004	1.135E+04	6.200E+06	4.165E+02	1.778E+02	4.960E+04	3.332E+00
2005	1.197E+04	6.541E+06	4.395E+02	1.876E+02	5.233E+04	3.516E+00
2006	1.226E+04	6.697E+06	4.500E+02	1.921E+02	5.358E+04	3.600E+00
2007	1.295E+04	7.074E+06	4.753E+02	2.028E+02	5.659E+04	3.802E+00
2008	1.352E+04	7.388E+06	4.964E+02	2.118E+02	5.910E+04	3.971E+00
2009	1.401E+04	7.653E+06	5.142E+02	2.194E+02	6.122E+04	4.113E+00
2010	1.442E+04	7.879E+06	5.294E+02	2.260E+02	6.304E+04	4.235E+00
2011	1.482E+04	8.098E+06	5.441E+02	2.322E+02	6.478E+04	4.353E+00
2012	1.519E+04	8.299E+06	5.576E+02	2.380E+02	6.640E+04	4.461E+00
2013	1.556E+04	8.499E+06	5.711E+02	2.437E+02	6.799E+04	4.568E+00
2014	1.596E+04	8.718E+06	5.857E+02	2.500E+02	6.974E+04	4.686E+00
2015	1.637E+04	8.944E+06	6.010E+02	2.565E+02	7.155E+04	4.808E+00
2016	1.683E+04	9.195E+06	6.178E+02	2.637E+02	7.356E+04	4.943E+00
2017	1.735E+04	9.478E+06	6.368E+02	2.718E+02	7.582E+04	5.094E+00
2018	1.787E+04	9.761E+06	6.558E+02	2.799E+02	7.809E+04	5.247E+00
2019	1.839E+04	1.005E+07	6.750E+02	2.881E+02	8.037E+04	5.400E+00
2020	1.891E+04	1.033E+07	6.942E+02	2.963E+02	8.266E+04	5.554E+00
2021	1.944E+04	1.062E+07	7.136E+02	3.046E+02	8.497E+04	5.709E+00
2022	1.997E+04	1.091E+07	7.331E+02	3.129E+02	8.728E+04	5.865E+00
2023	2.051E+04	1.120E+07	7.527E+02	3.212E+02	8.962E+04	6.021E+00
2024	2.104E+04	1.150E+07	7.724E+02	3.296E+02	9.196E+04	6.179E+00
2025	2.158E+04	1.179E+07	7.922E+02	3.381E+02	9.433E+04	6.338E+00
2026	2.213E+04	1.209E+07	8.122E+02	3.466E+02	9.670E+04	6.498E+00
2027	2.268E+04	1.239E+07	8.323E+02	3.552E+02	9.910E+04	6.658E+00
2028	2.323E+04	1.269E+07	8.526E+02	3.639E+02	1.015E+05	6.821E+00

Results (Continued)

Year	Carbon dioxide			NMOC		
	(Mg/year)	*(m^3/year)*	*(av ft^3/min)*	*(Mg/year)*	*(m^3/year)*	*(av ft^3/min)*
2029	2.378E+04	1.299E+07	8.730E+02	3.726E+02	1.039E+05	6.984E+00
2030	2.434E+04	1.330E+07	8.935E+02	3.814E+02	1.064E+05	7.148E+00
2031	2.491E+04	1.361E+07	9.143E+02	3.902E+02	1.089E+05	7.314E+00
2032	2.548E+04	1.392E+07	9.352E+02	3.991E+02	1.113E+05	7.481E+00
2033	2.605E+04	1.423E+07	9.562E+02	4.081E+02	1.139E+05	7.650E+00
2034	2.663E+04	1.455E+07	9.775E+02	4.172E+02	1.164E+05	7.820E+00
2035	2.721E+04	1.487E+07	9.989E+02	4.263E+02	1.189E+05	7.991E+00
2036	2.780E+04	1.519E+07	1.020E+03	4.355E+02	1.215E+05	8.164E+00
2037	2.840E+04	1.551E+07	1.042E+03	4.448E+02	1.241E+05	8.338E+00
2038	2.900E+04	1.584E+07	1.064E+03	4.542E+02	1.267E+05	8.514E+00
2039	2.960E+04	1.617E+07	1.086E+03	4.637E+02	1.294E+05	8.692E+00
2040	3.021E+04	1.650E+07	1.109E+03	4.733E+02	1.320E+05	8.871E+00
2041	3.083E+04	1.684E+07	1.132E+03	4.829E+02	1.347E+05	9.052E+00
2042	3.145E+04	1.718E+07	1.154E+03	4.927E+02	1.374E+05	9.235E+00
2043	3.208E+04	1.752E+07	1.177E+03	5.025E+02	1.402E+05	9.420E+00
2044	3.271E+04	1.787E+07	1.201E+03	5.125E+02	1.430E+05	9.606E+00
2045	3.335E+04	1.822E+07	1.224E+03	5.225E+02	1.458E+05	9.795E+00
2046	3.400E+04	1.858E+07	1.248E+03	5.327E+02	1.486E+05	9.985E+00
2047	3.466E+04	1.893E+07	1.272E+03	5.429E+02	1.515E+05	1.018E+01
2048	3.532E+04	1.930E+07	1.296E+03	5.533E+02	1.544E+05	1.037E+01
2049	3.599E+04	1.966E+07	1.321E+03	5.638E+02	1.573E+05	1.057E+01
2050	3.666E+04	2.003E+07	1.346E+03	5.744E+02	1.602E+05	1.077E+01
2051	3.735E+04	2.040E+07	1.371E+03	5.851E+02	1.632E+05	1.097E+01
2052	3.804E+04	2.078E+07	1.396E+03	5.959E+02	1.662E+05	1.117E+01
2053	3.874E+04	2.116E+07	1.422E+03	6.069E+02	1.693E+05	1.138E+01
2054	3.945E+04	2.155E+07	1.448E+03	6.179E+02	1.724E+05	1.158E+01
2055	4.016E+04	2.194E+07	1.474E+03	6.291E+02	1.755E+05	1.179E+01
2056	4.088E+04	2.234E+07	1.501E+03	6.405E+02	1.787E+05	1.201E+01
2057	4.162E+04	2.274E+07	1.528E+03	6.519E+02	1.819E+05	1.222E+01
2058	4.236E+04	2.314E+07	1.555E+03	6.635E+02	1.851E+05	1.244E+01
2059	4.311E+04	2.355E+07	1.582E+03	6.753E+02	1.884E+05	1.266E+01
2060	4.225E+04	2.308E+07	1.551E+03	6.619E+02	1.847E+05	1.241E+01
2061	4.142E+04	2.263E+07	1.520E+03	6.488E+02	1.810E+05	1.216E+01
2062	4.060E+04	2.218E+07	1.490E+03	6.360E+02	1.774E+05	1.192E+01
2063	3.979E+04	2.174E+07	1.461E+03	6.234E+02	1.739E+05	1.168E+01
2064	3.900E+04	2.131E+07	1.432E+03	6.110E+02	1.705E+05	1.145E+01
2065	3.823E+04	2.089E+07	1.403E+03	5.989E+02	1.671E+05	1.123E+01
2066	3.747E+04	2.047E+07	1.376E+03	5.871E+02	1.638E+05	1.100E+01
2067	3.673E+04	2.007E+07	1.348E+03	5.754E+02	1.605E+05	1.079E+01
2068	3.601E+04	1.967E+07	1.322E+03	5.640E+02	1.574E+05	1.057E+01
2069	3.529E+04	1.928E+07	1.295E+03	5.529E+02	1.542E+05	1.036E+01
2070	3.459E+04	1.890E+07	1.270E+03	5.419E+02	1.512E+05	1.016E+01
2071	3.391E+04	1.852E+07	1.245E+03	5.312E+02	1.482E+05	9.957E+00
2072	3.324E+04	1.816E+07	1.220E+03	5.207E+02	1.453E+05	9.760E+00
2073	3.258E+04	1.780E+07	1.196E+03	5.104E+02	1.424E+05	9.567E+00
2074	3.193E+04	1.745E+07	1.172E+03	5.003E+02	1.396E+05	9.377E+00
2075	3.130E+04	1.710E+07	1.149E+03	4.904E+02	1.368E+05	9.192E+00
2076	3.068E+04	1.676E+07	1.126E+03	4.806E+02	1.341E+05	9.010E+00
2077	3.007E+04	1.643E+07	1.104E+03	4.711E+02	1.314E+05	8.831E+00
2078	2.948E+04	1.610E+07	1.082E+03	4.618E+02	1.288E+05	8.656E+00
2079	2.889E+04	1.579E+07	1.061E+03	4.527E+02	1.263E+05	8.485E+00

Results (Continued)

Year	Carbon dioxide			NMOC		
	(Mg/year)	*(m^3/year)*	*(av ft^3/min)*	*(Mg/year)*	*(m^3/year)*	*(av ft^3/min)*
2080	2.832E+04	1.547E+07	1.040E+03	4.437E+02	1.238E+05	8.317E+00
2081	2.776E+04	1.517E+07	1.019E+03	4.349E+02	1.213E+05	8.152E+00
2082	2.721E+04	1.487E+07	9.988E+02	4.263E+02	1.189E+05	7.991E+00
2083	2.667E+04	1.457E+07	9.791E+02	4.179E+02	1.166E+05	7.833E+00
2084	2.615E+04	1.428E+07	9.597E+02	4.096E+02	1.143E+05	7.677E+00
2085	2.563E+04	1.400E+07	9.407E+02	4.015E+02	1.120E+05	7.525E+00
2086	2.512E+04	1.372E+07	9.221E+02	3.935E+02	1.098E+05	7.376E+00
2087	2.462E+04	1.345E+07	9.038E+02	3.857E+02	1.076E+05	7.230E+00
2088	2.414E+04	1.319E+07	8.859E+02	3.781E+02	1.055E+05	7.087E+00
2089	2.366E+04	1.292E+07	8.684E+02	3.706E+02	1.034E+05	6.947E+00
2090	2.319E+04	1.267E+07	8.512E+02	3.633E+02	1.013E+05	6.809E+00
2091	2.273E+04	1.242E+07	8.343E+02	3.561E+02	9.934E+04	6.674E+00
2092	2.228E+04	1.217E+07	8.178E+02	3.490E+02	9.737E+04	6.542E+00
2093	2.184E+04	1.193E+07	8.016E+02	3.421E+02	9.544E+04	6.413E+00
2094	2.141E+04	1.169E+07	7.857E+02	3.353E+02	9.355E+04	6.286E+00
2095	2.098E+04	1.146E+07	7.702E+02	3.287E+02	9.170E+04	6.161E+00
2096	2.057E+04	1.124E+07	7.549E+02	3.222E+02	8.988E+04	6.039E+00
2097	2.016E+04	1.101E+07	7.400E+02	3.158E+02	8.810E+04	5.920E+00
2098	1.976E+04	1.079E+07	7.253E+02	3.096E+02	8.636E+04	5.802E+00
2099	1.937E+04	1.058E+07	7.110E+02	3.034E+02	8.465E+04	5.688E+00
2100	1.899E+04	1.037E+07	6.969E+02	2.974E+02	8.297E+04	5.575E+00
2101	1.861E+04	1.017E+07	6.831E+02	2.915E+02	8.133E+04	5.465E+00
2102	1.824E+04	9.965E+06	6.695E+02	2.858E+02	7.972E+04	5.356E+00
2103	1.788E+04	9.768E+06	6.563E+02	2.801E+02	7.814E+04	5.250E+00
2104	1.753E+04	9.574E+06	6.433E+02	2.745E+02	7.659E+04	5.146E+00
2105	1.718E+04	9.385E+06	6.306E+02	2.691E+02	7.508E+04	5.044E+00
2106	1.684E+04	9.199E+06	6.181E+02	2.638E+02	7.359E+04	4.945E+00
2107	1.651E+04	9.017E+06	6.058E+02	2.586E+02	7.213E+04	4.847E+00
2108	1.618E+04	8.838E+06	5.938E+02	2.534E+02	7.071E+04	4.751E+00
2109	1.586E+04	8.663E+06	5.821E+02	2.484E+02	6.931E+04	4.657E+00
2110	1.554E+04	8.492E+06	5.706E+02	2.435E+02	6.793E+04	4.564E+00
2111	1.524E+04	8.323E+06	5.593E+02	2.387E+02	6.659E+04	4.474E+00
2112	1.493E+04	8.159E+06	5.482E+02	2.340E+02	6.527E+04	4.385E+00
2113	1.464E+04	7.997E+06	5.373E+02	2.293E+02	6.398E+04	4.299E+00
2114	1.435E+04	7.839E+06	5.267E+02	2.248E+02	6.271E+04	4.213E+00
2115	1.406E+04	7.684E+06	5.163E+02	2.203E+02	6.147E+04	4.130E+00
2116	1.379E+04	7.531E+06	5.060E+02	2.160E+02	6.025E+04	4.048E+00
2117	1.351E+04	7.382E+06	4.960E+02	2.117E+02	5.906E+04	3.968E+00
2118	1.325E+04	7.236E+06	4.862E+02	2.075E+02	5.789E+04	3.890E+00
2119	1.298E+04	7.093E+06	4.766E+02	2.034E+02	5.674E+04	3.813E+00

Appendix B

Project Increment LandGEM Output

Summary Report

Landfill Name or Identifier:

Date: Wednesday, September 26, 2018

Description/Comments:

37,670 tpy total waste placement at full buildout

About LandGEM:

First-Order Decomposition Rate Equation:

$$Q_{CH_4} = \sum_{i=1}^{n} \sum_{j=0.1}^{1} kL_o \left(\frac{M_i}{10} \right) e^{-kt_{ij}}$$

Where,

Q_{CH4} = annual methane generation in the year of the calculation *(m^3/year)*

i = 1-year time increment

n = (year of the calculation) - (initial year of waste acceptance)

j = 0.1-year time increment

k = methane generation rate *($year^{-1}$)*

L_o = potential methane generation capacity *(m^3/Mg)*

M_i = mass of waste accepted in the i^{th} year *(Mg)*

t_{ij} = age of the j^{th} section of waste mass M_i accepted in the i^{th} year (*decimal years*, e.g., 3.2 years)

LandGEM is based on a first-order decomposition rate equation for quantifying emissions from the decomposition of landfilled waste in municipal solid waste (MSW) landfills. The software provides a relatively simple approach to estimating landfill gas emissions. Model defaults are based on empirical data from U.S. landfills. Field test data can also be used in place of model defaults when available. Further guidance on EPA test methods, Clean Air Act (CAA) regulations, and other guidance regarding landfill gas emissions and control technology requirements can be found at http://www.epa.gov/ttnatw01/landfill/landflpg.html.

LandGEM is considered a screening tool — the better the input data, the better the estimates. Often, there are limitations with the available data regarding waste quantity and composition, variation in design and operating practices over time, and changes occurring over time that impact the emissions potential. Changes to landfill operation, such as operating under wet conditions through leachate recirculation or other liquid additions, will result in generating more gas at a faster rate. Defaults for estimating emissions for this type of operation are being developed to include in LandGEM along with defaults for convential landfills (no leachate or liquid additions) for developing emission inventories and determining CAA applicability. Refer to the Web site identified above for future updates.

Input Review

LANDFILL CHARACTERISTICS

Landfill Open Year	**2018**	
Landfill Closure Year (with 80-year limit)	**2058**	
Actual Closure Year (without limit)	***2058***	
Have Model Calculate Closure Year?	**No**	
Waste Design Capacity		*megagrams*

MODEL PARAMETERS

Methane Generation Rate, k	**0.020**	*year* $^{-1}$
Potential Methane Generation Capacity, L_o	**100**	*m* ^{3} */Mg*
NMOC Concentration	**4,000**	*ppmv as hexane*
Methane Content	**50**	*% by volume*

GASES / POLLUTANTS SELECTED

Gas / Pollutant #1:	**Total landfill gas**
Gas / Pollutant #2:	**Methane**
Gas / Pollutant #3:	**Carbon dioxide**
Gas / Pollutant #4:	**NMOC**

WASTE ACCEPTANCE RATES

Year	Waste Accepted		Waste-In-Place	
	(Mg/year)	*(short tons/year)*	*(Mg)*	*(short tons)*
2018	1,250	1,375	0	0
2019	2,500	2,750	1,250	1,375
2020	3,750	4,125	3,750	4,125
2021	5,000	5,500	7,500	8,250
2022	6,250	6,875	12,500	13,750
2023	7,500	8,250	18,749	20,624
2024	8,750	9,625	26,249	28,874
2025	10,000	11,000	34,999	38,499
2026	11,250	12,375	44,999	49,498
2027	12,500	13,750	56,248	61,873
2028	13,750	15,125	68,748	75,623
2029	15,000	16,499	82,497	90,747
2030	16,249	17,874	97,497	107,246
2031	17,499	19,249	113,746	125,121
2032	18,749	20,624	131,246	144,370
2033	19,999	21,999	149,995	164,995
2034	21,249	23,374	169,994	186,994
2035	22,499	24,749	191,244	210,368
2036	23,749	26,124	213,743	235,117
2037	24,999	27,499	237,492	261,241
2038	34,245	37,670	262,491	288,741
2039	34,245	37,670	296,737	326,411
2040	34,245	37,670	330,982	364,081
2041	34,245	37,670	365,228	401,751
2042	34,245	37,670	399,473	439,421
2043	34,245	37,670	433,719	477,091
2044	34,245	37,670	467,964	514,761
2045	34,245	37,670	502,210	552,431
2046	34,245	37,670	536,455	590,101
2047	34,245	37,670	570,701	627,771
2048	34,245	37,670	604,946	665,441
2049	34,245	37,670	639,191	703,111
2050	34,245	37,670	673,437	740,781
2051	34,245	37,670	707,682	778,451
2052	34,245	37,670	741,928	816,121
2053	34,245	37,670	776,173	853,791
2054	34,245	37,670	810,419	891,461
2055	34,245	37,670	844,664	929,131
2056	34,245	37,670	878,910	966,801
2057	34,245	37,670	913,155	1,004,471

WASTE ACCEPTANCE RATES (Continued)

Year	Waste Accepted		Waste-In-Place	
	(Mg/year)	*(short tons/year)*	*(Mg)*	*(short tons)*
2058	34,245	37,670	947,401	1,042,141
2059	0	0	981,646	1,079,811
2060	0	0	981,646	1,079,811
2061	0	0	981,646	1,079,811
2062	0	0	981,646	1,079,811
2063	0	0	981,646	1,079,811
2064	0	0	981,646	1,079,811
2065	0	0	981,646	1,079,811
2066	0	0	981,646	1,079,811
2067	0	0	981,646	1,079,811
2068	0	0	981,646	1,079,811
2069	0	0	981,646	1,079,811
2070	0	0	981,646	1,079,811
2071	0	0	981,646	1,079,811
2072	0	0	981,646	1,079,811
2073	0	0	981,646	1,079,811
2074	0	0	981,646	1,079,811
2075	0	0	981,646	1,079,811
2076	0	0	981,646	1,079,811
2077	0	0	981,646	1,079,811
2078	0	0	981,646	1,079,811
2079	0	0	981,646	1,079,811
2080	0	0	981,646	1,079,811
2081	0	0	981,646	1,079,811
2082	0	0	981,646	1,079,811
2083	0	0	981,646	1,079,811
2084	0	0	981,646	1,079,811
2085	0	0	981,646	1,079,811
2086	0	0	981,646	1,079,811
2087	0	0	981,646	1,079,811
2088	0	0	981,646	1,079,811
2089	0	0	981,646	1,079,811
2090	0	0	981,646	1,079,811
2091	0	0	981,646	1,079,811
2092	0	0	981,646	1,079,811
2093	0	0	981,646	1,079,811
2094	0	0	981,646	1,079,811
2095	0	0	981,646	1,079,811
2096	0	0	981,646	1,079,811
2097	0	0	981,646	1,079,811

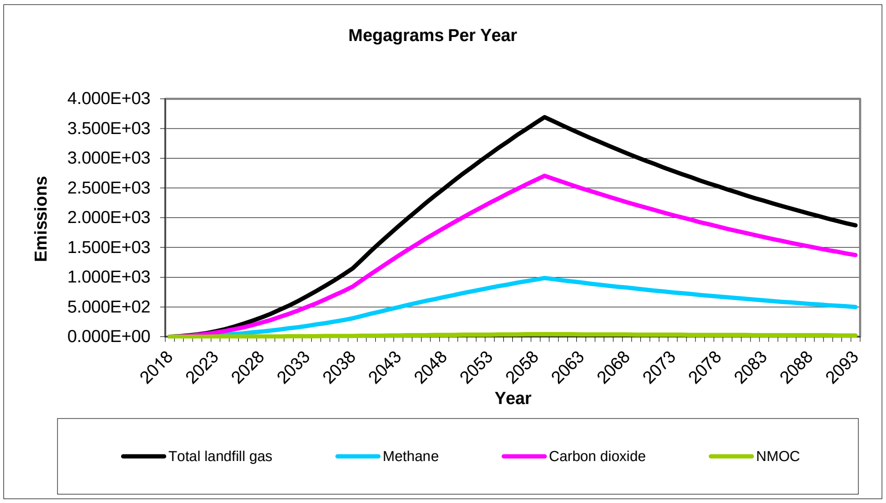
Pollutant Parameters

	Compound	Gas / Pollutant Default Parameters: Concentration (*ppmv*)	Molecular Weight	User-specified Pollutant Parameters: Concentration (*ppmv*)	Molecular Weight
Gases	Total landfill gas		0.00		
	Methane		16.04		
	Carbon dioxide		44.01		
	NMOC	4,000	86.18		
Pollutants	1,1,1-Trichloroethane (methyl chloroform) - HAP	0.48	133.41		
	1,1,2,2-Tetrachloroethane - HAP/VOC	1.1	167.85		
	1,1-Dichloroethane (ethylidene dichloride) - HAP/VOC	2.4	98.97		
	1,1-Dichloroethene (vinylidene chloride) - HAP/VOC	0.20	96.94		
	1,2-Dichloroethane (ethylene dichloride) - HAP/VOC	0.41	98.96		
	1,2-Dichloropropane (propylene dichloride) - HAP/VOC	0.18	112.99		
	2-Propanol (isopropyl alcohol) - VOC	50	60.11		
	Acetone	7.0	58.08		
	Acrylonitrile - HAP/VOC	6.3	53.06		
	Benzene - No or Unknown Co-disposal - HAP/VOC	1.9	78.11		
	Benzene - Co-disposal - HAP/VOC	11	78.11		
	Bromodichloromethane - VOC	3.1	163.83		
	Butane - VOC	5.0	58.12		
	Carbon disulfide - HAP/VOC	0.58	76.13		
	Carbon monoxide	140	28.01		
	Carbon tetrachloride - HAP/VOC	4.0E-03	153.84		
	Carbonyl sulfide - HAP/VOC	0.49	60.07		
	Chlorobenzene - HAP/VOC	0.25	112.56		
	Chlorodifluoromethane	1.3	86.47		
	Chloroethane (ethyl chloride) - HAP/VOC	1.3	64.52		
	Chloroform - HAP/VOC	0.03	119.39		
	Chloromethane - VOC	1.2	50.49		
	Dichlorobenzene - (HAP for para isomer/VOC)	0.21	147		
	Dichlorodifluoromethane	16	120.91		
	Dichlorofluoromethane - VOC	2.6	102.92		
	Dichloromethane (methylene chloride) - HAP	14	84.94		
	Dimethyl sulfide (methyl sulfide) - VOC	7.8	62.13		
	Ethane	890	30.07		
	Ethanol - VOC	27	46.08		

Pollutant Parameters (Continued)

	Gas / Pollutant Default Parameters:			User-specified Pollutant Parameters:	
	Compound	Concentration (*ppmv*)	Molecular Weight	Concentration (*ppmv*)	Molecular Weight
Pollutants	Ethyl mercaptan (ethanethiol) - VOC	2.3	62.13		
	Ethylbenzene - HAP/VOC	4.6	106.16		
	Ethylene dibromide - HAP/VOC	1.0E-03	187.88		
	Fluorotrichloromethane - VOC	0.76	137.38		
	Hexane - HAP/VOC	6.6	86.18		
	Hydrogen sulfide	36	34.08		
	Mercury (total) - HAP	2.9E-04	200.61		
	Methyl ethyl ketone - HAP/VOC	7.1	72.11		
	Methyl isobutyl ketone - HAP/VOC	1.9	100.16		
	Methyl mercaptan - VOC	2.5	48.11		
	Pentane - VOC	3.3	72.15		
	Perchloroethylene (tetrachloroethylene) - HAP	3.7	165.83		
	Propane - VOC	11	44.09		
	t-1,2-Dichloroethene - VOC	2.8	96.94		
	Toluene - No or Unknown Co-disposal - HAP/VOC	39	92.13		
	Toluene - Co-disposal - HAP/VOC	170	92.13		
	Trichloroethylene (trichloroethene) - HAP/VOC	2.8	131.40		
	Vinyl chloride - HAP/VOC	7.3	62.50		
	Xylenes - HAP/VOC	12	106.16		

Graphs


Megagrams Per Year
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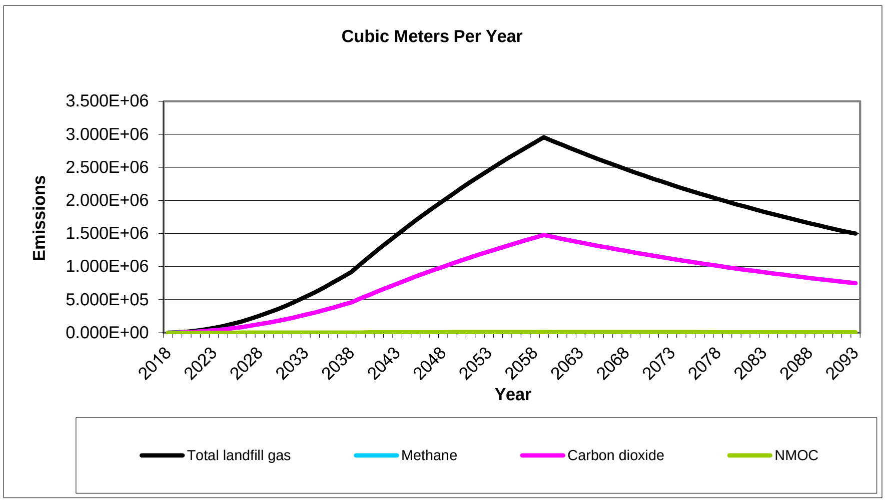
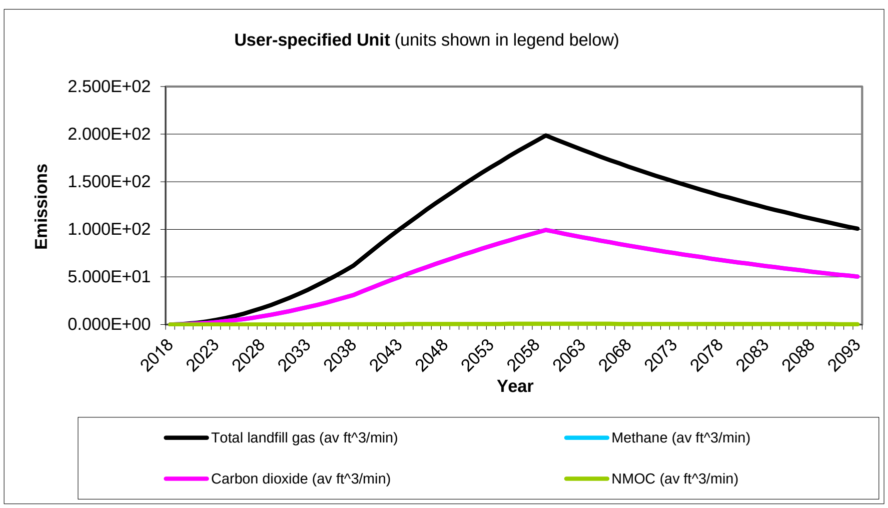
3.500E+03
3.000E+03
2.500E+03
2.000E+03
1.500E+03
1.000E+03
5.000E+02
0.000E+00
Emissions
2018 2023 2028 2033 2038 2043 2048 2053 2058 2063 2068 2073 2078 2083 2088 2093
Year
Total landfill gas
Methane
Carbon dioxide
NMOC


Cubic Meters Per Year
3.500E+06
3.000E+06
2.500E+06
2.000E+06
1.500E+06
1.000E+06
5.000E+05
0.000E+00
Emissions
2018 2023 2028 2033 2038 2043 2048 2053 2058 2063 2068 2073 2078 2083 2088 2093
Year
Total landfill gas
Methane
Carbon dioxide
NMOC


User-specified Unit (units shown in legend below)
2.500E+02
2.000E+02
1.500E+02
1.000E+02
5.000E+01
0.000E+00
Emissions
2018 2023 2028 2033 2038 2043 2048 2053 2058 2063 2068 2073 2078 2083 2088 2093
Year
Total landfill gas (av ft^3/min)
Methane (av ft^3/min)
Carbon dioxide (av ft^3/min)
NMOC (av ft^3/min)

Results

Year	Total landfill gas			Methane		
	(Mg/year)	*(m^3/year)*	*(av ft^3/min)*	*(Mg/year)*	*(m^3/year)*	*(av ft^3/min)*
2018	0	0	0	0	0	0
2019	6.188E+00	4.955E+03	3.329E-01	1.653E+00	2.478E+03	1.665E-01
2020	1.844E+01	1.477E+04	9.922E-01	4.926E+00	7.384E+03	4.961E-01
2021	3.664E+01	2.934E+04	1.971E+00	9.787E+00	1.467E+04	9.857E-01
2022	6.067E+01	4.858E+04	3.264E+00	1.620E+01	2.429E+04	1.632E+00
2023	9.041E+01	7.239E+04	4.864E+00	2.415E+01	3.620E+04	2.432E+00
2024	1.257E+02	1.007E+05	6.765E+00	3.359E+01	5.035E+04	3.383E+00
2025	1.666E+02	1.334E+05	8.962E+00	4.449E+01	6.669E+04	4.481E+00
2026	2.128E+02	1.704E+05	1.145E+01	5.684E+01	8.519E+04	5.724E+00
2027	2.643E+02	2.116E+05	1.422E+01	7.059E+01	1.058E+05	7.109E+00
2028	3.209E+02	2.570E+05	1.727E+01	8.572E+01	1.285E+05	8.633E+00
2029	3.826E+02	3.064E+05	2.059E+01	1.022E+02	1.532E+05	1.029E+01
2030	4.493E+02	3.598E+05	2.417E+01	1.200E+02	1.799E+05	1.209E+01
2031	5.208E+02	4.171E+05	2.802E+01	1.391E+02	2.085E+05	1.401E+01
2032	5.972E+02	4.782E+05	3.213E+01	1.595E+02	2.391E+05	1.606E+01
2033	6.782E+02	5.430E+05	3.649E+01	1.811E+02	2.715E+05	1.824E+01
2034	7.637E+02	6.116E+05	4.109E+01	2.040E+02	3.058E+05	2.055E+01
2035	8.538E+02	6.837E+05	4.594E+01	2.281E+02	3.418E+05	2.297E+01
2036	9.483E+02	7.594E+05	5.102E+01	2.533E+02	3.797E+05	2.551E+01
2037	1.047E+03	8.385E+05	5.634E+01	2.797E+02	4.192E+05	2.817E+01
2038	1.150E+03	9.210E+05	6.188E+01	3.072E+02	4.605E+05	3.094E+01
2039	1.297E+03	1.038E+06	6.978E+01	3.464E+02	5.192E+05	3.489E+01
2040	1.441E+03	1.154E+06	7.752E+01	3.848E+02	5.768E+05	3.876E+01
2041	1.582E+03	1.267E+06	8.510E+01	4.225E+02	6.333E+05	4.255E+01
2042	1.720E+03	1.377E+06	9.254E+01	4.594E+02	6.886E+05	4.627E+01
2043	1.855E+03	1.486E+06	9.983E+01	4.956E+02	7.429E+05	4.991E+01
2044	1.988E+03	1.592E+06	1.070E+02	5.311E+02	7.960E+05	5.349E+01
2045	2.118E+03	1.696E+06	1.140E+02	5.658E+02	8.482E+05	5.699E+01
2046	2.246E+03	1.798E+06	1.208E+02	5.999E+02	8.992E+05	6.042E+01
2047	2.371E+03	1.899E+06	1.276E+02	6.333E+02	9.493E+05	6.378E+01
2048	2.494E+03	1.997E+06	1.342E+02	6.661E+02	9.984E+05	6.708E+01
2049	2.614E+03	2.093E+06	1.406E+02	6.982E+02	1.047E+06	7.031E+01
2050	2.732E+03	2.187E+06	1.470E+02	7.296E+02	1.094E+06	7.348E+01
2051	2.847E+03	2.280E+06	1.532E+02	7.605E+02	1.140E+06	7.659E+01
2052	2.960E+03	2.370E+06	1.593E+02	7.907E+02	1.185E+06	7.963E+01
2053	3.071E+03	2.459E+06	1.652E+02	8.203E+02	1.230E+06	8.262E+01
2054	3.180E+03	2.546E+06	1.711E+02	8.494E+02	1.273E+06	8.554E+01
2055	3.286E+03	2.632E+06	1.768E+02	8.778E+02	1.316E+06	8.841E+01
2056	3.391E+03	2.715E+06	1.824E+02	9.057E+02	1.358E+06	9.122E+01
2057	3.493E+03	2.797E+06	1.879E+02	9.331E+02	1.399E+06	9.397E+01
2058	3.594E+03	2.878E+06	1.933E+02	9.599E+02	1.439E+06	9.667E+01
2059	3.692E+03	2.956E+06	1.986E+02	9.862E+02	1.478E+06	9.932E+01
2060	3.619E+03	2.898E+06	1.947E+02	9.666E+02	1.449E+06	9.735E+01
2061	3.547E+03	2.840E+06	1.909E+02	9.475E+02	1.420E+06	9.543E+01
2062	3.477E+03	2.784E+06	1.871E+02	9.287E+02	1.392E+06	9.354E+01
2063	3.408E+03	2.729E+06	1.834E+02	9.104E+02	1.365E+06	9.168E+01
2064	3.341E+03	2.675E+06	1.797E+02	8.923E+02	1.338E+06	8.987E+01
2065	3.275E+03	2.622E+06	1.762E+02	8.747E+02	1.311E+06	8.809E+01
2066	3.210E+03	2.570E+06	1.727E+02	8.573E+02	1.285E+06	8.634E+01
2067	3.146E+03	2.519E+06	1.693E+02	8.404E+02	1.260E+06	8.463E+01

Results (Continued)

Year	Total landfill gas			Methane		
	(Mg/year)	*(m^3/year)*	*(av ft^3/min)*	*(Mg/year)*	*(m^3/year)*	*(av ft^3/min)*
2068	3.084E+03	2.469E+06	1.659E+02	8.237E+02	1.235E+06	8.296E+01
2069	3.023E+03	2.420E+06	1.626E+02	8.074E+02	1.210E+06	8.132E+01
2070	2.963E+03	2.373E+06	1.594E+02	7.914E+02	1.186E+06	7.971E+01
2071	2.904E+03	2.326E+06	1.563E+02	7.758E+02	1.163E+06	7.813E+01
2072	2.847E+03	2.280E+06	1.532E+02	7.604E+02	1.140E+06	7.658E+01
2073	2.790E+03	2.234E+06	1.501E+02	7.453E+02	1.117E+06	7.506E+01
2074	2.735E+03	2.190E+06	1.472E+02	7.306E+02	1.095E+06	7.358E+01
2075	2.681E+03	2.147E+06	1.442E+02	7.161E+02	1.073E+06	7.212E+01
2076	2.628E+03	2.104E+06	1.414E+02	7.019E+02	1.052E+06	7.069E+01
2077	2.576E+03	2.063E+06	1.386E+02	6.880E+02	1.031E+06	6.929E+01
2078	2.525E+03	2.022E+06	1.358E+02	6.744E+02	1.011E+06	6.792E+01
2079	2.475E+03	1.982E+06	1.332E+02	6.611E+02	9.909E+05	6.658E+01
2080	2.426E+03	1.942E+06	1.305E+02	6.480E+02	9.712E+05	6.526E+01
2081	2.378E+03	1.904E+06	1.279E+02	6.351E+02	9.520E+05	6.397E+01
2082	2.331E+03	1.866E+06	1.254E+02	6.226E+02	9.332E+05	6.270E+01
2083	2.285E+03	1.829E+06	1.229E+02	6.102E+02	9.147E+05	6.146E+01
2084	2.239E+03	1.793E+06	1.205E+02	5.981E+02	8.966E+05	6.024E+01
2085	2.195E+03	1.758E+06	1.181E+02	5.863E+02	8.788E+05	5.905E+01
2086	2.152E+03	1.723E+06	1.158E+02	5.747E+02	8.614E+05	5.788E+01
2087	2.109E+03	1.689E+06	1.135E+02	5.633E+02	8.444E+05	5.673E+01
2088	2.067E+03	1.655E+06	1.112E+02	5.522E+02	8.276E+05	5.561E+01
2089	2.026E+03	1.622E+06	1.090E+02	5.412E+02	8.112E+05	5.451E+01
2090	1.986E+03	1.590E+06	1.069E+02	5.305E+02	7.952E+05	5.343E+01
2091	1.947E+03	1.559E+06	1.047E+02	5.200E+02	7.794E+05	5.237E+01
2092	1.908E+03	1.528E+06	1.027E+02	5.097E+02	7.640E+05	5.133E+01
2093	1.870E+03	1.498E+06	1.006E+02	4.996E+02	7.489E+05	5.032E+01
2094	1.833E+03	1.468E+06	9.864E+01	4.897E+02	7.340E+05	4.932E+01
2095	1.797E+03	1.439E+06	9.669E+01	4.800E+02	7.195E+05	4.834E+01
2096	1.762E+03	1.411E+06	9.477E+01	4.705E+02	7.053E+05	4.739E+01
2097	1.727E+03	1.383E+06	9.290E+01	4.612E+02	6.913E+05	4.645E+01
2098	1.692E+03	1.355E+06	9.106E+01	4.521E+02	6.776E+05	4.553E+01
2099	1.659E+03	1.328E+06	8.925E+01	4.431E+02	6.642E+05	4.463E+01
2100	1.626E+03	1.302E+06	8.749E+01	4.343E+02	6.510E+05	4.374E+01
2101	1.594E+03	1.276E+06	8.575E+01	4.257E+02	6.382E+05	4.288E+01
2102	1.562E+03	1.251E+06	8.406E+01	4.173E+02	6.255E+05	4.203E+01
2103	1.531E+03	1.226E+06	8.239E+01	4.090E+02	6.131E+05	4.120E+01
2104	1.501E+03	1.202E+06	8.076E+01	4.009E+02	6.010E+05	4.038E+01
2105	1.471E+03	1.178E+06	7.916E+01	3.930E+02	5.891E+05	3.958E+01
2106	1.442E+03	1.155E+06	7.759E+01	3.852E+02	5.774E+05	3.880E+01
2107	1.414E+03	1.132E+06	7.606E+01	3.776E+02	5.660E+05	3.803E+01
2108	1.386E+03	1.110E+06	7.455E+01	3.701E+02	5.548E+05	3.728E+01
2109	1.358E+03	1.088E+06	7.308E+01	3.628E+02	5.438E+05	3.654E+01
2110	1.331E+03	1.066E+06	7.163E+01	3.556E+02	5.330E+05	3.581E+01
2111	1.305E+03	1.045E+06	7.021E+01	3.486E+02	5.225E+05	3.510E+01
2112	1.279E+03	1.024E+06	6.882E+01	3.417E+02	5.121E+05	3.441E+01
2113	1.254E+03	1.004E+06	6.746E+01	3.349E+02	5.020E+05	3.373E+01
2114	1.229E+03	9.841E+05	6.612E+01	3.283E+02	4.920E+05	3.306E+01
2115	1.205E+03	9.646E+05	6.481E+01	3.218E+02	4.823E+05	3.241E+01
2116	1.181E+03	9.455E+05	6.353E+01	3.154E+02	4.728E+05	3.176E+01
2117	1.157E+03	9.268E+05	6.227E+01	3.092E+02	4.634E+05	3.114E+01
2118	1.134E+03	9.084E+05	6.104E+01	3.030E+02	4.542E+05	3.052E+01

Results (Continued)

Year	Total landfill gas			Methane		
	(Mg/year)	*(m^3/year)*	*(av ft^3/min)*	*(Mg/year)*	*(m^3/year)*	*(av ft^3/min)*
2119	1.112E+03	8.904E+05	5.983E+01	2.970E+02	4.452E+05	2.991E+01
2120	1.090E+03	8.728E+05	5.864E+01	2.911E+02	4.364E+05	2.932E+01
2121	1.068E+03	8.555E+05	5.748E+01	2.854E+02	4.278E+05	2.874E+01
2122	1.047E+03	8.386E+05	5.634E+01	2.797E+02	4.193E+05	2.817E+01
2123	1.027E+03	8.220E+05	5.523E+01	2.742E+02	4.110E+05	2.761E+01
2124	1.006E+03	8.057E+05	5.414E+01	2.688E+02	4.029E+05	2.707E+01
2125	9.863E+02	7.898E+05	5.306E+01	2.634E+02	3.949E+05	2.653E+01
2126	9.667E+02	7.741E+05	5.201E+01	2.582E+02	3.871E+05	2.601E+01
2127	9.476E+02	7.588E+05	5.098E+01	2.531E+02	3.794E+05	2.549E+01
2128	9.288E+02	7.438E+05	4.997E+01	2.481E+02	3.719E+05	2.499E+01
2129	9.104E+02	7.290E+05	4.898E+01	2.432E+02	3.645E+05	2.449E+01
2130	8.924E+02	7.146E+05	4.801E+01	2.384E+02	3.573E+05	2.401E+01
2131	8.747E+02	7.004E+05	4.706E+01	2.337E+02	3.502E+05	2.353E+01
2132	8.574E+02	6.866E+05	4.613E+01	2.290E+02	3.433E+05	2.307E+01
2133	8.404E+02	6.730E+05	4.522E+01	2.245E+02	3.365E+05	2.261E+01
2134	8.238E+02	6.597E+05	4.432E+01	2.200E+02	3.298E+05	2.216E+01
2135	8.075E+02	6.466E+05	4.344E+01	2.157E+02	3.233E+05	2.172E+01
2136	7.915E+02	6.338E+05	4.258E+01	2.114E+02	3.169E+05	2.129E+01
2137	7.758E+02	6.212E+05	4.174E+01	2.072E+02	3.106E+05	2.087E+01
2138	7.605E+02	6.089E+05	4.091E+01	2.031E+02	3.045E+05	2.046E+01
2139	7.454E+02	5.969E+05	4.010E+01	1.991E+02	2.984E+05	2.005E+01
2140	7.306E+02	5.851E+05	3.931E+01	1.952E+02	2.925E+05	1.966E+01
2141	7.162E+02	5.735E+05	3.853E+01	1.913E+02	2.867E+05	1.927E+01
2142	7.020E+02	5.621E+05	3.777E+01	1.875E+02	2.811E+05	1.888E+01
2143	6.881E+02	5.510E+05	3.702E+01	1.838E+02	2.755E+05	1.851E+01
2144	6.745E+02	5.401E+05	3.629E+01	1.802E+02	2.700E+05	1.814E+01
2145	6.611E+02	5.294E+05	3.557E+01	1.766E+02	2.647E+05	1.778E+01
2146	6.480E+02	5.189E+05	3.487E+01	1.731E+02	2.595E+05	1.743E+01
2147	6.352E+02	5.086E+05	3.417E+01	1.697E+02	2.543E+05	1.709E+01
2148	6.226E+02	4.986E+05	3.350E+01	1.663E+02	2.493E+05	1.675E+01
2149	6.103E+02	4.887E+05	3.283E+01	1.630E+02	2.443E+05	1.642E+01
2150	5.982E+02	4.790E+05	3.218E+01	1.598E+02	2.395E+05	1.609E+01
2151	5.864E+02	4.695E+05	3.155E+01	1.566E+02	2.348E+05	1.577E+01
2152	5.747E+02	4.602E+05	3.092E+01	1.535E+02	2.301E+05	1.546E+01
2153	5.634E+02	4.511E+05	3.031E+01	1.505E+02	2.256E+05	1.516E+01
2154	5.522E+02	4.422E+05	2.971E+01	1.475E+02	2.211E+05	1.486E+01
2155	5.413E+02	4.334E+05	2.912E+01	1.446E+02	2.167E+05	1.456E+01
2156	5.306E+02	4.248E+05	2.855E+01	1.417E+02	2.124E+05	1.427E+01
2157	5.200E+02	4.164E+05	2.798E+01	1.389E+02	2.082E+05	1.399E+01
2158	5.098E+02	4.082E+05	2.743E+01	1.362E+02	2.041E+05	1.371E+01

Results (Continued)

Year	Carbon dioxide			NMOC		
	(Mg/year)	*(m^3/year)*	*(av ft^3/min)*	*(Mg/year)*	*(m^3/year)*	*(av ft^3/min)*
2018	0	0	0	0	0	0
2019	4.535E+00	2.478E+03	1.665E-01	7.105E-02	1.982E+01	1.332E-03
2020	1.352E+01	7.384E+03	4.961E-01	2.117E-01	5.907E+01	3.969E-03
2021	2.685E+01	1.467E+04	9.857E-01	4.207E-01	1.174E+02	7.885E-03
2022	4.446E+01	2.429E+04	1.632E+00	6.965E-01	1.943E+02	1.306E-02
2023	6.626E+01	3.620E+04	2.432E+00	1.038E+00	2.896E+02	1.946E-02
2024	9.216E+01	5.035E+04	3.383E+00	1.444E+00	4.028E+02	2.706E-02
2025	1.221E+02	6.669E+04	4.481E+00	1.912E+00	5.335E+02	3.585E-02
2026	1.559E+02	8.519E+04	5.724E+00	2.443E+00	6.815E+02	4.579E-02
2027	1.937E+02	1.058E+05	7.109E+00	3.034E+00	8.464E+02	5.687E-02
2028	2.352E+02	1.285E+05	8.633E+00	3.684E+00	1.028E+03	6.906E-02
2029	2.804E+02	1.532E+05	1.029E+01	4.393E+00	1.226E+03	8.234E-02
2030	3.293E+02	1.799E+05	1.209E+01	5.158E+00	1.439E+03	9.669E-02
2031	3.817E+02	2.085E+05	1.401E+01	5.980E+00	1.668E+03	1.121E-01
2032	4.377E+02	2.391E+05	1.606E+01	6.856E+00	1.913E+03	1.285E-01
2033	4.970E+02	2.715E+05	1.824E+01	7.786E+00	2.172E+03	1.459E-01
2034	5.597E+02	3.058E+05	2.055E+01	8.769E+00	2.446E+03	1.644E-01
2035	6.258E+02	3.418E+05	2.297E+01	9.803E+00	2.735E+03	1.838E-01
2036	6.950E+02	3.797E+05	2.551E+01	1.089E+01	3.037E+03	2.041E-01
2037	7.674E+02	4.192E+05	2.817E+01	1.202E+01	3.354E+03	2.253E-01
2038	8.429E+02	4.605E+05	3.094E+01	1.320E+01	3.684E+03	2.475E-01
2039	9.505E+02	5.192E+05	3.489E+01	1.489E+01	4.154E+03	2.791E-01
2040	1.056E+03	5.768E+05	3.876E+01	1.654E+01	4.615E+03	3.101E-01
2041	1.159E+03	6.333E+05	4.255E+01	1.816E+01	5.066E+03	3.404E-01
2042	1.261E+03	6.886E+05	4.627E+01	1.975E+01	5.509E+03	3.702E-01
2043	1.360E+03	7.429E+05	4.991E+01	2.130E+01	5.943E+03	3.993E-01
2044	1.457E+03	7.960E+05	5.349E+01	2.283E+01	6.368E+03	4.279E-01
2045	1.553E+03	8.482E+05	5.699E+01	2.432E+01	6.785E+03	4.559E-01
2046	1.646E+03	8.992E+05	6.042E+01	2.579E+01	7.194E+03	4.834E-01
2047	1.738E+03	9.493E+05	6.378E+01	2.722E+01	7.595E+03	5.103E-01
2048	1.828E+03	9.984E+05	6.708E+01	2.863E+01	7.987E+03	5.367E-01
2049	1.916E+03	1.047E+06	7.031E+01	3.001E+01	8.372E+03	5.625E-01
2050	2.002E+03	1.094E+06	7.348E+01	3.136E+01	8.749E+03	5.879E-01
2051	2.087E+03	1.140E+06	7.659E+01	3.269E+01	9.119E+03	6.127E-01
2052	2.169E+03	1.185E+06	7.963E+01	3.399E+01	9.482E+03	6.371E-01
2053	2.251E+03	1.230E+06	8.262E+01	3.526E+01	9.837E+03	6.609E-01
2054	2.330E+03	1.273E+06	8.554E+01	3.651E+01	1.019E+04	6.843E-01
2055	2.409E+03	1.316E+06	8.841E+01	3.773E+01	1.053E+04	7.073E-01
2056	2.485E+03	1.358E+06	9.122E+01	3.893E+01	1.086E+04	7.297E-01
2057	2.560E+03	1.399E+06	9.397E+01	4.011E+01	1.119E+04	7.518E-01
2058	2.634E+03	1.439E+06	9.667E+01	4.126E+01	1.151E+04	7.734E-01
2059	2.706E+03	1.478E+06	9.932E+01	4.239E+01	1.183E+04	7.946E-01
2060	2.652E+03	1.449E+06	9.735E+01	4.155E+01	1.159E+04	7.788E-01
2061	2.600E+03	1.420E+06	9.543E+01	4.073E+01	1.136E+04	7.634E-01
2062	2.548E+03	1.392E+06	9.354E+01	3.992E+01	1.114E+04	7.483E-01
2063	2.498E+03	1.365E+06	9.168E+01	3.913E+01	1.092E+04	7.335E-01
2064	2.448E+03	1.338E+06	8.987E+01	3.835E+01	1.070E+04	7.189E-01
2065	2.400E+03	1.311E+06	8.809E+01	3.759E+01	1.049E+04	7.047E-01
2066	2.352E+03	1.285E+06	8.634E+01	3.685E+01	1.028E+04	6.908E-01
2067	2.306E+03	1.260E+06	8.463E+01	3.612E+01	1.008E+04	6.771E-01

Results (Continued)

Year	Carbon dioxide			NMOC		
	(Mg/year)	(m^3/year)	(av ft^3/min)	(Mg/year)	(m^3/year)	(av ft^3/min)
2068	2.260E+03	1.235E+06	8.296E+01	3.541E+01	9.878E+03	6.637E-01
2069	2.215E+03	1.210E+06	8.132E+01	3.470E+01	9.682E+03	6.505E-01
2070	2.171E+03	1.186E+06	7.971E+01	3.402E+01	9.490E+03	6.376E-01
2071	2.128E+03	1.163E+06	7.813E+01	3.334E+01	9.302E+03	6.250E-01
2072	2.086E+03	1.140E+06	7.658E+01	3.268E+01	9.118E+03	6.126E-01
2073	2.045E+03	1.117E+06	7.506E+01	3.204E+01	8.938E+03	6.005E-01
2074	2.005E+03	1.095E+06	7.358E+01	3.140E+01	8.761E+03	5.886E-01
2075	1.965E+03	1.073E+06	7.212E+01	3.078E+01	8.587E+03	5.770E-01
2076	1.926E+03	1.052E+06	7.069E+01	3.017E+01	8.417E+03	5.655E-01
2077	1.888E+03	1.031E+06	6.929E+01	2.957E+01	8.250E+03	5.543E-01
2078	1.850E+03	1.011E+06	6.792E+01	2.899E+01	8.087E+03	5.434E-01
2079	1.814E+03	9.909E+05	6.658E+01	2.841E+01	7.927E+03	5.326E-01
2080	1.778E+03	9.712E+05	6.526E+01	2.785E+01	7.770E+03	5.221E-01
2081	1.743E+03	9.520E+05	6.397E+01	2.730E+01	7.616E+03	5.117E-01
2082	1.708E+03	9.332E+05	6.270E+01	2.676E+01	7.465E+03	5.016E-01
2083	1.674E+03	9.147E+05	6.146E+01	2.623E+01	7.317E+03	4.917E-01
2084	1.641E+03	8.966E+05	6.024E+01	2.571E+01	7.173E+03	4.819E-01
2085	1.609E+03	8.788E+05	5.905E+01	2.520E+01	7.031E+03	4.724E-01
2086	1.577E+03	8.614E+05	5.788E+01	2.470E+01	6.891E+03	4.630E-01
2087	1.546E+03	8.444E+05	5.673E+01	2.421E+01	6.755E+03	4.539E-01
2088	1.515E+03	8.276E+05	5.561E+01	2.373E+01	6.621E+03	4.449E-01
2089	1.485E+03	8.112E+05	5.451E+01	2.326E+01	6.490E+03	4.361E-01
2090	1.456E+03	7.952E+05	5.343E+01	2.280E+01	6.361E+03	4.274E-01
2091	1.427E+03	7.794E+05	5.237E+01	2.235E+01	6.236E+03	4.190E-01
2092	1.399E+03	7.640E+05	5.133E+01	2.191E+01	6.112E+03	4.107E-01
2093	1.371E+03	7.489E+05	5.032E+01	2.147E+01	5.991E+03	4.025E-01
2094	1.344E+03	7.340E+05	4.932E+01	2.105E+01	5.872E+03	3.946E-01
2095	1.317E+03	7.195E+05	4.834E+01	2.063E+01	5.756E+03	3.868E-01
2096	1.291E+03	7.053E+05	4.739E+01	2.022E+01	5.642E+03	3.791E-01
2097	1.265E+03	6.913E+05	4.645E+01	1.982E+01	5.530E+03	3.716E-01
2098	1.240E+03	6.776E+05	4.553E+01	1.943E+01	5.421E+03	3.642E-01
2099	1.216E+03	6.642E+05	4.463E+01	1.905E+01	5.314E+03	3.570E-01
2100	1.192E+03	6.510E+05	4.374E+01	1.867E+01	5.208E+03	3.499E-01
2101	1.168E+03	6.382E+05	4.288E+01	1.830E+01	5.105E+03	3.430E-01
2102	1.145E+03	6.255E+05	4.203E+01	1.794E+01	5.004E+03	3.362E-01
2103	1.122E+03	6.131E+05	4.120E+01	1.758E+01	4.905E+03	3.296E-01
2104	1.100E+03	6.010E+05	4.038E+01	1.723E+01	4.808E+03	3.230E-01
2105	1.078E+03	5.891E+05	3.958E+01	1.689E+01	4.713E+03	3.166E-01
2106	1.057E+03	5.774E+05	3.880E+01	1.656E+01	4.619E+03	3.104E-01
2107	1.036E+03	5.660E+05	3.803E+01	1.623E+01	4.528E+03	3.042E-01
2108	1.016E+03	5.548E+05	3.728E+01	1.591E+01	4.438E+03	2.982E-01
2109	9.954E+02	5.438E+05	3.654E+01	1.559E+01	4.350E+03	2.923E-01
2110	9.757E+02	5.330E+05	3.581E+01	1.528E+01	4.264E+03	2.865E-01
2111	9.564E+02	5.225E+05	3.510E+01	1.498E+01	4.180E+03	2.808E-01
2112	9.374E+02	5.121E+05	3.441E+01	1.469E+01	4.097E+03	2.753E-01
2113	9.189E+02	5.020E+05	3.373E+01	1.439E+01	4.016E+03	2.698E-01
2114	9.007E+02	4.920E+05	3.306E+01	1.411E+01	3.936E+03	2.645E-01
2115	8.829E+02	4.823E+05	3.241E+01	1.383E+01	3.858E+03	2.592E-01
2116	8.654E+02	4.728E+05	3.176E+01	1.356E+01	3.782E+03	2.541E-01
2117	8.482E+02	4.634E+05	3.114E+01	1.329E+01	3.707E+03	2.491E-01
2118	8.314E+02	4.542E+05	3.052E+01	1.303E+01	3.634E+03	2.442E-01

Results (Continued)

Year	Carbon dioxide			NMOC		
	(Mg/year)	(m^3/year)	(av ft^3/min)	(Mg/year)	(m^3/year)	(av ft^3/min)
2119	8.150E+02	4.452E+05	2.991E+01	1.277E+01	3.562E+03	2.393E-01
2120	7.988E+02	4.364E+05	2.932E+01	1.251E+01	3.491E+03	2.346E-01
2121	7.830E+02	4.278E+05	2.874E+01	1.227E+01	3.422E+03	2.299E-01
2122	7.675E+02	4.193E+05	2.817E+01	1.202E+01	3.354E+03	2.254E-01
2123	7.523E+02	4.110E+05	2.761E+01	1.179E+01	3.288E+03	2.209E-01
2124	7.374E+02	4.029E+05	2.707E+01	1.155E+01	3.223E+03	2.165E-01
2125	7.228E+02	3.949E+05	2.653E+01	1.132E+01	3.159E+03	2.123E-01
2126	7.085E+02	3.871E+05	2.601E+01	1.110E+01	3.096E+03	2.081E-01
2127	6.945E+02	3.794E+05	2.549E+01	1.088E+01	3.035E+03	2.039E-01
2128	6.807E+02	3.719E+05	2.499E+01	1.066E+01	2.975E+03	1.999E-01
2129	6.672E+02	3.645E+05	2.449E+01	1.045E+01	2.916E+03	1.959E-01
2130	6.540E+02	3.573E+05	2.401E+01	1.025E+01	2.858E+03	1.921E-01
2131	6.411E+02	3.502E+05	2.353E+01	1.004E+01	2.802E+03	1.883E-01
2132	6.284E+02	3.433E+05	2.307E+01	9.844E+00	2.746E+03	1.845E-01
2133	6.159E+02	3.365E+05	2.261E+01	9.649E+00	2.692E+03	1.809E-01
2134	6.038E+02	3.298E+05	2.216E+01	9.458E+00	2.639E+03	1.773E-01
2135	5.918E+02	3.233E+05	2.172E+01	9.271E+00	2.586E+03	1.738E-01
2136	5.801E+02	3.169E+05	2.129E+01	9.087E+00	2.535E+03	1.703E-01
2137	5.686E+02	3.106E+05	2.087E+01	8.907E+00	2.485E+03	1.670E-01
2138	5.573E+02	3.045E+05	2.046E+01	8.731E+00	2.436E+03	1.637E-01
2139	5.463E+02	2.984E+05	2.005E+01	8.558E+00	2.388E+03	1.604E-01
2140	5.355E+02	2.925E+05	1.966E+01	8.389E+00	2.340E+03	1.572E-01
2141	5.249E+02	2.867E+05	1.927E+01	8.222E+00	2.294E+03	1.541E-01
2142	5.145E+02	2.811E+05	1.888E+01	8.060E+00	2.248E+03	1.511E-01
2143	5.043E+02	2.755E+05	1.851E+01	7.900E+00	2.204E+03	1.481E-01
2144	4.943E+02	2.700E+05	1.814E+01	7.744E+00	2.160E+03	1.452E-01
2145	4.845E+02	2.647E+05	1.778E+01	7.590E+00	2.118E+03	1.423E-01
2146	4.749E+02	2.595E+05	1.743E+01	7.440E+00	2.076E+03	1.395E-01
2147	4.655E+02	2.543E+05	1.709E+01	7.293E+00	2.035E+03	1.367E-01
2148	4.563E+02	2.493E+05	1.675E+01	7.148E+00	1.994E+03	1.340E-01
2149	4.473E+02	2.443E+05	1.642E+01	7.007E+00	1.955E+03	1.313E-01
2150	4.384E+02	2.395E+05	1.609E+01	6.868E+00	1.916E+03	1.287E-01
2151	4.297E+02	2.348E+05	1.577E+01	6.732E+00	1.878E+03	1.262E-01
2152	4.212E+02	2.301E+05	1.546E+01	6.599E+00	1.841E+03	1.237E-01
2153	4.129E+02	2.256E+05	1.516E+01	6.468E+00	1.804E+03	1.212E-01
2154	4.047E+02	2.211E+05	1.486E+01	6.340E+00	1.769E+03	1.188E-01
2155	3.967E+02	2.167E+05	1.456E+01	6.214E+00	1.734E+03	1.165E-01
2156	3.888E+02	2.124E+05	1.427E+01	6.091E+00	1.699E+03	1.142E-01
2157	3.811E+02	2.082E+05	1.399E+01	5.971E+00	1.666E+03	1.119E-01
2158	3.736E+02	2.041E+05	1.371E+01	5.853E+00	1.633E+03	1.097E-01