SUPERFUND LANDFILL METHANE-TO-ENERGY PILOT PROJECT

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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
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Office of Superfund Remediation and Technology Innovation
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Executive Summary

This report presents a summary of a study to evaluate the technical and economic feasibility of recovering methane at six Superfund National Priorities List (NPL) landfills in EPA Regions 1, 2, and 3 with expected landfill gas flows between 100 and 400 standard cubic feet per minute (SCFM). The recovered methane could be used to either generate electricity for on-site use, to generate electricity for sale to the local utility, to replace natural gas consumption at the landfill, or to export landfill gas to a near-by industry for fueling gas-fired technologies. Based on the information developed from the six landfill evaluations, the study developed the Landfill Gas Energy Project Assessment Tool to aid managers in conducting their own assessment of the economic feasibility of landfill gas energy projects at NPL landfills.

The Landfill Gas Energy Project Assessment Tool is presented in Section 3 of this report and provides assistance in:

- Estimating the gas potential of a landfill,
- Determining the energy demands of the on-site remediation equipment,
- Estimating the potential costs and revenues from a landfill gas energy project
- Evaluating the potential to improve a project's economics.

With the above assistance, a landfill manager can assess whether utilizing the energy value of their landfill gas can help offset site remediation costs or whether the gas can potentially provide a revenue stream for the landfill.

The six landfill project assessments conducted in this study suggested several attributes that tend to make NPL landfills good candidates for gas utilization projects. These attributes include:

- The landfill has more than 2 million tons of municipal solid waste (MSW),
- The landfill waste is more than 80 feet deep,
- The landfill has an impermeable cap and a liner,
- The landfill has an active gas collection system that continuously provides gas with a methane concentration of 40% or more,
- The landfill has an on-site need for more than 50 kW of electricity,
- The local electricity prices exceed $0.14/kWh

These observations on the attributes that may make a NPL landfill a good candidate for gas utilization reflect trends and not hard rules. Most sites have unique aspects that will affect the economics of developing a project at the site.

Based on existing gas utilization technology, beneficial use of methane is not economically feasible at four of the six landfills studied, and only marginally economical at the remaining two landfills. After the study was completed (2010), EPA has learned that advances in technology allows the use of lower methane concentrations to generate electricity when operating a microturbine. Thus it might be economically feasible to consider the beneficial use of methane from landfills with less than 40% methane concentration.

The scope of this study did not include the following items, due to various limitations:

- Research was not conducted into various financial incentives that may be available for energy projects at each individual landfill,

- A detailed cost analysis based on site-specific vendor quotes was not conducted,
- There was no coordination with municipalities or potentially responsible parties (PRPs) associated with each site,
- There was no community outreach to discuss the potential project and its merits, No assessment was made of how political incentives and EPA policy affect project feasibility,
- No calculation was made of the economic profitability to the project owner.

Two other NPL landfills in Region 9, discovered during the latter phase of this study, are mentioned in this report. The State of California provided information on the Crazy Horse NPL landfill that they are pursuing for commercial energy development. Since evaluations had already been completed for this landfill and plans were underway for a project, an analysis was not conducted under this study. However, the data for the Crazy Horse NPL landfill are included in the Appendix. EPA's Landfill Methane Outreach Program (LMOP) has evaluated the feasibility of a landfill gas energy project at the closed Fresno Sanitary Landfill. LMOP's initial analysis of the site indicates there may be potential for the economical implementation of an onsite landfill gas energy electric generation project.

1. Introduction

Methane (CH_4) is a large contributor to global warming, second only to carbon dioxide. Methane's overall contribution is large in part because it is a potent greenhouse gas (GHG), with 21 times the global warming potential of carbon dioxide. Furthermore, methane concentrations in the atmosphere are changing at a rapid rate, more than doubling over the last two centuries and continuing to rise annually. These increases are largely due to increasing emissions from anthropogenic sources, with anthropogenic emissions now constituting about 70 percent of total U.S. methane emissions. (*Methane and Nitrous Oxide Emissions From Natural Sources*, April 2010, EPA 430-R-10-001 and *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2008,* April 2010, U.S. EPA # 430-R-10-006)

There are many opportunities for reducing methane emissions through changes in practices and technologies which may have economic as well as environmental benefits. Efforts to reduce methane emissions are attractive for several reasons. First, because methane is a source of energy, many emissions control options have additional economic benefits. Methane emissions can often be recovered and utilized for fuel/energy or the quantity of methane emissions can be significantly reduced through

the use of cost-effective management methods. Second, in contrast to the numerous sources of other GHGs, a few sources often account for a large portion of emissions. Therefore, applying emission reductions strategies to these sources can result in a substantial decrease in estimated current and future methane emissions levels.

Anaerobic decomposition of waste in landfills is the major anthropogenic source of methane emissions in the US, accounting for over 22 percent of total US methane emissions in 2008. As the amount of waste deposited in landfills increases, the amount of methane generated by the landfills each year will also increase. (*Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2008,* April 2010, U.S. EPA # 430-R-10-006)

Increased use of landfill methane can provide an alternative or supplemental fuel supply while also reducing emissions from landfills. Historically, only a fraction of the landfills on the NPL have methane recovery systems to utilize the collected methane to generate power, and in turn reduce methane emissions from the landfill. Because landfill gas forms soon after waste is placed in a landfill, once a landfill is closed the gas production drops fairly quickly. Since most NPL sites stopped accepting municipal waste at least a decade or two ago, the gas generation rate is in decline at the majority of landfills on the NPL. Because of the declining gas generation rate there are fewer opportunities to economically recover the methane from landfills on the NPL. However, in some situations, there may be opportunities to economically recover methane to generate power from landfills on the NPL. In other situations, there may be sufficient methane available from the landfill to meet site energy requirements.

The EPA Office of Superfund Remediation and Technology Innovation (OSRTI), in collaboration with EPA's Federal Facilities Remediation and Reuse Office (FFRRO), EPA Regions 1, 2, and 3, and EPA's Landfill Methane Outreach Program (LMOP), conducted a study in 2010 to explore options for productively utilizing methane emissions from those landfills that are placed on the Superfund National Priorities List (NPL). The study included an evaluation of the technical and economic feasibility of recovering methane at six Superfund NPL landfills and using the methane to generate electricity for on-site use, to generate electricity for sale to the local utility, or to replace natural gas consumption. The six landfills were selected because they had confirmed methane flows and on-site remediation activities that could potentially benefit from electricity produced on site. The six landfills were not selected to provide a statistical representation of NPL landfills. Based on the information developed for the six landfill evaluations, the study developed the Landfill Gas Energy Project Assessment Tool to aid managers in conducting their own assessment of the feasibility of installing landfill gas energy projects at NPL landfills. The focus of both the pilot study and the Landfill Gas Energy Project Assessment Tool was primarily the cost effective use of methane to meet on-site electric or heat demands. However, the potential for commercial development was also assessed when the gas supply seemed adequate for commercial use.

Section 2 of this report summarizes general observations resulting from the site assessments regarding what attributes make a landfill a good candidate for an energy project. These observations reflect trends and not hard rules. Most sites have unique aspects that will affect the economics of developing a project at the site. This section also provides a summary of the findings from each of the assessments conducted on the six NPL landfills. The assessments were based on publically available information and information provided by EPA site managers for the respective landfills. The data was often several years old and often had not been verified by site visits or audits. No site visits were conducted as part of this study.

Section 3 of this report presents the Landfill Gas Energy Project Assessment Tool to aid managers in conducting their own assessment of the economic feasibility of landfill gas energy projects at NPL landfills.

Section 4 of this report provides recommendations for next steps that EPA might take to identify more NPL landfills that would be good candidates for energy projects. The recommendations focus on two separate objectives: identifying landfills that are candidates for installing projects to provide their own energy needs and identifying landfills that are candidates for installing projects to generate electricity for sale to other energy users.

The Appendix to this report contains the assessment reports for the six NPL landfills assessed in this study and the Landfill Gas Energy Project Assessment Tool Calculation Worksheet developed from the six assessment studies. The State of California also provided information on the Crazy Horse NPL landfill that they are pursuing for commercial energy development. Since evaluations had already been completed for this landfill and plans were underway for a project, an analysis was not conducted under this study. The state of California also provided data on the Fresno Sanitary Landfill. Although the data for Fresno landfill was submitted after completion of the assessment studies, the data on this landfill shows that it has an active gas collection system and it is producing significant quantities of methane. The data for the Crazy Horse NPL landfill and for the Fresno Sanitary landfill are included in the Appendix to make it available to future researchers.

2. Assessment Reports

Based on a screening of readily available information on approximately thirty inactive NPL landfills, six sites were selected for analysis of their potential to cost-effectively recover and utilize landfill gas. Their selection was based on meeting most of the following criteria, which would make them likely candidates for cost-effective methane recovery and use:

- They have a gas collection system and have measured their methane flow,
- They have several million tons of municipal waste in the landfill,
- They accepted municipal waste as recently as 1990, and
- They conduct on-site remediation activities that could potentially benefit from on-site energy production.

Most NPL landfills have not accepted municipal waste in the recent past, so records on municipal waste quantities and composition are limited and incomplete. As a result, the assessments were based on one or more of the following sources: available documents on the official NPL internet support sites, and documents from- and telephone conversations with- EPA site managers.

For each of the six sites, an assessment was conducted on the quantity and quality of landfill gas that will be available at the site over the next 15 years. This gas resource was matched to the on-site electric and heat demand to determine if it is adequate, or if it could be upgraded to meet on-site energy needs. Finally, the cost of capturing and utilizing on-site landfill gas to meet on-site needs was assessed. For landfills with a gas potential that far exceeds on-site energy demands, the potential for commercial gas production was also assessed.

There are several observations that can be made from the six assessment reports regarding what contributes to a landfill being a good candidate for an energy project. These observations reflect trends and not hard rules. Most sites have unique aspects that will affect the economics of developing a project at the site.

- Landfills with at least 2 million tons of waste in place are better candidates for energy recovery. Towards this lower size range, the waste depth should be greater than 80 feet at the deepest point. With few exceptions, landfills of any capacity that have a waste depth of less than 40 feet at the deepest point will have little anaerobic gas generation.
- Landfills with impermeable caps are better candidates for energy recovery. Many NPL sites have soil caps. Soil caps allow more air penetration through the cap and reduce the formation of methane by anaerobic decomposition. Landfills with impermeable caps will produce landfill gas with a higher methane concentration.
- Lined landfills are better candidates for energy projects. Unlined landfills often have perimeter gas migration and employ migration gas control measures that are counterproductive to gas production. These measures are 1) overdrawing on existing wells and 2) introducing vacuum on perimeter wells (wells outside the waste mass) to intercept gas migration off site and to on-site receptors. Both measures introduce ambient air and dilute the existing landfill gas. The perimeter well systems tend to draw predominately ambient air with little landfill gas. Overdrawing also affects gas

production by introducing aerobic conditions that are not habitable to the organisms that produce the methane-containing landfill gas.

- Sites with an active gas collection system are better candidates for an economically feasible project. Well drilling, well construction, header installation, and blowers are a significant portion of a project development cost. An existing active gas collection system significantly reduces capital cost. Additionally, an active gas collection system can provide valuable design information about the gas quantity and quality, specifically flow and methane content.
- Landfills with wells that penetrate the full depth of the waste are better candidates for energy projects. NPL sites often have limited well depths, or use less intrusive measures such as shallow gas collection trenches and permeable stone layers, to collect landfill gas with limited impact on ground water. These shallow gas collection systems have lower gas collection efficiencies. Deeper gas may stay stagnate or, since unlined, migrate laterally out of the waste mass.
- Energy projects for generating on-site electricity are more feasible at landfills with an electricity demand exceeding 50 kW and where the local electricity price is high (above $0.14/kWh), or the electricity availability or reliability is inadequate.
- Sites that can generate 1 MW or more of electricity may be a good candidate for a commercial electric project. However, the electricity buy-back rate must be substantial, likely reflecting a premium for renewable electricity.

The results of the six site assessments are summarized below.

<u>Site 1: Old Bethpage Landfill, Town of Oyster Bay, New York</u>
This landfill once operated a methane energy recovery project, but the operation ceased when the gas flow dropped below a commercially cost-effective level. However, there are still remediation activities being conducted on site that might benefit from an energy recovery project.

Waste in Place (estimated): 3.9 million tons over 68 acres.
Waste Characteristics: 67% MSW and 33% incinerator ash.
Period of Operation: 18 years from 1967 through 1986. (Between 1957 and 1967, only incinerator residual ash was accepted; well-combusted ash does not produce methane gas).
Landfill Gas Collection Activities: Active gas collection from 6 wells.
Estimated Gas Resource for Year 2011: Continuous flow of 375 scfm @ 20% methane (average).
On-Site Energy Demands: electricity for blower/flare system, condensate and leachate collection and treatment. Landfill gas is used as flare fuel for remediating perimeter well vapors and condensate.
Assessment Status: Beneficial-use is not economically feasible. Twenty percent methane is inadequate for operating electrical generators. A segregated system of additional wells to collect fuel for generating electricity would not be economically feasible. In 2006 the site purchased $134,506 of electricity. Assuming an electricity price of $0.11/kWh, it was assumed that the site may have an electric load as high as 140 kW. The cost to drill additional gas collection wells (assuming the wells would be productive) and to install microturbines to generate the required electricity would be extremely expensive and not

justified by the electricity savings. The cost to generate electricity at this site using landfill gas could be greater than $0.20/kWh.

Site 2: Charles George Reclamation Trust Landfill Superfund Site, Tyngsboro, Massachusetts

Waste in Place (estimated): 4 million tons over 70 acres.
Waste Characteristics: Mixed industrial, municipal and hazardous waste. For 3 years hazardous wastes and substances primarily in the form of drummed and bulk chemicals containing volatile organic compounds (VOCs) and toxic metal sludges was accepted with the MSW.
Period of Operation: 27 years (Mid 1950s through 1982).
Landfill Gas Collection Activities: Active gas collection from three or more wells, intermittent operation flaring (less than 10%).
Estimated Gas Resource for Year 2011: 190 scfm. Continuous gas collection data is not available for the site. During recent tests, a flow of 200 scfm and marginal methane concentrations were reported. Marginal in this case means that the gas collection and control system operates when the methane concentration reaches 20 percent or higher.
On-Site Energy Demands: leachate pumps, gas blower/flare system, electronic monitoring/control equipment.
Assessment Status: As the landfill gas system is currently configured, it cannot sustain the current extraction rate of 200 scfm for long periods. To operate an energy system at this site, the extraction and combustion equipment must be modified to only extract the quantity of landfill gas that the waste mass generates, without inducing air intrusion. This option would require the purchase of smaller blowers and an upgrade in the gas collection system to eliminate any leaks that may currently be allowing air intrusion. This option is only possible if the offsite landfill gas migration can be controlled at the lowered gas extraction rate. It is also possible that the upgraded gas collection system still would not provide the 40 scfm of landfill gas at 35% methane that is required to fuel a Capstone microturbine installation. In that case, a new wellfield would be required to extract the available gas that is shown in the table on page B-4. The option of adding deeper wells was discussed with the PRP, and it was determined that because of the potential for encountering buried drums and the risk of groundwater contamination, additional drilling would not be allowed.

Site 3: Combe Fill South Landfill, Morris County, New Jersey

Waste in Place (estimated): 5 million cubic yards over 65 acres.
Waste Characteristics (estimated): 95% municipal and 5% industrial waste.
Period of Operation: approximately 36 years from mid-1940s until 1981.
Landfill Gas Collection Activities: Passive gas collection from 65 in-waste gas wells.
Estimated Gas Resource for Year 2011: 300 scfm at an assumed 50% methane.
On-Site Energy Demands: continuously operating groundwater pump and treat system requiring 60 kW, and natural-gas-fueled heating system requiring 1 million Btu/hr of fuel in the winter months.
Assessment Status: Beneficial-use is economically marginal; the project could have a net negative cash flow of $62,000 per year.

The estimated average energy load is approximately 56.5kW; the electrical load fluctuates seasonally with a range of 34 to 84 kW. A developed project would consist of gas collection system improvements to convert a portion of the passive system to active, one 65 kW microturbine generator, and a gas compression and conditioning system. Considering a 10-year proforma period, replacing natural gas usage with a heat recovery option on the electrical generator would not cover the capital costs. A more detailed analysis of the LFG resource and economic needs could identify ways to reduce the costs or increase the profitability. Grants and low-interest loans may be available to improve the project's economic feasibility.

Site 4: Kent Highlands Landfill, Kent, Washington

Waste in Place (estimated): 8 million cubic yards over 60 acres.
Waste Characteristics (estimated): 99% municipal and 1% industrial waste.
Period of Operation: 18 years (1968 until 1986).
Landfill Gas Collection Activities: active collection wells in the waste, perimeter gas extraction wells, and 4 flares.
Estimated Gas Resource for Year 2011: 410 scfm (average) @ 22.5% CH_4.
On-Site Energy Demands: landfill gas blowers and control systems (approximately 15 kW).
Assessment Status: Beneficial-use of the landfill gas is not economically feasible. Based on the equipment type and flow rate, it is estimated that the on-site electrical demand is approximately 15 kW. The smallest microturbine produces 30 kW and would be under-utilized. Due to the low methane concentration from the current gas collection system, the collection system would need modifications to segregate potentially higher methane concentration wells and use them to supply higher quality gas to a Landfill Gas to Energy (LFGTE) facility. These modifications are expensive and would not be economically feasible for the low gas flows needed. There is insufficient gas flow to generate electricity for sale to the grid. Additionally, even if the total landfill gas generation at this site could be upgraded to support a LFGTE facility to provide for on-site demand, the current operating scenario of using the higher methane concentration gas wells to mix with perimeter migration control well gas may preclude this option because there would be an additional cost for supplemental fuel to remediate the perimeter well gas.

Site 5: Keystone Landfill, Union Township, Adams County, Pennsylvania

Waste in Place (estimated): 1.7 million cubic yards over 40 acres.
Waste Characteristics (estimated): 99% municipal and 1% industrial waste.
Period of Operation: 34 years (1966 through 1990).
Landfill Gas Collection Activities: active gas collection system including 16 in-waste wells and an enclosed flare with condensate injection system.
Estimated Gas Resource for Year 2011: 110 scfm average @ 31.5 to 66.1 CH_4%.
On-Site Energy Demands: landfill gas blowers and control systems, and 80-gpm-capacity on-site ground water treatment system consisting of two-stage flow equalization, one in-tank air sparging system, metals precipitation, gravity filtration, shallow-tray air stripping, liquid

phase granular activated carbon (LGAC) and vapor phase granular activated carbon (VGAC). Net electrical demand is estimated to be approximately 50 – 60 kW and natural gas heating demand is estimated to be approximately 1000 million Btu per month in the winter months.

Assessment Status: Beneficial use is economically marginal; the project will have a net negative cash flow of $52,000 per year. A 65 kW microturbine could be load leveled to follow most of the site's electrical demand as it cycles from 65 kWh to as low as 33 kWh. Considering the 15 kW demand for the gas compression and conditioning equipment associated with the turbine, a 65 kW turbine will supply a net 50 kW of the existing site demands. This turbine can also be fitted with equipment to recover waste heat from the turbine exhaust. Considering a 10-year proforma period, replacing natural gas usage with heat recovered from a turbine exhaust heat exchanger package did not cover capital costs. The cash flow analysis of the 65 kW turbine without heat recovery resulted in a net negative cash flow of $52,000 per year. A more detailed analysis could identify ways to improve the project economics, including the availability of grants and low-interest loans.

Site 6: Landfill & Resource Recovery Landfill, North Smithfield, Rhode Island

Landfill dimensions and breakdown of waste types are not available. The following is based upon limited information in public documents.

Waste in Place (estimated): 2 million cubic yards over 28 acres.

Waste Characteristics (estimated): mixed municipal, hazardous, and industrial waste.

Period of Operation: 58 years (1927 through 1985).

Landfill Gas Collection Activities: active gas collection system including 18 in-waste wells and an enclosed flare with condensate injection system. Limited data indicates maintenance issues may cause frequent gas collection system shutdowns.

Estimated Gas Resource for Year 2011: 440 scfm @ 33 CH_4%.

On-Site Energy Demands: landfill gas blowers and flare systems requiring approximately 15 kW.

Assessment Tool Status: Due to the low on-site electrical demand, installing a Landfill Gas to Energy (LFGTE) facility to supply on-site electricity would not be economically feasible. However, the total landfill gas generation at this site may warrant development of a LFGTE facility that would supply on-site demand and also export power to the grid. The economic analysis assumes that 8 microturbines will be generating 520 kW of electricity 90% of the time and will be replacing the existing electricity purchase; generating the additional on-site parasitic load from the compression equipment; and selling the remainder to the electric grid on a month-to-month basis. The electricity generation sale will total approximately $451,000 per year, at an estimated current market buy back rate of $0.11/kWh. Annual capital and operating costs are estimated to be $510,000. To break even, an electricity buy back rate of at least $0.125/kWh would be necessary. With every $0.01 change in the buy back rate, a $41,000 swing up or down in revenue occurs. Grants and low- interest loans may improve economic feasibility. If the utility is paying a premium rate for power generated from biogas, there may be positive cash flow.

3. The Landfill Gas Energy Project Assessment Tool

Another outcome of this project was the development of the Landfill Gas Energy Project Assessment Tool for assisting managers in assessing the economic feasibility of recovering energy from landfill gas at NPL sites. The goal was to develop a tool that could be used to identify likely candidates for an energy project based on readily available data. A detailed economic analysis could then be conducted on those sites that surfaced as likely candidates.

The six NPL landfill assessment reports served to identify what data are typically available on old NPL sites. These sites are typically closed and received their MSW during a period when landfills kept very spotty records of waste acceptance rates and composition. The six assessments also provided information on typical NPL landfill structure and management practices. Based on this information, a four step process was developed to guide managers through the screening of landfills for likely sites to install energy recovery projects.

The first step in the screening process is to estimate the quantity of gas that is available from the landfill. The tool provides assistance on estimating the quantity of waste in the landfill, and graphs are provided for estimating the gas production rate based on the quantity and age of the waste. The tool also provides assistance on how to estimate the fraction of the gas produced by the landfill that can be recovered based upon site limitations.

The second step in the screening process is to evaluate the adequacy of the gas supply to meet the site energy needs or to provide a marketable energy product. The tool provides suggestions on the required gas quality for fueling electric generators and on the landfill gas flow rates that would generally be required to meet on-site remediation equipment needs. Suggestions are also provided on the quantity of electricity required to attract energy users who would purchase landfill energy.

The third step in the process is to estimate the cost of producing energy from the landfill. Engineering cost models were used to develop graphs of the cost to produce a unit of electricity from landfill gas based on project size. For projects producing electricity for sale, the price obtained by the sale of electricity must exceed the cost to generate the electricity. For projects producing electricity for on-site use, the cost to produce the electricity should not exceed the cost of electricity purchased by the landfill. For situations where the project economics are not attractive, the tool provides suggestions on measures that can be taken to improve project economics.

Numerous assumptions and “rules of thumb” are applied in the assessment tool to make an initial assessment easy to implement with readily available information. A detailed final feasibility assessment should be conducted by qualified landfill gas professionals prior to preparing a system design, initiating construction, purchasing materials, or entering into agreements to provide or purchase energy from a landfill gas project.

The fourth step in the process is to evaluate options to improve project cost benefits. At times the cost benefits of a project can be improved by increasing the project size, utilizing waste heat from the engine/turbine for onsite thermal needs, and qualifying for grants, tax incentives, or the sale of carbon credits. EPA is encouraging renewable energy development on contaminated land and more information is available at http://www.epa.gov/renewableenergyland/

3.1 Introduction

This tool provides a stepwise process for conducting a preliminary cost benefit analysis for heat production for direct use or electricity generation for onsite use or sale to local markets. Numerous assumptions and "rules of thumb" are applied in this tool to make an initial assessment easy to implement. As a result, the outcome of the assessment should be considered preliminary. A detailed economic feasibility assessment should be conducted by qualified landfill gas professionals prior to preparing a system design, initiating construction, purchasing materials, or entering into agreements to provide or purchase energy from a landfill gas project.

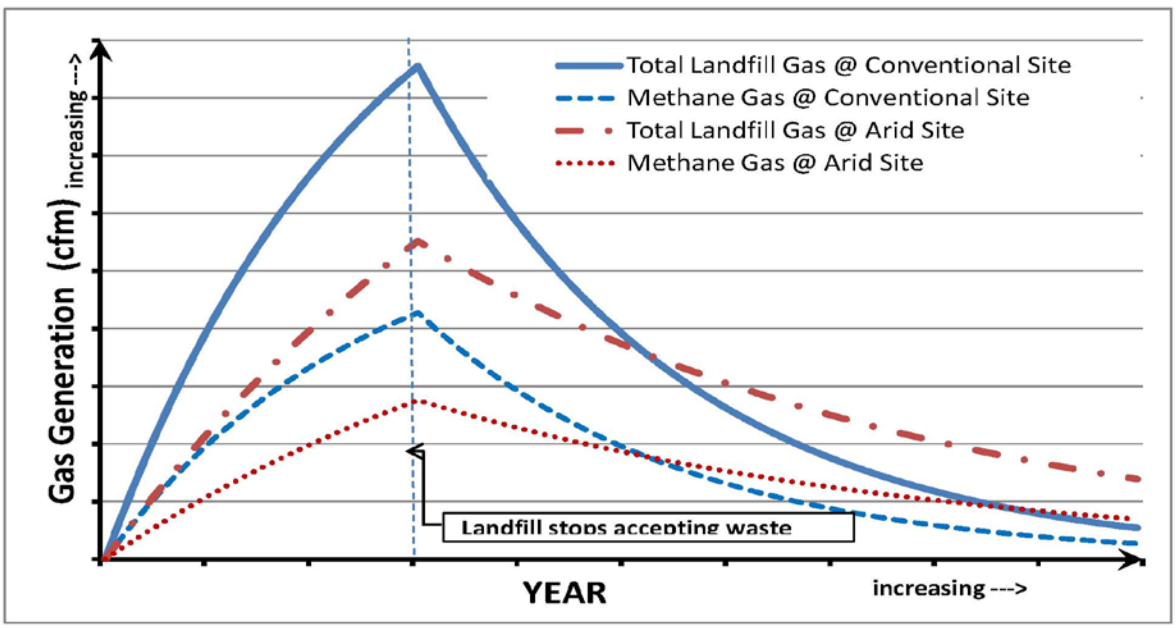
3.2 Background to Landfill Gas Formation

Most landfill gas is produced by bacterial decomposition that occurs when organic waste solids are broken down by bacteria naturally present in the waste, a process called methanogenesis. The process occurs under anaerobic conditions and within a narrow range of temperature, pH, and moisture content. Landfill gas is predominately comprised of carbon dioxide and methane, important greenhouse gases, with trace organic compounds. The methane content is typically between 40 and 60 percent in the early years after waste is covered. However, the concentration of methane begins to drop when most of the organic material has been consumed by the bacteria.

Typical gas generation curves for wet (typical) and dry areas (rainfall of less than 26 inches) are presented in Figure 1. Landfill gas forms soon after waste is placed in the landfill. As waste is added to the landfill, gas generation increases. The peak of production occurs in the first year or two after the last waste is entered and the landfill is closed. Once the landfill is closed, the gas production drops fairly quickly. Older waste produces less gas than waste placed relatively more recently. Most NPL sites stopped accepting municipal waste at least a decade or two ago. As a result the landfill gas generation rate is in decline, both in terms of flow rate and methane concentration.

When there is sufficient methane present in landfill gas, it can be collected and burned similarly to natural gas in engines for electricity production or in heaters and boilers for heat production. The minimum methane concentration required by most combustion equipment is 40%, although some equipment can use lower concentrations effectively. By using landfill gas to produce electrical or thermal energy, the landfill is often reducing its emission of greenhouse gases and offsetting the use of fossil fuels, further reducing greenhouse gases. Moreover, this energy can be used either on site or sold commercially to offsite consumers.

Figure 1. Typical Landfill Gas Generation Curves



The gas generation graph depicted does not have values because the actual curves will vary from site to site. What is important to note is that the gas generation drops off after the landfill stops accepting waste. It is important to note that the methane content of the gas is a portion of the total gas; for active and recently closed landfills with properly operated gas collection systems the methane content is typically between 40 and 60 percent. As the landfill ages, the percentage of methane often drops below 40 percent.

3.3 Evaluation of Project Cost Benefits

This document provides a tool that can assist a landfill or project manager in assessing the potential cost benefits of using landfill gas for the production of energy for use by either remediation equipment at the landfill or by the surrounding community. The tool is organized into the following 4 steps:

- Step 1. Estimate the Landfill Gas Supply
- Step 2. Assess the Adequacy of the Gas Supply
- Step 3. Evaluate the Project Costs
- Step 4. Evaluate Options to Improve Project Costs Benefits

After Step 4, this tool provides recommendations on how to conduct further analysis if the preliminary analysis indicates that an energy project may be feasible for the landfill. The next step should be to conduct a detailed final feasibility assessment using qualified landfill gas professionals prior to preparing a system design, initiating construction, purchasing materials, or entering into agreements to provide or purchase energy from a landfill gas project.

The Appendix to this report includes a Work Sheet that can be used to implement the calculations presented in Steps 1 through 3.

Definition of Units

CF	cubic feet
CY	cubic yards
kW	kilowatt
kWh	kilowatt-hour
mmBtu	million Btu
mmBtu/hr	million Btu/hr
MW	megawatts (i.e. 1000 kilowatts)
scf	standard cubic feet
scfm	standard cubic feet per minute

Step 1. Estimate the Landfill Gas Supply

Obtaining an estimate of the landfill gas supply is the first step in the evaluation process. If the landfill has a gas collection system and the gas flow rate has been measured in the past couple of years, you should proceed to Step 2. If a relatively recent measure of gas flow rate is not available, it can be estimated using the following approach. An initial estimate of landfill gas generation rates can be made assuming equal annual waste deposition amounts and using the simple gas generation curves presented in this section. Industrial and construction & demolition (C&D) waste landfills are not considered significant landfill gas generators and are not included in the modeling.

A. Calculate the Amount of Municipal Waste In Place:

If unknown, the quantity of municipal solid waste in place can be estimated from landfill dimensions:

Solid Waste In Place (cubic feet) = Average Depth of Waste (feet) x Area (square feet)

For example, consider a 25 acre site with an average depth of 50 feet with 5 percent industrial and 3 percent C&D waste. The total volume of Solid Waste In Place *(cubic feet)* is calculated by the following equation:

Solid Waste In Place (cubic feet) = 50 feet x 25 acres x 43,560 square feet per acre
= 54,450,000 cubic feet (CF) ÷ 27 cubic yards per CF
= 2,016,667 cubic yards (CY)

The total volume of Solid Waste In Place (CY) is then reduced by the percentage of non-municipal solid waste, which in this example is 8 percent. As a result, only 92 percent of the Solid Waste In Place or 1,855,333 CY will contribute to gas production. The volume of Solid Waste In Place (CY) is then converted to tons of waste in place. An acceptable conversion rate for Solid Waste In Place (CY) is 0.6 tons per cubic yard. For this example, Solid Waste In Place is approximately 1,113,200 tons.

Municipal Waste In Place (cubic feet) = 2,016,667 cubic yards (CY) x 0.92
= 1,855,333 CY
= 1,855,333 CY x 0.6 tons/CY
= 1,113,200 tons

B. Determine the Potential Gas Generation:

The first step in determining the gas generation potential of the landfill is to obtain the following two pieces of information:

a. The number of years the landfill was in operation, accepting waste, and
b. The number of years since the landfill's closure.

Using the graphs in either Figures 2, 3, or 4, develop a ballpark estimate of the current gas generation rate of the landfill. These graphs present the correlation between the quantity of Solid Waste In Place (in million tons) versus the potential flowrate of landfill gas (in cubic feet per minute) obtainable from the solid waste assuming a 60 percent collection efficiency and 40 percent methane concentration. The 60 percent collection efficiency is reasonable for most NPL and brownfield remediation sites, which tend to be unlined and partially or fully capped with soil. Further reductions may be warranted. While some projects may be able to use methane concentrations below 40 percent, to consider a project for off-site, direct use, the methane concentration in the gas should be consistently above 40 percent. Figures 2 through 4 are the correlations for landfills that collected waste over a 20, 30, or 40 year period, respectively. For the above example landfill, the available gas supply might range from 60 to 125 scfm (standard cubic feet per minute) depending on how long the landfill had been closed and how long it accumulated the waste.

It is important to note that the landfill gas flow rates from these graphs or from any modeling program assume a methane concentration. The graphs **do not** calculate the methane concentration. However, the graphs can be used to provide a general estimate of the potential landfill gas generation for different sites. The graphs show that:

- regardless of age, the quantity of landfill gas generated by a site with less than 1 million tons of municipal waste in place will be very low,
- sites closed more recently have greater gas production than those that closed earlier,
- when there are two sites with an equivalent amount of waste and similar closure years, the one that had a shorter operating period will have higher gas generation rates.

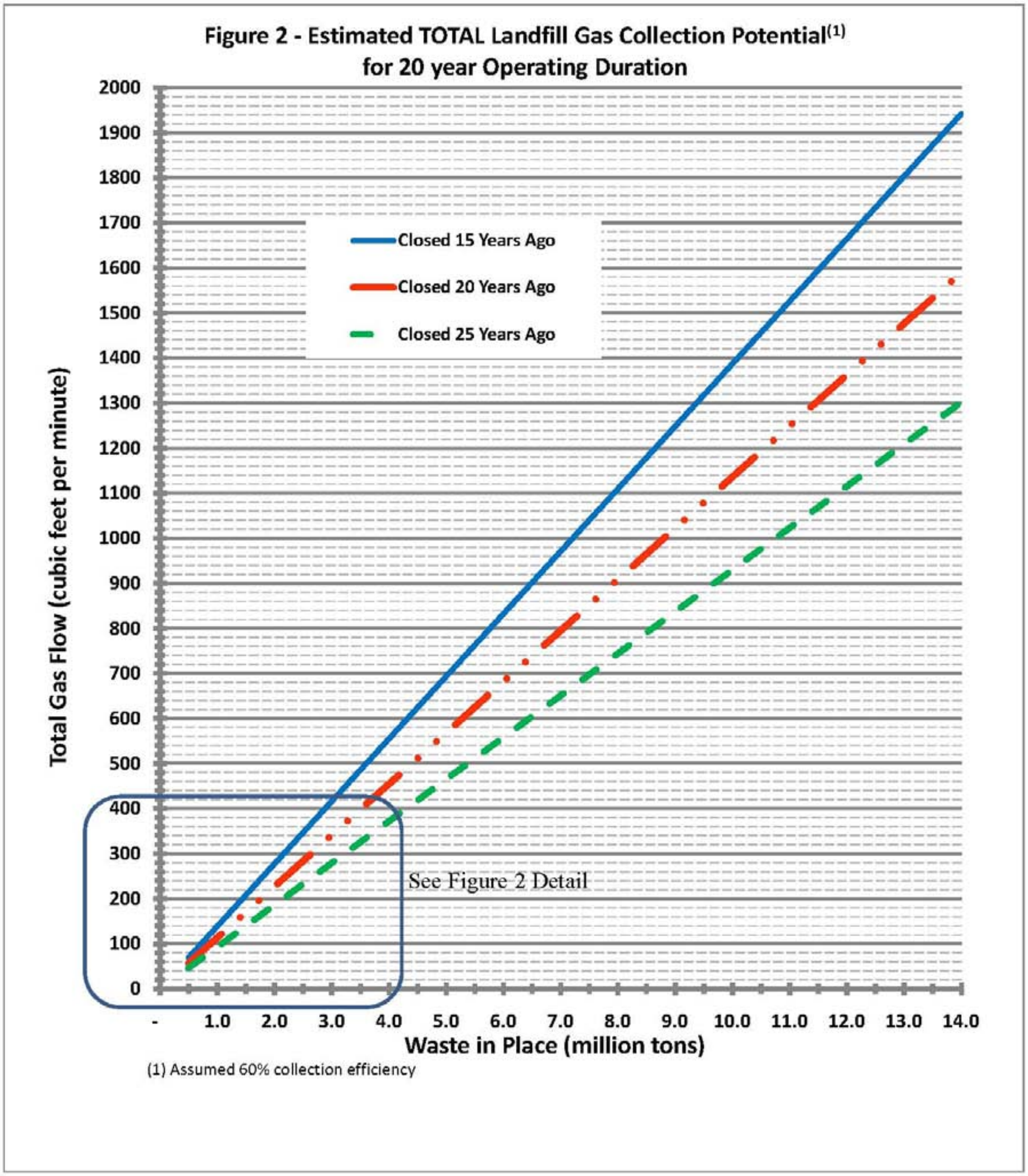
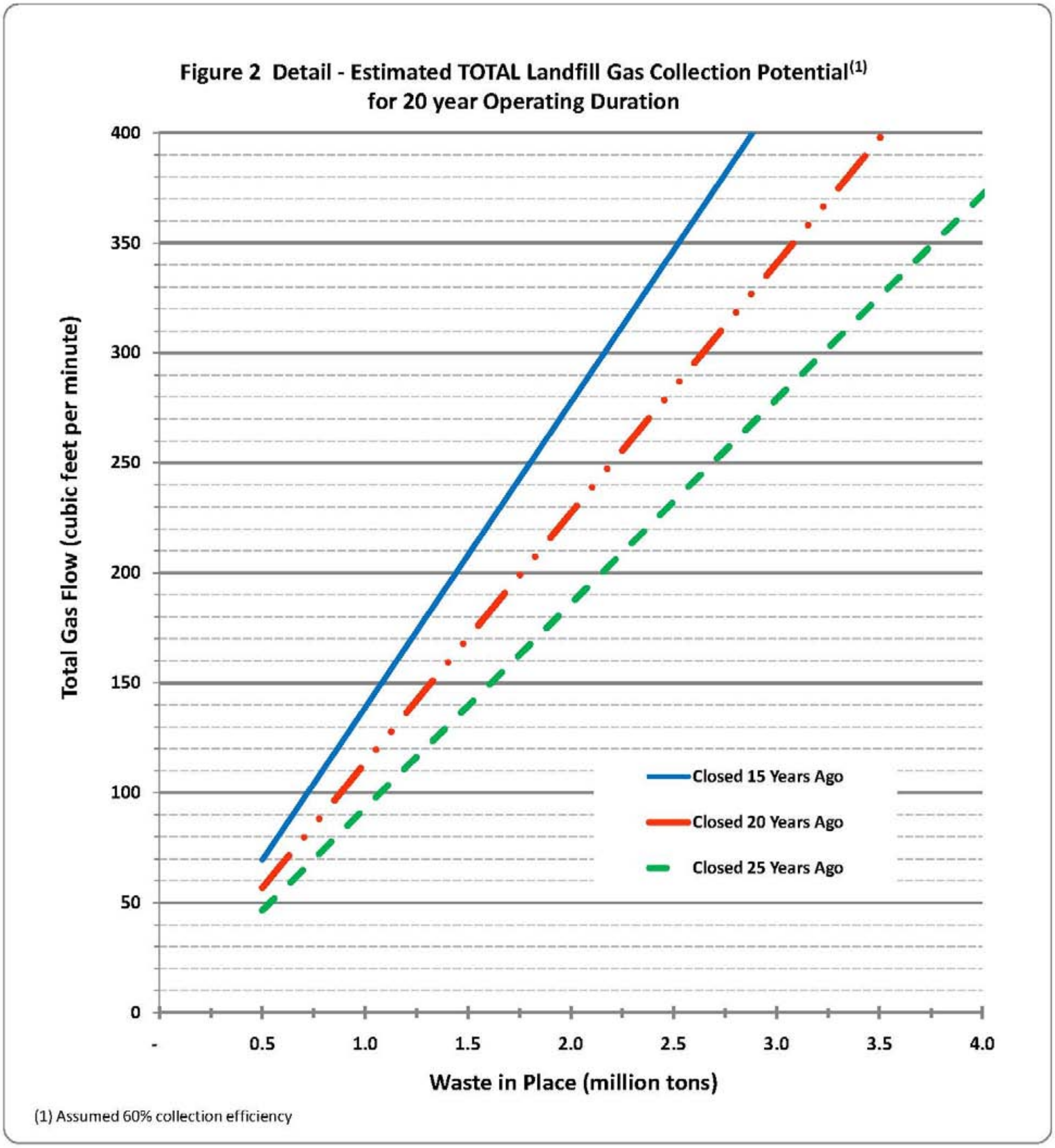


Figure 2 - Estimated TOTAL Landfill Gas Collection Potential(1)
for 20 year Operating Duration
Closed 15 Years Ago
Closed 20 Years Ago
Closed 25 Years Ago
See Figure 2 Detail
Total Gas Flow (cubic feet per minute)
Waste in Place (million tons)
(1) Assumed 60% collection efficiency

Each graph is accompanied by a companion graph showing an enlargement of the lower left corner of the graph.



Basis of Figures 2:

a) Graphs developed using LandGEM version 3.02, k=0.04, Lo=100

b) The graphs show total landfill gas assuming 60% collection efficiency and a methane content of 40%, older landfills may be lower.

c) Graphs assume greater than 25 inches of precipitation per year. Drier areas are estimated to have lower gas generation rates with steadier levels over time. See example graph in the Introduction. While wetter sites may see higher generation rates that decline faster.

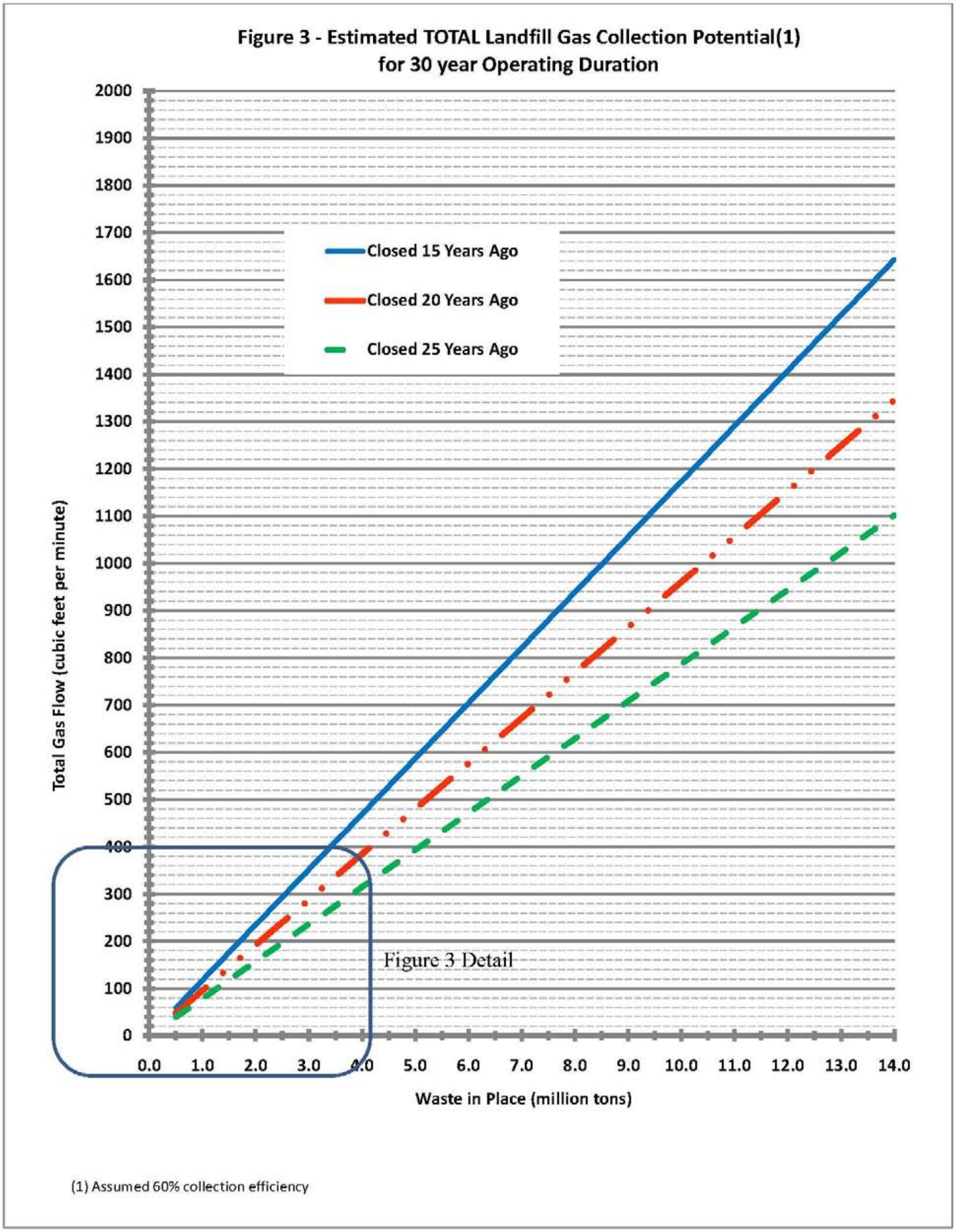
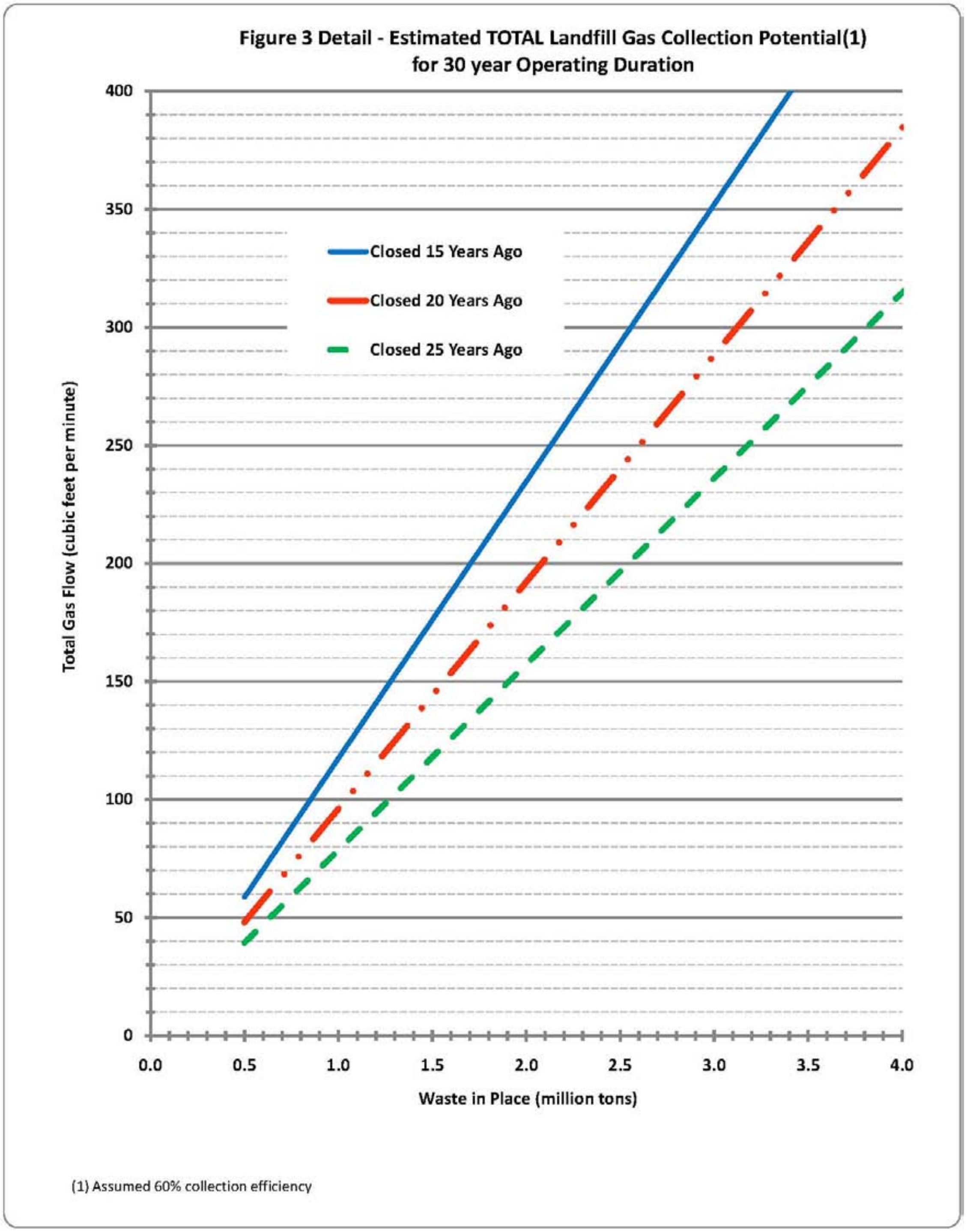


Figure 3 - Estimated TOTAL Landfill Gas Collection Potential(1)
for 30 year Operating Duration
Closed 15 Years Ago
Closed 20 Years Ago
Closed 25 Years Ago
Total Gas Flow (cubic feet per minute)
Waste in Place (million tons)
Figure 3 Detail
(1) Assumed 60% collection efficiency



Basis of Figures 3:

a) Graphs developed using LandGEM version 3.02, k=0.04, Lo=100
b) The graphs show total landfill gas assuming 60% collection efficiency and a methane content of 40%, older landfills may be lower.
c) Graphs assume greater than 25 inches of precipitation per year. Drier areas are estimated to have lower gas generation rates with steadier levels over time. See example graph in the Introduction. While wetter sites may see higher generation rates that decline faster.

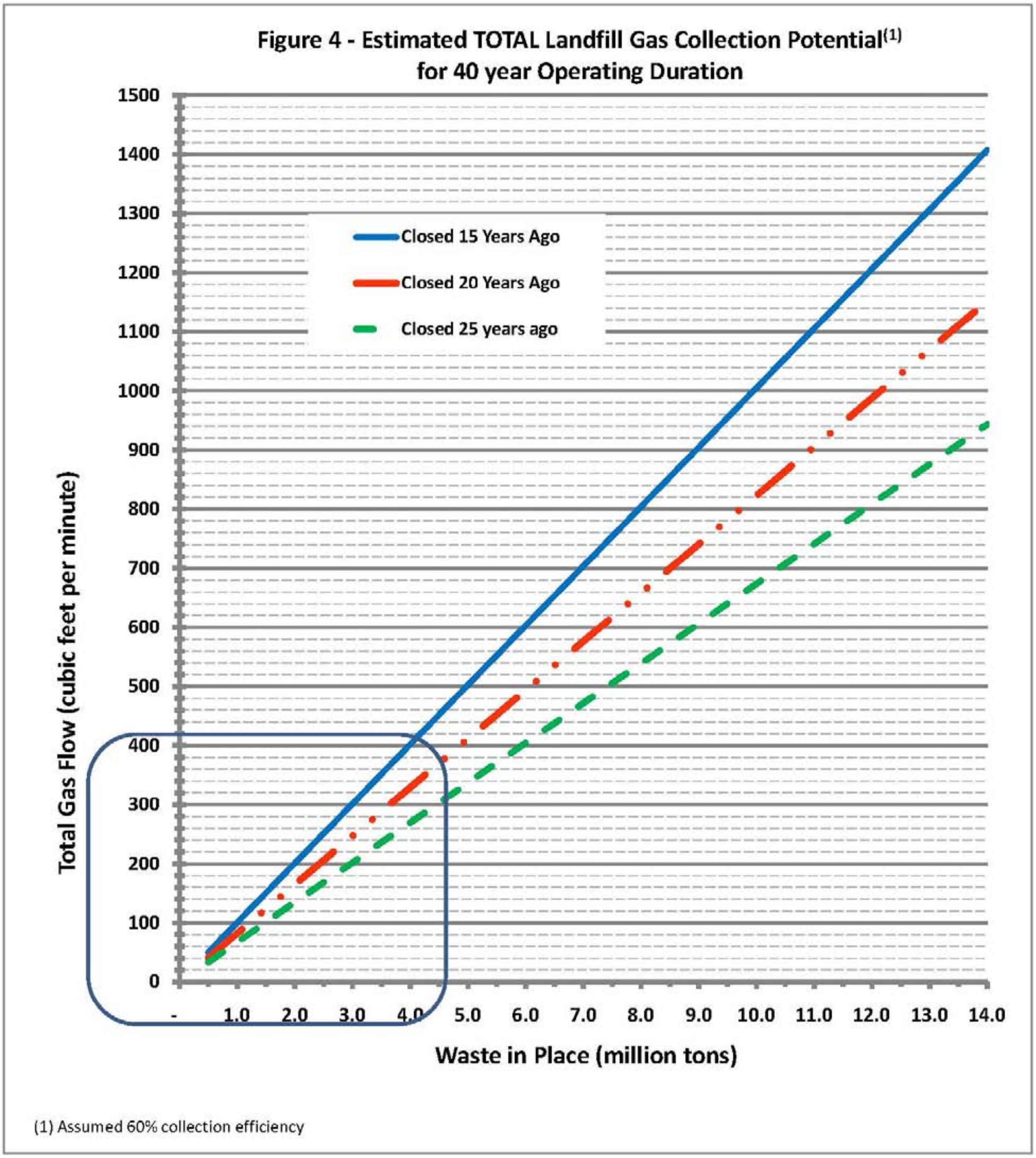
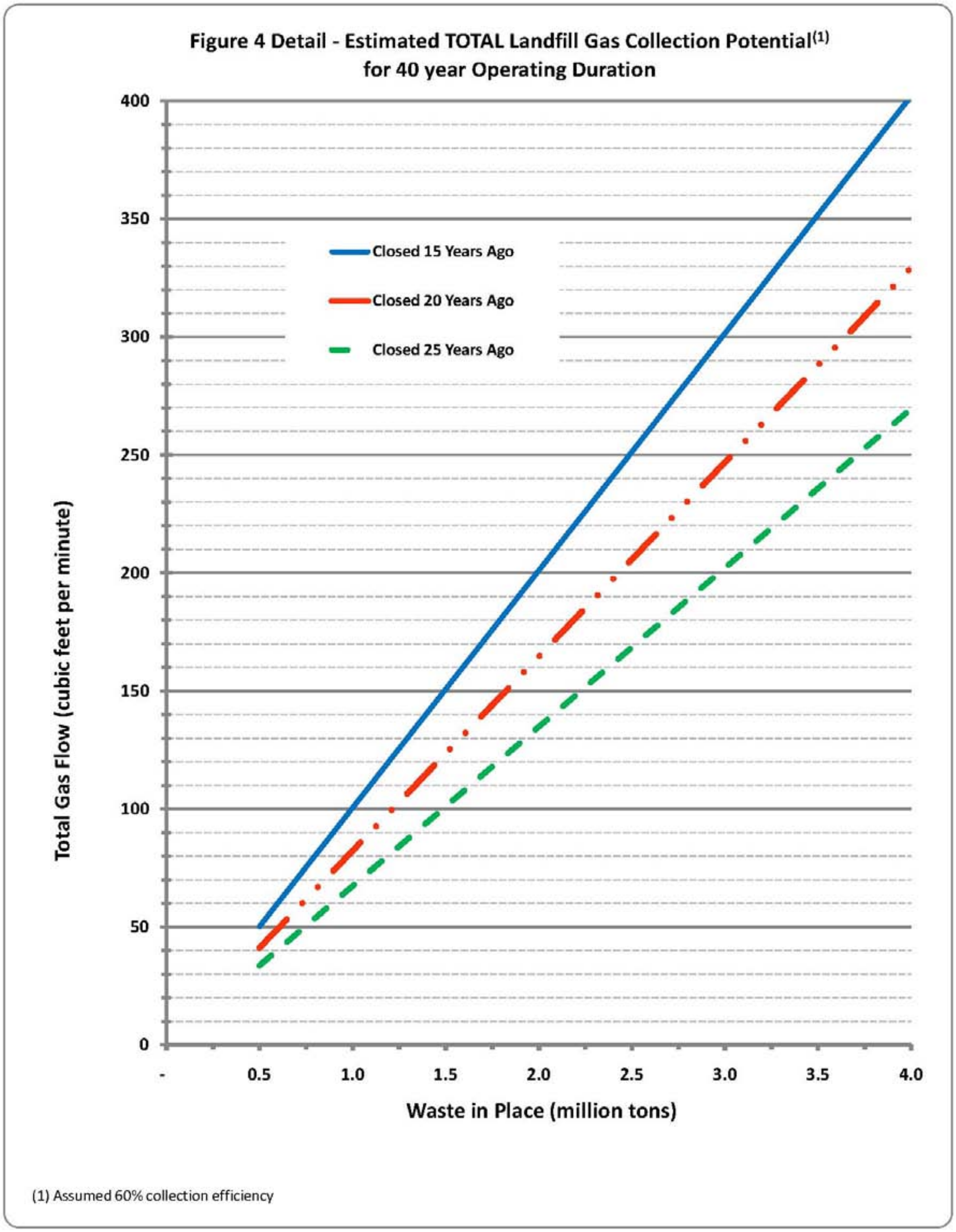


Figure 4 - Estimated TOTAL Landfill Gas Collection Potential(1)
for 40 year Operating Duration
Closed 15 Years Ago
Closed 20 Years Ago
Closed 25 years ago
Total Gas Flow (cubic feet per minute)
Waste in Place (million tons)
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
-
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0
11.0
12.0
13.0
14.0
(1) Assumed 60% collection efficiency



Basis of Figures 4:

a) Graphs developed using LandGEM version 3.02, k=0.04, Lo=100
b) The graphs show total landfill gas assuming 60% collection efficiency and a methane content of 40%, older landfills may be lower.
c) Graphs assume greater than 25 inches of precipitation per year. Drier areas are estimated to have lower gas generation rates with steadier levels over time. See example graph in the Introduction. While wetter sites may see higher generation rates that decline faster.

C. Determine the future gas generation potential:

The landfill gas generation rates from the graphs above provide ballpark values for gas flow rates based on the current year. However after closure, landfill gas flow rates continue to decrease at an annual rate of approximately 4 percent. Any potential use for the landfill gas must consider that the available flow rate should be adequate for the project duration. Therefore when evaluating a project at a closed landfill, consider that the flow rate will fall to 60 percent of the initial rate over the following 10 years. For this reason, it is common to size a project for 60 percent or less of the initial project-year gas flowrate.

D. Collection Efficiency:

The Estimated Total Landfill Gas Generation graphs on the previous pages are based on a collection efficiency of 60 percent. This collection efficiency is reasonable for most NPL and brownfield remediation sites, which tend to be unlined and partially or fully capped with soil. Further reductions may be warranted. Examples of conditions that may warrant additional reductions in the collection efficiency include conditions where gas collection wells and collection piping cannot be installed throughout the landfill, or if well depths are limited.

Step 2 Assess the Adequacy of the Gas Supply

Using either actual gas measurements from recent records or the estimated gas availability from Step 1, assess the adequacy of the gas supply. This is accomplished in two parts: the first is to assess the gas flow rate and the second is to assess the gas quality.

A. Assess the Adequacy of the Gas Flow to Support a Project:

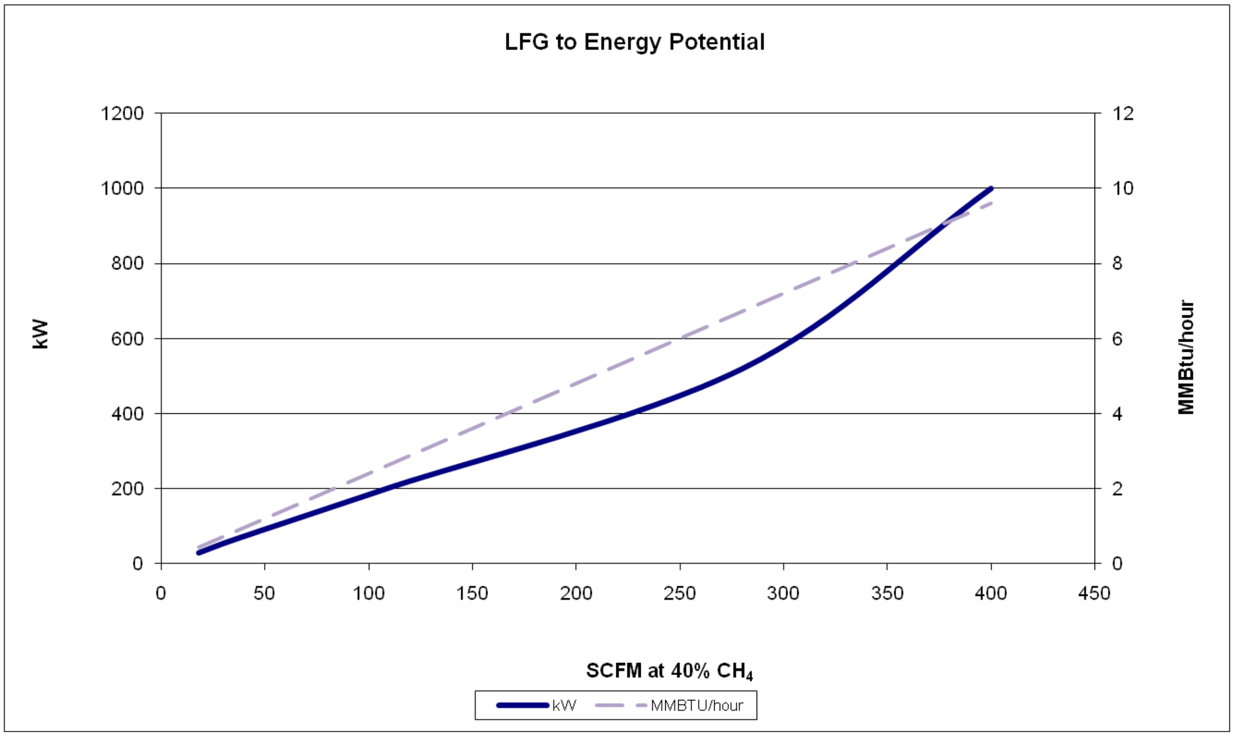
First, assess the adequacy of the gas flow rate for an energy recovery project. There are several options for utilizing landfill gas: produce gas or electricity to sell commercially or produce gas or electricity to use onsite. Commercial sale of electricity generally requires a 10 year production rate of 1 MW, or more, to interest power companies in the contract. At a methane concentration of 40 percent (as assumed in the graphs), the gas flow required to generate 1 MW is approximately 400 scfm. A similar gas flow rate over a similar time period would be needed to justify commercial sale of landfill gas for use in a boiler or furnace. A landfill gas flow rate of 400 scfm at 40 percent methane equates to a boiler or furnace size of a little less than 10 mmBtu/hr.

When considering electricity generation for onsite loads, determine the current electric load in kW, by dividing the highest monthly electricity usage in kWh by 744 hours/month. The microturbines that would typically be used to provide this load can produce 50 kW of net power from each turbine, and are commonly used in multiples of this size when more power is required. Each 50 kW of electricity required by onsite equipment requires a landfill gas flow rate of 20 to 25 scfm at a methane concentration of 40 percent. Note that 50 kW of net power requires 65 kW of gross turbine capacity, with a loss of 15 kW for parasitic loads.

Similarly, when considering using landfill gas to replace onsite natural gas usage, 2500 scf of landfill gas at 40 percent methane content are required to replace 1 million Btu or 1000 scf of natural gas. A unit that burns just under 10 mmBtu/hr of natural gas will require a landfill gas flow rate of approximately 400 scfm.

Figure 5 can be used to convert landfill gas flow to electricity or heat production.

Figure 5. Correlation of Landfill Gas Flow to Energy Production



B. Assess the Gas Quality

If the projected flow rate of landfill gas over each of the next 10 years is adequate to meet either the onsite energy requirements or the target commercial requirements, you must next assess the adequacy of the gas quality. This cannot be done using the graphs in Step 1, but can be done if there are recent gas composition measurements. Electric generation projects typically require a minimum concentration of 35 percent methane. However, 40 percent methane is significantly better for obtaining good performance from energy equipment. Small, innovative on-site direct use projects may be able to use methane concentrations below 40 percent, but to consider a project for off-site, direct use, the methane concentration in the gas should be consistently above 40 percent. In summary, a potentially viable project has the following characteristics or can be easily modified to meet these characteristics:

- Minimum methane content of 40 percent, and
- Continuous gas flow rate that matches the project demand

If information on the landfill gas methane content is not available, the methane content can be measured with a portable handheld infrared landfill gas analyzer. If the methane content and/or collection rate need improvement, there are measures that can be implemented. These measures are presented in the Recommendations for Further Analysis section.

Step 3 Evaluate the Project Costs

After determining that there is potentially an adequate supply of landfill gas with the appropriate quality to meet the needs of a project, the next step is to evaluate the potential cost benefits of a project. This section discusses the costs of both electric and direct use projects. Figure 5 depicts the approximate electrical generation or Btu sale potential for a given landfill gas flow. Information obtained from that graph can be used in conjunction with the information in this section to determine the expected economic benefit of a landfill gas use project.

Electric Projects

Electric projects utilizing microturbine technology typically include a compression-dehydration unit to compress the landfill gas to modest pressures and to dewater the gas to a dewpoint of approximately 35 ^{o}F. Electric projects utilizing reciprocating engine technology, may not need as much dehydration of the gas and their supply pressure requirements are less than the microturbine requirements.

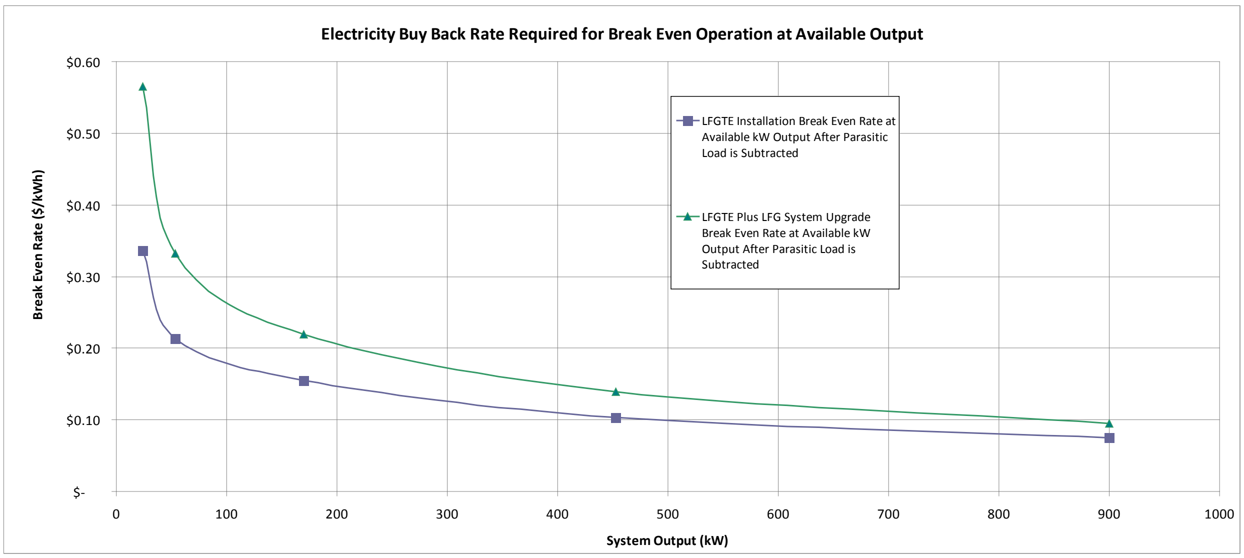
The other major component of an electric project is the engine-generator set that combusts the gas to produce electricity. There will also be electrical switch gear and conditioners to assure the electricity meets the criteria of the electrical system to which it is delivered. The compression-dehydration unit requires a modest amount of electricity, which is obtained from the engine-generator system, thereby reducing the net electrical output from the project by 10 to 15 percent, depending on the system size.

Figure 6 presents a graph of the estimated cost of net electricity production from a landfill gas project as a function of net electrical output. For landfills using the electricity onsite, the cost they are paying for electricity must be higher than the production cost in order for the project to save the landfill money. Similarly, for landfills planning to sell the electricity, the buy back rate for their electricity must be higher than the production cost in order for the project to make money for the landfill.

The lower curve in the graph represents the cost for an electric project in which the only costs are associated with the equipment mentioned above. The curve includes no cost for installing a gas collection system. The curve is based on the assumption that collection wells, piping, blowers and a flare are already installed at the landfill for other purposes.

The upper curve in Figure 6 is based on a landfill that has a good system of passive gas vents which must be converted into an active collection system as part of the project costs. A good passive vent system means that the wells penetrate at least 30 percent of the waste depth, and the wells are not screened near the surface (i.e. the upper 20 feet). Shallow trenched wells tend to be less effective because they are more likely to draw in ambient air. The cost of converting a passive system into an active system includes the added cost of installing well headers on the vents, manifold piping, blowers, and a flare. As depicted in Figure 6, the conversion of a passive system to an active system adds 30 to 40 percent to the cost of electricity produced by the system.

Figure 6. Electricity Production Costs for Landfill Gas Projects



A landfill gas project at a landfill without collection wells or passive vents will require the drilling of gas wells into the waste. The cost of these wells is extremely expensive and may have additional risk that the new wells may introduce pathways allowing contaminants to impact groundwater. There will be costs to address these changes that are not addressed in existing regulatory documents, such as Consent Agreements and Records of Decision. Additionally, the benefits of drilling additional wells through a closed NPL site must be weighed against the potential negative impacts of that well drilling. These regulatory and implementation costs will vary greatly from site, but will normally preclude the installation of a landfill gas energy project at a NPL landfill that does not have either collection wells or passive vents already installed.

Figure 6 indicates that an example project that is generating 250 kW of electricity would need to be earning more than $0.14/kwh for on-site power if an electricity generation project were to save enough money to off-set the project's capital and operation costs. If that site required upgrades to the gas collection well-field, the breakeven cost for on-site electricity increases to approximately $0.19/kwh.

Direct-Use Projects

Direct use projects are potentially feasible for both on-site and off-site applications. Some on-site uses can use lower gas flows and potentially lower gas concentrations, while others require sustained methane concentrations over 40 percent and conditioning of the LFG to remove moisture and other contaminants. Off-site uses typically require sufficient flow to justify the cost of a pipeline; gas conditioning; and sustained methane concentrations of 45 percent, or more.

The simplest on-site use involves modification of an existing flare to provide thermal energy for space heating of adjacent buildings. For this application, the methane content must be in the range necessary for stable flare operation, which is at least 20 percent. The primary expense with modification of an existing flare system for heat recovery is associated with construction of a custom, dual walled flare shroud and installation of insulated ducting that routes air from a blower through the shroud and into the building to be heated. A system utilizing this type of basic heat recovery would have low heat recovery efficiency, but the installed cost would also be low. The heat recovery efficiency from the flared gas could approximate 25 percent. This type of system could be designed and installed for less than $100,000. To be cost effective, this system must replace an annual heating expense of $10,000, or more. There are other simple on-site customized systems that have been installed, with mixed success. Prior to implementing this type of system, an experienced LFG system designer should be consulted.

Generally on-site use in an existing combustion device such as a heater or boiler has been limited since most onsite combustion systems are designed for low temperature natural gas-firing and will not perform well on the more corrosive landfill gas. Modifying this equipment to burn landfill gas would require the installation of specialized stainless steel burners and heat exchange elements as well as equipment to remove moisture from the gas. The cost for these modifications along with the potential for air permit modification requirements generally precludes using LFG on small space heating applications.

Off-site LFG uses are typically limited to applications requiring year-around gas flows of 300 to 500 scfm and elevated methane concentrations. We have included project development cost projections based on gas concentrations of 40 percent in Table 1 below for comparison to development of electrical generation projects utilizing landfill gas at a similar 40 percent level. In some specific instances, an off-site project may be feasible with lower gas flows, and we have included data on a 100 scfm project also. These size constraints are a result of the high costs involved with gas compression, conditioning, pipeline installation and burner modifications. Table 1 below presents the estimated cost to produce and deliver landfill gas to an off-site direct use project. The costs assume a 40 percent methane concentration; LFG dehumidification to a 35 ^{o}F dewpoint; a 10 year loan at 10 percent interest; 90 percent availability; and inclusion of construction, operating and wellfield maintenance costs. These costs do not include any gas royalty to the landfill or profit paid to the developer. To make a project attractive to an off-site user, the sale price of the LFG, including profit, must be less than his current fuel price.

Table 1 indicates that a direct use project that has a landfill gas flow rate of 300 cfm and requires the gas to be piped approximately 1 mile to an off-site user, would need to receive at least $6.65/

MMBTU to off-set the capital and operating costs for system implementation. Typically for an investment to be made into these types of projects, a gas purchase rate in excess of the breakeven rate is required.

Table 1. Cost to Produce Landfill Gas for Direct Use

LFG Flow Rate @ 40% CH_4 (scfm)	Pipeline Distance (miles)	Cost to Produce the LFG ($/mmBtu)
100	0.5	12.83
100	1	14.84
100	1.5	16.85
300	0.5	5.33
300	1.0	6.65
300	1.5	7.33
500	1	4.09
500	2	4.90
500	3	5.71
500	4	6.52

Step 4 Evaluate Options to Improve Project Cost benefits.

Often, the cost benefits of a project can be improved by one or more of the following ways:

- Increase the project size: project costs per unit of heat or electricity output generally decrease as the project size increases.
- Use waste heat from the engine/turbine for onsite thermal needs: engines and microturbines exhaust a significant quantity of waste heat that can potentially benefit the site if it is purchasing expensive fuels such as LPG or fuel oil.
- Qualify for grants, tax incentives, or the sale of carbon credits: various organizations, states and federal agencies offer financial support for projects that use biomass energy. The Landfill Methane Outreach Program (LMOP) tracks many of these financial incentives at their website: http://www.epa.gov/lmop/publications-tools/funding-guide/index.html.
- EPA is encouraging renewable energy development on current and formerly contaminated land and mine sites and has established tools that identify the renewable energy potential of these sites and provides other useful resources for communities, developers, industry, state and local governments interested in reusing these sites for renewable energy development: http://www.epa.gov/renewableenergyland/

Recommendations for Further Analysis

Using some basic landfill information, landfill gas generation models can provide more accurate estimates of the methane available from the municipal solid waste in the landfill. EPA's Landfill Gas Emissions Model (LandGEM), version 3.02 software; is a widely accepted gas estimation model: http://epa.gov/ttn/catc/products.html.

If the generation models indicate a potentially viable project, additional field testing should be performed by a landfill gas professional. If the resulting field data indicate gas quantity and quality is sufficient, a landfill gas pump test is recommended to further understand gas flows and quality. These pump tests are expensive and time consuming, and they are not recommended unless the cost benefit evaluation is very promising.

If the current landfill gas collection system does not produce gas with a 35 to 40 percent methane concentration, upgrades and modifications may be considered:

- Balance the gas collection well field - Low methane content in landfill gas can be due to excess vacuum at individual wells that draws air into the waste mass and ultimately into the gas collection system. Landfill gas quality can sometimes be improved by proper balancing of the well field to produce landfill gas with higher methane content. Balancing the well field involves adjusting the vacuum, and resulting flow, at each well so that the flow more closely matches the gas generation rate.
- Take gas collection wells off-line - Pull gas for the project only from wells that are producing adequate quantities of high quality gas. This may include replacing well head valves that are not seating properly in the closed position, or by isolating wells for the project from the other wells associated with the remediation activities.
- Reduce water levels in gas collection wells - Water from condensate or leachate accumulation at the bottom of wells can block the well-pipe perforations and reduce gas flow. Determine if dropping the water levels increases gas production in the well by comparing methane levels and gas flow before and after removing water from the well.
- Reduce oxygen and nitrogen – Oxygen or nitrogen in the landfill gas indicates the intrusion of air into the landfill, which inhibits methane production. An oxygen level greater than 2 percent or a nitrogen level above 10 percent generally indicates air is being pulled into the system. This can occur if air is being pulled through the landfill cap at breaks or cracks. If oxygen levels approach 5 percent or more, it is likely that there is a direct opening in a well hose, condensate knockout, manhole, or other point along the collection system. Perform a system check and seal any leaks in either the landfill cap or the collection piping.
- Reduce header vacuum and flow - A smaller blower may be needed if the current blower cannot be damped back enough to support well field balancing. Replacing the blower is typically an involved process; often the associated flare has to be modified or replaced with a smaller one to accommodate the flow and maintain good combustion. Construction and operating permit modifications are often required.
- Well maintenance - Flushing or other methods to unclog well perforations can improve gas flow and methane concentration.

These measures are not expected to yield dramatic results, perhaps 5 to 10 percent increase in methane concentration; however, they are relatively inexpensive to implement.

4. Recommendations For Future Assessments

Based on the observations from the six site reports developed under this study, site screening could be focused on those states with the highest electricity costs. Within those states, the selection screening could be based on the following criteria:

- The landfill has more that 2 million tons of MSW,
- The landfill waste is more than 80 feet deep,
- The landfill has an impermeable cap and a liner,
- The landfill has an active gas collection system that continuously provides gas with a methane concentration of 40% or more,
- The landfill has an on-site need for more than 50 kW of electricity.

Another selective screening process would focus on sites that could potentially sell electricity to the grid. This process would start with states with high electricity costs (greater than $0.14/kWh) and programs that promote purchase of renewable or green energy from landfill gas through such programs as renewable-energy portfolio standards (RPS). The selection process would select sites with greater than 4 million tons in place and with an active gas collection and control system producing a steady flow of landfill gas with a methane concentration greater than 40% and a flow rate of more than 350 scfm.

Other activities that EPA might consider include:

1. Develop a central database for NPL landfills, that compiles the necessary information for assessing the economic feasibility of recovering energy from the landfill,
2. Conduct economic feasibility assessments for recovering energy from the landfills in the centralized NPL database,
3. Sponsor a demonstration project at a NPL site with characteristics favoring energy recovery projects.
4. Publicize the benefits of energy recovery using the success of the above demonstration project,
5. Require energy assessments for all sites added to the NPL in the future.
6. Conduct economic feasibility assessments for recovering and utilizing energy with innovative technologies at remote off-the-grid landfills ; and sponsor a demonstration project at such a site with characteristics favoring energy recovery projects.

Appendix

A. Site assessment Report: Old Bethpage Landfill, Town of Oyster Bay, New York
B. Site assessment Report: Charles George Reclamation Trust Landfill Superfund Site, Tyngsboro, Massachusetts
C. Site assessment Report: Combe Fill South Landfill, Morris County, New Jersey
D. Site assessment Report: Kent Highlands Landfill, Kent, Washington
E. Site assessment Report: Keystone Landfill, Union Township, Adams County, Pennsylvania
F. Site assessment Report: Landfill & Resource Recovery Landfill, North Smithfield, Rhode Island
G. Landfill Gas Energy Project Assessment Tool Calculation Worksheet
H. Data submitted to the EPA Office of Superfund Remediation and Technology Innovation (OSRTI) on the Crazy Horse Landfill
I. Data submitted to the EPA Office of Superfund Remediation and Technology Innovation (OSRTI) on the Fresno Sanitary Landfill

Preliminary Feasibility Analysis for Energy Recovery and Utilization at the Old Bethpage Landfill, New York

Introduction

At many U.S. landfills, existing technologies could be used to recover and profitably utilize the landfill methane, yet only a fraction of landfills are using or even recovering the methane they generate. Increased use of landfill methane could reduce emissions from landfills as well as provide a reliable fuel supply. The EPA Office of Superfund Remediation and Technology Innovation (OSRTI), in collaboration with EPA's Federal Facilities Remediation and Reuse Office (FFRRO), EPA Regions, and EPA's Landfill Methane Outreach Program (LMOP), is exploring options to exploit methane from those landfills that are placed on the Superfund National Priorities List (NPL). As a first step in this effort a team of ERG, Shaw Environmental and Infrastructure, Inc. (Shaw) and Cornerstone Environmental Group, LLC (Cornerstone) evaluated the feasibility of using the LFG at example NPL landfills such as the Old Bethpage Landfill Site, New York to meet on-site energy demands or local community demands.

The 68-acre Old Bethpage Landfill is an inactive municipal landfill that is part of a sanitary landfill complex that was active from 1957 until 1986. In 1982, a methane gas collection system was installed at the site by the Town of Oyster Bay to monitor and prevent migration of gas beyond the boundary of the site. In 1988, a landfill gas to energy plant was also constructed at the landfill and operated until 2002. At that time, the available gas supply ceased to be sufficient for producing commercial electricity. The landfill currently draws gas from six interior wells for enriching the gas collected from perimeter remediation wells so that it can be flared. It appears that all of the gas from the interior wells is required for this enrichment. An analysis of the gas potential of the remaining waste in the landfill, suggests that the waste may be capable of producing 250 to 350 scfm of landfill gas at 40% to 50% methane. Based on electricity invoices, the site may have an electric load of 140 kW. To meet this electric load with onsite microturbines would require a majority of the remaining available landfill gas. The cost to drill potentially 40 to 50 wells in the remaining site in addition to the cost of the microturbines would be extremely expensive and not justified by the electricity savings from self-generation.

Resource Availability

The 68-acre Old Bethpage Landfill is an inactive municipal landfill that is part of a sanitary landfill complex that was active until 1986. The Town of Oyster Bay began operations at the Old Bethpage Landfill in 1957, primarily for disposing incinerator residue. In 1967, the Town began accepting garbage and trash and allowed home owners to dump trash. From 1968 through 1978, liquid and solid industrial process wastes and damaged drums containing organic residues were deposited at the landfill. After 1978, metal hydroxide sludges were the only industrial waste deposited at the landfill. According to the site manager's Information Data Sheet that was obtained for this project, there are approximately 1.65 million tons garbage, 0.97 million tons rubbish and 1.3 million tons incinerator ash at the site, for a total of 3.92 million tons of waste in place. The landfill closed in 1986.

In 1982, a methane gas collection system was installed by the Town of Oyster Bay to monitor and prevent migration of gas beyond the boundary of the site. A leachate collection system has been operating at the landfill since 1983. A clay cap was also applied to 29 acres of the 68-acre site, at that time. As part of EPA's 1988 Record of Decision (ROD), the following measures were selected to clean up groundwater contamination coming from the landfill and to effect contaminant source control: (1) installing, operating, and maintaining a system of groundwater recovery wells and treating the recovered water by an air stripper and, if necessary, carbon treatment; (2) completing the capping of the landfill to prevent water from entering and thus spreading contaminants; (3) improvements to the leachate-collection system; (4) improvements to the methane gas collection system; and (5) monitoring to determine the effectiveness of the cleanup actions. Construction of the groundwater treatment system was completed in March 1992. The last portion of the capping program was completed in December 1992. The improvements to the leachate-collection system and the methane gas collection system were completed in May 1992 and December 1992, respectively. The leachate collection and treatment system and the groundwater treatment system continue to operate and are expected to operate for at least 10 years.

In 1988, a landfill gas to energy plant was constructed and operated until 2002. A representative of the Town of Oyster reported that the energy plant developer replaced the engines at the project with smaller and smaller units as landfill gas supplies dwindled, until it was not practical to operate the plant.

The landfill is equipped with a gas remediation system that collects landfill gas from the perimeter wells and from interior landfill wells. According to the 2007 Emission Test Report 1, the collected landfill gas is typically 20 percent methane. The gas collection system consists of a network of 33 perimeter gas extraction wells and 6 interior (in-waste) gas collection wells, collection header piping, and blowers. There are two Rotron DR10 regenerative blowers to move gas from the collection system to the thermal oxidizer. The gas collection and control system is designed to prevent off-site migration of landfill gas. The collected gas is oxidized by an enclosed flare. The flare system is also used to destroy condensate. The condensate collection system is comprised of 4 condensate collection wells, 3 water separators and a demister. The system removes an estimated 135 gallons per day (gpd) at a flow rate of 1000 scfm in the winter and 91 gpd in the summer. The flare system is approximately ¼ mile from the groundwater treatment plant.

According to the 2007 Test Report, the landfill gas flow rate during 2007 ranged from 700 to 960 cfm, with an average of approximately 730 cfm. The report states that over the past few years the Town of Oyster has supplemented the perimeter gas from the landfill with gas drawn from wells in the interior of the landfill. During the testing conducted for the 2007 Test Report, the methane content of the combined gas flow to the flare averaged 24 percent and the gas flow rate was 500 cfm. More recent information from the site manager states that the current methane content is 14 percent and the gas flow rate is 900 scfm.

In the absence of gas flow data for the entire landfill, the EPA model, LandGEM was used to estimate the landfill gas generation rate for the years from 2011 to 2021. Actual annual waste deposition information was not available. Conservatively, the landfill gas estimate is based on the data provided. Based on the data provided by the NPL fact sheet and the data sheets for this project task, the total waste acceptance between 1957 and 1986 is estimated to be 3,920,000 tons. For the purposes of modeling gas generation, it is assumed that the waste in place was placed in equal amounts annually over the operating life of the landfill. The LandGEM guidance recommends using inventory values for the model constants to generate emission estimates for use in emission inventories and air permits in the absence of site-specific test data. Unless the site is a bioreactor, either conventional or dry parameters are assumed. For conventional sites, a Lo value of 100 m3/Mg and a k value of 0.4 year-1 are used in the model. As summarized in column 2 of the table below; the landfill gas generation is estimated to be between 575 and 380 scfm over the ten year potential project period.

Year	**Total landfill gas**		**Assume 65% collection**
	(Mg/year)	***(av ft^3/min)***	
2011	10084	573	373
2012	9689	551	358
2013	9309	529	344
2014	8944	508	330
2015	8593	488	317
2016	8256	469	305
2017	7932	451	293
2018	7621	433	282
2019	7323	416	271
2020	7035	400	260
2021	6760	384	250

The model does not assume collection efficiency for a proposed gas collection system. The available EPA data from NSPS surface monitoring, the Solid Waste Association of North America (SWANA), and several other industry sources, indicate that the average gas collection efficiency for a landfill is 60 to 95 percent. Collection efficiencies tend to be lower in older landfills. For the Old Bethpage site, a collection efficiency of 65 percent is assumed, yielding an estimated production rate for the landfill from 375 to 250 scfm between 2011 and 2021.

In summary, it is difficult to determine the portion of the 900 scfm that is attributable to the six gas extraction wells versus the perimeter wells. However, it can be assumed that most of the flow to the flare is from the perimeter wells. It is also likely that most, if not all, of the gas from the six wells is required to maintain stable combustion of the perimeter well gas and the injected condensate in the flare. Obtaining any additional data from the site regarding number of in-waste wells and perimeter wells, flow rates from the two systems, and individual well information including depth, flow, and gas characteristics would support a better assessment.

Landfill Gas to Energy Options Analysis

Although obtaining additional site information is recommended to assess the gas generation and collection, investing in a system that would segregate potentially higher methane concentration wells to utilize in a Landfill Gas to Energy (LFGTE) facility to offset those costs would not be economically feasible. In 2006 the site purchased $134,506 of electricity. Assuming an electricity price of $0.11/kWh, the site may have an electric load of 140 kW. This load would require a majority of the remaining available landfill gas to be burned in microturbines. The cost to drill potentially 40 to 50 wells in the remaining site in addition to the cost of the microturbines would be extremely expensive and not justified by the electricity savings. The analysis of other NPL landfills that have been conducted as part of this program have indicated that a well-functioning gas collection system must already be in place in order for onsite power production to be economical.

Preliminary Feasibility Analysis for Energy Recovery and Utilization at the Charles George Landfill, Massachusetts

Introduction

At many U.S. landfills, existing technologies could be used to recover and profitably utilize the landfill methane, yet only a fraction of landfills are using or even recovering the methane they generate. Increased use of landfill methane could reduce emissions from landfills as well as provide a reliable fuel supply. The EPA Office of Superfund Remediation and Technology Innovation (OSRTI), in collaboration with EPA's Federal Facilities Remediation and Reuse Office (FFRRO), EPA Regions, and EPA's Landfill Methane Outreach Program (LMOP), is exploring options to exploit methane from those landfills that are placed on the Superfund National Priorities List (NPL). As a first step in this effort a team of ERG, Shaw Environmental and Infrastructure, Inc. (Shaw) and Cornerstone Environmental Group, LLC (Cornerstone) evaluated the feasibility of using the LFG at example NPL landfills such as the Charles George Reclamation Trust Landfill Superfund Site (Site), Tyngsboro, Massachusetts to meet on-site energy demands or local community demands.

The Charles George Reclamation Trust Landfill Superfund Site (Site) is a seventy acre mixed industrial, municipal and hazardous waste landfill located approximately one mile southwest of the Town of Tyngsboro, Massachusetts. Municipal waste disposal activity was initiated at the site in the mid 1950's. In 1973, the site began accepting hazardous wastes and substances primarily in the form of drummed and bulk chemicals containing volatile organic compounds (VOCs) and toxic metal sludges. Hazardous waste disposal was terminated in June 1976 and the landfill was closed in 1982 with 4 million cubic yards of waste. The landfill was capped in 1990, and a gas collection and control system was installed in 1992 – 1993.

Continuous gas collection data is not available for the site, but the collection system appears to operate intermittently at a flow of 200 scfm and marginal methane concentrations. Landfill gas models estimate the current gas collection potential of the landfill to be 190 scfm, dropping to 100 scfm between 2011 and 2026. The site contains leachate pumps, gas blowers and electronic monitoring/control equipment for the remediation system. Specific, on site energy demand information was not made available from the EPA or the PRP. While there is potentially sufficient gas to operate a microturbine, as the landfill gas system is currently configured, it cannot sustain the gas rate required by the microturbine. To operate an energy system at this site, the extraction and combustion equipment must be modified to only extract the quantity of landfill gas that the system generates, without inducing air intrusion. Additional wells may also be required. Since the development of an energy recovery project at the Charles George Landfill will require a significant additional cost that appears to be beyond the economic benefits of the project, it appears that a landfill gas to energy project may not be feasible.

Resource Availability

The Charles George Reclamation Trust Landfill Superfund Site (Site) is a seventy acre mixed industrial, municipal and hazardous waste landfill located approximately one mile southwest of the Town of Tyngsboro, Massachusetts. Waste disposal activity at the Site was initiated in the mid 1950's. During the period from 1955 until the land was purchased by Charles George Sr. in 1967, the Site was operated as a municipal dump. The Site continued as a municipal dump following acquisition by Charles George Sr. in 1967, and the Charles George Land Reclamation Trust (Charles George Sr. and Dorothy George, Trustees) in 1971. In addition to operating as a municipal waste dump, in 1973, the Trust was issued a permit by the State to handle hazardous wastes in addition to municipal and domestic refuse. Disposal of hazardous wastes and substances primarily in the form of drummed and bulk chemicals containing volatile organic compounds (VOCs) and toxic metal sludges continued from January 1973 to at least June 1976. The landfill was closed in 1982. There is an estimated 4 million cubic yards of waste in place.

The landfill was capped in 1990 and the gas collection and control system was installed in 1992 – 1993. There are several Record of Decision documents for the four operating units associated with the site. The ROD required installation of a synthetic membrane and soil cover, a surface water management system, a passive landfill gas venting system, and a leachate collection system.

The landfill gas collection and venting system included a passive, crushed stone, gas collection trench system under the cap liner which directed the landfill gas through 28 vents along the top of the landfill. Three existing monitoring wells (acting as gas vents) were connected to an active horizontal header pipeline that lies atop the landfill. Twelve pre-existing vents were capped off. Landfill gas is being routed to an enclosed flare, part of ROD III. The landfill gas collection system delivered landfill gas to an interim open flare (later replaced by the enclosed flare). The enclosed flare, provided under ROD III, thermally destroys contaminants carried in the gas and minimizes impacts to the air. Landfill gas is currently being collected from an active gas extraction system of vents and header pipes via a blower, and then treated via combustion in an enclosed flare. A landfill gas collection and an interim open flare gas destruction system was constructed in 1994. An enclosed flare system was determined to be the preferred alternative. Construction involved replacing the open flare stack with an enclosed flare stack. This construction was completed in April 1998. Landfill gas is collected via a system of 29 gas extraction vents and three existing groundwater monitoring wells connected to an active horizontal header pipeline that lies atop the landfill. The pipeline is connected to a vacuum blower and enclosed flare for thermal treatment. There is no perimeter landfill gas collection system in place at the landfill. The landfill gas vents are not extraction wells but are shallow structures that connect to the gas venting layer located directly beneath the HDPE geomembrane. Not all of the passive vents were connected to the header pipe system; those passive vents that were not connected to the gas extraction system were capped off and are no longer functional.

According to the 2005 five year review report, the weekly flare inspection logs indicated that overall, the flare has had no major operational or maintenance problems, but has had more down time than operating time since the last Five Year Review. The percentage of time the flare was operational appears to have decreased steadily over the past five years, from approximately 35 percent during the first quarter of 2000, to approximately 21 percent for the first half of 2004. It was reported that the flare typically runs between eight (8) and 24 hours per week. Weekly observations have indicated that most of the time when the flare is off, it is a result of automatic shutdown due to a low temperature alarm in the stack. This information indicates that the flare temperature decreases after several hours or days of burning, regularly causing the flare to be extinguished. This likely occurs at a point when the levels of collected methane gas become too low to fuel the flare, and the levels of oxygen in the system are too high.

The 2005 report stated that it was believed that intrusion of oxygen into the gas collection system has been an ongoing problem since the start up of the interim open flare system. Methane concentrations at the flare are monitored and recorded at the flare sample port on a semiannual basis. Methane concentrations are also measured within the gas collection system at several landfill gas header sample ports, but also on a semiannual basis. However, it should be noted that the flare was not operating immediately prior to the majority of the semiannual flare sample port and landfill header port sampling events. Therefore, methane measurements are not likely representative of full-scale operating conditions and are likely biased high due to build-up of gas in the system while the flare is not burning. Flare sample port methane concentrations were, on average, around 50 percent. Based on the above information, the frequent shutdown of the flare indicates that the landfill may not be generating enough methane to keep the flare running as currently configured and that there may likely be oxygen infiltration into the header system at the drain connection. However as discussed below, based on landfill gas monitoring performed in soil gas probes located around the perimeter of the landfill, it appears that landfill gas is being contained within the gas collection system and is not apparently migrating beyond the landfill cap.

More recently, it was reported in the data collection sheets for this project that the flow rate to the flare is between 200 and 250 scfm. The methane content was reported as ranging from 30 to 75 percent but the information is skewed because the quarterly monitoring has occurred after the flare system had been shut down for a period of time. The flare emission testing report from February 2010 was reviewed for relevant information. This document reported that the landfill gas at the flare inlet was 3.4% Oxygen (O2), 22.4% Carbon Dioxide (CO2), and 38.6% Methane (CH4). For the purposes of this assessment report, this data is not considered representative of the landfill gas because it was collected after a period of shut down.

Since the existing gas collection system is not producing enough gas to sustain flare operation and thus would not support a landfill gas to energy (LFGTE) plant. Another approach to develop a LFGTE project would be to install new conventional gas wells and abandoning the shallow collection system that has air intrusion. Based on a conversation with the MADEP site manager, deeper wells were not installed because there are over 9000 drums in the landfill. The landfill owner and the major PRP, Charles George, Sr., would not allow deeper wells to be installed because there was a risk that drums could be ruptured, contributing more contamination to the groundwater.

The EPA model, LandGEM[1], was used to estimate the landfill gas generation rate for the years from 2011 to 2026. Actual annual waste deposition information was not available. Conservatively, the landfill gas estimate is based on the assumption that the waste was placed in equal amounts annually over the operating life of the landfill (1966 to 1990) ,resulting in a total of 4 million cubic yards of waste in place. A conversion density of 0.6 tons per CY was assumed. The LandGEM guidance recommends using inventory values for the equation constants for estimating emission estimates for use in emission inventories and air permits in the absence of site-specific test data. Unless the site is a bioreactor, either conventional or dry parameters are assumed. For conventional sites, a L_o value of 100 m^3/Mg and a k value of 0.4 $year^{-1}$ are used in the model. As summarized in column 2 of the table below, the landfill gas generation is estimated to be 300 scfm in 2011 with a drop to 160 scfm in 2026.

[1] Landfill Gas Emissions Model (LandGEM) Version 3.02

YEAR	Total LFG Generation (cfm)	Assume 75% collection	Assume 65% collection
2011	299	224	194
2012	287	215	187
2013	276	207	179
2014	265	199	172
2015	255	191	166
2016	245	184	159
2017	235	176	153
2018	226	169	147
2019	217	163	141
2020	209	156	136
2021	200	150	130
2022	193	144	125
2023	185	139	120
2024	178	133	116
2025	171	128	111
2026	164	123	107

The model does not assume the collection efficiency for the gas collection system. Available EPA data from NSPS surface monitoring, the Solid Waste Association of North America (SWANA), and several other industry and regulatory sources, indicate that the average gas collection efficiency for a landfill is 60 to 95 percent, with a typical average of 75 percent. Using the LandGEM generation estimates, the available total gas for an on-site energy project would start at approximately 225 scfm in 2011 and drop to 120 scfm in 15 years. The actual methane content of this gas cannot be estimated by desktop methods. Field evaluation testing would need to be conducted.

Collection efficiencies tend to drop for older landfills . Older landfills are less "tight" since they are unlined and have no geomembrane over the slopes. As a result, they have to decrease collection rates to prevent air from infiltrating the system. For the Charles George Landfill site, a collection efficiency lower than the 75 percent average would be assumed for a beneficial use project. Using a 65 percent collection efficiency, the gas collection rate for the landfill is estimated to be 190, dropping to 100 scfm between 2011 and 2026. The third column in the table above presents the annual estimated gas collection rates for 65 percent collection efficiency.

Landfill Gas to Energy Options Analysis

The site contains leachate pumps, gas blowers and electronic monitoring/control equipment for the remediation system. Specific, on-site energy demand information was not made available from the EPA or the PRP. While there is potentially sufficient gas to operate a microturbine, as the landfill gas system is currently configured, it cannot sustain the current extraction rate of 200 scfm for very long periods. To operate an energy system at this site, the extraction and combustion equipment must be modified to only extract the quantity of landfill gas that the system generates, without inducing air intrusion. This option would require the purchase of smaller blowers and an upgrade in the gas collection system to eliminate leaks. The option is only possible if the offsite landfill gas migration can be controlled at the lowered gas extraction rate. It is also possible that the upgraded gas collection system still could not provide the 40 scfm of landfill gas at 35% methane that is required to fuel a Capstone microturbine installation. In that case, a new wellfield would be required to extract the available gas that is shown in the above tables. The potential for adding deeper wells has been previously discussed with the PRP, and it was determined that because of the potential for encountering buried drums, no additional drilling would be allowed.

Since the development of an energy recovery project at the Charles George Landfill will require a significant additional cost that appears to be beyond the economic benefits of the project, it appears that a landfill gas to energy project may not be feasible at this site.

Preliminary Feasibility Analysis for Energy Recovery and Utilization at the Combe Fill South Landfill, New Jersey

Introduction

At many U.S. landfills, existing technologies could be used to recover and profitably utilize the landfill methane, yet only a fraction of landfills are using or even recovering the methane they generate. Increased use of landfill methane could reduce emissions from landfills as well as provide a reliable fuel supply. The EPA Office of Superfund Remediation and Technology Innovation (OSRTI), in collaboration with EPA's Federal Facilities Remediation and Reuse Office (FFRRO), EPA Regions, and EPA's Landfill Methane Outreach Program (LMOP), is exploring options to exploit methane from those landfills that are placed on the Superfund National Priorities List (NPL). As a first step in this effort a team of ERG, Shaw Environmental and Infrastructure, Inc. (Shaw) and Cornerstone Environmental Group, LLC (Cornerstone) evaluated the feasibility of using the LFG at example NPL landfills such as the Combe Fill South Landfill to meet on-site energy demands or local community demands.

The Combe Fill South Landfill is a MSW landfill located in Morris County, New Jersey, between Chester and Washington Townships. The landfill contains approximately 5 million CY of solid waste that was collected from the 1940's until 1981. The waste is predominately MSW with about 5 percent industrial waste. The landfill was capped between 1994 and 1995, and was fitted with gas vents and a groundwater pump and treat system. The electrical load of the remediation equipment ranges seasonally from 34 to 84 kW.

A review of the landfill characteristics and available site test data suggests that the landfill has the potential to produce 200 scfm of landfill gas at a methane concentration of 35%. This is sufficient gas flow to provide for the electrical needs of the site. A 65kW microturbine could meet the base load requirements of the site at a landfill gas flow of approximately 40 scfm. The installed cost for the wellfield improvements to convey the LFG to the microturbine is approximately $190,000, and the installed cost for the microturbine system is approximately $400,000. The economic analysis indicates that there will be an annual expenditure of $124,269 for debt service, and operations and maintenance. The electricity generation offset will total approximately $61,495, giving the project a net negative cash flow of $62,774 per year.

Resource Availability

The Combe Fill South Landfill includes three separate fill areas comprising 65 acres. The site operated as a municipal landfill from the 1940's until 1981. Based on information provided by the EPA site manager, it is estimated that there are approximately 5 million CY of solid waste in place. The waste is predominately MSW with about 5 percent industrial waste. The landfill was capped between 1994 and 1995. The cap consists of 2 feet of clay topped with a geomembrane where the maximum slope allowed. In 2008, a small cap extension comprised of a geocomposite liner and a textured geomembrane was constructed. The site is adjacent to an electrical company ROW and, according to a news report, the electric company has submitted a NOI for a substation on an adjacent property[1].

There are 59 perimeter gas probes at the site to monitor gas migration. There is a passive gas system at the site consisting of 65 in-waste wells that were installed in 1994. The ROD required an active gas collection system, condensate collection, and flaring. After installation of the

[1] "Tewksbury Township residents appalled by JCP&L plan", Hunterdon Review, 24 March 2010

passive gas collection system, the EPA recommended testing selected gas wells to determine the correct size of the required flare. Subsequently, qualitative and quantitative testing on selected vents was performed in 1994 and 1998 in support of passive venting.[2] Other data provided on the site included a spreadsheet of quarterly methane concentration and flow measurements from the years 2001 to 2008. There are 10 gas wells (V-42, -43,-44, -45, -46, -47, -48, -49, -50, -65) represented in the data, although only 5 wells (47, 48, 49, 50 & 65) are consistently measured. No data have been provided on how these 10 wells were selected. The methane content of the 5 wells is elevated, ranging from 1% to 71%. This is a broad range, but typically concentrations range between 30% and 60%.

Based on information provided in March 2010, eight gas wells are currently being monitored quarterly, with other wells being monitored on occasion. Gas flows for the eight wells were provided. These wells are V-02, -04, -13, -47, -48, -49, -50, -65. No data have been provided on how these 8 wells were selected for current monitoring activities. If the wells have been selected because they produce the most gas of the 65 wells, then an extrapolation from 8 wells to 65 wells would not reasonably represent the potentially available landfill gas quantity and quality.

	August 2009		October 2009		November 2009	
	barometric P = 30.12		*barometric P = 29.85*		*barometric P = 29.62*	
VENT #	Temp (deg C)	ACFM	Temp (deg C)	ACFM	Temp (deg C)	ACFM
V-47	29	0.0	7.9	0.0	10.6	0.0
V-48	28.1	6.1	8.7	0.4	14.2	8.3
V-65	28.7	2.8	7.5	0.0	9	1.3
V-49	30.5	0.0	7.6	0.4	8.6	0.9
V-50	28.5	4.8	7	0.0	8.3	0.0
V-02	29.3	3.5	6.9	0.0	10	0.0
V-13	28.7	0.0	9.5	1.3	12.4	3.1
V-04	28.5	0.0	8.3	0.4	12.3	3.1
Total flow		17.2		2.6		16.6
Avg. Temp	28.9125		7.925		10.675	
Avg. Deg F	84.0425		46.265		51.215	
Total SCFM		**16.9**		**2.8**		**17.3**

There are insufficient data on the water levels in the landfill or on the conditions of the eight passive gas wells to determine if their gas flow could be improved.

In the absence of gas flow data for the entire landfill, the EPA model, LandGEM[3], was used to estimate the landfill gas generation rate for the years from 2011 to 2021. Actual annual waste deposition information was not available. Conservatively, the landfill gas estimate is based on the assumption that the waste was placed in equal amounts annually over the operating life of the landfill (1945 to 1981) resulting in a total of 4.6 million megagrams of waste in place. The LandGEM guidance recommends using "inventory values" for the modeling parameters when generating emission estimates for use in emission inventories and air permits in the absence of site-specific test data. Unless the site is a bioreactor, either conventional or dry parameters are assumed. For conventional sites, a Lo value of 100 m^3/Mg and a k value of 0.4 $year^{-1}$ are used in

[2] Explanation of Significant Differences: COMBE FILL SOUTH LANDFILL, EPA/ESD/E2006020001438-2006
[3] Landfill Gas Emissions Model (LandGEM) Version 3.02

the model. As summarized in column 2 of the table below; the landfill gas generation is estimated to be between 390 to 474 scfm.

The model estimates total methane generation as opposed to the quantity of methane that can be collected by a gas collection system. Available EPA data from NSPS surface monitoring, the Solid Waste Association of North America (SWANA), and several other industry and regulatory sources, indicate that the average gas collection efficiency for a landfill is 60 to 95 percent, with a typical average of 75 percent. Collection efficiencies tend to drop for older landfills . Older landfills are less "tight" since they are unlined and have no geomembrane over the slopes. As a result they have to decrease collection rates to prevent air from infiltrating the system. For the Combe site, a collection efficiency lower than the 75 percent average should be assumed. Using 65 percent collection efficiency, the gas production rate for the landfill is estimated to be from 300 to 200 scfm between 2011 and 2021. The third column in the table below presents the annual estimated gas collection rates.

YEAR	LFG Generation (cfm)	Assume 65% collection
2011	473	307
2012	455	296
2013	437	284
2014	420	273
2015	403	262
2016	388	252
2017	372	242
2018	358	233
2019	344	224
2020	330	215
2021	317	206

<u>Landfill Gas to Energy Options Analysis</u>

Onsite activities and energy demand

Currently there is a continuously operating groundwater pump and treat system in place. The system consists of eighteen groundwater recovery wells, a sequencing batch reactor, metals removal, sand and carbon filtration and sludge dewatering. It is anticipated that the groundwater pumping and treatment will continue until 2027. There is no landfill gas collection blower or flare system in place. There is both a natural gas demand for heating, and an electric demand for the on-site equipment operation.

Data related to the onsite electrical demand is included in the attachment. That data shows that from July 2008 through June 2009, the average monthly expense for electricity use at the site was $4,941.90, or $59,302.80 for the year. That equates to a load of approximately 56.5kW at an average cost of $0.16 / kWh. The electrical load fluctuates seasonally with between 34 and 48 kW usage in the warmer months and between 61 and 84 kW usage in the cooler months of the year.

The natural gas usage at the site was also provided for the period of July 29, 2008 through June 25, 2009. These data depict a seasonal variation from a low of about $95.00 / month in May, June and July, to a high of about $4,000 to $4,600 in November, December and January. The natural gas usage is also included in the attachment.

Onsite Electrical Generation Options

Due to the seasonal electrical use fluctuation, the most economical electrical generation scenario would typically include planning for close to the minimum hourly electrical demand in order to provide a relatively constant base load for the generation equipment. That low end electrical use value is approximately 34 kWh. However, new microturbine technology allows the turbine to follow the electrical load, down to approximately 50% of its rated capacity. In Combe Landfill's case, a 65 kW microturbine could be load leveled to follow most of the site's electrical demand from 65 kWh to as low as 33 kWh. There will also be an additional onsite electrical demand of approximately 15 kWh for the gas compression and conditioning equipment necessary to provide the fuel to the turbine. Thus a 65 kW turbine will only supply a net 50 kW of the existing site demands.

In the event of the planned or unplanned shutdown of the gas to energy project, we have planned for the landfill gases to be manually routed to a small solar ignited flare. The New Jersey Department of Environmental Protection will be consulted to determine the flaring protocol.

A single, Capstone 65 kW microturbine requires 842,000 btus/hr of fuel. At a methane concentration of 35%, which is the minimum that the turbine requires to perform well, that equates to approximately 40 scfm of landfill gas. Based on the above summary of landfill gas generation, there should be in excess of this quantity of landfill gas generated for the duration of the on-site groundwater pump and treat equipment operation.

Onsite Heating Supply Options

An option to offset the natural gas use at the site would be to include a heat exchanger on the microturbine exhaust. This would be an efficient way to provide the heat load for the on-site facilities caused by the seasonal spike in natural gas usage. Package units are available which include both the turbine generation and heat reclaiming equipment. That unit provides approximately 251,000 Btu/hour of hot water through an air to liquid heat exchanger. The hot liquid could be pumped to the facility and piped through a liquid to air heat exchanger to provide heat.

Project Design and Construction Requirements

The existing landfill includes a passive venting system. Installation of an energy generation project will require the addition of gas collection piping, wellheads and condensate management systems. It is assumed that the collected condensate will be pumped to the existing groundwater treatment system, and that no separate onsite storage of this liquid will be required.

The gas flow data summarized above provides information on the passive venting of landfill gas, not the volume available if a vacuum is placed on the wells. It is notable that even in a passive condition, several of the wells had very low methane content. The data from the LandGem gas generation model indicate that there should be an excess of landfill gas available for use in an onsite electrical generation project. Since there should be an excess of landfill gas available, a collection system that only includes wells with the highest methane concentration and gas volume should be considered. Not all of the 65 passive venting wells will need to be connected. For purposes of estimating the gas collection system components, we are assuming that approximately 3.5 to 5 scfm of landfill gas at 35% methane will be collected from each well. This is based on the estimated gas collection volumes in the table on page C-3 being divided by the 65 existing wells, and seems corroborated by the limited monitoring of 8 wells. In order to collect the minimum of 40 scfm of gas that the turbine requires, twelve of the passive wells must be connected to the collection system. If the gas header pipe is passing by some of the wells to get to the higher producing wells, there will be minimal additional cost to provide that additional collection capability.

The energy generation component will include the gas compression and conditioning system, along with the microturbine and generator. As an option, it could also include the heat reclaiming package for building space heating. The gas compressor will provide a system vacuum so that a separate blower will not be required. A utility interconnection will also be required. We are assuming that the system will be installed to provide electricity to the onsite equipment, with the utility providing power when equipment demand is greater than the turbine output. During those times when the turbine can produce in excess of the onsite power demand, it will be managed to load level and only produce power to that demand. If the turbine is shut down, the utility will provide all onsite electrical load.

The turbine and gas compression and conditioning equipment can be installed outside. For purposes of facilitating maintenance activities, we recommend that the compressor be installed in a small enclosure.

Project Capital and Operating Cost

The proposed wellfield additions will include approximately 2,500 lineal feet of gas header piping in order to collect gas from the existing passive wells. Since we currently have no information on the location of the highest producing wells, we have assumed that the gas header pipe will extend approximately 1,000 feet in two directions, and include connecting piping to the microturbine facility. Approximately 12 of the existing gas wells will be connected to the header pipe. Condensate management will be provided through the installation of a dripleg and a condensate knockout pumping station.

The total installed cost for the wellfield improvements is approximately $228,000. The single largest cost in this estimate relates to the header pipe installation at an assumed cost of $50.00/lineal foot. If sufficient gas can be located in close proximity to the proposed turbine facility, this cost could be reduced. Prior to designing the gas collection system, a pump test on specific wells should be conducted to determine the header pipe routing.

The electric power generator installation will include a Capstone 65 kW microturbine generator, a gas compression and conditioning system, a small enclosure for the compression system, and related utility interconnection. The system will not be set up to export power to the grid. Gas conditioning will consist of only moisture removal. Sulfur removal is not included since the microturbines are very tolerant of elevated sulfur levels. Siloxane removal is not anticipated due to the age of the waste materials. The total installed cost for the microturbine installation is approximately $485,000. If the heat recovery option is added, the total installed cost is approximately $535,000.

Operation and maintenance activities will be required on both the wellfield and the power generation system. We have assumed that currently site visits and minimal maintenance is being conducted. For the proposed project, one wellfield site trip will be required per month to monitor and adjust the wells and monitor the system. That activity should cost approximately $1,500 per month for a local firm to perform. The microturbine maintenance should average about $0.015 per generated kWh, and the compression/conditioning should average about $0.005 per generated kWh. The compression/conditioning system will add about 15 kW to the electric load on the site from the electric motors and controls.

Site design and permitting activities will be required to permit and construct the microturbine facility and the wellfield. We have included site design costs as a percentage of the installed capital costs. The wellfield design would be approximately $38,000 and the energy recovery and utility interconnect design would be approximately $80,000. If additional site investigative activities such as pump testing are required, there may be additional costs.

Project Economics and Proforma

The attached Combe Landfill economic analysis depicts the system installation and operating costs along with projected yearly energy savings at the site. Site specific data related to energy costs have been discussed earlier in this report and are included in the overall analysis. A site purchased electricity rate of $0.16/kWh has been included. The economic analysis assumes that the microturbine will be generating 65 kWh of electricity 90% of the time and will be offsetting electricity purchase for that amount of power on a month to month basis. Based on the data included in the analysis above, there will be five winter months when the peak energy use is in excess of the 65 kW output, and power will still need to be purchased, and there are seven months when the energy use closely matches the turbine output or is a little lower. On an annual basis, this difference is considered incidental and it has not been taken into account in this analysis.

The economic analysis indicates that there will be an annual expenditure of $144,287 for debt service and operations and maintenance for the electrical generation only option. The electricity generation offset will total approximately $81,994, which includes the additional power usage for the gas compression and conditioning equipment. The project will have a net negative cash flow of $62,293 per year.

If the heat recovery option is included, and if the recovered heat can be utilized, approximately 25% to 66% of the winter peak heat load could be offset from November through April, and provide potential savings of approximately $1,100 each of those months at an average natural gas offset price of $5.65 / MMBtu. The remaining months of the year, the heat recovery option could generate an excess amount of heat and would offset approximately $800 of natural gas use. It doesnot appear that adding the heat recovery option at a cost of approximately $50,000 is warranted given these potential savings.

ASSUMPTIONS

= input site parameters

Technical:

LFG Recovery Rate (Initial)	331	SCFM
Current Methane Content (by volume)	35%	
Methane BTU Value	1,012	BTU per ft^3
Generator Model	Capstone Microturbine	
Generator Heat Rate	12,950	BTU per KW-hr
Generator Full Load	65	KW
Generator Run Time	90%	
Natural Gas Heat Value	1,000	BTU per ft^3

Financial Variables:

Electricity Price	$0.1600	per KW-hr
Generator + Compressor O&M Cost	$0.02	per KW-hr
GCCS O&M Cost	$1,500	per month
Capital Loan Interest Rate	10.0%	

Capital Project Costs:

Landfill Improvements	$228,000
2500' LFG Collection Pipe @ $50/ft	$125,000
(12) Wellheads @ $2,000/ea	$25,000
(1) Dripleg	$15,000
(1) Knockout	$25,000
Engineering (20%)	$38,000

Gas to Energy Facilities	$485,000
Turbine	$105,000
Compressor	$115,000
Building	$30,000
Installation	$100,000
Utility Interconnect	$50,000
Solar Flare	$5,000
Engineering (20%)	$80,000

	unit	Year 2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
LFG Resource												
LFG Recovery Rate	SCFM	331	319	306	294	282	272	260	251	241	231	222
LFG Methane Content		35.0%	35.0%	35.0%	35.0%	35.0%	35.0%	35.0%	35.0%	35.0%	35.0%	35.0%
LFG Heat Content	BTU/ft^3	354	354	354	354	354	354	354	354	354	354	354
LFG Heat Rate	BTU/hr	7,034,412	6,779,388	6,503,112	6,248,088	5,993,064	5,780,544	5,525,520	5,334,252	5,121,732	4,909,212	4,717,944
Equivalent Number of Generators at Full Load		9.3	8.9	8.6	8.2	7.9	7.6	7.3	7.0	6.8	6.5	6.2
Electricity Generation												
Capstone Microturbine	KW-hr/yr 90% Online	512,460	512,460	512,460	512,460	512,460	512,460	512,460	512,460	512,460	512,460	512,460
Heat Rate Required	BTU/hr	841,750	841,750	841,750	841,750	841,750	841,750	841,750	841,750	841,750	841,750	841,750
EXCESS / (DEFICIT) LFG Heat Rate	BTU/hr	6,192,662	5,937,638	5,661,362	5,406,338	5,151,314	4,938,794	4,683,770	4,492,502	4,279,982	4,067,462	3,876,194
Selected Number of Operating Generators		1	1	1	1	1	1	1	1	1	1	1
Electricity Generation for Generator(s) at Full Load	KW-hr/yr 90% Online	512,460	512,460	512,460	512,460	512,460	512,460	512,460	512,460	512,460	512,460	512,460
Heat Rate Required for Generator(s) at Full Load	BTU/hr	841,750	841,750	841,750	841,750	841,750	841,750	841,750	841,750	841,750	841,750	841,750
EXCESS / (DEFICIT) LFG Heat Rate	BTU/hr	6,192,662	5,937,638	5,661,362	5,406,338	5,151,314	4,938,794	4,683,770	4,492,502	4,279,982	4,067,462	3,876,194
Commodities Prices (manually edit as necessary)												
Electricity Price (average of peak & off-peak)	per KW-hr	$ 0.1600	$ 0.1600	$ 0.1600	$ 0.1600	$ 0.1600	$ 0.1600	$ 0.1600	$ 0.1600	$ 0.1600	$ 0.1600	$ 0.1600
Expenditures												
Landfill Improvements		$ 228,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Gas to Energy Facilities		$ 485,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Capital Loan		$ (713,000)	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Capital Loan Payment (Principal + Interest)	10% @ 10 years	$ -	$ 116,037	$ 116,037	$ 116,037	$ 116,037	$ 116,037	$ 116,037	$ 116,037	$ 116,037	$ 116,037	$ 116,037
Generator + Compressor O&M Cost	$0.02/Generated kWh	$ -	$ 10,249	$ 10,249	$ 10,249	$ 10,249	$ 10,249	$ 10,249	$ 10,249	$ 10,249	$ 10,249	$ 10,249
GCCS O&M Cost	$1,500/Month	$ -	$ 18,000	$ 18,000	$ 18,000	$ 18,000	$ 18,000	$ 18,000	$ 18,000	$ 18,000	$ 18,000	$ 18,000
Gross Expenditures		$ -	$ 144,287	$ 144,287	$ 144,287	$ 144,287	$ 144,287	$ 144,287	$ 144,287	$ 144,287	$ 144,287	$ 144,287
Revenue												
Offset Electricity Cost (Elec. Price X Elec. Generation at 90%)		$ -	$ 81,994	$ 81,994	$ 81,994	$ 81,994	$ 81,994	$ 81,994	$ 81,994	$ 81,994	$ 81,994	$ 81,994
Gross Revenue		$ -	$ 81,994	$ 81,994	$ 81,994	$ 81,994	$ 81,994	$ 81,994	$ 81,994	$ 81,994	$ 81,994	$ 81,994
Net Cash Flow		$ -	$ (62,293)	$ (62,293)	$ (62,293)	$ (62,293)	$ (62,293)	$ (62,293)	$ (62,293)	$ (62,293)	$ (62,293)	$ (62,293)

Preliminary Feasibility Analysis for Energy Recovery and Utilization at the Kent Highlands Landfill, Washington

Introduction

At many U.S. landfills, existing technologies could be used to recover and profitably utilize the landfill methane, yet only a fraction of landfills are using or even recovering the methane they generate. Increased use of landfill methane could reduce emissions from landfills as well as provide a reliable fuel supply. The EPA Office of Superfund Remediation and Technology Innovation (OSRTI), in collaboration with EPA's Federal Facilities Remediation and Reuse Office (FFRRO), EPA Regions, and EPA's Landfill Methane Outreach Program (LMOP), is exploring options to exploit methane from those landfills that are placed on the Superfund National Priorities List (NPL). As a first step in this effort a team of ERG, Shaw Environmental and Infrastructure, Inc. (Shaw) and Cornerstone Environmental Group, LLC (Cornerstone) evaluated the feasibility of using the LFG at example NPL landfills such as the Kent Highlands Superfund Site to meet on-site energy demands or local community demands.

The Seattle municipal landfill, Kent Highlands, is located in the city of Kent, Washington, approximately 14 miles south of Seattle. From 1968 to 1986, the City of Seattle leased the site and disposed of refuse on about 60 acres of a 90-acre ravine located on a hillside above the Green River. In addition to municipal wastes, the landfill accepted paint residues, industrial sludge, and other industrial wastes. The site is being addressed through state and municipal actions. The landfill is capped. A geomembrane cover was placed on top of the existing cap, with a prepared soil base. A drainage layer was placed on top of the geomembrane to direct water away from the landfill. Topsoil was placed as the final layer and vegetated.

Currently, the landfill gas collection system produces an average gas flow of 410 standard cubic feet per minute (scfm) at an average methane concentration of 22.5%. This methane concentration is insufficient for fueling a microturbine, but the gas collection system could possibly be upgraded to provide a higher methane concentration. The on-site energy demand is 15 kW for the landfill gas blowers and control systems. Due to the low on-site electrical demand, investing in a system that would segregate potentially higher methane concentration wells to utilize in a Landfill Gas to Energy (LFGTE) facility to offset those costs would not be economically feasible.

Resource Availability

The landfill waste mass is predominately MSW and between 42 and 24 years old. According to the 2003 5-year review, the landfill began accepting MSW in 1968. In 1983, it began accepting industrial and construction and demolition debris. It stopped accepting waste in 1986, with an estimated 8 million cubic yards of waste in-place. The cap was constructed in 1995.

Landfill gas was collected by vent pipes that were installed in the landfill during filling. Most of these pipes were connected to a forced exhaust system that discharges the gas to flares at two locations near the western and northern edges of the site. Gas migration west of the site was detected in 1984 and a series of perimeter gas extraction wells were installed in native soils along the site perimeter to bring the gas migration under control. This system has now been extended along the north and south sides of the landfill and includes four enclosed flares.

Currently, the landfill gas collection system produces an average gas flow of 410 standard cubic feet per minute (scfm) at an average gas composition of: 22.5% methane, 3.0% oxygen, 20.6% carbon dioxide, and 53.9% nitrogen. Based on this gas composition, air infiltration may be occurring in the system.

Based on discussions with the site operational managers, the landfill is scheduled to replace the existing flares with a single smaller one. It may be possible to improve the landfill gas quality when the flare system is downsized. If the overall gas flow to the flare is reduced for the smaller flare, the vacuum on the gas collection wells could be reduced. If the landfill gas can be maintained above 100 scfm and, more importantly, the methane content increased to a more consistent 35%, then an on-site electrical project could be considered.

Onsite Activities and Energy Demand

Current landfill gas concentrations will not support a landfill gas to energy facility. With a methane concentration of around 22%, neither a microturbine nor a reciprocating engine could sustain combustion. The minimum methane content that a microturbine requires is 35%, and the various reciprocating engines require a higher value. If an energy recovery project is considered for the Kent Highlands Landfill, the gas collection system would need to be configured to allow collection of higher concentration gas from internal landfill wells, and segregation of the lower concentration wells and the perimeter migration control wells. This segregation may not be feasible since the perimeter migration wells which are typically very low in methane content will still need to be blended with higher methane content wells in order to sustain combustion in the flares.

Currently the only on-site energy demand is for the landfill gas blowers and control systems. There are no operating groundwater recovery and treatment activities, nor any on-site natural gas usage at the site. No data has been provided for on site electrical demand. Based on the volume of gas being collected and flared, and the fact that two blowers are in operation, we have assumed that each blower is operating at approximately a 10 horsepower load. This assumption is based on standard blower manufacturer data, providing approximately 400 scfm of flow at a static pressure of 50 inches water column gauge. We have also used a national average of $0.16/kWh as an on-site electricity charge.

Based on the above assumptions, the annual on site electrical demand would be 131,400 kWh, and the annual cost would be approximately $21,000.

Onsite Electrical Generation Options

The small microturbine produces 30 kW. Due to the low on-site electrical demand of 15 kW, investing in a system that would segregate potentially higher methane concentration wells to utilize in a Landfill Gas to Energy (LFGTE) facility to offset those costs would not be economically feasible. Additionally, even though the total landfill gas generation at this site might be upgraded to support a LFGTE facility that would offset the onsite costs and export power to the grid, the current requirement to use the higher methane concentration gas wells to mix with perimeter migration control well gas may preclude this option. The mixed gas concentration of 22% methane is nearing the limit that can sustain combustion in a flare.

Preliminary Feasibility Analysis for Energy Recovery and Utilization at the Keystone Landfill, Pennsylvania

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Introduction

At many U.S. landfills, existing technologies could be used to recover and profitably utilize the landfill methane, yet only a fraction of landfills are using or even recovering the methane they generate. Increased use of landfill methane could reduce emissions from landfills as well as provide a reliable fuel supply. The EPA Office of Superfund Remediation and Technology Innovation (OSRTI), in collaboration with EPA's Federal Facilities Remediation and Reuse Office (FFRRO), EPA Regions, and EPA's Landfill Methane Outreach Program (LMOP), is exploring options to exploit methane from those landfills that are placed on the Superfund National Priorities List (NPL). As a first step in this effort a team of ERG, Shaw Environmental and Infrastructure, Inc. (Shaw) and Cornerstone Environmental Group, LLC (Cornerstone) evaluated the feasibility of using the LFG at example NPL landfills such as the Keystone Landfill in Pennsylvania to meet on-site energy demands or local community demands.

The Keystone Landfill Site consists of a 40-acre landfill facility located in Union Township, Adams County, Pennsylvania. The landfill was constructed without a liner or leachate collection system. The landfill facility operated from 1966 through 1990 and is estimated to contain more than 1.7 million cubic yards of waste. The landfill has a soil cap. In 2002 and 2003, the cap soil was upgraded with low permeability soil where the thickness was less than 2 feet thick; grading was performed for surface water drainage; and a gas monitoring, extraction, and destruction system (enclosed flare) was installed. The remediation action includes the operation and maintenance of on-site groundwater extraction wells and a treatment plant to capture, contain and reduce the concentrations of VOCs and metals in groundwater. The groundwater treatment system has been operating since August 2000. Groundwater is pumped from a series of extraction wells, treated and discharged to a nearby stream.

According to the most recent landfill gas report for Keystone, the average gas flow is approximately 110 scfm and the methane content ranges from 31.5 to 66.1 percent. Specific, on site energy demand information was not made available from the EPA nor the PRP. However, based on the available data, the onsite electrical demand is expected to be approximately 56.5kW. A Capstone 65 kW microturbine generator with associated gas compression and conditioning system will have an installed cost of approximately $462,000 and produce 50 kW after meeting parasitic loads. There will be an annual expenditure of $115,438 for debt service and operations and maintenance for the electrical generation. The electricity generation offset will total approximately $63,000, which includes the additional 15 kW power usage for the gas compression and conditioning equipment. The project will have a net negative cash flow of $52,366 per year.

Resource Availability

The Phase I gas system became operational on May 28, 2003. The Phase I gas system currently includes 23 gas extraction wells (LFG-1 through LFG-23). The enclosed landfill flare includes a condensate injection system.

Monitoring frequency and the parameters are as follows:

- The gas extraction wells are monitored monthly for flow, temperature, static pressure, CH_4, O_2, CO_2, and N_2;
- The flare inlet is measured monthly for temperature, static pressure, CH_4, O_2, CO_2, and N_2

- The flare inlet has a totalizer that measures gas flow continuously.

The LFG collection and control system operates continuously. The enclosed flare includes a condensate injection system, which pumps condensate into the flare to destroy VOCs. The pump operates when enough condensate has accumulated. For the last two months within the time period July 2008 to March 2009, the total condensate time (minutes) was 360 minutes. The average condensate injection flow rate was 0.5 gpm. The most recent semi-annual report[1] was reviewed to assess the gas flow and quality. Although this performance monitoring report concentrated on the VOC removal action, information was available to conduct a preliminary assessment of the gas collection. According to this report, the average gas flow, from May 2003 to January 2009, was 110 scfm and the methane content ranged from 31.5 to 66.1 percent. This document also reported that efforts have been made recently to increase the gas extraction rate in certain wells, which has resulted in a consistent flow rate of 130 scfm since December 2008. According to the most recent data (December 17, 2008 through June 13, 2009), the composition of the LFG at the flare inlet was in the range of:

- CH4% = 38.5 to 44.1
- CO2% = 31.9 to 35.3
- O2% = 1.1 to 3.8
- Balance Gas = 19.0 to 26.9

January data for the LFG extraction wells indicate all the wells have sufficient methane content to support combustion. The methane content ranged from 31.5 to 66.1%; with all except one well having concentrations above 50 percent. Specific well flow data were not reported . Collecting such data would allow further assessment of each gas collection well's productivity. In comparing the individual well data and the flare station data, there appears to be an opportunity to tune the well field operation to increase the methane content and reduce the oxygen content.

Depending on the on-site energy requirements and based on the information provided, current gas collection at 110 to 130 scfm is sufficient for beneficial use. There appear to be opportunities to improve the gas collection. For example, gas extraction well LFG-6 is noted to be filled with liquid. This well and any other wells that have liquid could be pumped down to determine if LFG flow could be increased.

Estimating the future gas generation and collection is also important in assessing the feasibility of developing a cost effective project. The EPA model, LandGEM[2], was used to estimate the landfill gas generation rate for the years from 2011 to 2026. Actual annual waste deposition information was not available. Conservatively, the landfill gas estimate is based on the assumption that the waste was placed in equal amounts annually over the operating life of the landfill (1966 to 1990) for a total of 1.7 million cubic yards of waste-in-place. A conversion rate of 0.6 tons per CY was assumed. The LandGEM guidance recommends using inventory values to generate emission estimates for use in emission inventories and air permits in the absence of site-specific test data. Unless the site is a bioreactor, either conventional or dry parameters are

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[1] Performance Monitoring Report, Round 11 (January 2009), Enhanced Landfill Gas Extraction System, Operable Unit 1 (Ou-1), Alternate Source Control Remedy, Keystone Sanitation Landfill, Union Township, Adams County, Pennsylvania, Prepared for Waste Management of Pennsylvania, Inc., Prepared by Golder Associates Inc., dated July 2009.

[2] Landfill Gas Emissions Model (LandGEM) Version 3.02

assumed. For conventional sites, a L_o value of 100 m^3/Mg and a k value of 0.4 $year^{-1}$ are used in the model. As summarized in column 2 of the table below, the landfill gas generation is estimated to be between 80 to 150 scfm.

The model does not assume the collection efficiency for the gas collection system. Available EPA data from NSPS surface monitoring, the Solid Waste Association of North America (SWANA), and several other industry and regulatory sources, indicate that the average gas collection efficiency for a landfill is 60 to 95 percent, with a typical average of 75 percent. Collection efficiencies tend to drop when balancing the gas collection system of older landfills to provide gas with the higher methane content needed for energy projects. Older landfills are less "tight" since they are unlined and have no geomembrane over the slopes. As a result they have to decrease collection rates to prevent air from infiltrating the system. For the Keystone site, a collection efficiency of lower than the 75 percent average would be assumed, most likely between 60 and 70 percent. Using 65 percent collection efficiency, the gas production rate for the landfill is estimated to be from 70 to 110 scfm between 2011 and 2026. The third column in the table below presents the annual estimated gas collection rates for 65 percent collection efficiency.

Although there is a tendency to compare LandGEM results with past collection data, the actual results will vary in the short term. For example, in this case, revising the collection efficiency to 75 percent provides a collection rate in year 2011 that is closer to what is currently reported. Column 4 of the table below presents the annual estimated gas collection rates for 75 percent collection efficiency. It is recommended that more accurate waste deposition rates be used in the model. For example, it may be known that the waste stream into the landfill in the later years of operation was higher than earlier years. In that case, the gas generation for the 2011 to 2026 time period would be higher, and the 65 percent collection would also be higher.

YEAR	Total LFG Generation (scfm)	Assume 65% collection (scfm)	Assume 75% collection (scfm)
2011	148	96	111
2012	142	92	106
2013	136	89	102
2014	131	85	98
2015	126	82	94
2016	121	79	91
2017	116	76	87
2018	112	73	84
2019	107	70	80
2020	103	67	77
2021	99	64	74
2022	95	62	71
2023	91	59	69
2024	88	57	66
2025	84	55	63
2026	81	53	61

Landfill Gas to Energy Options Analysis

Onsite Activities and Energy Demand

Specific, on site energy demand information was not made available from the EPA nor the PRP. Below is a brief description of on site water treatment equipment and gas collection equipment with assumptions made to account for an approximate energy demand.

The original treatment system consisted of two-stage flow equalization, metals precipitation, gravity filtration, shallow-tray air stripping, liquid phase granular activated carbon (LGAC) and vapor phase granular activated carbon (VGAC). The hydraulic capacity of the original system was limited to 45 gallons per minute (gpm). The groundwater treatment system was modified in 2002 to increase the capacity from 45 gpm to 80 gpm.

The modified system utilizes air sparging as the first step in the treatment process to remove VOCs. More specifically, the existing outside equalization tank was retrofitted with a fine bubble, diffused air, aeration system. A small amount of potassium permanganate solution is added to enhance the oxidation of both metals and VOCs. The system was further modified by the addition of two greensand filters operated in parallel to remove iron and manganese. The LGAC and VGAC units were retained and are used as a final polishing step for the treated water and off-gases. The gravity sand filter and shallow-tray air stripper have been removed from service. In addition, caustic and acid are no longer required for pH adjustment and have been eliminated. In 2005, the system was operating at 50 gpm.

A recent evaluation for a landfill site in a similar climate with both VOC and metals contamination that was also being rectified with a similar type of system was used for comparison. That system has both an electrical load for the equipment, and a natural gas demand for seasonal heating. Given the lack of specific on-site energy demand data for the Keystone Landfill, a preliminary evaluation of a potential energy recovery installation can still be accomplished utilizing this referenced data.

Based on the above data, the onsite electrical demand is expected to be approximately 56.5kW. This load equates to a cost of approximately $60,000 for the year at an average electricity cost of $0.16/kWh. The natural gas usage for seasonal heating at the site would be expected to be approximately $4,000 to $6,000 per month from September through April, with minimal heat needed throughout the remaining months. The total annual natural gas cost is expected to be approximately $28,000, with $27,000 of that cost occurring September through April.

Onsite Energy Generation Options

New microturbine technology allows the turbine to follow the on-site electrical load, down to approximately 50% of its rated capacity. In Keystone Landfill's case, a 65 kW microturbine could be load leveled to follow most of the site's electrical demand from 65 kWh to as low as 33 kWh. There will also be an additional onsite electrical demand of approximately 15 kWh for the gas compression and conditioning equipment necessary to provide the fuel to the turbine. Thus a 65 kW turbine will supply a net 50 kW of the existing site demands.

A single, Capstone 65 kW microturbine requires 842,000 btus/hr of fuel. At a methane concentration of 35%, which is the minimum that the turbine requires to perform well, that equates to approximately 40 scfm of landfill gas. Based on the above summary of landfill gas generation, there should be in excess of this quantity and quality of landfill gas generated for the duration of the on-site groundwater pump and treat equipment operation. The remaining, unused landfill gas will continue to be routed to the existing flare. In the event of a planned or unplanned shutdown of the gas to energy project, we have planned for those gases to also be routed to the existing flare. There is not sufficient gas quantity available to warrant the installation of additional microturbines to sell power to the utility and offset the utility interconnect cost.

Onsite Heating Supply Options

An option to offset the natural gas use at the site would be to include a heat exchanger on the microturbine exhaust. This could be an efficient manner to provide the heat load for the on-site facilities that is depicted by the seasonal spike in natural gas usage. Capstone manufactures a package unit that includes both the turbine generator and the heat reclaiming equipment. That unit provides approximately 251,000 Btu's /hour of hot water through an air to liquid heat exchanger. The hot liquid could be pumped to the facility and piped through a liquid to air heat exchanger to provide heat. This option will add approximately $50,000 to the equipment costs.

A second option for offsetting the natural gas heating cost would be to burn landfill gas. The compressor and gas conditioning equipment that will be utilized for the microturbine, could be sized to also provide compressed landfill gas to that heating unit. Sulfur removal would likely be required since the heating equipment was likely designed for natural gas and would have very low tolerance to sulfur and other corrosives in the landfill gas. As an alternative, a separate, stand alone heater that is designed for landfill gas could be purchased to replace the natural gas heater currently used by the site. We anticipate that both of these options would be more costly that the option of using the waste heat from the microturbine.

Project Design and Construction Requirements

The existing landfill includes an active gas collection system. Modification of that system will be limited to the addition of the piping interconnect from the existing blower to the new compressor, and related controls. The existing blower will remain in place and continue to route excess collected gas to the flare. For purposes of estimating gas flow to the proposed energy recovery equipment, we have assumed a worst case methane content of 35%. At that methane content, approximately 40 scfm of landfill gas will be required to power a 65 kW Capstone microturbine.

The energy generation component will include the gas compression and conditioning system, along with the microturbine and generator. As an option, it could also include the heat reclaiming package for building space heating. A utility interconnection will also be required. We are assuming that the system will be installed to provide electricity to the onsite equipment, with the utility providing power when equipment demand is greater than the turbine output. During those times when the turbine can produce in excess of the onsite power demand, it will be managed to load level and only produce power to that demand. If the turbine is shut down, the utility will provide all onsite electrical load.

The turbine and gas compression and conditioning equipment can be installed outside. For purposes of facilitating maintenance activities, we recommend that the compressor be installed in a small enclosure.

Project Capital and Operating Cost

We have assumed that the proposed blower piping system modification will include approximately 300 feet of gas header piping between the blower and the proposed microturbine installation, and an automated valve. We have accounted for this cost in the power generation estimate.

The electric power generator installation will include a Capstone 65 kW microturbine generator, a gas compression and conditioning system, a small enclosure for the compression system, and related utility interconnection. The system will not be set up to export power to the grid. Gas conditioning will consist of only moisture removal. Sulfur removal is not included since the microturbines are very tolerant of elevated sulfur levels. Siloxane removal is not anticipated due to the age of the waste materials. The total installed cost for the microturbine installation is approximately $462,000. If the heat recovery option is added, the total installed cost is approximately $512,000.

Operation and maintenance activities will be required on both the wellfield and the power generation system. We have assumed that currently site visits and minimal maintenance are being conducted. For the proposed project, one wellfield site trip will be required per month to monitor and adjust the wells and monitor the system. That activity should cost approximately $2,500 per month for a local firm to perform. The microturbine maintenance should average about $0.015 per generated kWh, and the compression/conditioning maintenance should average about $0.005 per generated kWh. The compression/conditioning system will add about 15 kW to the electric load on the site for the electric motors and controls.

Site design and permitting activities will be required to permit and construct the microturbine facility and the wellfield modifications. We have included site design costs as a percentage of the installed capital costs. The energy recovery and utility interconnect design would be approximately $77,000

Project Economics and Proforma

The attached Keystone Landfill economic analysis depicts the system installation and operating costs along with projected yearly energy savings at the site. Site specific data related to energy costs have been discussed earlier in this report and are included in the overall analysis. A site purchased electricity rate of $0.16/kWh has been included. The economic analysis assumes that the microturbine will be generating 65 kWh of electricity 90% of the time and will be offsetting electricity purchase for that amount of power on a month to month basis. Based on the data included in the analysis above, there will be five winter months when the peak electrical energy use is in excess of the 65 kW output, minus the 15 kW parasitic load, and power will still need to be purchased., There will also be seven months when the energy use closely matches the turbine output or is a little lower. On an annual basis, this difference is considered incidental and it has not been taken into account in this analysis. Installation of a second turbine to make up the minor difference between power use and output is not warranted.

The economic analysis indicates that there will be an annual expenditure of $115,438 for debt service and operations and maintenance for the electrical generation only option. The electricity generation offset will total approximately $63,072, which includes the additional 15 kW power usage for the gas compression and conditioning equipment. The project will have a net negative cash flow of $52,366 per year.

If the heat recovery option is included, and if the recovered heat can be utilized, approximately 25% to 66% of the winter peak heat load could be offset from November through April, providing potential savings of approximately $1,100 each of those months at an average natural gas offset price of $5.65/MMBtu. The remaining months of the year, the heat recovery option would generate an excess amount of heat and would offset approximately $800 of natural gas use. It does not appear that adding the heat recovery option at a cost of approximately $50,000 is warranted given these potential savings.

ASSUMPTIONS

= input site parameters

Technical:

LFG Recovery Rate (Initial)	111	SCFM
Current Methane Content (by volume)	35%	
Methane BTU Value	1,012	BTU per ft^3
Generator Model	Capstone Microturbine	
Generator Heat Rate	12,950	BTU per KW-hr
Generator Full Load (65kW minus 15kW parasitic load)	50	KW
Generator Run Time	90%	
Natural Gas Heat Value	1,000	BTU per ft^3

Financial Variables:

Electricity Price	$0.1600	per KW-hr
Generator + Compressor O&M Cost	$0.02	per KW-hr
GCCS O&M Cost	$2,500	per month
Capital Loan Interest Rate	10.0%	

Capital Project Costs:

Landfill Improvements	$0

Gas to Energy Facilities	$462,000
Turbine	$85,000
Compressor	$115,000
Building	$30,000
Installation	$100,000
Utility Interconnect	$50,000
Piping to Compressor	$5,000
Engineering (20%)	$77,000

	unit	Year 2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
LFG Resource												
LFG Recovery Rate	SCFM	111	106	102	98	94	91	87	84	80	77	74
LFG Methane Content		35.0%	35.0%	35.0%	35.0%	35.0%	35.0%	35.0%	35.0%	35.0%	35.0%	35.0%
LFG Heat Content	BTU/ft^3	354	354	354	354	354	354	354	354	354	354	354
LFG Heat Rate	BTU/hr	2,358,972	2,252,712	2,167,704	2,082,696	1,997,688	1,933,932	1,848,924	1,785,168	1,700,160	1,636,404	1,572,648
Equivalent Number of Generators at Full Load		4.0	3.9	3.7	3.6	3.4	3.3	3.2	3.1	2.9	2.8	2.7
Electricity Generation												
Capstone Microturbine	KW-hr/yr 90% Online	394,200	394,200	394,200	394,200	394,200	394,200	394,200	394,200	394,200	394,200	394,200
Heat Rate Required	BTU/hr	647,500	647,500	647,500	647,500	647,500	647,500	647,500	647,500	647,500	647,500	647,500
EXCESS / (DEFICIT) LFG Heat Rate	BTU/hr	1,711,472	1,605,212	1,520,204	1,435,196	1,350,188	1,286,432	1,201,424	1,137,668	1,052,660	988,904	925,148
Selected Number of Operating Generators	1	1	1	1	1	1	1	1	1	1	1	1
Electricity Generation for Generator(s) at Full Load	KW-hr/yr 90% Online	394,200	394,200	394,200	394,200	394,200	394,200	394,200	394,200	394,200	394,200	394,200
Heat Rate Required for Generator(s) at Full Load	BTU/hr	647,500	647,500	647,500	647,500	647,500	647,500	647,500	647,500	647,500	647,500	647,500
EXCESS / (DEFICIT) LFG Heat Rate	BTU/hr	1,711,472	1,605,212	1,520,204	1,435,196	1,350,188	1,286,432	1,201,424	1,137,668	1,052,660	988,904	925,148
Commodities Prices (manually edit as necessary)												
Electricity Price (average of peak & off-peak)	per KW-hr	$ 0.1600	$ 0.1600	$ 0.1600	$ 0.1600	$ 0.1600	$ 0.1600	$ 0.1600	$ 0.1600	$ 0.1600	$ 0.1600	$ 0.1600
Expenditures												
Landfill Improvements		$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Gas to Energy Facilities		$ 462,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Capital Loan		$ (462,000)	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Capital Loan Payment (Principal + Interest)	10% @ 10 years	$ -	$ 75,188	$ 75,188	$ 75,188	$ 75,188	$ 75,188	$ 75,188	$ 75,188	$ 75,188	$ 75,188	$ 75,188
Generator + Compressor O&M Cost	$0.02/Generated kWh	$ -	$ 10,249	$ 10,249	$ 10,249	$ 10,249	$ 10,249	$ 10,249	$ 10,249	$ 10,249	$ 10,249	$ 10,249
GCCS O&M Cost	$2,500/Month	$ -	$ 30,000	$ 30,000	$ 30,000	$ 30,000	$ 30,000	$ 30,000	$ 30,000	$ 30,000	$ 30,000	$ 30,000
Gross Expenditures		$ -	$ 115,438	$ 115,438	$ 115,438	$ 115,438	$ 115,438	$ 115,438	$ 115,438	$ 115,438	$ 115,438	$ 115,438
Revenue												
Offset Electricity Cost (Elec. Price X Elec. Generation at 90%)		$ -	$ 63,072	$ 63,072	$ 63,072	$ 63,072	$ 63,072	$ 63,072	$ 63,072	$ 63,072	$ 63,072	$ 63,072
Gross Revenue		$ -	$ 63,072	$ 63,072	$ 63,072	$ 63,072	$ 63,072	$ 63,072	$ 63,072	$ 63,072	$ 63,072	$ 63,072
Net Cash Flow		$ -	$ (52,366)	$ (52,366)	$ (52,366)	$ (52,366)	$ (52,366)	$ (52,366)	$ (52,366)	$ (52,366)	$ (52,366)	$ (52,366)

Preliminary Feasibility Analysis for Energy Recovery and Utilization at the Landfill & Resource Recovery Landfill, Rhode Island

Introduction

At many U.S. landfills, existing technologies could be used to recover and profitably utilize the landfill methane, yet only a fraction of landfills are using or even recovering the methane they generate. Increased use of landfill methane could reduce emissions from landfills as well as provide a reliable fuel supply. The EPA Office of Superfund Remediation and Technology Innovation (OSRTI), in collaboration with EPA's Federal Facilities Remediation and Reuse Office (FFRRO), EPA Regions, and EPA's Landfill Methane Outreach Program (LMOP), is exploring options to exploit methane from those landfills that are placed on the Superfund National Priorities List (NPL). As a first step in this effort a team of ERG, Shaw Environmental and Infrastructure, Inc. (Shaw) and Cornerstone Environmental Group, LLC (Cornerstone) evaluated the feasibility of using the LFG at example NPL landfills such as the Landfill & Resource Recovery (L&RR) Superfund Site to meet on-site energy demands or local community demands.

The L&RR Landfill is a 28-acre closed landfill located in North Smithfield, Providence County, Rhode Island. The Site is a former sand and gravel pit which reportedly began accepting municipal wastes for disposal around 1927. Over its years of operation, the landfill also accepted commercial and industrial wastes for disposal. EPA has estimated that more than 2 million gallons of hazardous chemicals including solvents, plating waste, asbestos, oils, and dyes were brought to the landfill for disposal (*de maximis*, 1997). The landfill stopped accepting wastes in January 1985. Landfill closure began in 1985 pursuant to a 1983 Court Order and Consent Order and Agreement between RIDEM and L&RR, Inc. In 1986, L&RR, Inc., covered a majority of the landfill with a 20-mil polyvinyl chloride (PVC) geomembrane and 24 inches of soil and installed a system of 18 gas vents. The remaining 20 percent of the landfill was capped in 1994 and an enclosed flare was installed. The January and February, 2010, monthly monitoring reports indicate that the LFG flow is a little more than 440 scfm at a methane content ranging from 30 to 37 percent.

Currently there is a monthly on-site energy demand for the landfill gas blower and control system of approximately 10,000 kwh at a cost of $0.11/kWh. Due to the low on-site electrical demand, installing a Landfill Gas to Energy (LFGTE) facility to offset those costs would not be economically feasible. However, given the available LFG flow rate, it appears that a LFGTE project could support eight, 65 kW Capstone microturbines, with the excess power being sold to the local utility. The installed cost for the wellfield improvements to convey the LFG to the microturbines is approximately $5,000 and the installed cost for the microturbine system is approximately $1,710,000. The economic analysis indicates that there will be an annual expenditure of $510,000 for debt service, and operations and maintenance. The analysis also shows that at the electricity buy-back rate of $0.11/kWh, the project revenues of $451,000 do not equal the annual expenditures. There would be an annual deficit of $59,000. With every $0.01 change in the buy-back rate, a $41,000 swing up or down in annual revenue occurs. If the utility is paying a premium rate for power generated from biogas, there may be positive cash flow.

Resource Availability

In 1986, under the direction of RIDEM, L&RR, Inc. covered a majority of the landfill with a 20-mil polyvinyl chloride (PVC) geomembrane and 24 inches of soil and installed a system of 18 gas vents. The remaining 20 percent of the landfill was capped in 1994 and an enclosed flare was installed. In December 1998, a LFG condensate injection system was installed by John Zink Company LLC.

The extraction and treatment systems are maintained monthly. This monitoring includes the measurement of methane, oxygen, carbon dioxide, temperature, and vacuum at the 18 gas extraction wells; adjustment of the flow from individual wells as needed; and monitoring of methane, oxygen, carbon dioxide, flame temperature, and air flow rate at the flare. According to the 2004 5-year review, 2 or 3 of the 18 gas extraction wells are often off line; for example, gas extraction well W14 was closed in May 2002 due to an apparent leak in the piping between the extraction wellhead and the sampling wellhead, and it was still closed during a site inspection in May 2004. Well W-6 has been closed for several years. Despite these and other well closings, control of methane migration is still achieved when the system is in operation. The January and February, 2010, monthly monitoring reports for the site indicate that extraction Well W-6 remains closed.

In April 2010, a summary of historic data for the extraction wells and the flare was provided. The data show that the LFG flowrate has been fairly consistent, but the methane content has dropped.

Year	**1995**	**1997**	**2003**	**2004**	**2005**	**2006**
Methane content (%)	55.73	47.38	41.57	38.63	33.96	36.75
Flowrate (cfm)	532	448	483	513	585	548

Monitoring data from the January and February, 2010 reports show that the LFG flow was 442 and 441 scfm and the methane content was 37.3 and 29.7 percent, respectively.

The current gas flow rate and methane content is conducive to implementing a beneficial use project, as presented. However, to improve the economic feasibility of the project, more consistent operation and control over the gas quality would be necessary. Gas well quality and increased hours of operation requires an experienced gas well technician to monitor and tune the well field and make more timely repairs. This assessment reviews the economic feasibility of a project with increased operation, maintenance and monitoring costs.

Gas generation curves were provided for the site. These wells are titled SWANA gas generation curves. With the exception of the parameters L_o and K, the data provided to develop the curves were not provided. A review of the curves found that two of the eight curves, Curves IV and VIII (attached), were closest to the current flowrate. They show a decrease in gas generation of 25 to 30 percent over the next 10 years. It is recommended that a more in-depth study of the estimated gas generation be conducted.

Landfill Gas to Energy Options Analysis

Onsite activities and energy demand

Currently the only on-site energy demand is for the landfill gas blower and control system. There are no operating groundwater recovery and treatment activities at the site. Data related to the onsite electrical demand was provided for the months of January and February, 2010. In January, the electrical demand was 10,422 kWh for a total cost of $1,763 while February had an electrical demand of 5,462 kWh for a cost of $924. The electricity cost for the site was $0.11/kWh. We anticipate that the January demand is a typical monthly demand while the February demand indicates that the blower/flare was shut down due to repairs or some other malfunction. If we assume that January was a typical month, then the annual electrical demand is approximately $21,200.

There is no natural gas usage at the site.

Onsite Electrical Generation Options

Due to the low on-site electrical demand, installing a Landfill Gas to Energy (LFGTE) facility to offset those costs would not be economically feasible. However, the total landfill gas generation at this site may warrant development of a LFGTE facility that would offset those onsite costs and also export power to the grid. The below discussion provides an installation summary and financial proforma for an installation that would be sized to export electricity to the grid.

Given the above LFG projected flow rate and percent methane content, it appears that a LFGTE project could be sized to expect approximately 300 scfm, or more, of LFG at a methane concentration of approximately 35% for a period of 10 years or more. A single, Capstone 65 kW microturbine requires 842,000 btu/hr of fuel. Methane concentration of 35%, which is the minimum that the turbine requires to perform well, equates to approximately 40 scfm of landfill gas. The site's quantity of landfill gas would support eight, 65 kW Capstone microturbines. A reciprocating engine project at this site would not be feasible due to their requirement for a higher methane content in the LFG. As stated above, routine management of the landfill would be required to maintain a methane content that would support the turbines. In the future, as the LFG quantity subsides, the Capstone microturbine has the capability to derate itself up to 50% to match the available gas supply, so the LFGTE plant can continue to run past the expected 10 year life, as long as the methane content remains above 35%.

In the event of a planned or unplanned shutdown of the gas to energy project, the landfill gases will be manually routed to a flare. The Rhode Island Department of Environmental Management should be consulted to determine the flaring protocol. For purposes of this discussion, we will assume that the existing flare will be utilized to burn the gases when required.

Project Design and Construction Requirements

The existing landfill includes an active LFG extraction system that is adequate for supplying gas to the electric project. Therefore, there will not be a cost for a gas collection system as part of this project.

The energy generation component will include the gas compression and conditioning system, along with the microturbines. Since there is no on site heat load, heat reclamation will not be included in the design. The gas compressor will obtain the gas flow from the existing blower. A utility interconnection for sale to the grid will also be required. We are assuming that the system will be installed to provide electricity to the on-site equipment, with the remainder of the power being exported to the utility. If the turbines are shut down, the utility will provide all on-site electrical load.

The turbines and gas compression and conditioning equipment can be installed without enclosures, but for purposes of facilitating maintenance activities, we recommend that the compressor be installed in an enclosure.

Project Capital and Operating Cost

The electric power generator installation will include eight Capstone 65 kW microturbine generators, a gas compression and conditioning system, a small enclosure for the compression system, and related utility interconnection. Gas conditioning will consist of only moisture removal. Sulfur removal is not included since the microturbines are very tolerant of elevated sulfur levels. Siloxane removal is not anticipated due to the age of the waste materials. The total installed cost for the microturbine installation is approximately $1,715,000.

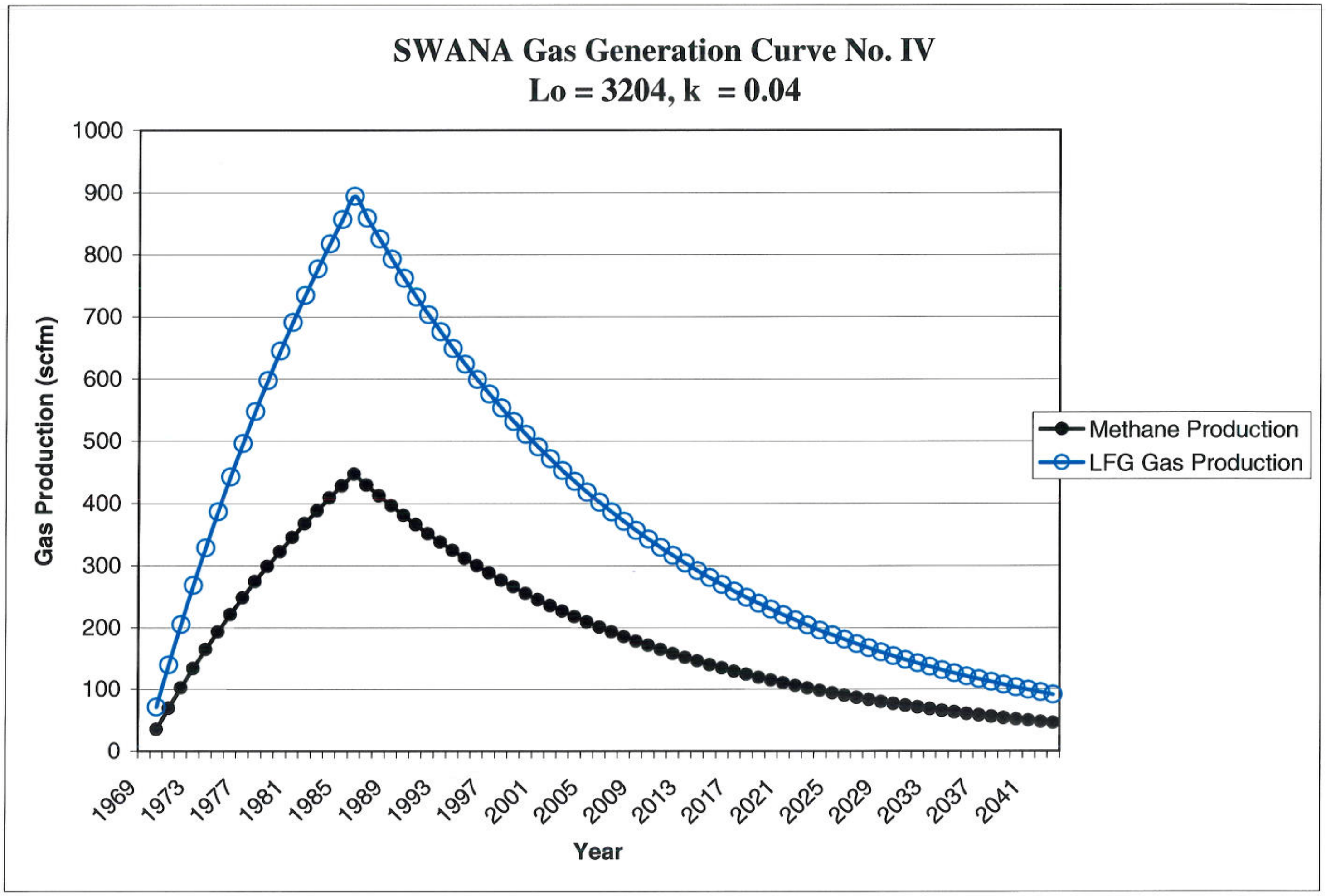
Operation and maintenance activities will be required on both the wellfield and the power generation system. We have assumed that site visits and minimal maintenance are currently being conducted. For the proposed project, one wellfield site trip will be required per month to monitor and adjust the wells and monitor the system. That activity should cost approximately $2,000 per month for a local firm to perform. The microturbine maintenance should average about $0.015 per generated kWh, and the compression/conditioning maintenance cost should average about $0.005 per generated kWh. The compression/conditioning system will add about 120 kW to the electric load at the site from the electric motors and controls, but that will be offset by the on-site power generation.

Site design and permitting activities will be required to permit and construct the microturbine facility and the wellfield modifications. We have included these engineering costs as a percentage of the installed capital costs; and that percentage equals approximately $285,000.

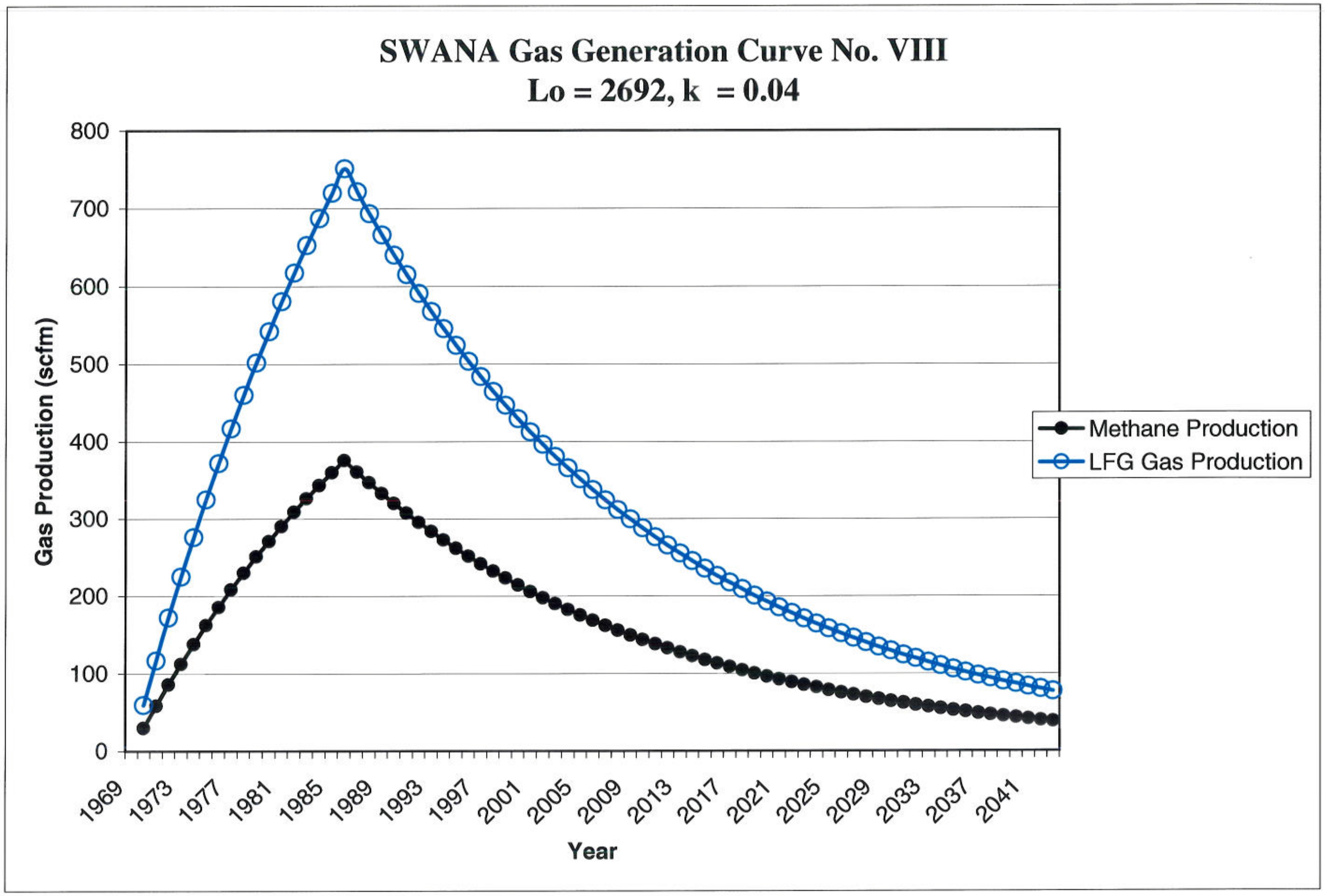
Project Economics and Proforma

The attached L&RR Landfill economic analysis depicts the system installation and operating costs along with projected yearly energy revenue at the site. A site purchased electricity rate of $0.11/kWh has been provided and included in the overall analysis. The economic analysis assume that the microturbines will be generating 520 kW of electricity 90% of the time and will be off- setting the existing electricity purchase; generating the additional on-site parasitic load from the compression equipment; and selling the remainder to the electric grid on a month to month basis. We have accounted for the on-site electric load in the attached analysis by including it in the Expenditures Section on an annualized basis.

The economic analysis indicates that electricity generation sale will total approximately $451,000 per year, at a buy back rate of $0.11/kWh. Annual capital and operating costs of $279,000 for debt service, $106,000 for operations and maintenance, and $125,000 for the on-site parasitic load must be subtracted from that total to obtain the net project revenue. The attached analysis shows that the $510,000 in annual costs are not offset by the $451,000 in revenues. The electricity buy back rate must be at least $0.125/kWh for the project to be close to a breakeven venture. With every $0.01 change in the buy back rate, a $41,000 swing up or down in revenue occurs. If the utility is paying a premium rate for power generated from biogas, there may be positive cash flow on a project like this.



SWANA Gas Generation Curve No. IV
Lo = 3204, k = 0.04
Gas Production (scfm)
1000
900
800
700
600
500
400
300
200
100
0
1969
1973
1977
1981
1985
1989
1993
1997
2001
2005
2009
2013
2017
2021
2025
2029
2033
2037
2041
Year
Methane Production
LFG Gas Production


SWANA Gas Generation Curve No. VIII
Lo = 2692, k = 0.04
Gas Production (scfm)
800
700
600
500
400
300
200
100
0
1969
1973
1977
1981
1985
1989
1993
1997
2001
2005
2009
2013
2017
2021
2025
2029
2033
2037
2041
Year
Methane Production
LFG Gas Production

ASSUMPTIONS (shaded = input site parameters)

Technical:

LFG Recovery Rate (Initial)	442	SCFM
Current Methane Content (by volume)	35%	
Methane BTU Value	1,012	BTU per ft^3
Generator Model	Capstone Microturbine	
Generator Heat Rate	12,950	BTU per KW-hr
Generator Full Load	65	KW
Generator Run Time	90%	
Natural Gas Heat Value	1,000	BTU per ft^3

Financial Variables:

Electricity Price	$0.1100	per KW-hr
Generator + Compressor O&M Cost	$0.02	per KW-hr
GCCS O&M Cost	$2,000	per month
Capital Loan Interest Rate	10.0%	

Capital Project Costs:

Landfill Improvements	$5,000
Interconnect gas piping	$5,000
Design (included in Gas to Energy)	

Gas to Energy Facilities	$1,710,000
Turbines	$680,000
Compressor/Conditioning	$340,000
Building	$50,000
Installation	$155,000
Utility Interconnect	$200,000
Engineering (20%)	$285,000

	unit	Year 2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
LFG Resource												
LFG Recovery Rate	SCFM	442	427	412	398	384	370	357	345	333	322	310
LFG Methane Content		35.0%	35.0%	35.0%	35.0%	35.0%	35.0%	35.0%	35.0%	35.0%	35.0%	35.0%
LFG Heat Content	BTU/ft^3	354	354	354	354	354	354	354	354	354	354	354
LFG Heat Rate	BTU/hr	9,393,384	9,074,604	8,755,824	8,458,296	8,160,768	7,863,240	7,586,964	7,331,940	7,076,916	6,843,144	6,588,120
Equivalent Number of Generators at Full Load		11.2	10.8	10.4	10.0	9.7	9.3	9.0	8.7	8.4	8.1	7.8
Electricity Generation												
Capstone Microturbine	KW-hr/yr 90% Online	512,460	512,460	512,460	512,460	512,460	512,460	512,460	512,460	512,460	512,460	512,460
Heat Rate Required/Microturbine	BTU/hr	841,750	841,750	841,750	841,750	841,750	841,750	841,750	841,750	841,750	841,750	841,750
EXCESS / (DEFICIT) LFG Heat Rate	BTU/hr	8,551,634	8,232,854	7,914,074	7,616,546	7,319,018	7,021,490	6,745,214	6,490,190	6,235,166	6,001,394	5,746,370
Selected Number of Operating Generators	8	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	7.8
Electricity Generation for Generator(s) at Full Load	KW-hr/yr 90% Online	4,099,680	4,099,680	4,099,680	4,099,680	4,099,680	4,099,680	4,099,680	4,099,680	4,099,680	4,099,680	3,997,188
Heat Rate Required for Generator(s) at Full Load	BTU/hr	6,734,000	6,734,000	6,734,000	6,734,000	6,734,000	6,734,000	6,734,000	6,734,000	6,734,000	6,734,000	6,565,650
EXCESS / (DEFICIT) LFG Heat Rate	BTU/hr	2,659,384	2,340,604	2,021,824	1,724,296	1,426,768	1,129,240	852,964	597,940	342,916	109,144	22,470
Commodities Prices (manually edit as necessary)												
Electricity Price (average of peak & off-peak)	per KW-hr	$ 0.1100	$ 0.1100	$ 0.1100	$ 0.1100	$ 0.1100	$ 0.1100	$ 0.1100	$ 0.1100	$ 0.1100	$ 0.1100	$ 0.1100
Expenditures												
Landfill Improvements		$ 5,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Gas to Energy Facilities		$ 1,710,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Capital Loan		$ (1,715,000)	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Capital Loan Payment (Principal + Interest) 10%	@ 10 years	$ -	$ 279,108	$ 279,108	$ 279,108	$ 279,108	$ 279,108	$ 279,108	$ 279,108	$ 279,108	$ 279,108	$ 279,108
Generator + Compressor O&M Cost	$0.02/Generated kWh	$ -	$ 81,994	$ 81,994	$ 81,994	$ 81,994	$ 81,994	$ 81,994	$ 81,994	$ 81,994	$ 81,994	$ 79,944
GCCS O&M Cost	$2,000/Month	$ -	$ 24,000	$ 24,000	$ 24,000	$ 24,000	$ 24,000	$ 24,000	$ 24,000	$ 24,000	$ 24,000	$ 24,000
Load (Blower,$21,200)+(Comp/Cond,$115,600@90%)	$125,300		$ 125,300	$ 125,300	$ 125,300	$ 125,300	$ 125,300	$ 125,300	$ 125,300	$ 125,300	$ 125,300	$ 125,300
Gross Expenditures		$ -	$ 510,402	$ 510,402	$ 510,402	$ 510,402	$ 510,402	$ 510,402	$ 510,402	$ 510,402	$ 510,402	$ 508,352
Revenue												
Electricity Generation (Elec. Price X Elec. Generation at 90%)		$ -	$ 450,965	$ 450,965	$ 450,965	$ 450,965	$ 450,965	$ 450,965	$ 450,965	$ 450,965	$ 450,965	$ 439,691
Gross Revenue		$ -	$ 450,965	$ 450,965	$ 450,965	$ 450,965	$ 450,965	$ 450,965	$ 450,965	$ 450,965	$ 450,965	$ 439,691
Net Cash Flow ($)		-	(59,437)	(59,437)	(59,437)	(59,437)	(59,437)	(59,437)	(59,437)	(59,437)	(59,437)	(68,661)

LANDFILL GAS ENERGY PROJECT ASSESSMENT TOOL

Calculation Worksheet for Assessing the Cost and Benefits of Landfill Gas Energy Projects at NPL Landfills

Calculation Worksheet

The attached Worksheet contains the calculations that are presented in Steps 1 through 3 of this report. It can be used in conjunction with the text to evaluate the cost benefit of a potential project.

Calculation Worksheet

Site Name: ______________________________

Step 1 - Estimate the Landfill Gas Supply
If the landfill has a gas collection system and the flow rate has been measured in the past couple of years, proceed to Step 2.

A. **Calculate the amount of municipal waste in place**.

Line A.1: Solid waste in place (yd^3) = Area of waste (ft^2) x Ave. depth of waste (ft.) x 1 yd^3/27 ft^3

= (__________ x __________) / 27 = ____________

Line A.2: Municipal waste in place (yd^3) = Solid waste in place (yd^3) x Fraction of municipal waste in landfill

= ____________________ x _______ = _______________
Calculated from Line A.1

Line A.3: Municipal waste in place (tons) = Municipal waste in place (yd^3) x 0.6 tons/ yd^3

= _____________________ x 0.6 = __________________
Calculated from Line A.2

B. Estimate the current methane generation rate

Line B.1: Number of years the landfill accepted waste = ___________________

Line B.2: Number of years since the landfill's closure = ____________________

Line B.3: Current methane generation rate (scfm) = ___________________ (Applying Lines B.1 & B.2 to Figures 2, 3 or 4)

C. Estimate the future methane generation rate (after ten years)

Line C.1: Future methane generation rate (scfm) = Current methane generation rate (scfm) x 0.60

= _________________ x 0.60 = _____________
From Line B.3

Step 2 – Assess the Adequacy of the Gas Supply

A. Assess the Gas Flow

To determine if the gas supply could be adequate to support a commercial-scale methane-to-energy project, proceed to Line A.1. If the methane will be used on-site to generate electricity or feed a combustion device, proceed to Line A.2 or Line A.6, respectively.

Line A.1: Is the adjusted future methane generation rate from Step 1 Line C.1 greater than 400 scfm? (*Note: A flow rate of approximately 400 scfm at 40% methane corresponds to the production of 1 MW of electricity or 10 mmBTU/hr of heat***)**

_____ **Yes. Commercial sale <u>may be</u> viable if the gas quality is adequate (Proceed to Step 3).**

_____ **No. Commercial sale <u>may not be</u> viable.** Refer to Step 4 in the Tool Document for potential ways to improve gas flow and/or methane concentration.

For generating electricity for use on-site, proceed to Line A.2. For direct use in an on-site boiler or furnace proceed to Line A.6.

<u>For electricity production</u>

Line A.2: Current electric load (kW) = Highest monthly electricity usage (kWh) (Obtained from the utility bill) / 744 hours per month (31 days @ 24 hrs/day)

= ____________________ / 744 = _____________kW

Line A.3: Electricity that can be produced for on-site use (kW) = _________________ (Applying Step 1, Line C.1 to Figure 5)

Line A.4: Compare the electricity produced (from Line A.3) to the current electric load (from Line A.2) to determine the percentage of produced electricity that can be utilized on-site. [*Note: The excess electricity might be purchased by the servicing utility and provide a potential revenue stream for the project. The economics of doing so will depend on the utility's buy back rate, the cost of tying into the electric grid, and other factors.*]

<u>For direct use in on-site boilers or furnaces</u>

Line A.6: Current heating demand (mmBTU/hr) = Highest monthly total usage (mmBTU) (Obtained from the local utility bill) / 744 hours per month (31 days @ 24 hrs/day)

= ____________________ / 744 = _____________mmBTU/hr

Line A.7: Energy that can be produced for on-site use (mmBTU/hr) = ________________ (Applying Step 1, Line C.1 to Figure 5)

Line A.8: Compare the Energy (from Line A.6) to the current energy availability (from Line A.7) to determine the percentage of the produced energy that can be utilized on-site.

B. Assess the Gas Quality

The preceding analysis assumed a methane concentration of 40%. In some cases concentrations between 40% and 35% can be utilized, but that requires a site-specific determination beyond the scope and purpose of this tool. Methane concentrations below 35% are typically too low to be considered for commercial sale.

Step 3: Evaluate the Project Costs

Figure 6 and Table 1 can be used to estimate the breakeven rate of producing electricity or utilizing gas directly in boilers or furnaces. To estimate the break even rate for producing electricity proceed to Line A.1 and for utilizing the energy content in boilers or furnaces (direct use) proceed to Line A.3.

For Eletricity Generation Projects

Line A.1: Break even rate ($/kWh) = ______________________ (Applying Step 2, Line A.3 to Figure 6)

Line A.2: Is the break even rate from Line A.1, above, equal or greater than the current electric cost?

_____ **Yes. The methane-to-energy project may be cost effective.**

_____ **No. The methane-to-energy project may not be cost effective**. Refer to Step 4 in the Tool Document for potential ways to improve gas flow and/or methane concentration.

For Non-Commercial Scale Direct Use Projects

Line A.3: Break even rate ($/mmBTU) = ______________________ (Applying Step 1, Line C.1 to Table 1)

Line A.2: Is the break even rate from Line A.3, above, equal or greater than the current natural gas cost that is or would be supplied to the combustor?

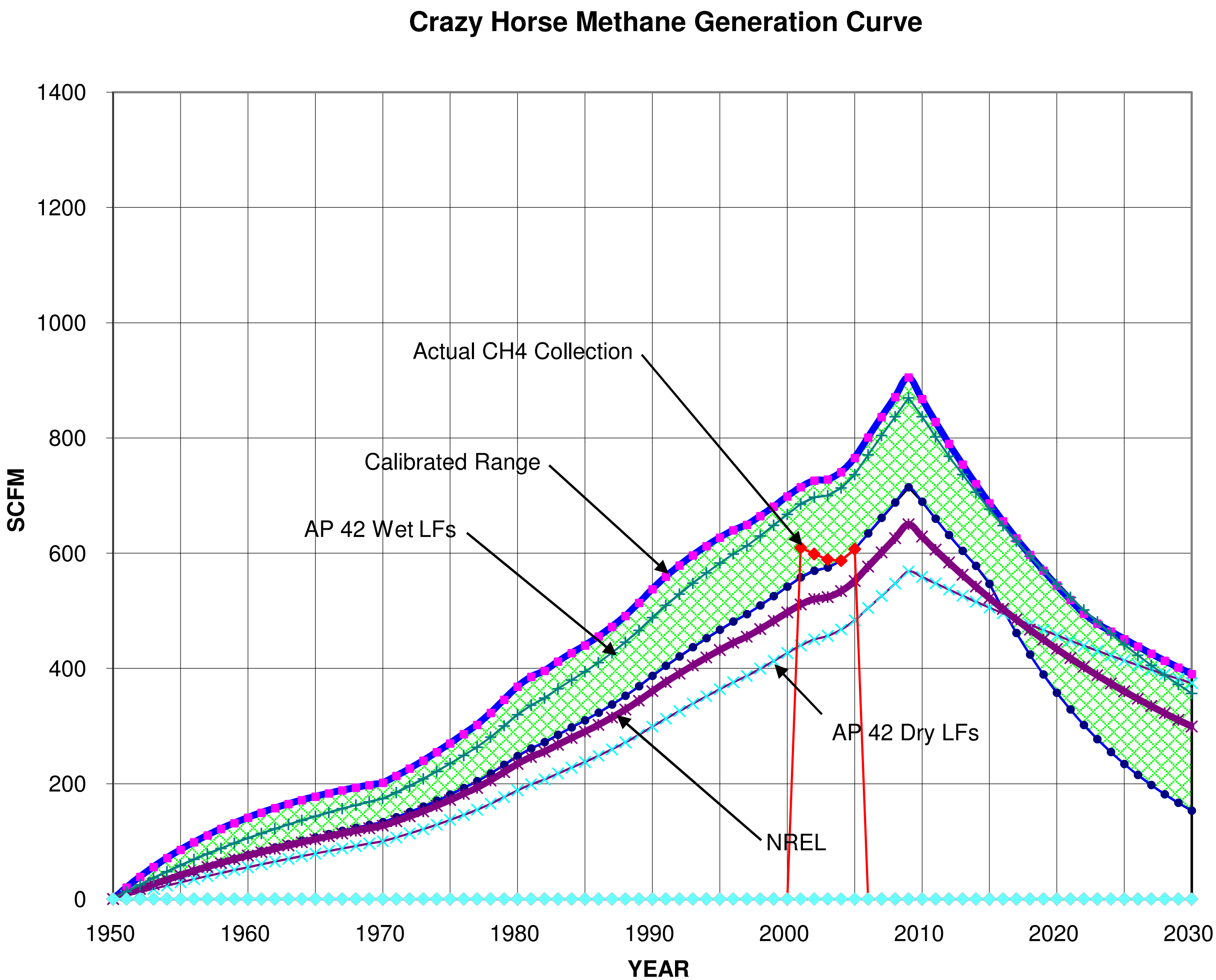
_____ **Yes. The methane-to-energy project may be cost effective.**

_____ **No. The methane-to-energy project may not be cost effective**. Refer to Step 4 in the Tool Document for potential ways to improve gas flow and/or methane concentration.

Appendix H

Crazy Horse Landfill Gas Collection Data

GEM ID	Name	Date Time	CH4 % by vol	CO2 % by vol	O2 % by vol	Bal Gas % by vol	Init Flow scfm	Ref Temp	Temp	Init Stat Press In. H2O	Adj Stat Press In. H2O	Diff Press In. H2O	Comment
CHLF0BFS	BFS	1/7/2010 14:04	46.3	35.5	0.8	17.4	1866	609	1609	-29.9	-29.9	29.549	-
CHLF0BFS	BFS	1/7/2010 14:48	46.9	36.8	0.4	15.9	1848	550	1550	-30.1	-30.1	29.789	-
CHLF0BFS	BFS	1/7/2010 14:50	46.9	35.7	0.6	16.79	1848	550	1550	4.7	4.6	-4.65	-
CHLF0BFS	BFS	1/13/2010 8:44	45.2	36.8	0.7	17.29	1834	545	1545	-32.8	-32.7	32.546	-
CHLF0BFS	BFS	1/13/2010 12:46	45.4	34.9	0.3	19.39	1834	538	1538	-31.8	-31.7	31.4	-
CHLF0BFS	BFS	1/13/2010 12:48	45.8	34.6	0.3	19.3	1834	538	1538	4.5	4.5	-4.568	-
CHLF0BFS	BFS	1/15/2010 10:30	43.3	36.9	0.2	19.59	1868	537	1537	-31.6	-31.8	31.616	-
CHLF0BFS	BFS	1/19/2010 9:08	46.3	36.5	0	17.2	1844	526	1526	-31.7	-31.6	31.244	-
CHLF0BFS	BFS	1/19/2010 13:25	48.1	38.7	0.2	13	1834	545	1545	-30.8	-31.2	30.652	-
CHLF0BFS	BFS	1/19/2010 13:28	47.4	38.2	0.4	13.99	1834	545	1545	4.6	4.3	-4.389	-
CHLF0BFS	BFS	1/27/2010 9:18	42.2	34.1	2.4	21.3	1871	535	1535	-31.2	-31.2	31.023	-
CHLF0BFS	BFS	1/27/2010 16:52	45.6	36.9	0.3	17.2	1866	552	1552	-31.1	-31.2	30.872	-
CHLF0BFS	BFS	1/27/2010 16:55	46	37.1	0.3	16.6	1866	552	1552	4.7	4.7	-4.668	-
CHLF0BFS	BFS	1/28/2010 9:15	45.7	36.9	0.9	16.49	1862	551	1551	-32.6	-32.6	32.344	-
CHLF0BFS	BFS	1/28/2010 10:58	45.3	36.9	0.7	17.09	1848	539	1539	-31.7	-31.8	31.46	-
CHLF0BFS	BFS	1/28/2010 11:00	44	35.8	0.6	19.6	1848	539	1539	-31.8	-31.8	31.423	-
CHLF0BFS	BFS	2/1/2010 10:31	47.2	36.8	0.3	15.7	1838	556	1556	-32.1	-32.2	31.764	-
CHLF0BFS	BFS	2/1/2010 10:49	47.2	37.3	0.1	15.4	1837	559	1559	-32	-32	31.574	-
CHLF0BFS	BFS	2/4/2010 8:55	47	37.2	0.8	14.99	1832	541	1541	-32.2	-32.2	31.94	-
CHLF0BFS	BFS	2/4/2010 13:01	47.8	37.8	0.4	14	1833	539	1539	-31.1	-31.1	30.886	-
CHLF0BFS	BFS	2/4/2010 13:03	47.1	36.8	0.6	15.5	1833	539	1539	4.2	4.1	-4.164	-
CHLF0BFS	BFS	2/8/2010 9:17	47.2	36.3	0.5	16	1852	551	1551	-31.9	-31.8	31.802	-
CHLF0BFS	BFS	2/8/2010 14:04	50.3	37.6	0.4	11.7	1854	549	1549	-31.2	-31.3	30.938	-
CHLF0BFS	BFS	2/8/2010 14:05	50.3	37.6	0.4	11.7	1854	549	1549	-31.2	-31.3	30.953	-
CHLF0BFS	BFS	2/8/2010 14:06	49.6	36.8	0.4	13.2	1854	549	1549	4.6	4.6	-4.631	-
CHLF0BFS	BFS	2/12/2010 13:34	39.7	31.8	2.9	25.6	1857	545	1545	-30.9	-30.9	30.507	-
CHLF0BFS	BFS	2/15/2010 10:23	43.2	33.8	2.4	20.6	1869	558	1558	-30.6	-30.7	30.354	-
CHLF0BFS	BFS	2/15/2010 13:32	43.3	32.3	2.1	22.3	1863	544	1544	-29.5	-29.5	28.972	-
CHLF0BFS	BFS	2/15/2010 13:34	43	31.6	2.3	23.1	1863	544	1544	4.7	4.7	-4.756	-
CHLF0BFS	BFS	2/19/2010 11:39	42.1	33.6	2.5	21.8	1755	534	1534	-34.6	-34.5	-31.411	-
CHLF0BFS	BFS	2/22/2010 12:29	44.6	34.2	2.3	18.9	1809	591	1591	-32.9	-32.8	32.495	-
CHLF0BFS	BFS	2/24/2010 8:48	42.7	34	2.9	20.4	1761	53	1534	-35.2	-35.2	-30.665	-
CHLF0BFS	BFS	2/24/2010 8:48	42.7	34	2.9	20.4	1761	534	1534	-35.2	-35.2	-30.673	-
CHLF0BFS	BFS	2/24/2010 14:51	41.5	34	2.5	22	1760	544	1544	-34.1	-34.1	-31.614	-
CHLF0BFS	BFS	2/24/2010 14:53	41.9	34	2.7	21.39	1760	544	1544	3.2	2.9	-2.752	-
CHLF0BFS	BFS	3/2/2010 9:42	43.3	34.2	2.5	20	847	547	1547	-29.2	-29.2	29.312	-
CHLF0BFS	BFS	3/2/2010 9:42	43.3	34.2	2.5	20	847	547	1547	-29.2	-29.5	29.432	-
CHLF0BFS	BFS	3/2/2010 14:56	45	35.2	1.9	17.9	1845	555	1555	-30.8	-31	30.968	-
CHLF0BFS	BFS	3/2/2010 14:59	44.6	33.7	1.9	19.8	1845	555	1555	4.8	4.5	-4.739	-
CHLF0BFS	BFS	3/4/2010 16:00	49.7	37.8	0.7	11.8	1750	540	1540	-34.4	-34.4	-30.925	-
CHLF0BFS	BFS	3/4/2010 16:02	50.2	37.3	0.7	11.8	1750	540	1540	4.2	4.1	-4.237	-
CHLF0BFS	BFS	3/9/2010 8:15	49.2	36.4	0.5	13.89	1848	547	1547	-32.6	-32.6	32.692	-
CHLF0BFS	BFS	3/9/2010 12:53	46	36.5	1	16.5	1834	534	1534	-31.3	-31.3	31.502	-
CHLF0BFS	BFS	3/9/2010 12:56	45.6	36.1	0.9	17.4	1834	534	1534	4.6	4.5	-4.626	-
CHLF0BFS	BFS	3/11/2010 12:23	43.5	33.9	1.3	21.3	1814	564	1564	-31.6	-31.6	31.731	-
CHLF0BFS	BFS	3/11/2010 12:39	43.2	33.1	1.2	22.5	1816	559	1559	-31.3	-31.4	31.635	-
CHLF0BFS	BFS	3/15/2010 8:41	43.2	35	1.5	20.29	1844	578	1578	-31.9	-31.8	32.483	-
CHLF0BFS	BFS	3/15/2010 12:43	45.5	35.4	0.8	18.29	1809	549	1549	-31.7	-31.7	31.937	-
CHLF0BFS	BFS	3/15/2010 12:46	44.5	34.7	0.8	20	1809	549	1549	4.5	4.3	-4.357	-
CHLF0BFS	BFS	3/22/2010 11:05	45.6	34.7	1.6	18.1	1862	558	1558	-29.5	-29.5	29.748	-
CHLF0BFS	BFS	3/22/2010 11:07	46	34.3	1.5	18.2	1862	558	1558	4.7	4.8	-4.88	-
CHLF0BFS	BFS	3/23/2010 14:54	44.8	33.9	1.5	19.79	1848	541	1541	-28.4	-28.5	28.659	-
CHLF0BFS	BFS	3/23/2010 14:58	44.9	33.6	1.6	19.9	1848	541	1541	4.7	4.7	-4.744	-
CHLF0BFS	BFS	3/30/2010 8:35	46.2	38.1	0.4	15.3	1722	542	1542	-36.7	-36.5	-28.49	-
CHLF0BFS	BFS	3/30/2010 17:50	45.4	37.3	0.2	17.09	1718	533	1533	-36	-35.9	-29.372	-
CHLF0BFS	BFS	3/30/2010 17:52	46.1	37.2	0.3	16.4	1718	533	1533	3.9	4	-4.071	-



Information used in the landfill gas generation model includes numerous assumptions concerning refuse composition, decomposition rate, moisture content and other semi or non quantifiable information. It should be recognized that the decomposable fraction of refuse at any landfill along with numerous other semi-quantifiable variables are impossible to quantify. While specific methane and/or LFG production rates are included in this figure, these rates are impossible to accurately predict. All results must be used with caution. No warranty is expressed or implied. The work provided is consistent with the standard of care and skill ordinarily exercised by members of our profession currently practicing under similar conditions in Southern California.

Appendix I

Fresno Sanitary Landfill Gas Collection Data

Information Request

Fresno Municipal Sanitary Landfill

1. Landfill Characteristics

   Acres: 145______Average Depth:_____________ CY/tons in place: 4,800,000 tons___________
   Date of Waste Acceptance- Begin: 1935__ End: 1989____ % MSW:______________
   Closure/Capping Year: 2000-2003 . Gas System Installation Year: first tried in 1991 but failed to prevent migration of gas beyond the migration barriers, current system was in 2001 __________________
   What type of cap was used: ____

2. Landfill Gas-Active Collection System

   Is an active in-waste gas collection system operating currently? Yes ______
   If present but no longer active , please provide year it was deactivated:__________
   Does active system run continuously or is it cycled on and off? _____________
   Describe the landfill gas treatment system (flare) present on site: Flare ________________________
   Monitoring Frequency and parameters monitored (flow rate/gas composition/pressure/other) of the active collection and treatment system: ____

3. Monitoring Data
   Please provide most recent monitoring data related to Item 3 (one year for frequent monitoring, additional years for less frequent monitoring) or describe how we can obtain a copy:
   - Gas Quality:____
   - Gas Flow (Cubic Feet):____

4. Feasibility Studies

   Have any feasibilities studies related to landfill gas generation or production (landfill gas curves, flows, quality, etc.) been performed? Please attach report or describe how we can obtain a copy:
   ____

5. Remediation Activities

   A. List any remediation activities that are taking place at the facility: Groundwater pump and treat system, leachate collection system, and a gas collection and control system. ____________________

   B. List of remediation/operations equipment still operating, including pertinent data such as pump size, aeration blower size, etc. and how often it is operated: Blower/flare stations and pump(s) for leachate collection and groundwater treatment HP rating- Blowers:___________Pump(s):_________

   C. Are recent electric and/or gas utility bills for the site available? Please provide or describe how we can obtain a copy:____

   D. What is the expected remaining duration of the operations described in 5A. __________________
   ____

DataField CS - GA Mode Data Output

Device ID	Date/Time	CH4	CO2	O2	Balance
	mm/dd/yyyy	%	%	%	%
--------	5/24/2010 9:33	22.4	27.4	1.6	48.6
--------	5/24/2010 9:33	22.4	27.2	1.5	48.9
FRESBLOT	5/24/2010 9:36	24.4	27	1.4	47.19
FRESEW04	5/24/2010 10:04	48.6	38.2	1.3	11.9
FRESEW03	5/24/2010 10:07	27.5	21.3	9.6	41.6
FRESEW02	5/24/2010 10:10	52.9	39.8	0.2	7.09
FRESEW01	5/24/2010 10:13	22.2	29.6	0.1	48.1
FRESEW05	5/24/2010 10:38	32.1	33.7	0.9	33.3
FRESEW06	5/24/2010 10:40	18.9	27.4	1.1	52.6
FRESEW07	5/24/2010 10:44	18.3	26.6	0.6	54.5
FRESEW07	5/24/2010 10:46	41.1	35.5	1.9	21.5
FRESEX05	5/24/2010 11:04	40.2	32.1	6.4	21.3
FRESEX05	5/24/2010 11:04	41.1	35.6	1.5	21.8
FRESEW08	5/24/2010 11:08	38.9	33.1	1	27
FRESEW09	5/24/2010 11:12	30.8	27.9	1.5	39.79
FRESEW09	5/24/2010 11:12	31.3	28.1	1.1	39.5
FRSGLFG3	5/24/2010 11:20	32.1	31	0.4	36.5
FRESEW10	5/24/2010 11:23	23.3	28.1	0.9	47.69
FRESEW11	5/24/2010 11:26	19.1	26.8	0.2	53.9
FRESEW12	5/24/2010 11:30	3.5	4.6	16.4	75.5
FRESEX04	5/24/2010 11:33	34	30.4	0.3	35.3
FRESEW14	5/24/2010 11:36	32.8	29.2	4.3	33.69
FRESEW13	5/24/2010 11:40	39.1	32.9	0.2	27.8
FRESEW15	5/24/2010 11:41	39.1	32.4	0.5	28
FRESEW16	5/24/2010 11:42	38.7	31.9	1.2	28.2
FRESEX03	5/24/2010 11:44	38.6	32.1	1.6	27.7
FRESEW19	5/24/2010 12:01	28.7	19.7	9.4	42.2
FRSGLFG4	5/24/2010 12:03	37	26.9	5.5	30.59
FRESEW17	5/24/2010 12:04	0.4	0	19.7	79.89
FRESEW17	5/24/2010 12:05	37.7	26.5	6.2	29.59
FRESEW18	5/24/2010 12:10	47.1	34.1	1.5	17.3
FRESEW20	5/24/2010 12:11	46.2	34.2	1.8	17.79
FRESEW21	5/24/2010 12:17	31.7	29.2	3	36.1
FRESEX02	5/24/2010 12:20	21.8	20.3	7.9	49.99
FRESEW24	5/24/2010 12:22	26.8	23.5	6.4	43.29
FRESEW23	5/24/2010 12:25	1.1	15.9	2.1	80.9
FRESEW22	5/24/2010 12:28	16.2	24.1	0.5	59.2
FRESEW25	5/24/2010 12:33	21.5	25.9	1.2	51.4
FRESEW26	5/24/2010 12:36	15.9	22	1.8	60.3
FRESEW27	5/24/2010 12:39	28.3	30.2	0.5	40.99
FRESEX01	5/24/2010 12:43	40.4	28.9	4.2	26.5
FRESEW76	5/24/2010 12:44	39.7	28.2	4.6	27.49
FRESEW29	5/24/2010 12:49	40	28.6	4.4	27
FRESEW28	5/24/2010 12:52	38.7	28.1	4.9	28.29

FRESEW30	5/24/2010 12:52	0.3	0	19.8	79.89
FRESEW30	5/24/2010 12:53	38.7	27.7	5	28.59
FRESEW31	5/24/2010 12:58	34.8	32.7	0.7	31.79
FRESEW79	5/24/2010 13:00	35.3	32.3	0.6	31.79
FRESEW82	5/24/2010 13:37	33.5	22.2	8.2	36.09
FRESEW34	5/24/2010 13:39	46.5	32.5	2.6	18.4
FRESEW32	5/24/2010 13:41	47.4	34.9	1.6	16.09
FRESEW33	5/24/2010 13:46	14.9	21.3	3.8	60
FRESEW35	5/24/2010 13:49	15.3	23.5	1.2	59.99
FRESEW36	5/24/2010 13:52	12.8	21.8	2.3	63.09
FRESEW84	5/24/2010 13:55	47.4	34.9	1.2	16.49
FRESEW88	5/24/2010 13:58	54.5	37.2	1.3	6.99
FRESEW38	5/24/2010 14:02	0.1	0	20.2	79.69
FRESEW37	5/24/2010 14:06	34.7	29.7	1	34.6
FRSGLFG5	5/24/2010 14:08	35	29.5	0.6	34.9
FRESEW39	5/24/2010 14:10	34	29.4	1.2	35.39
FRESEW40	5/24/2010 14:16	0.1	0	20.2	79.69
FRESEW91	5/24/2010 14:20	59.5	40.2	0.6	N/A
FRESEW94	5/24/2010 14:27	58.9	36.1	0.7	4.3
FRESEW42	5/24/2010 14:30	22.9	16.4	10	50.69
FRESEW41	5/24/2010 14:34	9.5	8.4	13.1	69
FRESEW43	5/24/2010 14:37	16.1	13.5	11.2	59.2
FRESEW44	5/24/2010 14:40	25.3	22.2	5.8	46.69
FRESEW45	5/24/2010 14:44	42.5	27	6	24.5
FRSEW105	5/24/2010 14:49	58.7	38.3	0.8	2.2
FRSEW104	5/24/2010 14:53	53.5	36.7	1.4	8.39
FRESEW49	5/24/2010 14:56	51.2	37	3.2	8.59
FRESEW46	5/25/2010 8:11	50	38	0.2	11.8
FRESEW47	5/25/2010 8:15	60.3	43.3	0	N/A
FRESEW48	5/25/2010 8:18	43.6	34.4	0.4	21.6
FRESEW50	5/25/2010 8:20	63	40.4	0	N/A
FRSEW103	5/25/2010 8:22	45.4	37.2	4.8	12.59
FRSEW101	5/25/2010 8:25	42.5	36.1	0.1	21.3
FRSEW102	5/25/2010 8:27	44.8	36.2	1.4	17.6
FRSEW100	5/25/2010 8:30	55.2	39.4	2	3.39
FRESEW99	5/25/2010 8:33	45.6	36.9	0.8	16.7
FRESEW98	5/25/2010 8:35	48.7	37.1	0.7	13.5
FRESEW96	5/25/2010 8:38	48.4	39.5	0.5	11.59
FRESEW97	5/25/2010 8:40	64.5	34.1	0.2	1.2
FRESEW93	5/25/2010 9:01	51.3	36.4	0.4	11.9
FRESEW95	5/25/2010 9:04	54.4	36.5	0.8	8.29
FRESEW92	5/25/2010 9:09	53.6	35.7	3.3	7.4
FRESEW89	5/25/2010 9:12	61.6	41.4	1.8	N/A
FRESEW90	5/25/2010 9:15	39.6	29.4	2.5	28.5
FRESEW87	5/25/2010 9:18	51.4	30.2	11.1	7.29
FRESEW87	5/25/2010 9:18	54.5	36.4	0.4	8.69
FRESEW86	5/25/2010 9:23	40.9	26.9	16.4	15.79

FRESEW86	5/25/2010 9:23	49.9	37.4	2.1	10.59
FRESEW85	5/25/2010 9:24	51.8	38.1	0.5	9.6
FRESEW83	5/25/2010 9:35	44	34.2	0.5	21.3
FRESEW81	5/25/2010 9:38	42.7	33.8	0.1	23.4
FRSGLFG1	5/25/2010 9:41	39.4	33.5	0.2	26.89
FRESEW80	5/25/2010 9:45	53	37.5	0.9	8.6
FRESEW77	5/25/2010 9:47	54.9	38.9	0.5	5.69
FRESEW78	5/25/2010 9:48	56.2	40.1	0	3.7
FRESEW75	5/25/2010 9:51	50.1	36.5	1	12.4
FRESEW74	5/25/2010 9:54	21.8	27.1	0.4	50.69
FRESEW73	5/25/2010 9:58	44.8	35.3	0.2	19.7
FRESEW71	5/25/2010 10:02	25.7	26.9	0.4	47
FRESEW72	5/25/2010 10:05	58.2	39.3	0.3	2.2
FRESEW70	5/25/2010 10:09	42.5	32.9	3	21.59
FRESEW69	5/25/2010 10:11	43.7	33.7	2.4	20.19
FRESEW67	5/25/2010 10:17	20	25.3	0.3	54.4
FRESEW68	5/25/2010 10:21	56.6	37.8	0.2	5.4
FRESEW65	5/25/2010 10:25	55.2	38.3	0.3	6.2
FRESEW66	5/25/2010 10:29	18.8	24	2.4	54.79
FRESEW64	5/25/2010 10:35	50.5	38.1	0.3	11.1
FRESEW62	5/25/2010 10:38	51.3	38.5	0.6	9.6
FRESEW63	5/25/2010 10:48	51.1	38.1	0.4	10.4
FRESEW61	5/25/2010 10:58	57.2	35	2	5.79
FRESEW53	5/25/2010 11:49	58.4	40.5	0.6	0.49
FRESEW60	5/25/2010 12:10	53.4	38.6	0.6	7.4
FRESEW59	5/25/2010 12:12	28.7	20.7	13.3	37.3
FRESEW58	5/25/2010 12:17	24	18.7	9.2	48.1
FRESEW56	5/25/2010 12:20	56.2	39.1	0.6	4.1
FRESEW57	5/25/2010 12:23	53.5	38.5	0.5	7.5
FRESEW55	5/25/2010 12:28	53.4	38.2	0.8	7.59
FRSGLFG2	5/25/2010 12:33	46.7	33.3	1.5	18.5
FRESEW51	5/25/2010 12:34	43.2	23.5	9.3	24
FRESEW52	5/25/2010 12:36	51.8	36.9	2.9	8.39
FRESEW54	5/25/2010 12:38	52.2	38.1	1.3	8.4
FRESEW53	6/24/2010 8:00	54.4	37.9	1.5	6.19
FRESEW04	6/24/2010 8:01	54.4	37.6	1.5	6.5
FRESEW04	6/24/2010 8:02	54.3	37.8	1.6	6.3
FRESEW03	6/24/2010 8:05	48.6	35.1	3.5	12.8
FRESEW02	6/24/2010 8:07	50.6	36.5	1.8	11.1
FRESEW01	6/24/2010 8:09	54.9	39.5	0.9	4.69
FRESEW05	6/24/2010 8:11	55.8	39.1	0.9	4.2
FRESEW06	6/24/2010 8:14	62.5	35.5	1	1
FRESEW07	6/24/2010 8:16	0.6	0	19.2	80.19
FRESEW08	6/24/2010 8:17	48.8	34.5	3.4	13.3
FRESEX05	6/24/2010 8:19	58.8	40.4	1	N/A
FRESEX05	6/24/2010 8:20	58.8	39.8	1.5	N/A
FRESKOPI	6/24/2010 8:50	15.2	14.9	9.9	60

FRESBLOT	6/24/2010 8:51	25.6	26.1	3	45.3
FRSGLFG3	6/24/2010 8:57	54.7	37.6	1.5	6.2
FRESEW10	6/24/2010 9:04	48.8	33.8	3.2	14.2
FRESEW11	6/24/2010 9:06	53.9	37	1.6	7.49
FRESEW12	6/24/2010 9:12	55.1	37.3	1.5	6.1
FRESEX04	6/24/2010 9:14	34.5	21.5	7.6	36.4
FRESEW14	6/24/2010 9:16	55	39	1.4	4.6
FRESEW13	6/24/2010 9:19	54.8	37.9	1.6	5.69
FRESEW15	6/24/2010 9:21	0.6	2.6	17.6	79.2
FRESEW16	6/24/2010 9:28	1.5	2	18.5	78
FRESEX03	6/24/2010 9:31	55.5	38.7	1.9	3.89
FRESEW19	6/24/2010 9:34	39.9	26.5	6.1	27.49
FRSGLFG4	6/24/2010 9:36	50.2	34.8	3.4	11.6
FRESEW17	6/24/2010 9:38	33.6	25.9	4.6	35.9
FRESEW20	6/24/2010 9:41	0.3	0.1	20	79.6
FRESEW21	6/24/2010 9:41	39	29.4	5.1	26.5
FRESEX02	6/24/2010 9:45	41.9	30.1	4.2	23.8
FRESEW24	6/24/2010 9:48	0.2	0	19.6	80.2
FRESEW23	6/24/2010 9:51	27.3	23.7	6.2	42.79
FRESEW22	6/24/2010 9:54	8.1	4.8	16.5	70.6
FRESEW25	6/24/2010 9:57	12.4	10.9	12.7	63.99
FRESEW26	6/24/2010 10:00	0.1	0	20.1	79.8
FRESEW27	6/24/2010 10:03	16.3	12.9	11.8	58.99
FRESEX01	6/24/2010 10:05	29.1	24.4	5.4	41.1
FRESEW76	6/24/2010 10:08	15.2	11.6	13	60.2
FRESEW29	6/24/2010 10:10	23.4	18.1	9.6	48.9
FRESEW28	6/24/2010 10:13	9.9	13.9	8.4	67.79
FRESEW30	6/24/2010 10:15	9.1	17.5	6.4	67
FRESEW31	6/24/2010 10:20	17.1	20	7.2	55.7
FRESEW79	6/24/2010 10:22	26.3	18.5	11.1	44.1
FRESEW82	6/24/2010 10:25	7.5	6.8	15.3	70.39
FRESEW34	6/24/2010 10:28	7.7	9.4	13	69.9
FRESEW32	6/24/2010 10:31	0	0	20.5	79.5
FRESEW33	6/24/2010 10:38	0	0	20.6	79.4
FRESEW35	6/24/2010 10:41	0	0	20.7	79.3
FRESEW35	6/24/2010 10:46	2.1	18.6	1.3	78
FRESEW35	6/24/2010 10:46	2.2	18.7	1.3	77.8
FRESEW36	6/24/2010 10:48	31.5	32.8	0.9	34.8
FRESEW84	6/24/2010 10:51	32.6	29	0.9	37.5
FRESEW88	6/24/2010 10:54	37.2	34.1	0.9	27.8
FRESEW38	6/24/2010 10:56	14.1	11.8	11	63.1
FRESEW37	6/24/2010 10:59	16.3	23.2	2	58.49
FRSGLFG5	6/24/2010 11:01	34.4	30.7	0.9	33.99
FRESEW39	6/24/2010 11:05	37.1	34.1	1.2	27.6
FRESEW40	6/24/2010 11:08	32	26.6	4.2	37.2
FRESEW91	6/24/2010 11:11	34.2	29.6	1.8	34.4
FRESEW94	6/24/2010 11:25	40.8	31.2	0.9	27.1

FRESEW42	6/24/2010 11:28	43.9	31.2	1.6	23.29
FRESEW41	6/24/2010 11:31	48.8	36.1	0.9	14.2
FRESEW43	6/24/2010 11:33	54.7	41	0.8	3.49
FRESEW44	6/24/2010 11:36	53.8	39.7	1.7	4.8
FRESEW45	6/24/2010 11:39	56	34.7	1.1	8.19
FRSEW105	6/24/2010 11:42	42.8	33.4	1	22.8
FRSEW104	6/24/2010 11:44	48.3	35.5	1	15.2
FRESEW49	6/24/2010 11:47	50.9	39.2	0.9	8.99
FRESEW46	6/24/2010 11:50	33.8	30.8	0.9	34.49
FRESEW47	6/24/2010 11:52	53.5	38.1	1.1	7.3
FRESEW47	6/24/2010 11:53	52.5	38.3	1.5	7.7
FRESEW48	6/24/2010 11:55	45.7	35.6	0.9	17.8
FRESEW50	6/24/2010 11:58	51	38.9	0.9	9.19
FRSEW103	6/24/2010 12:00	47.2	37	1	14.79
FRSEW101	6/24/2010 12:02	47.6	36.6	1	14.8
FRSEW102	6/24/2010 12:07	45.3	35.6	0.9	18.2
FRSEW100	6/24/2010 12:11	40.5	33.4	1.1	24.99
FRESEW99	6/24/2010 12:13	41.6	35.5	0.9	22
FRESEW98	6/24/2010 12:15	23.8	27.9	1.7	46.59
FRESEW96	6/24/2010 12:18	15	24.5	2.4	58.1
FRESEW97	6/24/2010 12:21	43.8	35.5	1	19.7
FRESEW93	6/24/2010 12:23	32.6	30	1	36.4
FRESEW95	6/24/2010 12:25	20.6	26.6	1.3	51.5
FRESEW92	6/24/2010 12:28	17.7	25.8	0.9	55.6
FRESEW89	6/24/2010 12:30	60.5	39.4	0.9	N/A
FRESEW90	6/24/2010 12:32	30	31.3	0.9	37.8
FRESEW87	6/24/2010 12:34	23.2	27.7	0.9	48.2
FRESEW86	6/24/2010 12:46	20.3	26.2	1	52.49
FRESEW85	6/24/2010 12:49	17.5	23.7	2.8	56
FRESEW83	6/24/2010 12:52	13.7	23.2	1.2	61.9
FRSGLFG1	6/25/2010 7:53	13.2	23.1	3.5	60.2
FRESEW80	6/25/2010 7:56	15	24	1	60
FRESEW77	6/25/2010 7:59	20.5	28.5	1.4	49.6
FRESEW78	6/25/2010 8:01	6.5	21.6	1.4	70.5
FRESEW75	6/25/2010 8:06	6.5	21.4	2.2	69.9
FRESEW74	6/25/2010 8:09	1.7	20.7	1.3	76.3
FRESEW73	6/25/2010 8:12	6.3	22.9	0.7	70.1
FRESEW71	6/25/2010 8:15	0.2	0	19.7	80.1
FRESEW71	6/25/2010 8:18	0.9	18.2	0.6	80.29
FRESEW72	6/25/2010 8:20	16.8	24.8	0.7	57.69
FRESEW70	6/25/2010 8:23	36.6	34.1	0.4	28.9
FRESEW69	6/25/2010 8:31	15.3	22.6	0.3	61.8
FRESEW67	6/25/2010 8:34	25.5	26	1.3	47.2
FRESEW68	6/25/2010 8:36	43.8	35.5	0.1	20.6
FRESEW65	6/25/2010 8:39	46.2	33.5	3.7	16.59
FRESEW65	6/25/2010 8:39	46.4	33.8	3.6	16.19
FRESEW66	6/25/2010 8:42	45.9	34.8	0.2	19.09

FRESEW64	6/25/2010 8:45	53.1	37.8	1.6	7.5
FRESEW62	6/25/2010 8:48	52.1	36.8	1.7	9.4
FRESEW63	6/25/2010 8:49	0.4	0	19.8	79.8
FRESEW63	6/25/2010 8:53	53.7	39	1	6.29
FRESEW61	6/25/2010 8:56	56.3	37.4	0.7	5.59
FRESEW60	6/25/2010 8:58	50.7	36	2	11.29
FRESEW59	6/25/2010 9:01	54.3	33.1	2.7	9.9
FRESEW58	6/25/2010 9:06	33.4	23.2	7.8	35.59
FRESEW56	6/25/2010 9:08	59.7	39.3	0.3	0.7
FRESEW57	6/25/2010 9:11	60.5	40.5	0.4	N/A
FRESEW55	6/25/2010 9:13	50.4	37.9	2.1	9.59
FRSGLFG2	6/25/2010 9:15	51.2	38.4	0.3	10.09
FRESEW51	6/25/2010 9:20	60	41.4	0.2	N/A
FRESEW52	6/25/2010 9:35	59.9	40.3	1	N/A
FRESEW52	6/25/2010 9:35	59.9	39.8	0.7	N/A
FRESEW52	6/25/2010 9:36	60.4	40.5	0.7	N/A
FRESEW54	6/25/2010 9:40	57.5	41.2	0.7	0.59
FRESEW53	6/25/2010 9:44	60	39.9	0.6	N/A
FRESKOPI	7/29/2010 9:57	29	23.7	6.4	40.89
FRESBLOT	7/29/2010 9:59	29.5	23.8	6	40.7
FRESEW04	7/29/2010 10:05	60.2	40.9	0.6	N/A
FRESEW03	7/29/2010 10:13	59	38.8	2.4	N/A
FRESEW02	7/29/2010 10:15	53.9	37.3	2.1	6.69
FRESEW01	7/29/2010 10:17	56.9	38.8	1.2	3.09
FRESEW05	7/30/2010 7:08	59.4	41.6	0.8	N/A
FRESEW06	7/30/2010 7:10	59.9	37.9	3.6	N/A
FRESEW07	7/30/2010 7:13	60.5	42.4	1.5	N/A
FRESEX05	7/30/2010 7:15	61.2	43.4	0.7	N/A
FRESEW08	7/30/2010 7:17	61.1	42.7	1	N/A
FRESEW09	7/30/2010 7:19	58.6	42	1.1	N/A
FRSGLFG3	7/30/2010 7:21	61.3	41.5	1	N/A
FRESEW10	7/30/2010 7:23	57.8	35.4	6.6	0.19
FRESEW10	7/30/2010 7:23	57.8	40.1	1.1	1
FRESEW11	7/30/2010 7:25	61.2	36.7	0.7	1.39
FRESEW12	7/30/2010 7:30	57.4	39.8	3.5	N/A
FRESEX04	7/30/2010 7:31	61.6	34.1	0.4	3.9
FRESEW14	7/30/2010 7:33	58.8	41.2	2.6	N/A
FRESEW13	7/30/2010 7:35	60.1	40.3	1.1	N/A
FRESEW15	7/30/2010 7:37	55.5	37.5	1.3	5.7
FRESEW16	7/30/2010 7:38	44.2	28.6	2	25.2
FRESEW16	7/30/2010 7:39	44.2	28.2	1.6	25.99
FRESEW16	7/30/2010 7:41	56	40	1.6	2.4
FRESEX03	7/30/2010 7:42	59.4	40	4.3	N/A
FRESEW19	7/30/2010 7:44	55.9	40.1	2	2
FRSGLFG4	7/30/2010 7:47	59.6	41.4	1.1	N/A
FRESEW17	7/30/2010 7:49	43.7	27.9	2.7	25.7
FRESEW18	7/30/2010 7:51	0.3	0	20.4	79.29

FRESEW20	7/30/2010 7:53	32.7	28.7	1.3	37.3
FRESEW20	7/30/2010 7:53	32.7	28.6	1.1	37.6
FRESEW21	7/30/2010 7:55	53	39.6	1.7	5.7
FRESEX02	7/30/2010 7:56	52.5	35.9	2.1	9.49
FRESEW24	7/30/2010 7:59	53.7	40	1.8	4.49
FRESEW23	7/30/2010 8:01	37.1	27.8	1.6	33.5
FRESEW22	7/30/2010 8:03	0.3	0	20.4	79.29
FRESEW25	7/30/2010 8:05	42.2	30.2	1.9	25.7
FRESEW26	7/30/2010 8:06	0.4	0	20.3	79.3
FRESEW27	7/30/2010 8:08	48.2	37	1.9	12.9
FRESEX01	7/30/2010 8:10	44	32.9	1.9	21.2
FRESEW76	7/30/2010 8:12	53.6	37.7	1.4	7.3
FRESEW29	7/30/2010 8:14	54.9	38.5	2.2	4.39
FRESEW28	7/30/2010 8:16	32.1	26.6	2.8	38.5
FRESEW30	7/30/2010 8:18	46.5	36.8	0.7	16
FRESEW31	7/30/2010 8:20	55.8	37	2.1	5.1
FRESEW79	7/30/2010 8:22	58.7	41.4	0.3	N/A
FRESEW82	7/30/2010 8:24	48.4	34.9	1.9	14.79
FRESEW34	7/30/2010 8:26	54.4	37.9	2.3	5.39
FRESEW32	7/30/2010 8:29	19.5	23.1	2.7	54.7
FRESEW33	7/30/2010 8:30	29.2	29.2	1.9	39.7
FRESEW35	7/30/2010 8:32	18.4	24.4	1.8	55.4
FRESEW36	7/30/2010 8:34	45.7	35.6	1.5	17.2
FRESEW84	7/30/2010 8:36	38.2	29.7	1.9	30.2
FRESEW88	7/30/2010 8:38	41.8	32.4	1.5	24.3
FRESEW38	7/30/2010 8:40	36.6	28.7	3.6	31.1
FRESEW37	7/30/2010 8:42	31.5	30.4	2.3	35.8
FRSGLFG5	7/30/2010 8:44	34	31.2	0.8	34
FRESEW39	7/30/2010 8:47	26.7	28.6	1.8	42.9
FRESEW40	7/30/2010 8:49	52.9	35.1	1.6	10.4
FRESEW91	7/30/2010 8:51	54.8	37.6	0.5	7.1
FRESEW94	7/30/2010 8:52	42.7	32.6	1.2	23.5
FRESEW42	7/30/2010 8:57	33.5	29.3	3	34.2
FRESEW41	7/30/2010 8:59	16.3	22	1.8	59.9
FRESEW43	7/30/2010 9:01	30.7	31.3	1	37
FRESEW44	7/30/2010 9:06	50.5	38.5	1.2	9.8
FRESEW45	7/30/2010 9:08	38.6	32.3	1.3	27.8
FRSEW105	7/30/2010 9:10	43.4	33.3	1.4	21.9
FRSEW104	7/30/2010 9:12	37.1	33.2	0.9	28.8
FRESEW49	7/30/2010 9:14	31.5	30.7	1.2	36.59
FRESEW46	7/30/2010 9:16	21.4	28	1.1	49.5
FRESEW47	7/30/2010 9:52	21.3	29.5	1.8	47.4
FRESEW48	7/30/2010 9:54	25.8	31.9	1.3	40.99
FRESEW50	7/30/2010 9:56	24.8	31	1	43.19
FRSEW103	7/30/2010 9:58	22.2	30.9	1	45.9
FRSEW101	7/30/2010 10:00	38.5	36.7	0.9	23.9
FRSEW102	7/30/2010 10:01	26.8	30.9	1.5	40.79

FRSEW100	7/30/2010 10:03	32.2	30.5	2.2	35.1
FRESEW99	7/30/2010 10:05	34.4	36	1.5	28.09
FRESEW98	7/30/2010 10:09	26.6	27.8	2.3	43.3
FRESEW96	7/30/2010 10:10	18.6	25.9	2.1	53.4
FRESEW97	7/30/2010 10:13	42.8	34.1	1.4	21.7
FRESEW93	7/30/2010 10:15	33.4	28.5	0.9	37.19
FRESEW95	7/30/2010 10:17	27.1	25.9	1.6	45.4
FRESEW92	7/30/2010 10:18	27.1	28.5	1.7	42.7
FRESEW89	7/30/2010 10:20	54.6	35.9	1.8	7.7
FRESEW90	7/30/2010 10:22	45.1	33.5	1.3	20.1
FRESEW87	7/30/2010 10:25	37.9	28.7	3.5	29.89
FRESEW86	7/30/2010 10:28	36.4	25.9	6.7	30.99
FRESEW85	7/30/2010 10:30	35.9	32.3	2.6	29.2
FRESEW83	7/30/2010 10:32	22.7	24	2.3	51
FRESEW81	7/30/2010 10:39	34.5	27.6	1.3	36.6
FRSGLFG1	7/30/2010 10:41	35.5	30.7	2.7	31.09
FRESEW80	7/30/2010 10:43	34.1	31.3	1.1	33.5
FRESEW77	7/30/2010 10:45	37.4	29.2	1.1	32.3
FRESEW78	7/30/2010 10:49	37.3	27.1	5.9	29.7
FRESEW75	7/30/2010 10:51	53.5	37.8	1.1	7.6
FRESEW74	7/30/2010 10:53	21.1	25.8	0.9	52.2
FRESEW73	7/30/2010 10:55	26.9	26.2	1.2	45.69
FRESEW72	7/30/2010 10:58	39.9	31.5	2.1	26.49
FRESEW71	7/30/2010 11:00	14.4	19.9	1	64.69
FRESEW70	7/30/2010 11:03	44.9	35.8	0.9	18.4
FRESEW69	7/30/2010 11:06	40.8	33.3	1.1	24.8
FRESEW67	7/30/2010 11:09	46.5	34.3	2.3	16.9
FRESEW68	7/30/2010 11:11	54.1	35.3	0.9	9.7
FRESEW65	7/30/2010 11:13	52.6	36.2	2.6	8.6
FRESEW66	7/30/2010 11:15	39	29.3	1.2	30.5
FRESEW64	7/30/2010 11:18	58.4	40.2	0.9	0.49
FRESEW63	7/30/2010 11:21	59	40.5	1	N/A
FRESEW62	7/30/2010 11:24	58.8	39.8	1.1	0.3
FRESEW61	7/30/2010 11:26	57.8	38.1	1	3.1
FRESEW60	7/30/2010 11:29	57.7	39.7	1	1.59
FRESEW59	7/30/2010 11:31	59.1	39.3	1.1	0.5
FRESEW58	7/30/2010 11:33	59	37.2	0.9	2.89
FRESEW56	7/30/2010 11:35	58.3	39	0.9	1.8
FRESEW57	7/30/2010 11:37	58.2	37.7	1.1	2.99
FRESEW55	7/30/2010 11:39	58.1	40.9	0.9	0.1
FRSGLFG2	7/30/2010 11:41	58.6	40.1	1.1	0.2
FRESEW51	7/30/2010 11:43	59.5	40.3	0.9	N/A
FRESEW52	7/30/2010 11:46	58.9	41.2	1.3	N/A
FRESEW54	7/30/2010 11:49	57.7	40	1	1.29
FRESEW53	7/30/2010 11:51	59.8	38.1	1.4	0.7
GP000001	7/30/2010 11:59	0.1	0	19.8	80.1
GP000002	7/30/2010 12:00	0.2	0	19.9	79.9

GP000003	7/30/2010 12:54	0.1	0	21	78.9
GP000004	7/30/2010 13:17	0.1	1.4	20.1	78.4
GP000005	7/30/2010 14:02	0.1	0	20.8	79.1
GP000006	7/30/2010 14:06	0.1	4.6	15.1	80.2
--------	8/30/2010 7:59	16.4	13.1	12.6	57.9
FRESKOPI	8/30/2010 8:00	13.9	10.9	13.6	61.6
--------	8/30/2010 8:01	24.4	20.2	9	46.4
FRESBLOT	8/30/2010 8:01	24.9	20.3	9.2	45.6
FRESEW04	8/30/2010 8:07	52.3	39.6	1.9	6.2
FRESEW03	8/30/2010 8:09	44.5	35.5	2.2	17.79
FRESEW02	8/30/2010 8:11	49.6	37.4	2.4	10.6
FRESEW01	8/30/2010 8:13	46.2	36.7	2	15.09
FRESEW05	8/30/2010 8:15	50.1	39.2	0.7	10
FRESEW06	8/30/2010 8:17	46.8	36.1	1.7	15.4
FRESEW07	8/30/2010 8:20	54.3	38.8	2.2	4.7
FRESEX05	8/30/2010 8:22	52.9	41.5	0.8	4.79
FRESEW08	8/30/2010 8:24	46.3	35.9	2.9	14.9
FRESEW09	8/30/2010 8:27	52.6	42.7	0.5	4.2
FRSGLFG3	8/30/2010 8:30	37.3	28.8	5.3	28.6
FRESEW10	8/30/2010 8:32	52.8	38.6	1.1	7.5
FRESEW11	8/30/2010 8:34	47.1	35.6	2.5	14.8
FRESEW12	8/30/2010 8:36	50.6	38.7	1.8	8.9
FRESEX04	8/30/2010 8:39	9.6	6	16.4	68
FRESEW14	8/30/2010 8:41	51.6	39.9	1.5	7
FRESEW13	8/30/2010 8:43	51.5	38.7	1.1	8.69
FRESEW15	8/30/2010 8:47	0.3	0.1	20.4	79.19
FRESEW16	8/30/2010 8:50	0.2	0.1	20.4	79.3
FRESEW16	8/30/2010 8:50	0.3	0.1	20.5	79.1
FRESEX03	8/30/2010 8:52	55.1	38.2	1.3	5.4
FRESEW19	8/30/2010 8:55	48.5	36.4	2.9	12.19
FRSGLFG4	8/30/2010 8:57	45.2	32.2	4.8	17.79
FRESEW18	8/30/2010 8:59	54.5	39.7	2.1	3.69
FRESEW20	8/30/2010 9:02	27.4	20.2	9.5	42.9
FRESEW21	8/30/2010 9:04	50.6	41.8	1	6.6
FRESEX02	8/30/2010 9:06	50.5	40.2	1.7	7.59
FRESEW22	8/30/2010 9:12	30.2	25.6	8.3	35.9
FRESEW25	8/30/2010 9:14	30.9	28.9	0.9	39.29
FRESEW26	8/30/2010 9:17	21	23.5	0.6	54.9
FRESEW27	8/30/2010 9:19	25.7	24.3	3.1	46.9
FRESEX01	8/30/2010 9:22	32.5	26.7	3.8	37
FRESEW76	8/30/2010 9:24	39.4	30.8	5.5	24.3
FRESEW29	8/30/2010 9:26	37.6	29.6	4.4	28.4
FRESEW28	8/30/2010 9:28	39.3	32.8	3.7	24.2
FRESEW30	8/30/2010 9:31	24	24.7	3.8	47.5
FRESEW31	8/30/2010 9:38	32.3	30.8	0.8	36.09
FRESEW79	8/30/2010 9:40	45.1	36.2	2.1	16.6
FRESEW82	8/30/2010 9:42	22.6	18.7	8.2	50.5

FRESEW34	8/30/2010 9:44	24	23.9	4.4	47.69
FRESEW32	8/30/2010 9:46	12.9	20.8	2.1	64.2
FRESEW33	8/30/2010 9:48	36.4	32.1	5.3	26.2
FRESEW35	8/30/2010 9:50	33.4	34.7	0.8	31.09
FRESEW36	8/30/2010 9:52	41.5	33.6	1.6	23.3
FRESEW84	8/30/2010 9:54	51.2	36.6	1.2	11
FRESEW88	8/30/2010 9:56	31	25.7	5.4	37.89
FRESEW38	8/30/2010 9:58	46.2	36.6	0.9	16.3
FRESEW37	8/30/2010 10:00	39.9	36	1.3	22.8
FRSGLFG5	8/30/2010 10:02	55.6	39.2	0.7	4.5
FRESEW39	8/30/2010 10:05	31.7	28	3.3	37
FRESEW40	8/30/2010 10:07	42.8	30.8	4.7	21.7
FRESEW94	8/30/2010 10:08	36	27.6	5.5	30.9
FRESEW91	8/30/2010 10:10	35.4	26.9	5.7	31.99
FRESEW42	8/30/2010 10:15	51.5	36.6	2.5	9.4
FRESEW41	8/30/2010 10:17	50.3	39.1	1.9	8.7
FRESEW43	8/30/2010 10:19	50.5	38.2	2.5	8.79
FRESEW44	8/30/2010 10:20	41.1	34.4	1.3	23.2
FRESEW45	8/30/2010 10:23	29.3	21.3	9.4	40
FRSEW105	8/30/2010 10:25	51	35.3	1.6	12.1
FRSEW104	8/30/2010 10:27	56.8	41.2	0.8	1.2
FRESEW49	8/30/2010 10:33	56.6	40.6	0.7	2.1
FRESEW46	8/30/2010 10:35	54.9	38.2	1.6	5.29
FRESEW47	8/30/2010 10:37	48	40.3	1.2	10.5
FRESEW48	8/30/2010 10:40	49.1	37.2	2.1	11.6
FRESEW50	8/30/2010 10:41	54.8	35.9	1.3	7.99
FRSEW103	8/30/2010 10:44	47.5	35.8	2.9	13.8
FRSEW101	8/30/2010 10:45	25.5	25.6	5.4	43.5
FRSEW102	8/30/2010 10:47	49.8	39.4	1.7	9.09
FRSEW100	8/30/2010 10:50	49.8	38.6	0.8	10.8
FRESEW99	8/30/2010 10:51	48.1	38.8	1.7	11.4
FRESEW98	8/30/2010 10:53	45.4	34.6	1.4	18.6
FRESEW96	8/30/2010 10:55	46.4	37.8	1.1	14.69
FRESEW97	8/30/2010 10:59	37.7	29.6	3.9	28.79
FRESEW93	8/30/2010 11:02	22.3	20	6.3	51.4
FRESEW95	8/30/2010 11:04	43	29.6	5.5	21.9
FRESEW92	8/31/2010 9:01	32.2	30.7	0.7	36.4
FRESEW89	8/31/2010 9:03	19.9	25.1	3.6	51.4
FRESEW90	8/31/2010 9:05	30.6	30.3	2.1	37
FRESEW87	8/31/2010 9:07	34.5	29.9	3.6	31.99
FRESEW86	8/31/2010 9:10	31	25.1	7.3	36.6
FRESEW85	8/31/2010 9:13	42.6	37	1.1	19.3
FRESEW83	8/31/2010 9:16	31.3	29.8	1.5	37.39
FRESEW81	8/31/2010 9:18	29.7	23.6	6.8	39.9
FRSGLFG1	8/31/2010 9:21	29.1	32.1	1.9	36.9
FRESEW80	8/31/2010 9:23	39	36.6	1.9	22.5
FRESEW77	8/31/2010 9:26	25.1	27.5	2.7	44.7

FRESEW78	8/31/2010 9:28	37.1	28.2	4.7	30
FRESEW75	8/31/2010 9:32	37.2	32.7	1.3	28.8
FRESEW74	8/31/2010 9:34	9.7	19.6	2.9	67.8
FRESEW73	8/31/2010 9:36	21.1	24.1	2.1	52.7
FRESEW71	8/31/2010 9:38	4	15.6	3.2	77.2
FRESEW72	8/31/2010 9:40	19.5	24	1.4	55.1
FRESEW70	8/31/2010 9:43	19.2	15.1	12.2	53.5
FRESEW69	8/31/2010 9:45	29.2	26.2	0.9	43.7
FRESEW67	8/31/2010 9:47	24.9	26.2	1.2	47.69
FRESEW68	8/31/2010 9:49	49.1	36.6	0.7	13.6
FRESEW65	8/31/2010 9:53	49.7	36.4	2.5	11.39
FRESEW66	8/31/2010 9:55	42.7	32.7	0.7	23.89
FRESEW64	8/31/2010 9:57	37.6	31.1	1.4	29.9
FRESEW62	8/31/2010 10:01	33.8	30.9	1.4	33.89
FRESEW63	8/31/2010 10:04	40.6	30.2	3	26.2
FRESEW63	8/31/2010 10:04	40.7	30.3	3.1	25.9
FRESEW61	8/31/2010 10:07	37.3	28	6.2	28.5
FRESEW60	8/31/2010 10:10	41.4	34.7	1	22.89
FRESEW59	8/31/2010 10:11	39.8	33.7	1.1	25.4
FRESEW58	8/31/2010 10:14	55.9	39.5	0.6	3.99
FRESEW56	8/31/2010 10:16	30.4	23.7	8.7	37.19
FRESEW57	8/31/2010 10:19	35.5	29.6	3.9	31
FRESEW55	8/31/2010 10:21	41.7	33.4	2.3	22.59
FRSGLFG2	8/31/2010 10:23	34.1	30.6	3.4	31.9
FRESEW51	8/31/2010 10:26	45.4	36.5	2.8	15.29
FRESEW51	8/31/2010 10:27	44.7	35.7	3.2	16.39
FRESEW54	8/31/2010 10:37	48.2	38.6	1.7	11.5
FRESEW53	8/31/2010 10:39	49.4	36.9	2.5	11.19
FRESEW52	8/31/2010 10:41	43.9	32.7	4.6	18.79
GP000001	8/31/2010 10:54	0	1.1	19.8	79.1
GP000002	8/31/2010 10:56	0	0	21.3	78.69
GP000003	8/31/2010 11:06	0	2.8	17.2	80
GP000004	8/31/2010 11:13	0	0	20.8	79.19
GP000005	8/31/2010 11:17	0	2.4	17.4	80.19
GP000006	8/31/2010 11:22	0	3.9	16.3	79.8
FRESKOPI	9/29/2010 8:52	15.8	15.2	10.7	58.3
FRESBLOT	9/29/2010 8:54	26.4	26.6	4.7	42.3
FRESBLOT	9/29/2010 8:54	26	26.1	4.8	43.1
FRESEW04	9/29/2010 8:59	48.7	37.8	2.5	11
FRESEW03	9/29/2010 9:03	33.8	28.8	5.4	31.99
FRESEW02	9/29/2010 9:05	33.3	25.8	7.8	33.09
FRESEW01	9/29/2010 9:07	38.3	34.3	0.9	26.5
FRESEW05	9/29/2010 9:09	38.7	34	2.2	25.09
FRESEW06	9/29/2010 9:11	41.2	34.6	3.3	20.9
FRESEW07	9/29/2010 9:14	48.4	38.4	2.5	10.69
FRESEX05	9/29/2010 9:16	41	34.1	4.1	20.8
FRESEW08	9/29/2010 9:18	47.6	38.2	1.8	12.4

FRESEW09	9/29/2010 9:20	35.1	31.9	3	30
FRSGLFG3	9/29/2010 9:23	44.7	32.7	4.3	18.29
FRESEW10	9/29/2010 9:25	34.3	29.9	2.4	33.39
FRESEW11	9/29/2010 9:26	27.4	23.1	6.9	42.6
FRESEW12	9/29/2010 9:29	41.7	33.7	3.4	21.2
FRESEX04	9/29/2010 9:31	21.7	14.1	12.2	52
FRESEW14	9/29/2010 9:34	36.7	29.2	4.1	29.99
FRESEW13	9/29/2010 9:36	31.2	27.3	2.5	39
FRESEW15	9/29/2010 9:39	0	0	20	80
FRESEW16	9/29/2010 9:56	52.7	38.3	1	8
FRESEW16	9/29/2010 9:58	0.1	0	20.1	79.8
FRESEW16	9/29/2010 9:59	0.1	0	20.2	79.69
FRESEX03	9/29/2010 10:01	31.3	25.4	4.4	38.89
FRESEW19	9/29/2010 10:03	50.9	39.2	1.6	8.29
FRSGLFG4	9/29/2010 10:05	54.5	38.8	1.6	5.1
FRESEW17	9/29/2010 10:07	33.3	25.6	7.8	33.3
FRESEW17	9/29/2010 10:07	32.9	25.4	7.8	33.89
FRESEW18	9/29/2010 10:09	51.4	39.9	1.2	7.49
FRESEW20	9/29/2010 10:12	42.9	32.2	3.7	21.19
FRESEW21	9/29/2010 10:14	48.7	39.6	2.2	9.5
FRESEX02	9/29/2010 10:16	43.7	36.2	3.2	16.89
FRESEW24	9/29/2010 10:19	41	36.6	1	21.4
FRESEW23	9/29/2010 10:21	47.3	39.4	1.6	11.69
FRESEW22	9/29/2010 10:24	14	8.5	13.5	64
FRESEW22	9/29/2010 10:24	14	8.6	13.5	63.9
FRESEW25	9/29/2010 10:26	44.2	35.2	2.7	17.89
FRESEW26	9/29/2010 10:28	19.1	18	5.3	57.6
FRESEW27	9/29/2010 10:30	47.6	34.2	3.4	14.8
FRESEX01	9/29/2010 10:32	48.5	37.3	2.1	12.1
FRESEW76	9/29/2010 10:34	55.5	39.3	1.8	3.4
FRESEW29	9/29/2010 10:36	34.2	24.6	8.2	33
FRESEW28	9/29/2010 10:38	12.5	12.6	9.4	65.5
FRESEW30	9/29/2010 10:40	31.5	27.3	7.2	34
FRESEW31	9/29/2010 10:42	14.5	13	11.6	60.9
FRESEW79	9/29/2010 10:44	42.1	33.5	2.9	21.5
FRESEW82	9/29/2010 10:46	35.1	25.7	7.6	31.6
FRESEW34	9/29/2010 10:48	48.7	36.3	3.1	11.9
FRESEW32	9/29/2010 10:51	26.3	26.5	5.1	42.1
FRESEW33	9/29/2010 10:53	43.4	37.4	3	16.19
FRESEW35	9/29/2010 10:55	26.4	29.3	2	42.3
FRESEW36	9/29/2010 10:57	22.9	22.5	6.8	47.8
FRESEW84	9/29/2010 10:59	13.9	13.4	10.7	61.99
FRESEW88	9/29/2010 11:01	50.8	38.5	2.4	8.3
FRESEW38	9/29/2010 11:03	18.2	16.6	9.2	56
FRESEW37	9/29/2010 11:05	11.3	15.3	8.9	64.49
FRSGLFG5	9/29/2010 11:08	9.6	10.8	12.3	67.29
FRESEW39	9/29/2010 11:10	16.6	17.1	8.2	58.1

FRESEW40	9/29/2010 11:12	39.4	27.8	6.7	26.09
FRESEW91	9/29/2010 11:15	48.9	33.2	3.3	14.59
FRESEW94	9/29/2010 11:17	42.3	29.4	4.7	23.6
FRESEW42	9/29/2010 11:19	5.5	5	16.9	72.6
FRESEW41	9/29/2010 11:21	3.9	4.5	16.5	75.1
FRESEW43	9/29/2010 11:24	20.2	21.7	7	51.1
FRESEW44	9/29/2010 11:26	16.9	19.2	7.7	56.19
FRESEW45	9/29/2010 11:29	28.1	20	10.5	41.4
FRSEW105	9/29/2010 11:31	10.6	7.6	15.5	66.3
FRSEW104	9/29/2010 11:33	3.9	3.9	17.7	74.5
FRESEW49	9/29/2010 11:36	16.8	19.9	7.4	55.89
FRESEW46	9/29/2010 11:38	5.3	10.9	11.4	72.39
FRESEW47	9/29/2010 11:40	16.7	23.1	5.7	54.5
FRESEW48	9/29/2010 11:42	18.9	25.5	4	51.6
FRESEW50	9/29/2010 11:44	15.7	19.2	7.2	57.9
FRSEW103	9/29/2010 12:51	19.2	26.7	2.8	51.3
FRSEW101	9/29/2010 12:54	30.8	33.4	1.4	34.39
FRSEW102	9/29/2010 12:56	13.4	18	7.7	60.9
FRSEW100	9/29/2010 12:59	9.7	11.9	12.4	66
FRESEW99	9/29/2010 13:01	6.3	11.6	11.4	70.69
FRESEW98	9/29/2010 13:02	13.8	20.5	6.5	59.19
FRESEW96	9/29/2010 13:04	9	13.9	10.2	66.9
FRESEW97	9/29/2010 13:07	42.9	34.3	2.1	20.7
FRESEW93	9/29/2010 13:09	47	32.9	3.3	16.79
FRESEW95	9/29/2010 13:11	20.4	21.3	4.9	53.4
FRESEW92	9/29/2010 13:13	24.8	28.1	2.2	44.9
FRESEW89	9/29/2010 13:15	52.4	36.1	2.5	9
FRESEW90	9/30/2010 7:38	18.3	14.5	12.6	54.6
FRESEW87	9/30/2010 7:40	15	13.7	12.3	59
FRESEW86	9/30/2010 7:42	17.3	15.3	11.8	55.59
FRESEW85	9/30/2010 7:47	21.2	26.4	3.4	49
FRESEW83	9/30/2010 7:49	6.8	10.8	11.5	70.89
FRESEW81	9/30/2010 7:57	41.4	35.8	0.6	22.2
FRSGLFG1	9/30/2010 7:59	33.5	36.6	0.4	29.5
FRESEW80	9/30/2010 8:01	42	39.6	0.3	18.1
FRESEW77	9/30/2010 8:02	46.5	36.6	3.6	13.3
FRESEW78	9/30/2010 8:04	55.5	41.1	0.4	3
FRESEW75	9/30/2010 8:13	51.5	38.7	2	7.79
FRESEW74	9/30/2010 8:15	35.5	36.7	0.4	27.4
FRESEW73	9/30/2010 8:16	53.6	41.6	0.6	4.2
FRESEW71	9/30/2010 8:19	38.5	32.6	0.6	28.3
FRESEW72	9/30/2010 8:26	52.5	40.4	0.6	6.49
FRESEW70	9/30/2010 8:28	40	45.2	0.2	14.6
FRESEW69	9/30/2010 8:31	32.4	29.1	0.9	37.59
FRESEW67	9/30/2010 8:33	27.9	27.4	1.8	42.9
FRESEW68	9/30/2010 8:35	43.6	36.7	0.2	19.5
FRESEW65	9/30/2010 8:37	51.6	38.7	1.1	8.6

FRESEW66	9/30/2010 8:41	28.7	29.4	0.8	41.1
FRESEW64	9/30/2010 8:44	32.1	28.7	1.4	37.8
FRESEW62	9/30/2010 8:45	33.8	32	0.9	33.29
FRESEW63	9/30/2010 8:47	43.7	34.4	0.8	21.09
FRESEW61	9/30/2010 8:49	55.1	41.6	0.6	2.7
FRESEW60	9/30/2010 8:51	42.8	35.9	0.3	21
FRESEW59	9/30/2010 8:53	40.9	35.4	0.4	23.29
FRESEW58	9/30/2010 8:55	37.3	30.3	4.6	27.8
FRESEW56	9/30/2010 8:58	53.7	38.4	1.3	6.59
FRESEW57	9/30/2010 9:00	41.7	35.1	0.4	22.8
FRESEW55	9/30/2010 9:02	40	35	1.6	23.4
FRSGLFG2	9/30/2010 9:04	31.2	30.1	3.1	35.6
FRESEW51	9/30/2010 9:08	51.2	41.2	0.4	7.19
FRESEW52	9/30/2010 9:10	56.6	41.3	0.7	1.4
FRESEW54	9/30/2010 9:11	48.1	40.4	0.4	11.1
FRESEW53	9/30/2010 9:13	55.2	41.9	0.4	2.49
GMW10000	9/30/2010 9:21	0	0	20.5	79.5
MMW30000	9/30/2010 9:26	0.1	0.4	20.3	79.19
MMW20000	9/30/2010 9:30	1.7	3.1	17.9	77.3
MMW70000	9/30/2010 9:36	0	2.9	15.7	81.4
CMW50000	9/30/2010 9:41	0	0.2	20.3	79.5
MMW70000	9/30/2010 9:46	0	1	19.7	79.3
MMW60000	9/30/2010 9:51	0	0.1	20.6	79.3
MMW50000	9/30/2010 9:55	0	0	20.9	79.1
MMW40000	9/30/2010 9:58	0	0	21	79
CMW10000	9/30/2010 10:03	0	1.8	18.9	79.29
GMW40000	9/30/2010 10:15	0	0	21	79
CMW60000	9/30/2010 10:18	0	0	21	79
GMW30000	9/30/2010 10:29	0	0	21.2	78.8
GMW10000	9/30/2010 10:34	0	0	21.1	78.9

999084988700922000114589000011458 90

Account Number	Bill Date	Amount Due	Due Date	Amount Enclosed
8498870092-2	01/22/2009	**$11,458.90**	02/09/2009	11,458.90

4908.11.243.55263 1 AT 0.346

CITY OF FRESNO
PARKS DIV
2326 FRESNO ST STE 101
FRESNO CA 93721-1824

PG&E
BOX 997300
SACRAMENTO CA
95899-7300

200.0137

Please return this portion with your payment. Thank you.

Telephone Assistance
1-800-743-5000
Assistance is available by telephone 24 hours per day, 7 days per week.

Local Office Address
705 P ST
FRESNO CA 93760

Account Number
8498870092-2

January 2009

ACCOUNT SUMMARY

Service	Service Dates	Amount
Electric	12/19/2008 To 01/21/2009	$11,439.36
Energy Commission Tax		19.54
TOTAL CURRENT CHARGES		$11,458.90
Previous Balance		22,655.95
01/13 Payment - Thank You		13,132.43-
01/13 Payment - Thank You		9,523.52-

TOTAL AMOUNT DUE **$11,458.90**
DUE DATE - 02/09/2009

Be winter-wise! Cold weather can triple heating use; fewer daylight hours can increase lighting use by a third. Spending more time indoors and billing periods with 5 weekends can also cause higher bills. To save money, set heaters lower and turn lights off when not needed.

Moving? Please call PG&E customer service at 1-800-PGE-5000 to notify us of your new mailing address.

146

Form 01-6630 9/98

CITY OF FRESNO
1707 W JENSEN AVE
FRESNO CA 93706

ELECTRIC ACCOUNT DETAIL

Service ID #: 8498870005 SPORTS COMPLEX
Rate Schedule: E19P Medium General Demand-Metered TOU Service
Billing Days: 34 days

Serial	Rotating Outage Blk	Meter #	Prior Meter Read	Current Meter Read	Difference	Meter Constant	Usage
X	5K	P28876	2,978	3,052	74	1,200	88,800 Kwh

Charges

12/19/2008 - 12/31/2008

Electric Charges	$4,389.09	
Net Charges		$4,389.09

The net charges shown above include the following component(s).
Please see definitions on Page 2 of the bill.

Generation	$1,841.60
Transmission	704.81
Distribution	1,149.69
Public Purpose Programs	325.61
Nuclear Decommissioning	9.17
DWR Bond Charge	161.96
Ongoing CTC	88.28
Energy Cost Recovery Amount	107.97

Taxes and Other

Energy Commission Tax $7.47

Time of Use Detail

Season: Winter	Energy
Peak	
Partial-Peak	12,847 @ $0.08322
Off-Peak	21,106 @ $0.07293

Season: Winter	Demand
Peak	
Partial-Peak	600 @ $0.75000
Off-Peak	600 @ $5.90000

Charges

01/01/2009 - 01/21/2009

Electric Charges	$7,050.27	
Net Charges		$7,050.27

The net charges shown above include the following component(s).
Please see definitions on Page 2 of the bill.

Generation	$2,913.95
Transmission	1,162.40
Distribution	1,930.17
Public Purpose Programs	304.95
Nuclear Decommissioning	15.36
DWR Bond Charge	269.30
Ongoing CTC	327.44
Energy Cost Recovery Amount	126.70

CITY OF FRESNO

Taxes and Other

Energy Commission Tax $12.07

Time of Use Detail

Season: Winter	Energy	
Peak		
Partial-Peak	20,753 @ $0.08005	
Off-Peak	34,094 @ $0.06938	
Season: Winter	Demand	
Peak		
Partial-Peak	600 @ $0.78000	
Off-Peak	600 @ $6.22000	

TOTAL CHARGES $11,458.90

Usage Comparison	Days Billed	Kwh Billed	Kwh per Day
This Year	34	88,800	2,611.8
Last Year	31	50,400	1,625.8

Rotating outage blocks are subject to change without advance notice due to operational conditions.

Generation includes charges for the portion of your energy usage provided by the Department of Water Resources (DWR) and is being collected by PG&E as an agent for DWR. DWR is collecting 8.640 cents per kWh from Bundled customers for each kWh it provides plus the Power Charge Indifference Adjustment component of the Cost Responsibility Surcharge from Direct Access and Transitional Bundled Service customers.

The rates shown above are applicable to bundled service customers. Direct Access and Community Choice Aggregation customers pay only a portion of these rates. Please see the appropriate rate schedule for the applicable charges.

99908498870092200006412790000641279

Account Number	Bill Date	Amount Due	Due Date	Amount Enclosed
8498870092-2	02/20/2009	**$6,412.79**	03/09/2009	6412.79

5043.41.957.198293 1 AT 0.346

CITY OF FRESNO
PARKS DIV
2326 FRESNO ST STE 101
FRESNO CA 93721-1824

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95899-7300

200.0161

Please return this portion with your payment. Thank you.

Telephone Assistance

1-800-743-5000
Assistance is available by telephone 24 hours per day, 7 days per week.

Local Office Address

705 P ST
FRESNO CA 93760

Account Number

8498870092-2

February 2009

ACCOUNT SUMMARY

Service	Service Dates	Amount
Electric	01/22/2009 To 02/20/2009	$6,398.01
Energy Commission Tax		14.78
TOTAL CURRENT CHARGES		$6,412.79
Previous Balance		11,458.90
02/10 Payment - Thank You		11,458.90-

TOTAL AMOUNT DUE	**$6,412.79**
DUE DATE - 03/09/2009	

In 2009, Daylight Saving Time will be four weeks earlier starting on March 8 and ending on November 1. During the additional weeks of Daylight Saving Time, your Time-of-Use periods will begin and end one hour later. You can visit www.pge.com or call us at 1-800-PGE-5000 for additional information.

CITY OF FRESNO
1707 W JENSEN AVE
FRESNO CA 93706

ELECTRIC ACCOUNT DETAIL

Service ID #: 8498870005 SPORTS COMPLEX
Rate Schedule: E19P Medium General Demand-Metered TOU Service
Billing Days: 30 days

Serial	Rotating Outage Blk	Meter #	Prior Meter Read	Current Meter Read	Difference	Meter Constant	Usage
X	5K	P28876	3,052	3,108	56	1,200	67,200 Kwh

Charges

01/22/2009 - 02/20/2009
Electric Charges $6,398.01
Net Charges $6,398.01

The net charges shown above include the following component(s).
Please see definitions on Page 2 of the bill.

Generation	$3,579.58
Transmission	475.78
Distribution	1,063.84
Public Purpose Programs	373.63
Nuclear Decommissioning	18.81
DWR Bond Charge	329.95
Ongoing CTC	401.19
Energy Cost Recovery Amount	155.23

Taxes and Other

Energy Commission Tax $14.78

Time of Use Detail

Season: Winter	Energy
Peak	
Partial-Peak	26,400 @ $0.08005
Off-Peak	40,800 @ $0.06938

Season: Winter	Demand
Peak	
Partial-Peak	180 @ $0.78000
Off-Peak	192 @ $6.22000

TOTAL CHARGES **$6,412.79**

Usage Comparison	Days Billed	Kwh Billed	Kwh per Day
This Year	30	67,200	2,240.0
Last Year	30	46,800	1,560.0

Rotating outage blocks are subject to change without advance notice due to operational conditions.

Generation includes charges for the portion of your energy usage provided by the Department of Water Resources (DWR) and is being collected by PG&E as an agent for DWR. DWR is collecting 8.640 cents per kWh from Bundled customers for each kWh it provides plus the Power Charge Indifference Adjustment component of the Cost Responsibility Surcharge from Direct Access and Transitional Bundled Service customers.

The rates shown above are applicable to bundled service customers. Direct Access and Community Choice Aggregation customers pay only a portion of these rates. Please see the appropriate rate schedule for the applicable charges.

Form 01-6630 9/98

Telephone Assistance
1-800-743-5000
Assistance is available by telephone 24 hours per day, 7 days per week.

Local Office Address
705 P ST
FRESNO CA 93760

Account Number
8498870092-2

March 2009

ACCOUNT SUMMARY

Service	Service Dates	Amount
Electric	02/21/2009 To 03/16/2009	$7,544.54
Energy Commission Tax		12.15
Current Charges Due 04/09/2009		$7,556.69
Previous Balance		6,412.79
No Payment Received by 03/23/2009		
TOTAL AMOUNT DUE		**$13,969.48**

Optional rates are available to many customers and may lower your PG&E bills. To find out if you have options available, please call 1-800-468-4743. The back of this bill has other important messages.

Page 1 of

Recycled Paper 30% Post-Consumer Waste

Form 01-6630

99908498870092200025080000002508000

Account Number	Bill Date	Amount Due	Due Date	Amount Enclosed
8498870092-2	05/27/2009	**$25,080.00**	06/15/2009	

5478.3.46.9618 1 AV 0.335

CITY OF FRESNO
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FRESNO CA 93721-1824

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Telephone Assistance
1-800-743-5000
Assistance is available by telephone 24 hours per day, 7 days per week.

Local Office Address
705 P ST
FRESNO CA 93760

Account Number
8498870092-2

May 2009

ACCOUNT SUMMARY

Service	Service Dates	Amount
Electric	03/17/2009 To 05/22/2009	$25,041.72
Energy Commission Tax		38.28
TOTAL CURRENT CHARGES		$25,080.00
Previous Balance		25,678.90
No Payment Received by 05/27/2009		
Total Bill Corrections		25,678.90-

TOTAL AMOUNT DUE	**$25,080.00**
DUE DATE - 06/15/2009	

CITY OF FRESNO
1707 W JENSEN AVE
FRESNO CA 93706

ELECTRIC ACCOUNT DETAIL

Service ID #: 8498870005 SPORTS COMPLEX
Rate Schedule: E19P Medium General Demand-Metered TOU Service
Billing Days: 33 days

Serial	Rotating Outage Blk	Meter #	Prior Meter Read	Current Meter Read	Difference	Meter Constant	Usage
X	5K	1004578328	0	72	72	1,200	85,200 Kwh Est

Charges

03/17/2009 - 04/18/2009

Electric Charges	$10,761.56	
Net Charges		$10,761.56

The net charges shown above include the following component(s).
Please see definitions on Page 2 of the bill.

Generation	$5,315.29
Transmission	1,515.90
Distribution	2,309.02
Public Purpose Programs	473.71
Nuclear Decommissioning	23.85
DWR Bond Charge	418.33
Ongoing CTC	508.65
Energy Cost Recovery Amount	196.81

Taxes and Other

Energy Commission Tax $18.74

Time of Use Detail

Season: Winter	Energy
Peak	
Partial-Peak	40,800 @ $0.08882
Off-Peak	44,400 @ $0.07737

Season: Winter	Demand
Peak	
Partial-Peak	480 @ $0.78000
Off-Peak	480 @ $6.66000

TOTAL CHARGES **$10,780.30**

Rate Schedule: E19P Medium General Demand-Metered TOU Service
Billing Days: 34 days

Serial	Rotating Outage Blk	Meter #	Prior Meter Read	Current Meter Read	Difference	Meter Constant	Usage
X	5K	1004578328	72	147	75	1,200	88,800 Kwh

Charges

04/19/2009 - 04/30/2009

Electric Charges	$4,503.91	
Net Charges		$4,503.91

The net charges shown above include the following component(s).
Please see definitions on Page 2 of the bill.

Generation	$2,172.42	
Transmission	670.36	
Distribution	998.88	
Public Purpose Programs	193.49	
Nuclear Decommissioning	9.74	
DWR Bond Charge	170.87	
Ongoing CTC	207.76	
Energy Cost Recovery Amount	80.39	

Taxes and Other

Energy Commission Tax $7.66

Time of Use Detail

Season: Winter	Energy
Peak	
Partial-Peak	16,800 @ $0.08882
Off-Peak	18,000 @ $0.07737

Season: Winter	Demand
Peak	
Partial-Peak	528 @ $0.76000
Off-Peak	528 @ $6.66000

Charges

05/01/2009 - 05/22/2009

Electric Charges	$9,776.25	
Net Charges		$9,776.25

The net charges shown above include the following component(s).
Please see definitions on Page 2 of the bill.

Generation	$5,716.09
Transmission	1,092.52
Distribution	1,940.02
Public Purpose Programs	300.24
Nuclear Decommissioning	15.12
DWR Bond Charge	265.14
Ongoing CTC	322.38
Energy Cost Recovery Amount	124.74

Taxes and Other

Energy Commission Tax $11.88

Time of Use Detail

Season: Summer	Energy
Peak	6,000 @ $0.15606
Partial-Peak	13,200 @ $0.10407
Off-Peak	34,800 @ $0.08154

Season: Summer	Demand
Peak	144 @ $12.29000
Partial-Peak	468 @ $2.79000
Off-Peak	468 @ $6.66000

TOTAL CHARGES **$14,299.70**

Bill Corrections

03/16/2009 - 04/23/2009		
Cancellation	98,400.00000 Kwh	12,958.49-
04/23/2009 - 05/22/2009		
Cancellation	75,600.00000 Kwh	$12,720.41-

Usage Comparison	Days Billed	Kwh Billed	Kwh per Day
This Year	67	174,000	2,597.0
Last Year	32	88,800	2,775.0

Rotating outage blocks are subject to change without advance notice due to operational conditions.

Generation includes charges for the portion of your energy usage provided by the Department of Water Resources (DWR) and is being collected by PG&E as an agent for DWR. DWR is collecting 8.640 cents per kWh from Bundled customers for each kWh it provides plus the Power Charge Indifference Adjustment component of the Cost Responsibility Surcharge from Direct Access and Transitional Bundled Service customers.

The rates shown above are applicable to bundled service customers. Direct Access and Community Choice Aggregation customers pay only a portion of these rates. Please see the appropriate rate schedule for the applicable charges.

This is an estimated bill due to insufficient billing information. We are currently in the process of reviewing your account. Please contact us at 1-800-743-5000 if you have any questions.

PG&E Pacific Gas and Electric Company®

99908498870092200015321070001532107

Account Number	Bill Date	Amount Due	Due Date	Amount Enclosed
8498870092-2	06/22/2009	**$15,321.07**	07/09/2009	15,321.07

5601.47.1114.239122 1 AT 0.357

CITY OF FRESNO
PARKS DIV
2326 FRESNO ST STE 101
FRESNO CA 93721-1824

PG&E
BOX 997300
SACRAMENTO CA
95899-7300

200.0264

Please return this portion with your payment. Thank you.

Telephone Assistance
1-800-468-4743
Assistance is available by telephone: Monday - Friday, 7:00 a.m.-7:30 p.m. and Saturday, 8:00 a.m.-4:30 p.m.

Local Office Address
705 P ST
FRESNO CA 93760

Account Number
8498870092-2

June 2009

ACCOUNT SUMMARY

Service	Service Dates	Amount
Electric	05/23/2009 To 06/22/2009	$15,302.59
Energy Commission Tax		18.48
TOTAL CURRENT CHARGES		$15,321.07
Previous Balance		25,080.00
05/28 Payment - Thank You		12,958.49
06/11 Payment - Thank You		12,121.51
TOTAL AMOUNT DUE		**$15,321.07**
DUE DATE - 07/09/2009		

Recycled Paper
30% Post-Consumer Waste

Form 01-6630 9/9

CITY OF FRESNO
1707 W JENSEN AVE
FRESNO CA 93706

ELECTRIC ACCOUNT DETAIL

Service ID #: 8498870005 SPORTS COMPLEX
Rate Schedule: E19P Medium General Demand-Metered TOU Service
Billing Days: 31 days

Serial	Rotating Outage Blk	Meter #	Prior Meter Read	Current Meter Read	Difference	Meter Constant	Usage
X	5K	1004578328	147	217	70	1,200	84,000 Kwh

Charges

05/23/2009 - 06/22/2009

Electric Charges $15,302.59
Net Charges $15,302.59

The net charges shown above include the following component(s).
Please see definitions on Page 2 of the bill.

Generation	$8,766.09
Transmission	1,841.88
Distribution	3,096.10
Public Purpose Programs	467.04
Nuclear Decommissioning	23.51
DWR Bond Charge	412.44
Ongoing CTC	501.49
Energy Cost Recovery Amount	194.04

Taxes and Other

Energy Commission Tax $18.48

Time of Use Detail

Season: Summer	Energy
Peak	10,800 @ $0.15606
Partial-Peak	20,400 @ $0.10407
Off-Peak	52,800 @ $0.08154

Season: Summer	Demand
Peak	132 @ $12.29000
Partial-Peak	576 @ $2.79000
Off-Peak	576 @ $6.66000

TOTAL CHARGES **$15,321.07**

Usage Comparison	Days Billed	Kwh Billed	Kwh per Day
This Year	31	84,000	2,709.7
Last Year	32	91,200	2,850.0

Rotating outage blocks are subject to change without advance notice due to operational conditions.

Generation includes charges for the portion of your energy usage provided by the Department of Water Resources (DWR) and is being collected by PG&E as an agent for DWR. DWR is collecting 8.640 cents per kWh from Bundled customers for each kWh it provides plus the Power Charge Indifference Adjustment component of the Cost Responsibility Surcharge from Direct Access and Transitional Bundled Service customers.

The rates shown above are applicable to bundled service customers. Direct Access and Community Choice Aggregation customers pay only a portion of these rates. Please see the appropriate rate schedule for the applicable charges.

9990849887009220001841133000184113

Account Number	Bill Date	Amount Due	Due Date	Amount Enclosed
8498870092-2	07/22/2009	**$18,411.33**	08/10/2009	

5771.9.184.42936 1 AV 0.335 R07/28

CITY OF FRESNO
PARKS DIV
2326 FRESNO ST STE 101
FRESNO CA 93721-1824

PG&E
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95899-7300

200.0290

Please return this portion with your payment. Thank you.

Telephone Assistance

1-800-468-4743
Assistance is available by telephone: Monday - Friday, 7:00 a.m.-7:30 p.m. and Saturday, 8:00 a.m.-4:30 p.m.

Local Office Address

705 P ST
FRESNO CA 93760

Account Number

8498870092-2

July 2009

ACCOUNT SUMMARY

Service	Service Dates	Amount
Electric	06/23/2009 To 07/22/2009	$18,389.15
Energy Commission Tax		22.18
TOTAL CURRENT CHARGES		$18,411.33
Previous Balance		15,321.07
07/02 Payment - Thank You		15,321.07-

TOTAL AMOUNT DUE **$18,411.33**
DUE DATE - 08/10/2009

For all of your account, billing or service needs, please contact our Business Customer Service Center at 1-800-468-4743.

Recycled Paper 30% Post-Consumer Waste

Form 01-6630 9/98

CITY OF FRESNO
1707 W JENSEN AVE
FRESNO CA 93706

ELECTRIC ACCOUNT DETAIL

Service ID #: 8498870005 SPORTS COMPLEX
Rate Schedule: E19P Medium General Demand-Metered TOU Service
Billing Days: 30 days

Serial	Rotating Outage Blk	Meter #	Prior Meter Read	Current Meter Read	Difference	Meter Constant	Usage
X	5K	1004578328	217	300	83	1,200	100,800 Kwh

Charges

06/23/2009 - 07/22/2009

Electric Charges $18,389.15

Net Charges $18,389.15

The net charges shown above include the following component(s).
Please see definitions on Page 2 of the bill.

Generation	$11,050.77
Transmission	1,902.00
Distribution	3,518.18
Public Purpose Programs	560.44
Nuclear Decommissioning	28.23
DWR Bond Charge	494.92
Ongoing CTC	601.77
Energy Cost Recovery Amount	232.84

Taxes and Other

Energy Commission Tax $22.18

Time of Use Detail

Season: Summer	Energy
Peak	13,200 @ $0.15606
Partial-Peak	26,400 @ $0.10407
Off-Peak	61,200 @ $0.08154

Season: Summer	Demand
Peak	228 @ $12.29000
Partial-Peak	600 @ $2.79000
Off-Peak	600 @ $6.66000

TOTAL CHARGES **$18,411.33**

Usage Comparison	Days Billed	Kwh Billed	Kwh per Day
This Year	30	100,800	3,360.0
Last Year	29	99,600	3,434.5

Rotating outage blocks are subject to change without advance notice due to operational conditions.

Generation includes charges for the portion of your energy usage provided by the Department of Water Resources (DWR) and is being collected by PG&E as an agent for DWR. DWR is collecting 8.640 cents per kWh from Bundled customers for each kWh it provides plus the Power Charge Indifference Adjustment component of the Cost Responsibility Surcharge from Direct Access and Transitional Bundled Service customers.

The rates shown above are applicable to bundled service customers. Direct Access and Community Choice Aggregation customers pay only a portion of these rates. Please see the appropriate rate schedule for the applicable charges.

PG&E Electric Company® WE DELIVER ENERGY. **Energy Statement**

9990849887009220000925138000094576 1

Account Number	Bill Date	Amount Due	Amount Enclosed
8498870092-2	08/21/2009	**$9,457.61**	9457.61

5899.11.230.51953 1 AV 0.335

CITY OF FRESNO
PARKS DIV
2326 FRESNO ST STE 101
FRESNO CA 93721-1824

PG&E
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95899-7300

200.0316

Please return this portion with your payment. Thank you.

Telephone Assistance
1-800-468-4743
Assistance is available by telephone: Monday - Friday, 7:00 a.m.-7:30 p.m. and Saturday, 8:00 a.m.-4:30 p.m.

Local Office Address
705 P ST
FRESNO CA 93760

Account Number
8498870092-2

August 2009

ACCOUNT SUMMARY

Service	Service Dates	Amount
Electric	08/05/2009 To 08/21/2009	$9,241.35
Energy Commission Tax		10.03
Current Charges Due 09/08/2009		$9,251.38
Previous Balance		24,791.63
08/21 Payment - Thank You		6,174.07-
08/21 Payment - Thank You		18,411.33-
TOTAL AMOUNT DUE		**$9,457.61**

Optional rates are available to many customers and may lower your PG&E bills. To find out if you have options available, please call 1-800-468-4743. The back of this bill has other important messages.

For all of your account, billing or service needs, please contact our Business Customer Service Center at 1-800-468-4743.

CITY OF FRESNO
1707 W JENSEN AVE
FRESNO CA 93706

ELECTRIC ACCOUNT DETAIL

Service ID #: 8498870005 SPORTS COMPLEX
Rate Schedule: E19P Medium General Demand-Metered TOU Service
Billing Days: 17 days

Serial	Rotating Outage Blk	Meter #	Prior Meter Read	Current Meter Read	Difference	Meter Constant	Usage
X	5K	1004578328	329	366	37	1,200	45,600 Kwh

100.00% Power Factor = -0.90% Adjustment

Charges

08/05/2009 - 08/21/2009

Electric Charges	$9,275.55	
Power Factor Adjustment	34.20-	
Net Charges		$9,241.35

The net charges shown above include the following component(s).
Please see definitions on Page 2 of the bill.

Generation	$5,386.90
Transmission	954.30
Distribution	2,032.40
Public Purpose Programs	253.53
Nuclear Decommissioning	12.77
DWR Bond Charge	223.89
Ongoing CTC	272.23
Energy Cost Recovery Amount	105.33

Taxes and Other

Energy Commission Tax $10.03

Time of Use Detail

Season: Summer	Energy
Peak	7,200 @ $0.15606
Partial-Peak	12,000 @ $0.10407
Off-Peak	26,400 @ $0.08154

Season: Summer	Demand
Peak	228 @ $12.29000
Partial-Peak	528 @ $2.79000
Off-Peak	528 @ $6.66000

TOTAL CHARGES **$9,251.38**

Usage Comparison	Days Billed	Kwh Billed	Kwh per Day
This Year	17	45,600	2,682.4
Last Year	N/A	N/A	N/A

Rotating outage blocks are subject to change without advance notice due to operational conditions.

Generation includes charges for the portion of your energy usage provided by the Department of Water Resources (DWR) and is being collected by PG&E as an agent for DWR. DWR is collecting 8.640 cents per kWh from Bundled customers for each kWh it provides plus the Power Charge Indifference Adjustment component of the Cost Responsibility Surcharge from Direct Access and Transitional Bundled Service customers.

99908498870092200015297660001529766

Account Number	Bill Date	Amount Due	Due Date	Amount Enclosed
8498870092-2	09/21/2009	**$15,297.66**	10/08/2009	

6016.38.889.181521 1 AT 0.357

CITY OF FRESNO
PARKS DIV
2326 FRESNO ST STE 101
FRESNO CA 93721-1824

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200.0341

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Telephone Assistance
1-800-468-4743
Assistance is available by telephone: Monday - Friday, 7:00 a.m.-7:30 p.m. and Saturday, 7:00 a.m.-4:30 p.m.

Local Office Address
705 P ST
FRESNO CA 93760

Account Number
8498870092-2

September 2009

ACCOUNT SUMMARY

Service	Service Dates	Amount
Electric	08/22/2009 To 09/21/2009	$15,280.24
Energy Commission Tax		17.42
TOTAL CURRENT CHARGES		$15,297.66
Previous Balance		9,457.61
09/09 Payment - Thank You		9,457.61-

TOTAL AMOUNT DUE **$15,297.66**
DUE DATE - 10/08/2009

Optional rates are available to many customers and may lower your PG&E bills. To find out if you have options available, please call 1-800-468-4743. The back of this bill has other important messages.

For all of your account, billing or service needs, please contact our Business Customer Service Center at 1-800-468-4743.

CITY OF FRESNO
1707 W JENSEN AVE
FRESNO CA 93706

ELECTRIC ACCOUNT DETAIL

Service ID #: 8498870005 SPORTS COMPLEX
Rate Schedule: E19P Medium General Demand-Metered TOU Service
Billing Days: 31 days

Serial	Rotating Outage Blk	Meter #	Prior Meter Read	Current Meter Read	Difference	Meter Constant	Usage
X	5K	1004578328	366	432	66	1,200	79,200 Kwh

100.00% Power Factor = -0.90% Adjustment

Charges

08/22/2009 - 09/21/2009

Electric Charges	$15,339.64	
Power Factor Adjustment	59.40-	
Net Charges		$15,280.24

The net charges shown above include the following component(s).
Please see definitions on Page 2 of the bill.

Generation	$8,494.23
Transmission	1,807.32
Distribution	3,471.49
Public Purpose Programs	440.36
Nuclear Decommissioning	22.17
DWR Bond Charge	388.88
Ongoing CTC	472.83
Energy Cost Recovery Amount	182.96

Taxes and Other

Energy Commission Tax $17.42

Time of Use Detail

Season: Summer	Energy
Peak	10,800 @ $0.15606
Partial-Peak	22,800 @ $0.10407
Off-Peak	45,600 @ $0.08154

Season: Summer	Demand
Peak	132 @ $12.29000
Partial-Peak	564 @ $2.79000
Off-Peak	564 @ $6.66000

TOTAL CHARGES **$15,297.66**

Usage Comparison	Days Billed	Kwh Billed	Kwh per Day
This Year	31	79,200	2,554.8
Last Year	N/A	N/A	N/A

Rotating outage blocks are subject to change without advance notice due to operational conditions.

Generation includes charges for the portion of your energy usage provided by the Department of Water Resources (DWR) and is being collected by PG&E as an agent for DWR. DWR is collecting 8.640 cents per kWh from Bundled customers for each kWh it provides plus the Power Charge Indifference Adjustment component of the Cost Responsibility Surcharge from Direct Access and Transitional Bundled Service customers.

Energy Statement

99908498870092200017934310001793431

Account Number	Bill Date	Amount Due	Due Date	Amount Enclosed
8498870092-2	10/21/2009	**$17,934.31**	11/09/2009	

6123.13.293.60205 1 AV 0.335

CITY OF FRESNO
PARKS DIV
2326 FRESNO ST STE 101
FRESNO CA 93721-1824

PG&E
BOX 997300
SACRAMENTO CA
95899-7300

200.0367

Please return this portion with your payment. Thank you.

Telephone Assistance

1-800-468-4743
Assistance is available by telephone: Monday - Friday, 7:00 a.m.-7:30 p.m. and Saturday, 7:00 a.m.-4:30 p.m.

Local Office Address

705 P ST
FRESNO CA 93760

Account Number

8498870092-2

October 2009

ACCOUNT SUMMARY

Service	Service Dates	Amount
Electric	09/22/2009 To 10/20/2009	$17,915.30
Energy Commission Tax		19.01
TOTAL CURRENT CHARGES		$17,934.31
Previous Balance		15,297.66
10/20 Payment - Thank You		15,297.66-

TOTAL AMOUNT DUE **DUE DATE - 11/09/2009**	**$17,934.31**

For all of your account, billing or service needs, please contact our Business Customer Service Center at 1-800-468-4743.

Form 01-6630 9/98

CITY OF FRESNO
1707 W JENSEN AVE
FRESNO CA 93706

ELECTRIC ACCOUNT DETAIL

Service ID #: 8498870005 SPORTS COMPLEX
Rate Schedule: E19P Medium General Demand-Metered TOU Service
Billing Days: 29 days

Serial	Rotating Outage Blk	Meter #	Prior Meter Read	Current Meter Read	Difference	Meter Constant	Usage
X	5K	1004578328	432	504	72	1,200	86,400 Kwh

100.00% Power Factor = -0.90% Adjustment

Charges

09/22/2009 - 09/30/2009

Electric Charges	$5,572.82	
Power Factor Adjustment	20.11-	
Net Charges		$5,552.71

The net charges shown above include the following component(s).
Please see definitions on Page 2 of the bill.

Generation	$3,338.34
Transmission	520.33
Distribution	1,183.77
Public Purpose Programs	149.08
Nuclear Decommissioning	7.51
DWR Bond Charge	131.66
Ongoing CTC	160.08
Energy Cost Recovery Amount	61.94

Taxes and Other

Energy Commission Tax $5.90

Time of Use Detail

Season: Summer	Energy
Peak	3,724 @ $0.15606
Partial-Peak	8,566 @ $0.10407
Off-Peak	14,524 @ $0.08154

Season: Summer	Demand
Peak	312 @ $12.29000
Partial-Peak	528 @ $2.79000
Off-Peak	528 @ $6.66000

Charges

10/01/2009 - 10/20/2009

Electric Charges	$12,407.28	
Power Factor Adjustment	44.69-	
Net Charges		$12,362.59

The net charges shown above include the following component(s).
Please see definitions on Page 2 of the bill.

Form 01-6630 9/98

Generation	$7,418.55
Transmission	1,156.31
Distribution	2,630.58
Public Purpose Programs	331.29
Nuclear Decommissioning	16.69
DWR Bond Charge	292.56
Ongoing CTC	355.74
Energy Cost Recovery Amount	160.87

Taxes and Other

Energy Commission Tax $13.11

Time of Use Detail

Season: Summer	Energy
Peak	8,276 @ $0.15645
Partial-Peak	19,034 @ $0.10446
Off-Peak	32,276 @ $0.08193

Season: Summer	Demand
Peak	312 @ $12.29000
Partial-Peak	528 @ $2.79000
Off-Peak	528 @ $6.66000

TOTAL CHARGES **$17,934.31**

Usage Comparison	Days Billed	Kwh Billed	Kwh per Day
This Year	29	86,400	2,979.3
Last Year	N/A	N/A	N/A

Rotating outage blocks are subject to change without advance notice due to operational conditions.

Generation includes charges for the portion of your energy usage provided by the Department of Water Resources (DWR) and is being collected by PG&E as an agent for DWR. DWR is collecting 8.640 cents per kWh from Bundled customers for each kWh it provides plus the Power Charge Indifference Adjustment component of the Cost Responsibility Surcharge from Direct Access and Transitional Bundled Service customers.

The rates shown above are applicable to bundled service customers. Direct Access and Community Choice Aggregation customers pay only a portion of these rates. Please see the appropriate rate schedule for the applicable charges.

Pacific Gas and Electric Company® WE DELIVER ENERGY.™

99908498870092200015983740001142177

Account Number	Bill Date	Amount Due	Due Date	Amount Enclosed
8498870092-2	11/20/2009	**$11,421.77**	12/07/2009	

6221.14.314.68328 1 AV 0.335

CITY OF FRESNO
PARKS DIV
2326 FRESNO ST STE 101
FRESNO CA 93721-1824

PG&E
BOX 997300
SACRAMENTO CA
95899-7300

200.0392

Please return this portion with your payment. Thank you.

Telephone Assistance
1-800-468-4743
Assistance is available by telephone: Monday - Friday, 7:00 a.m.-7:30 p.m. and Saturday, 7:00 a.m.-4:30 p.m.

Local Office Address
705 P ST
FRESNO CA 93760

Account Number
8498870092-2

November 2009

ACCOUNT SUMMARY

Service	Service Dates	Amount
Electric	10/21/2009 To 11/19/2009	$15,961.83
Energy Commission Tax		21.91
TOTAL CURRENT CHARGES		$15,983.74
Previous Balance		17,934.31
11/16 Payment - Thank You		17,934.31-
Total Adjustments		4,561.97-

TOTAL AMOUNT DUE **$11,421.77**
DUE DATE - 12/07/2009

This bill statement includes a one-time electric credit. The credit represents reduced electric procurement costs for recent and projected electricity purchases due to lower natural gas prices. We are pleased to be providing this bill credit to our customers. Thank you.

For all of your account, billing or service needs, please contact our Business Customer Service Center at 1-800-468-4743.

Moving? Please call PG&E customer service at 1-800-PGE-5000 to notify us of your new mailing address.

Recycled Paper
30% Post-Consumer Waste

Form 01-6630 9/98

CITY OF FRESNO

1707 W JENSEN AVE
FRESNO CA 93706

ELECTRIC ACCOUNT DETAIL

Service ID #: 8498870005 SPORTS COMPLEX
Rate Schedule: E19P Medium General Demand-Metered TOU Service
Billing Days: 30 days

Serial	Rotating Outage Blk	Meter #	Prior Meter Read	Current Meter Read	Difference	Meter Constant	Usage
X	5K	1004578328	504	587	83	1,200	99,600 Kwh

100.00% Power Factor = -0.90% Adjustment

Charges

10/21/2009 - 10/31/2009

Electric Charges	$7,796.16	
Power Factor Adjustment	25.20-	
Net Charges		$7,770.96

The net charges shown above include the following component(s).
Please see definitions on Page 2 of the bill.

Generation	$4,807.67
Transmission	656.98
Distribution	1,653.79
Public Purpose Programs	186.82
Nuclear Decommissioning	9.41
DWR Bond Charge	164.98
Ongoing CTC	200.59
Energy Cost Recovery Amount	90.72

Taxes and Other

Energy Commission Tax $7.39

Time of Use Detail

Season: Summer	Energy
Peak	4,800 @ $0.15645
Partial-Peak	13,200 @ $0.10446
Off-Peak	15,600 @ $0.08193

Season: Summer	Demand
Peak	492 @ $12.29000
Partial-Peak	564 @ $2.79000
Off-Peak	564 @ $6.66000

Charges

11/01/2009 - 11/19/2009

Electric Charges	$8,240.37	
Power Factor Adjustment	49.50-	
Net Charges		$8,190.87

The net charges shown above include the following component(s).
Please see definitions on Page 2 of the bill.

Generation	$4,063.50
Transmission	1,022.08
Distribution	1,823.57
Public Purpose Programs	366.96
Nuclear Decommissioning	18.48
DWR Bond Charge	324.06
Ongoing CTC	394.02
Energy Cost Recovery Amount	178.20

Taxes and Other

Energy Commission Tax $14.52

Time of Use Detail

Season: Winter	Energy
Peak	
Partial-Peak	26,400 @ $0.08921
Off-Peak	39,600 @ $0.07776

Season: Winter	Demand
Peak	
Partial-Peak	516 @ $0.78000
Off-Peak	516 @ $6.66000

TOTAL CHARGES **$15,983.74**

Adjustments

Electric Procurement Bill Credit $4,561.97-

Usage Comparison	Days Billed	Kwh Billed	Kwh per Day
This Year	30	99,600	3,320.0
Last Year	N/A	N/A	N/A

Rotating outage blocks are subject to change without advance notice due to operational conditions.

Generation includes charges for the portion of your energy usage provided by the Department of Water Resources (DWR) and is being collected by PG&E as an agent for DWR. DWR is collecting 8.640 cents per kWh from Bundled customers for each kWh it provides plus the Power Charge Indifference Adjustment component of the Cost Responsibility Surcharge from Direct Access and Transitional Bundled Service customers.

The rates shown above are applicable to bundled service customers. Direct Access and Community Choice Aggregation customers pay only a portion of these rates. Please see the appropriate rate schedule for the applicable charges.

9990849887009220001135223000113 5223

Account Number	Bill Date	Amount Due	Due Date	Amount Enclosed
8498870092-2	12/21/2009	**$11,352.23**	01/07/2010	

6323.35.821.183558 1 AT 0.357

CITY OF FRESNO
PARKS DIV
2326 FRESNO ST STE 101
FRESNO CA 93721-1824

PG&E
BOX 997300
SACRAMENTO CA
95899-7300

200.0417

Please return this portion with your payment. Thank you.

Telephone Assistance
1-800-468-4743
Assistance is available by telephone: Monday - Friday, 7:00 a.m.-7:30 p.m. and Saturday, 7:00 a.m.-4:30 p.m.

Local Office Address
705 P ST
FRESNO CA 93760

Account Number
8498870092-2

December 2009

ACCOUNT SUMMARY

Service	Service Dates	Amount
Electric	11/20/2009 To 12/21/2009	$11,334.01
Energy Commission Tax		18.22
TOTAL CURRENT CHARGES		$11,352.23
Previous Balance		11,421.77
12/16 Payment - Thank You		11,421.77-

TOTAL AMOUNT DUE **$11,352.23**
DUE DATE - 01/07/2010

Your electricity is being billed on a nonresidential (commercial or industrial) rate. If this account supplies a single-family residence or a multifamily complex (including common use areas), please call Pacific Gas and Electric Company to determine your correct rate.

For all of your account, billing or service needs, please contact our Business Customer Service Center at 1-800-468-4743.

CITY OF FRESNO
1707 W JENSEN AVE
FRESNO CA 93706

ELECTRIC ACCOUNT DETAIL

Service ID #: 8498870005 SPORTS COMPLEX
Rate Schedule: E19P Medium General Demand-Metered TOU Service
Billing Days: 32 days

Serial	Rotating Outage Blk	Meter #	Prior Meter Read	Current Meter Read	Difference	Meter Constant	Usage
X	5K	1004578328	587	656	69	1,200	82,800 Kwh

100.00% Power Factor = -0.90% Adjustment

Charges

11/20/2009 - 12/21/2009

Electric Charges	$11,396.11	
Power Factor Adjustment	62.10-	
Net Charges		$11,334.01

The net charges shown above include the following component(s).
Please see definitions on Page 2 of the bill.

Generation	$5,115.25
Transmission	1,681.14
Distribution	2,929.64
Public Purpose Programs	460.37
Nuclear Decommissioning	23.18
DWR Bond Charge	406.55
Ongoing CTC	494.32
Energy Cost Recovery Amount	223.56

Taxes and Other

Energy Commission Tax $18.22

Time of Use Detail

Season: Winter	Energy
Peak	
Partial-Peak	34,800 @ $0.08921
Off-Peak	48,000 @ $0.07776

Season: Winter	Demand
Peak	
Partial-Peak	528 @ $0.78000
Off-Peak	528 @ $6.66000

TOTAL CHARGES **$11,352.23**

Usage Comparison	Days Billed	Kwh Billed	Kwh per Day
This Year	32	82,800	2,587.5
Last Year	N/A	N/A	N/A

Rotating outage blocks are subject to change without advance notice due to operational conditions.

Generation includes charges for the portion of your energy usage provided by the Department of Water Resources (DWR) and is being collected by PG&E as an agent for DWR. DWR is collecting 8.640 cents per kWh from Bundled customers for each kWh it provides plus the Power Charge Indifference Adjustment component of the Cost Responsibility Surcharge from Direct Access and Transitional Bundled Service customers.

999084988700922000007351940000735194

Account Number	Bill Date	Amount Due	Due Date	Amount Enclosed
8498870092-2	01/21/2010	**$7,351.94**	02/08/2010	

6437.8.171.34778 1 AT 0.357

CITY OF FRESNO
PARKS DIV
2326 FRESNO ST STE 101
FRESNO CA 93721-1824

PG&E
BOX 997300
SACRAMENTO CA
95899-7300

200.0017

Please return this portion with your payment. Thank you.

Telephone Assistance
1-800-468-4743
Assistance is available by telephone: Monday - Friday, 7:00 a.m.-7:30 p.m. and Saturday, 7:00 a.m.-4:30 p.m.

Local Office Address
705 P ST
FRESNO CA 93760

Account Number
8498870092-2

January 2010

ACCOUNT SUMMARY

Service	Service Dates	Amount
Electric	12/22/2009 To 01/21/2010	$7,340.59
Energy Commission Tax		11.35
TOTAL CURRENT CHARGES		$7,351.94
Previous Balance		11,352.23
01/15 Payment - Thank You		11,352.23-

TOTAL AMOUNT DUE **$7,351.94**
DUE DATE - 02/08/2010

For all of your account, billing or service needs, please contact our Business Customer Service Center at 1-800-468-4743.

Be winter-wise! Cold weather can triple heating use; fewer daylight hours can increase lighting use by a third. Spending more time indoors and billing periods with 5 weekends can also cause higher bills. To save money, set heaters lower and turn lights off when not needed.

Moving? Please call PG&E customer service at 1-800-PGE-5000 to notify us of your new mailing address.

Form 01-6630 9/98

CITY OF FRESNO
1707 W JENSEN AVE
FRESNO CA 93706

ELECTRIC ACCOUNT DETAIL

Service ID #: 8498870005 SPORTS COMPLEX
Rate Schedule: E19P Medium General Demand-Metered TOU Service
Billing Days: 31 days

Serial	Rotating Outage Blk	Meter #	Prior Meter Read	Current Meter Read	Difference	Meter Constant	Usage
X	5K	1004578328	656	700	44	1,200	51,600 Kwh

100.00% Power Factor = -0.90% Adjustment

Charges

12/22/2009 - 12/31/2009

Electric Charges	$2,339.98	
Power Factor Adjustment	12.48-	
Net Charges		$2,327.50

The net charges shown above include the following component(s).
Please see definitions on Page 2 of the bill.

Generation	$1,020.00
Transmission	332.45
Distribution	651.79
Public Purpose Programs	92.55
Nuclear Decommissioning	4.66
DWR Bond Charge	81.73
Ongoing CTC	99.38
Energy Cost Recovery Amount	44.94

Taxes and Other

Energy Commission Tax $3.66

Time of Use Detail

Season: Winter	Energy
Peak	
Partial-Peak	6,194 @ $0.08921
Off-Peak	10,452 @ $0.07776

Season: Winter	Demand
Peak	
Partial-Peak	324 @ $0.78000
Off-Peak	324 @ $6.66000

Charges

01/01/2010 - 01/21/2010

Electric Charges	$5,039.31	
Power Factor Adjustment	26.22-	
Net Charges		$5,013.09

The net charges shown above include the following component(s).
Please see definitions on Page 2 of the bill.

9990849887009220000756003000075600З

Account Number	Bill Date	Amount Due	Due Date	Amount Enclosed
8498870092-2	02/22/2010	**$7,560.03**	03/11/2010	7560.03

6575.34.798.175930 1 AT 0.357

CITY OF FRESNO
PARKS DIV
2326 FRESNO ST STE 101
FRESNO CA 93721-1824

PG&E
BOX 997300
SACRAMENTO CA
95899-7300

200.0043

Please return this portion with your payment. Thank you.

Telephone Assistance
1-800-468-4743
Assistance is available by telephone: Monday - Friday, 7:00 a.m.-7:30 p.m. and Saturday, 7:00 a.m.-4:30 p.m.

Local Office Address
705 P ST
FRESNO CA 93760

Account Number
8498870092-2

February 2010

ACCOUNT SUMMARY

Service	Service Dates	Amount
Electric	01/22/2010 To 02/22/2010	$7,546.57
Energy Commission Tax		13.46
TOTAL CURRENT CHARGES		$7,560.03
Previous Balance		7,351.94
02/08 Payment - Thank You		7,351.94-

TOTAL AMOUNT DUE	**$7,560.03**
DUE DATE - 03/11/2010	

In 2010, Daylight Saving Time will be two weeks earlier starting on March 14 and ending one week later on November 7. During the additional weeks of Daylight Saving Time, your Time-of-Use periods will begin and end one hour later. Please visit **www.pge.com** or call us at 1-800-PGE-5000 for additional information.

For all of your account, billing or service needs, please contact our Business Customer Service Center at 1-800-468-4743.

Recycled Paper 30% Post-Consumer Waste

44

Form 01-6630 9/98

CITY OF FRESNO
1707 W JENSEN AVE
FRESNO CA 93706

ELECTRIC ACCOUNT DETAIL

Service ID #: 8498870005 SPORTS COMPLEX
Rate Schedule: E19P Medium General Demand-Metered TOU Service
Billing Days: 32 days

Serial	Rotating Outage Blk	Meter #	Prior Meter Read	Current Meter Read	Difference	Meter Constant	Usage
X	5K	1004578328	700	750	50	1,200	61,200 Kwh

100.00% Power Factor = -0.90% Adjustment

Charges

01/22/2010 - 02/22/2010

Electric Charges	$7,592.47	
Power Factor Adjustment	45.90-	
Net Charges		$7,546.57

The net charges shown above include the following component(s).
Please see definitions on Page 2 of the bill.

Generation	$3,559.82
Transmission	698.94
Distribution	1,841.67
Public Purpose Programs	644.43
Nuclear Decommissioning	17.75
DWR Bond Charge	315.18
Ongoing CTC	243.57
Energy Cost Recovery Amount	225.21

Taxes and Other

Energy Commission Tax $13.46

Time of Use Detail

Season: Winter	Energy
Peak	
Partial-Peak	20,400 @ $0.09075
Off-Peak	40,800 @ $0.07996

Season: Winter	Demand
Peak	
Partial-Peak	240 @ $0.87000
Off-Peak	240 @ $6.83000

TOTAL CHARGES **$7,560.03**

Usage Comparison	Days Billed	Kwh Billed	Kwh per Day
This Year	32	61,200	1,912.5
Last Year	N/A	N/A	N/A

Rotating outage blocks are subject to change without advance notice due to operational conditions.

Generation includes charges for the portion of your energy usage provided by the Department of Water Resources (DWR) and is being collected by PG&E as an agent for DWR. DWR is collecting 23.139 cents per kWh from Bundled customers for each kWh it provides plus the Power Charge Indifference Adjustment component of the Cost Responsibility Surcharge from Direct Access and Transitional Bundled Service customers.

Form 01-6630 9/98

Telephone Assistance
1-800-743-5000
Assistance is available by telephone 24 hours per day, 7 days per week.

Local Office Address
705 P ST
FRESNO CA 93760

Account Number
8498870092-2

March 2009

ACCOUNT SUMMARY

Service	Service Dates	Amount
Electric	02/21/2009 To 03/16/2009	$7,544.54
Energy Commission Tax		12.15
Current Charges Due 04/09/2009		$7,556.69
Previous Balance		6,412.79
No Payment Received by 03/23/2009		
TOTAL AMOUNT DUE		**$13,969.48**

Optional rates are available to many customers and may lower your PG&E bills. To find out if you have options available, please call 1-800-468-4743. The back of this bill has other important messages.

Form 01-8630

Pacific Gas and Electric Company

CITY OF FRESNO
1707 W JENSEN AVE
FRESNO CA 93706

ELECTRIC ACCOUNT DETAIL

Service ID #: 8498870005 SPORTS COMPLEX
Rate Schedule: E19P Medium General Demand-Metered TOU Service
Billing Days: 24 days

Serial	Rotating Outage Blk	Meter #	Prior Meter Read	Current Meter Read	Difference	Meter Constant	Usage
X	5K	P28876	3,108	3,154	46	1,200	
X	5K	1004578328	0	0	0	1,200	
						Billing Usage	55,200 Kwh

Charges

02/21/2009 - 02/28/2009

Electric Charges	$2,371.16	
Net Charges		$2,371.1(

The net charges shown above include the following component(s).
Please see definitions on Page 2 of the bill.

Generation	$991.38
Transmission	389.66
Distribution	639.98
Public Purpose Programs	102.30
Nuclear Decommissioning	5.15
DWR Bond Charge	90.34
Ongoing CTC	109.85
Energy Cost Recovery Amount	42.50

Taxes and Other

Energy Commission Tax $4.0

Time of Use Detail

Season: Winter	Energy
Peak	
Partial-Peak	8,400 @ $0.08005
Off-Peak	10,000 @ $0.06938

Season: Winter	Demand
Peak	
Partial-Peak	468 @ $0.78000
Off-Peak	528 @ $6.22000

Charges

03/01/2009 - 03/16/2009

Electric Charges	$5,173.38	
Net Charges		$5,173.3

The net charges shown above include the following component(s).
Please see definitions on Page 2 of the bill.

CITY OF FRESNO

Generation	$2,287.28
Transmission	905.80
Distribution	1,279.99
Public Purpose Programs	204.61
Nuclear Decommissioning	10.30
DWR Bond Charge	180.69
Ongoing CTC	219.70
Energy Cost Recovery Amount	85.01

Taxes and Other

Energy Commission Tax $8.10

Time of Use Detail

Season: Winter	Energy
Peak	
Partial-Peak	16,800 @ $0.08882
Off-Peak	20,000 @ $0.07737

Season: Winter	Demand
Peak	
Partial-Peak	468 @ $0.78000
Off-Peak	528 @ $6.66000

TOTAL CHARGES **$7,556.69**

Usage Comparison	Days Billed	Kwh Billed	Kwh per Day
This Year	24	55,200	2,300.0
Last Year	30	75,600	2,520.0

Rotating outage blocks are subject to change without advance notice due to operational conditions.

Generation includes charges for the portion of your energy usage provided by the Department of Water Resources (DWR) and is being collected by PG&E as an agent for DWR. DWR is collecting 8.640 cents per kWh from Bundled customers for each kWh it provides plus the Power Charge Indifference Adjustment component of the Cost Responsibility Surcharge from Direct Access and Transitional Bundled Service customers.

The rates shown above are applicable to bundled service customers. Direct Access and Community Choice Aggregation customers pay only a portion of these rates. Please see the appropriate rate schedule for the applicable charges.

GWTP POWER BILL

		DATE:	7/1/2009 0:00
GWTP METER READINGS-			
BILLING START DATE:	6/23/2009 0:00	KWH:	2,155,360
BILLING END DATE:	7/22/2009 0:00	KWH:	2,196,000
		TOTAL KWH HOURS USED:	40,640

TOTAL POWER BILL IN KWH:	100,800
TOTAL GWTP METER READING IN KWH:	40,640

PERCENTAGE OF POWER BILL FOR GWTP:	40.31746032

$ 18,411.33 **Total bill to the Park's Department**

$ 18,411.33 X 40.31746 1/100= $ 7,422.98

$ 7,422.98 **Total cost to Public Utilities Department for the Ground Water Treatment Plant**

GWTP POWER BILL

				DATE:
GWTP METER READINGS-				
BILLING START DATE:		8/5/2009 0:00	KWH:	2,220,000
BILLING END DATE:		8/21/2009 0:00	KWH:	2,249,920
		TOTAL KWH HOURS USED:		29,920

TOTAL POWER BILL IN KWH:	45,600
TOTAL GWTP METER READING IN KWH:	29,920

PERCENTAGE OF POWER BILL FOR GWTP:	65.61403509

$ 9,457.61 Total bill to the Park's Department

$ 9,457.61 X 65.614035 1/100= $ 6,205.52

$ 6,205.52 Total cost to Public Utilities Department for the Ground Water Treatment Plant

GWTP POWER BILL

GWTP METER READINGS-				
BILLING START DATE:		**8/22/2009 0:00**	KWH:	**2,251,840**
BILLING END DATE:		**9/21/2009 0:00**	KWH:	**2,298,080**
		TOTAL KWH HOURS USED:		**46,240**

TOTAL POWER BILL IN KWH:	**79,200**
TOTAL GWTP METER READING IN KWH:	**46,240**

PERCENTAGE OF POWER BILL FOR GWTP:	58.38383838

$ 15,297.66 **Total bill to the Park's Department**

$ 15,297.66 X 58.383838 1/100= $ 8,931.36

$ 8,931.36 **Total cost to Public Utilities Department for the Ground Water Treatment Plant**

GWTP POWER BILL

GWTP METER READINGS-				
BILLING START DATE:		9/22/2009 0:00	KWH:	2,299,520
BILLING END DATE:		10/20/2009 0:00	KWH:	2,344,160
			TOTAL KWH HOURS USED:	44,640

TOTAL POWER BILL IN KWH:	86,400
TOTAL GWTP METER READING IN KWH:	44,640

PERCENTAGE OF POWER BILL FOR GWTP:	51.66666667

$ 17,915.30 Total bill to the Park's Department

$ 17,915.30 X 51.666667 1/100= $ 9,256.24

$ 9,256.24	Total cost to Public Utilities Department for the Ground Water Treatment Plant

GWTP POWER BILL

GWTP METER READINGS-				
BILLING START DATE:		10/21/2009 0:00	KWH:	2,601,920
BILLING END DATE:		11/19/2009 0:00	KWH:	2,638,400
		TOTAL KWH HOURS USED:		36,480

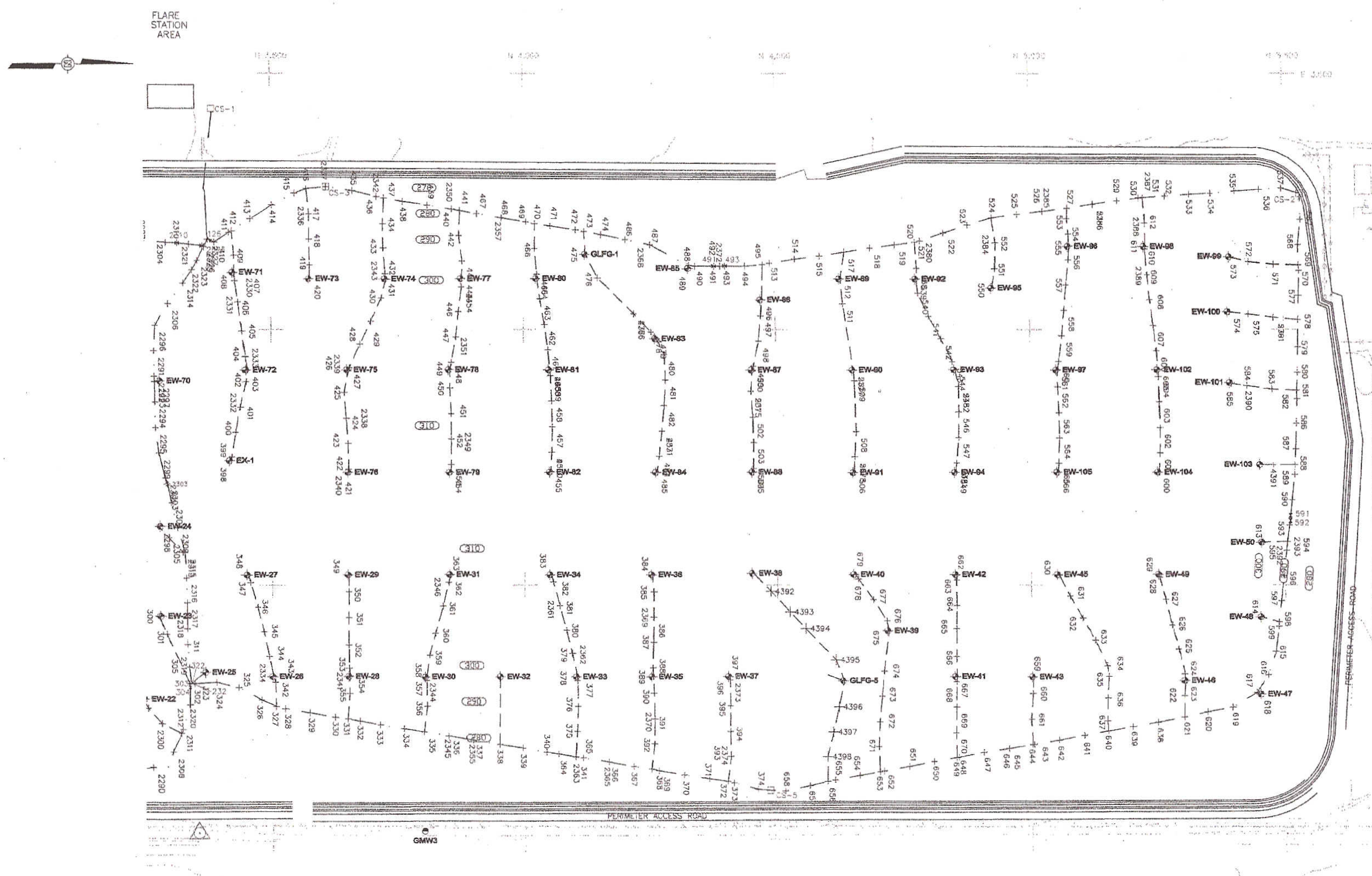
TOTAL POWER BILL IN KWH:	99,600
TOTAL GWTP METER READING IN KWH:	36,480

PERCENTAGE OF POWER BILL FOR GWTP:	36.62650602

$ 15,961.83 Total bill to the Park's Department

$ 15,961.83 X 36.626506 1/100= $ 5,846.26

$ 5,846.26 **Total cost to Public Utilities Department for the Ground Water Treatment Plant**



AS BUILT

LEGEND

- 12" LFG HEADER PIPE WITH 2" CONDENSATE AND 2" AIR PIPES
- 12" LFG HEADER PIPE
- 6" LATERAL PIPE
- 2" FORCE MAIN
- 2" DOUBLE-CONTAINED CONDENSATE PIPE
- MONITORING WELLS
- GAS EXTRACTION WELLS

SCALE IN FEET
0 100 200

RECORD DRAWINGS

THESE DRAWINGS ARE RECORDS COMPILING THE DESIGN INFORMATION, FIELD CHANGES, AND SURVEY INFORMATION USED DURING CONSTRUCTION. THE INTENT IS TO PROVIDE THE CLIENT WITH A DOCUMENT TO SHOW THE EXTENT OF THE LANDFILL AND THE CLOSURE DESIGN TO FACILITATE THE LONG-TERM MAINTENANCE. ALTHOUGH CARE WAS TAKEN IN THE COMPILATION OF RECORDS, MINOR DEVIATIONS MAY OCCUR; IF NECESSARY, FIELD VERIFY FEATURES SHOWN ON THE DRAWINGS

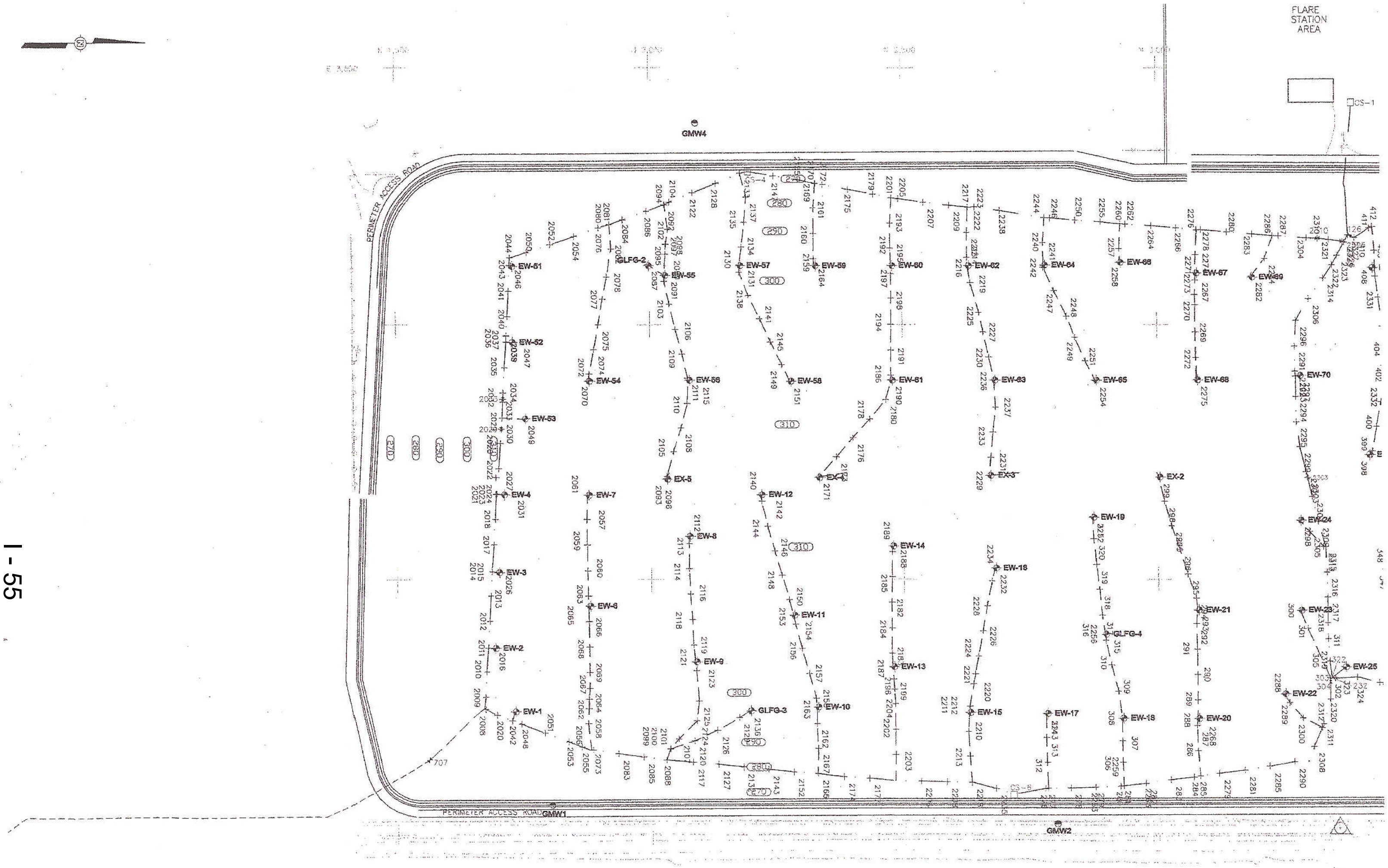
REGISTERED PROFESSIONAL ENGINEER
JOHN G. PEPIN
No. C 51223
Exp. 6-30-05
CIVIL
STATE OF CALIFORNIA

IT CORPORATION

CITY OF FRESNO
FRESNO SANITARY LANDFILL
FRESNO, CALIFORNIA

DRAWING 2
LANDFILL GAS SYSTEM RECORD DRAWING
(SHEET 2 OF 2)
FRESNO SANITARY LANDFILL
FRESNO, CALIFORNIA

DRAWN BY		CHECKED BY		APPROVED BY		DRAWING NUMBER
K. Troyer	3/22/2002	R. Bruno	3/22/2002	J. Pepin	3/22/2002	808765



AS BUILT

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●	MONITORING WELLS
✦	GAS EXTRACTION WELLS

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SCALE IN FEET
0 100 200

REGISTERED PROFESSIONAL ENGINEER No. C 61233 Exp. 9-30-05 CIVIL STATE OF CALIFORNIA

IT CORPORATION

CITY OF FRESNO
FRESNO SANITARY LANDFILL
FRESNO, CALIFORNIA

DRAWING 1
LANDFILL GAS SYSTEM RECORD DRAWING
(SHEET 1 OF 2)
FRESNO SANITARY LANDFILL
FRESNO, CALIFORNIA

DRAWN BY		CHECKED BY		APPROVED BY		DRAWING NUMBER
K. Troyer	3/22/2002	R. Bruno	3/22/2002	J. Papin	3/22/2002	808765