MONITORING, REPORTING AND VERIFICATION PROTOCOL FOR THE GREATER NEW BEDFORD LFG UTILIZATION PROJECT CRAPO HILL LANDFILL , DARTMOUTH MASSACHUSETTS

MRV CNBE 2005 12

Prepared for
CommonWealth New Bedford Energy LLC, a wholly owned subsidiary of CommonWealth Resource Management Corporation

by

Environmental Resources Trust, Inc.
Washington, DC

December 2005

Table of Contents

1 Introduction

CommonWealth New Bedford Energy LLC (CNBE) is a Massachusetts based limited liability company, wholly owned by CommonWealth Resource Management Corporation (CRMC) a Massachusetts based corporation. Environmental Resources Trust, Inc. is a non-profit environmental organization specializing in market-based solutions to environmental problems.

On behalf of CNBE, CRMC has commissioned this Monitoring, Reporting, and Verification Guideline (the Guideline) to provide transparency and credibility in the quantification of the greenhouse gas emission reductions, and in the allocation of corresponding property rights, generated through methane (CH_4) emission reductions at the Greater New Bedford LFG Utilization Project located at the Crapo Hill Landfill in Dartmouth Massachusetts.

The Guideline describes a system to quantify and verify methane (CH_4) emission reductions at the Greater New Bedford LFG Utilization Project.

1.1 Guideline Objectives

The primary objectives of this Guideline are to address methodology, data collection, data quality control, related to the monitoring, reporting, and verifying of methane emission reductions from a landfill gas (LFG) capture project. The ultimate objective is that by following these guidelines a “true and fair” representation of the project’s net direct emissions performance, which can be verified, will result.

In order to be verified, emission reductions must meet the following criteria:

- The project must result in a reduction of direct emissions within the project’s boundaries and such reductions must derive from specific and identifiable actions such as changes in equipment, technologies, processes, or operations.
- Emission reductions must be additional (i.e., surplus) to emission reductions that may be required by existing regulatory requirements.
- Ownership of the emission reductions must be clearly demonstrable by contract or written agreement. Owners of the relevant facilities, the entities paying the operational costs of the facility, and the entities that paid for or subsidized the initial and the ongoing costs of the emission reduction action must be identified.
- Emission reductions must be quantifiable by acceptable, transparent, and replicable measurement and calculation tools and techniques. Raw data must be available to verify measurements and calculations and statistical information provided to support the level of certainty/significance of the data. Baseline emissions determination must be explained and specified. The actual reduction beyond the baseline emission level must be specified.

Given those criteria, this MRV Guideline shall

- Define project boundaries
- Clearly establish ownership of the credits by clearly demonstrable contract or written

agreement. Identify the owners of the relevant facility, the entities paying the operational costs of the facility, and the entities that paid for or subsidized the initial and the ongoing costs of the emission reduction action.

- Identify emissions sources
- Address issues of additionality and leakage
- Specify a project baseline against which emission reductions will be determined
- Specify monitoring and data collection techniques and procedures
- Specify emission factors & calculation methods, where applicable
- Identify supporting data for emissions quantification
- Describe data management and quality control procedures
- Specify reporting and documentation requirements, including frequency
- Address uncertainty
- Describe procedures for verification and registration of emission reductions
- Specify an attestation statement by project operators

1.2 Applicability

This guideline is specifically applicable to methane gas emission reductions from LFG capture projects where:

- The captured gas is flared, or
- The captured gas is used to generate electricity or heat, but no emission reductions are claimed for avoiding emissions from other sources (e.g. if electricity generation is displaced or landfill-related transportation activities are reduced).

1.3 Periodic Reviews and Revisions

Environmental Resources Trust, Inc. (ERT) may require revisions to this Guideline to ensure that the monitoring, reporting, and verification system adequately addresses changes in the project's activities.

An annual emissions report should be submitted by CNBE to ERT and will be subject to an annual review. As a part of this review, ERT will:

- Review the report and prepare adjustments or corrections
- Verify the data by applying audit-sampling methods
- Register verified emission reductions in the GHG Registry[SM]

This MRV Guideline also specifies the frequency of other MRV activities.

2 General description of Project

CNBE owns and operates the Greater New Bedford LFG Utilization Project that consists of a 3.3 MW landfill gas-to-energy facility (the "Project) located in the Crapo Hill Landfill (the "Landfill") in the town of Dartmouth, Massachusetts. CNBE owns the exclusive rights to the LFG from the Landfill as well as all Environmental Attributes associated with the LFG. The Landfill is owned and operated by a multi-community solid waste management district, the Greater New Bedford Regional Refuse Management District (the "District"). The District owns and operates a LFG management system (consisting of a LFG collection system and a LFG flare) that extracts LFG from the Landfill and delivers the LFG to the Project (see figure below).
.

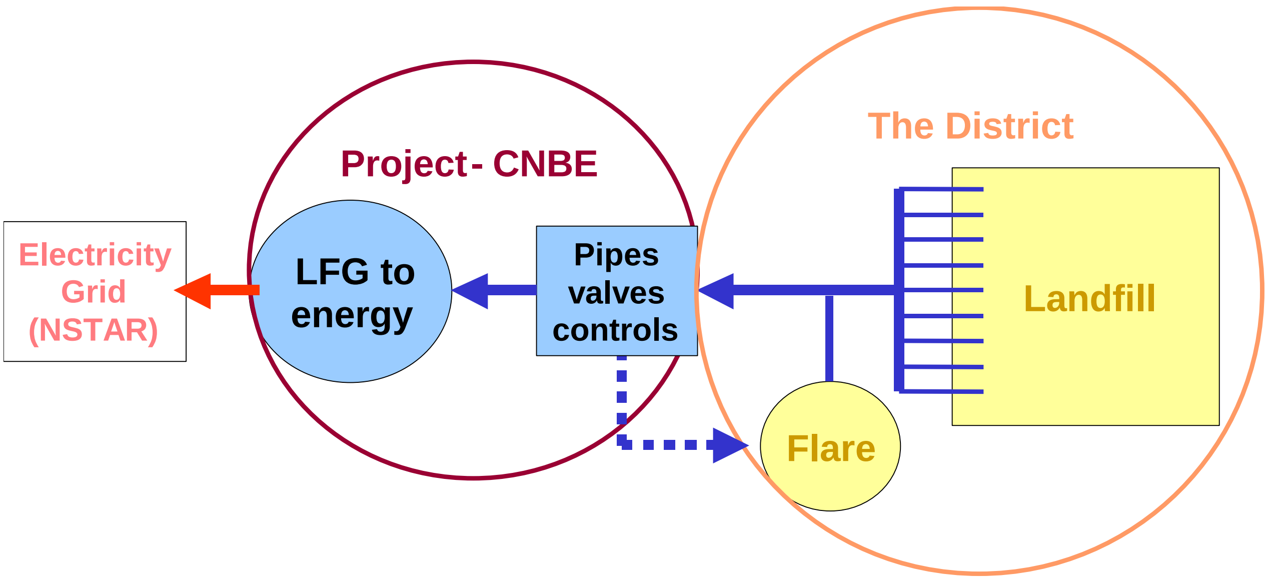


Figure 1: General description of the Landfill and the Project

2.1 Landfill description

The Landfill is owned by the District, a legislatively-created solid waste management District comprising the City of New Bedford and the Town of Dartmouth. The Landfill comprises a 152-acre parcel of land that is owned by the District and located west of Samuel Barnet Boulevard in the northeast portion of the Town of Dartmouth, Massachusetts. The portion of the Landfill property that was permitted by the Massachusetts Department of Environmental Protection (MDEP) to be used for solid waste disposal includes 69.8 acres of the 152-acre parcel of land. The Landfill is being developed in phases. The first phase, comprising a footprint of 20 acres commenced operations in 1995 and was partially filled prior to operations moving to the second phase area in 2002. The second phase, which consists of approximately 10 acres was opened in

2002. The Landfill has been used for solid wasted disposal since 1995, during which time it has received over 1,100,000 tons of solid waste for disposal. The waste stream has been composed of municipal solid waste, and construction and demolition debris. The Landfill serves member communities of the District only and is permitted to receive up to 115,000 tons of solid waste in any calendar year. Overall, the Landfill is anticipated to have the capacity to accept solid waste for disposal at current rates for the next 15 to 20 years. The District plans to develop the Landfill to continue serving the member communities for the next 15 years. The approved design capacity of the Landfill is not expected to exceed 2.75 million tons (the threshold under the federal New Source Performance Standards, or "NSPS") for several years. See Site Plan attached in Appendix III that shows the Landfill phases 1 and 2 (Figure 6).

The Landfill was designed and constructed in accordance with stringent environmental standards currently in effect in Massachusetts, and incorporates features such as a bottom liner with leachate collection, and a flexible geo-synthetic liner and earthen cap on closed areas.

2.2 LFG management system

Landfill gas is the natural byproduct of the actions of anaerobic bacteria that cause the organic matter that exists within a landfill to decompose. Undiluted landfill gas typically has a composition of between 40 and 60 percent methane and roughly 45 percent carbon dioxide with lesser amounts of hydrogen, oxygen, nitrogen and minute concentrations of other gases. The emission of landfill gas is a major contributor to the buildup of methane in the atmosphere. The migration of the landfill gas underground can also cause groundwater contamination or has the potential to build up in a closed area or a building and become an explosive hazard. The removal of the landfill gas has other benefits, such as odor control.

The Landfill was originally designed and permitted to incorporate passive gas vents in order to allow methane generated in subsurface areas of waste deposition to be emitted to the atmosphere uncontrolled. The purpose of such gas vents was to prevent the methane from building up pressure, thereby avoiding lateral migration of the methane underground and reducing the potential for underground fires or explosions. Passive gas vents continue to be utilized to vent methane to the atmosphere from certain sections of the Landfill. In addition, an active collection system has been added to the Landfill. The active landfill gas (LFG) collection system was voluntarily constructed and has been in operation since the beginning of 2000.

The LFG management system consists of (a) a network of vertical and horizontal wells, laterals and header pipes to extract the LFG that is being generated under the surface of the Landfill, and (b) a flare to combust any LFG not consumed by the Project. Two vacuum blowers pull LFG under pressure from the Landfill through the wells and pipes and through the main header to the Project where the LFG is destroyed by combustion.

The LFG extracted from the Landfill is composed of approximately 55 percent methane that has a heating value of approximately 550 BTUs per cubic foot.

2.3 Project description

Methane, the major component of the landfill gas, is the principal constituent of natural gas and, therefore, landfill gas is an alternative fuel to natural gas, fuel oil or coal. This waste product can be put to a productive use as fuel for the generation of electrical or heat energy. This particular Project diverts the landfill gas for use as fuel in four reciprocating internal combustion engine-generator sets that are specially designed for combustion of LFG. The right to develop the Project at the Landfill was awarded to CRMC by the District via a public procurement process. The Project is sited in close proximity to the District Facilities on a portion of the Landfill property outside the limits of waste deposition that has been leased by the District to CNBE. The term of the Site Lease is 15 years, with a five year renewal option. The Project is expected to enter into commercial operations during the fourth quarter of calendar year 2005.

The Project consists, in general terms, of the following components:

1. Piping valves and controls for (a) conveying LFG from the District Facilities to the Project's LFG processing equipment and (b) conveying any excess or otherwise unused LFG to the District Facilities for destruction in the District's existing LFG flare
2. A LFG processing system and related ancillaries and controls for conditioning the delivered LFG by removing moisture, and other contaminants prior to use of the LFG in the Project's electric power generating equipment. The moisture and contaminants are conveyed directly to the District's discharge piping to the New Bedford waste water treatment facility.
3. Electric power generating equipment, including engine-generators sets and related ancillaries and controls for combusting the processed LFG fuel to produce mechanical energy for generating electric power
4. Switchgear, transformers, relays and related controls and equipment for delivering the electric power to the local distribution utility, NSTAR
5. Buildings, enclosures, foundations, access-ways, fencing and related utilities and civil structures necessarily associated with the above

Appendix IV provides a site plan and general arrangement of the Project. The pictures below show some of its components.

Figure 2: The Project – row 1: LFG piping and Project facilities; row 2: LFG pumps and electric power generating equipment; row 3: transformer and control room

The Project has the capacity to combust up to 40.2 MMBtu per our or 1,326 scfm of LFG at 50 percent methane. Combustion of the LFG fuel in the engines creates mechanical shaft power that turns appropriately-matched electrical generators to generate up to 3.3 MW (net) of electricity. The capacity of the Project is based on the use of four Caterpillar model 3516 engine-generator sets rated nominally at 825 kW (gross) per set. Caterpillar internal combustion engine technology and its competitive analogs are widely available and have a long record of successful use in LFG applications over many decades and under a wide range of operating conditions. Electricity generated at the Project is delivered to the regional power grid via an interconnection with the local electricity distribution company, Commonwealth Electric Company d/b/a NStar electric (NSTAR).

2.4 Starting date of the Project activity

The landfill gas collection system has been in operation since 2000. The flare system was installed in 1999 and commenced operation at the beginning of 2000. The LFG-to-energy system will become operational in the fourth quarter of 2005.

2.5 Project boundaries and emission sources

The Project and system boundaries comprise all elements of the LFG-to-energy system and destruction of LFG in the District's flare. GHG emissions included in the Project boundaries consist of: direct on-site emissions associated with the generation of mechanical shaft power used for electricity production and destruction of LFG in the District flare. It does not include emissions from activities that may be associated with the Landfill but that occur off of the Landfill site. E.g. It does not include incidental emissions from mobile source fuel combustion or indirect (e.g. offsetting) effects upon emissions due to the transfer of electricity into the grid.

The Project includes the following emission pathways:

- Fugitive methane emissions from the engines and flaring
- Carbon dioxide (CO_2) from flare
- CO_2 from landfill gas combustion in leachate engines

The CO_2 emissions from the Project are assumed to be from biogenic-based carbon. As for standard GHG accounting convention, these emissions are therefore assumed not to lead to a net addition of carbon to the atmosphere[1].

1 It is the convention in project-level greenhouse gas emissions accounting that CO_2 emissions from biogenic-based carbon are not treated as a net source of carbon to the atmosphere. This convention is based on the assumption that the carbon in the materials that are oxidized—in this case waste materials—is replaced by new growth of plant matter after the original biomass is harvested. National level GHG inventories, account for changes in the stocks of carbon stored in terrestrial ecosystems to measure net biogenic-based carbon emissions.

2.6 Additionality

The primary test as to whether a landfill gas capture project leads to additional (i.e., surplus) emission reductions relates to the existing federal, state, or local regulatory requirements on the Landfill to capture and/or treat landfill gas. The installation of an active LFG collection and control system at the Crapo Hill Landfill was incorporated into the Landfill's state-approved operating plan at the initiative of the District, on the basis of the District's own judgment as a public agency that active gas management was the most effective and appropriate way to prevent odor complaints and to provide for the possible beneficial use of LFG in the long-term. The District has not been required, pursuant to any environmental law, to destroy or control the emission of methane, hazardous air pollutants or any other component of landfill gas. ERT must be informed of any changes to the regulatory status of the Project that may affect the additionality test. E.g. at such time that the Landfill owner or operator is required under any Environmental Law or any state government law or rule to destroy or control the emission of methane, hazardous air pollutants or any other component of landfill gas, the operator of the Landfill or the Project developer, will advise ERT and the buyer of emission reductions in writing.

Specifically, the Crapo Hill Landfill is not covered by the U.S. Environmental Protection Agency's (EPA's) New Source Performance Standards (NSPS) and Existing Facility Guidelines (EGs) for Landfills (40 CFR 51, 52 and 60 March 12, 1996), National Emissions Standards for Hazardous Air Pollutants (NESHAP): Municipal Solid Waste Landfills, or other local, state, or federal regulations requiring the operation of landfill gas collection system.

Under the NSPS rules landfills that commenced construction after May 30, 1991, began accepting waste on or after that date, have an approved design capacity to dispose of greater than 2.75 million tons of solid waste or 3.27 million cubic yards of solid waste, and are projected to emit more than 55 tons per year (50 megagrams per year) of Non-Methane Organic Compounds (NMVOCs) without controls, are required to install and operate an active or passive LFG collection system that meets specified performance criteria and to install devices that combust and destroy at least 98 percent of the NMVOCs. The current construction approval capacity for the Crapo Hill Landfill is approximately 2 millions tons of solid waste, thus below the 2.75 million tons threshold requiring installation of LFG collection and combustion systems. The potential maximum expansion of the Landfill would bring its overall capacity to 3.5 million tons, thus above the regulatory threshold. Even including this expansion; however, projected emissions of NMVOCs (in absence of intervention) would not exceed 55 tons and thus the Landfill would not be required to meet the regulatory standard. If and when Landfill expansion was to occur, CNBE would have to demonstrate that actual Landfill capacity and emissions remain below the regulatory thresholds.

Under the NESHAP at 40 CFR 63, landfills that have accepted waste after November 8, 1987 and are a major source of Hazardous Air Pollutants (HAPs) or co-located with a major source of HAPs, or subject to the requirement of NSPS are required to implement equivalent collection and controls under the NSPS/EGs for landfills. For these rules 'major sources of HAPs' are defined as sources with 10 tons per year of a HAP or 25 tons per year of all HAPs. Federal

NESHAP regulations do not apply to the Crapo Hill Landfill because the Landfill does not classify as a 'major source of HAPs' and is not subject to the requirements of the NSPS.

The relevant state regulations are Massachusetts 310 CMR 19.0. These rules require control of LFG to prevent conditions that would cause hazards to health, safety and property. A monitoring program is required to determine the potential of such a condition. There is no specific requirement for installing and operating an active LFG collection or control system. The State of Massachusetts has not required Crapo Hill Landfill to actively collect and control LFG to satisfy applicable state regulatory criteria: i.e. to prevent conditions that would cause hazards to health, safety and property. In fact, as part of its process for permitting the Landfill, the state required that a health impact assessment be conducted under the assumption that there would be a zero percent LFG capture efficiency throughout the Landfill's active life[2]. The assessment concluded that the Landfill would pose no such hazard.

2.7 Leakage

There are no significant sources of leakage (i.e., indirect increases in greenhouse gas emissions outside of the Project's boundaries).

2.8 Baseline determination

Traditionally a project baseline takes into account historic trends, technology developments, regulatory requirements, and investments/divestures/other structural adjustments in operational control of entity. In the case of Crapo Hill Landfill the applicable baseline scenario is the continued uncontrolled release of landfill gas to the atmosphere, as this site does not fall under any regulatory requirements to control the methane gas.

Consistent with the Project boundaries (see section 2.5) the Project baseline does not include the incidental emissions from mobile source fuel combustion or indirect (e.g. offsetting) effects upon emissions due to the transfer of electricity into the grid.

---

2 Guidance for Conducting Facility Impact Assessment for Solid Waste Facility Site Assignment and Permitting in Support of 310 CMR 16.00 & 19.00 March 12, 2004

2.9 Ownership

The District owns the rights over the landfill gas generated in the Crapo Hill Landfill and has contractually transferred all rights to emission reductions from the Landfill to CommonWealth New Bedford Energy LLC. The relevant contractual language is reproduced below.

> 6.4 Environmental Attributes. Lessee (where Lessee is defined as CNBE) and/or its designees, successors and assigns, shall have the right, beginning on the date that the Generating Facility becomes operational and so long as this Lease Agreement is in effect thereafter, to all attributes of an environmental or other nature, known or unknown at the time of this Lease Agreement, including but not limited to allowances, certificates, RECs or other green power price premiums or similar constructs generated by or attributable to the Generating Facility by virtue of its classification as a renewable energy project under Applicable Laws, emissions credits and all other credits, offsets, tradable renewable certificates (sometimes referred to as "green tags"), and all similar rights issued, recognized, created or otherwise arising from use or disposition of the Landfill Gas delivered to Lessee, including but not limited to the generation and/or sale of electricity at the Generating Facility using Landfill Gas, the delivery and/or sale of capacity (the Generating Facility's capability to reliably generate a specific amount of electricity at a given point in time) and electricity to any purchaser thereof, the production of thermal energy or other energy products as a by-product of generating electricity at the Generating Facility, and the destruction of such Landfill Gas ("***Environmental Attributes***"). Environmental Attributes include but shall not be limited to those that are created by regulations, statutes, or other governmental action enacted before or after the Effective Date. Environmental Attributes include but shall not be limited to those that can be used to (1) claim responsibility for the reduction of emissions and/or pollutants, (2) claim ownership of emission and/or pollution reduction rights, and (3) claim reduction or avoidance of emissions or pollutants. Emissions and pollutants include, but are not limited to, acid rain precursors, carbon dioxide, carbon monoxide, chlorinated hydrocarbons, greenhouse gases, mercury, metals, methane, nitrogen oxides, nitrogen-oxygen compounds, ozone precursors, particulate matter, sulfur dioxide, toxic air pollutants, other carbon and sulfur compounds, and similar pollutants or contaminants of air, water or soil, under any governmental, regulatory or voluntary program, including but not limited to the United Nations Framework Convention on Climate Change and related Kyoto Protocol or any other program. Environmental Attributes exclude Section 45 tax credits, Section 29 tax credits and any and all other tax credits or benefits associated with the ownership or operation of the Generating Facility or production of Landfill Gas. Prior to the date that the Generating Facility becomes operational, Lessor shall have the right to any Environmental Attributes attributable to the Landfill or the LFGMS.

Environmental Resources Trust, Inc. recognizes that emission reductions may be achieved offsite related to the displacement of fossil fuel generation as a result of the electricity generated by the Project. However, ownership rights to these reductions cannot be assigned a priori to either CNBE or others at this time. Tradable Renewable Energy Certificates can be generated from this site and a marginal generation analysis can be developed to quantify any emissions that may be reduced (i.e., "backed down") as a result of on-site generation.

3 Calculation Methodology

For landfill methane gas capture projects such as this one, it is essential to accurately and transparently measure the methane combusted in the Project (i.e. the emission reduction attributable to the Project).

The emissions not released to the atmosphere can be directly monitored. It is assumed that every ton of methane collected and destroyed equals one ton of methane not released to the atmosphere and thus one ton of methane emissions reduced.

This Project reduces emissions of methane through the following combustion reaction:

$$CH_4 + O_2 \Rightarrow CO_2 + 2\,H_2O$$

The combustion reaction, which occurs under controlled conditions in the Project, involves the combination of methane (CH_4) with oxygen (O_2) to create carbon dioxide (CO_2) and water (H_2O). That is, the result of the combustion is to destroy the methane while creating carbon dioxide and water vapor. The Project combusts methane in electric power generating equipment and in a landfill gas flare.

Typically for electric power generating equipment the percent of methane combusted is almost complete. For landfill gas flares, emission tests to document the percent of the methane destroyed are rarely performed, although the limited testing show destruction approaching 100 percent. EPA typically uses a 98 percent efficiency factor for flares unless evidence for a higher rate is supplied, arguing that "Since flares do not lend themselves to conventional emission testing techniques, only a few attempts have been made to characterize flare emissions. Recent EPA tests using propylene as flare gas indicated that efficiencies of 98 percent can be achieved when burning an off gas with at least 11,200 kJ/m^3 (300 Btu/ft^3)"[3]

Methane is a far more potent contributor to the greenhouse effect than carbon dioxide – 23 times more potent in accordance with the most recent publication of the United Nations Intergovernmental Panel on Climate Change (IPCC [4]). Thus, the Project provides a substantial net reduction in greenhouse gas emissions through destruction of methane even after accounting for the tons of CO_2 released during the combustion process.

Methane that is emitted to the atmosphere uncontrolled despite the Project (that is, methane that is emitted directly from the Landfill without being destroyed in the combustion device) would also be emitted to the atmosphere uncontrolled if there were no Project. Such quantities of methane are not considered in the quantification of emission reductions associated with the

---

3 See http://www.epa.gov/ttn/chief/ap42/ch13/final/c13s05.pdf

4 Houghton, J.T., Y. Ding, D.J. Griggs, M. Noguer, P.J. van der Linden and D. Xiaosu. Climate Change 2001: The Scientific Basis. Contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change. United Nations IPCC. Table 3, Global Warming Potential, entry under methane and 100 yrs. See www.grida.no/climate/ipcc_tar/wg1/020.htm#c6 or www.eia.doe.gov/oiaf/1605/gwp.html

Project.

In accordance with the above, the reduction of greenhouse gases associated with the Project, in tons of carbon equivalents, is calculated in three steps as follows:

1. Determine the volume of methane in cubic feet destroyed in the engines and flare.
2. Convert the volume of methane in cubic feet to the mass of methane in metric tons.
3. Calculate the global warming potential on a gross basis of the destroyed mass of methane as measured in metric tons of carbon-dioxide-equivalents.

The volume of methane in cubic feet delivered to the engines and the flare over a given time interval is determined in accordance with the following formula:

Volume of methane delivered to the engines (or flare) (cubic feet)	=	TRend – TRstart	x	(MCend – MC start)/2

Where:

TRend = Totalizer Reading at the end of the time interval (standard cubic feet)
TRstart = Totalizer Reading at the start of the time interval (standard cubic feet)
MCend = Methane content by volume at the end of the time interval (percent)
MCstart = Methane content by volume at the start of the time interval (percent)

For the quantification of the methane volume destroyed by the Project the calculation above will take place on no less frequent basis than weekly.

The quantity of methane is converted from volume in cubic feet to mass in metric tons as follows:

Mass of methane destroyed (metric tons)	=	Volume of methane delivered (standard cubic feet)	x	Efficiency fraction of methane oxidized (%)	x	16 pounds per pound-mole (the molar weight of methane)	/	2205 pounds per metric ton	/	385 standard cubic feet per pound-mole (gas constant)

This conversion uses the ideal gas relationship: n = PV/RT where,

n = Mass of methane destroyed in metric tons
P = Pressure in atmospheres (assumed to be 1 atmosphere)
V = Volume of methane destroyed in standard cubic feet
RT = Gas constant at standard conditions (385 standard cubic feet per pound-mole)

The gas constant is converted to metric tons by multiplying the entire formula by the molar weight of methane (16 pounds per pound-mole) and dividing by a conversion factor of 2,205 pounds per metric ton.

The default factor utilized for engine efficiency in methane oxidation is 99.9 percent
The default factor utilized for flare efficiency in methane oxidation is 98 percent.

The gross global warming potential of the methane is calculated as follows:

Gross global warming potential of methane (metric tons of CO_2-equivalents)	=	Mass of methane destroyed (metric tons)	x	21 (global warming potential potency factor in metric tons of CO_2-equivalents per metric ton of methane)

4 Monitoring and data collection

Critical for the accuracy and transparency of the calculation is that:

1. Measurements of LFG flows are undertaken with reliable equipment that is regularly calibrated;
2. Sampling of Methane concentration in LFG is undertaken with reliable equipment that is regularly calibrated;
3. Sampling of Methane concentration in LFG takes place with a frequency that is sufficient to calculate average concentration factors that are statistically unbiased (i.e. they reflect the actual methane concentration of the LFG);
4. Measurements of LFG flows are undertaken at least on a monthly basis and are as frequent as necessary to apply statistically valid methane concentration factors (as described in (3), above);
5. Measurement and calibration equipment and processes and changes thereof are clearly described as part of the GHG emissions reporting process.

Unless otherwise specified through the GHG emissions reporting process, the following system is assumed to be in place.

4.1 Data measurements

Implementation of the calculation methodology described in Section 3 above requires measurement of the following two quantities:

- Volume of landfill gas collected from the Landfill.
- Methane content of the landfill gas

The volumes of landfill gas collected from the Landfill, in actual cubic feet, are measured continuously on a real-time basis with accumulating volumetric flow meters. The flow meters are located directly upstream of the Project. The specific devices used to take readings are orifice flow meters capable of measuring flows from 0 to 1,600 actual cubic feet per minute. One flow meter serves as the unit for flow meter measurements to the four engines, and one unit for flow meter measurements to the flare. Each flow meter is equipped with a totalizer that indicates the cumulative actual cubic feet of gas that have passed through that flow meter. For the engines, total flow is measured each minute and totalized and recorded each hour and day. The totalized intervals for flow to the engines are automatically converted to standard cubic feet per hourly and daily interval and stored on a computer monitoring system. For the flare, the totalilized flow will be read by the operator approximately on a weekly basis, and will record the date and time of each reading.

The methane content of the landfill gas, on a percent volume basis, is measured at a sampling port in the main header pipe near the flow meter with the use of a California Analytical Instrument Non-dispersive infrared (NDIR) analyzer. The methane content is measured at the approximately the same time as readings are taken on the flow meter totalizer. The average methane content over the interval is then calculated as the average of the reading taken at the start of the interval and the reading taken at the end of the interval.

The operator typically balances the landfill gas collection wellfield on a weekly basis on the same day that the totalizer reading is taken at the flare. The operator measures and records the methane content, carbon dioxide content, oxygen content, and balance gas content. In addition, in the course of balancing the wellfield, the operator records the methane content, carbon dioxide content, oxygen content, and balance gas content at each individual well or other extraction point in the landfill gas collection system. The results of a recent component analysis of the landfill gas at the Landfill flare is provided below:

Component	Units	Value
Methane	Percent by volume	55%
Carbon dioxide	Percent by volume	40%
Oxygen	Percent by volume	0.1%
Balance gas	Percent by volume	4.9%

Measured by Operator, July 6, 2004.

Records of all data discussed in this section are recorded in a on-site computer system automatically and as needed manually by CNBE. CNBE will enter these records into a summary spreadsheet that will be used for the calculations described previously. All reports and calculations will be archived to facilitate verification.

4.2 Instrument calibration

The flow instruments and the California Analytical Instruments NDIR analyzer are calibrated periodically to ensure accurate measurements.

The flow instruments are calibrated at the Project during normal operations at least once during each calendar year and more frequently as necessary. The calibration is performed by measuring the flow at a point in close proximity to the orifice flow meters. A pitot tube attached to a manometer measures the flow. The pitot tube is inserted into the pipe and several points are measured across the full diameter of the pipe. The measurements taken by the pitot tube and manometer include velocity pressure and static pressure. Other measurements taken during calibration include gas temperature and barometric pressure.

Note that the pitot tube is the standard device used to calibrate all other gas velocity measuring devices. CNBE uses a pitot tube Model 160-18,5/16-inch, which is manufactured to AMCA and ASHRAE standards by Dwyer Instruments, Inc.

The pitot tube consists of an impact tube that receives total pressure input from the gas stream. The impact tube is fastened concentrically inside a second tube of slightly larger diameter. The second tube receives static pressure input from radial sensing holes around the tip. The air space between inner and outer tubes permits transfer of pressure from the sensing holes to the static pressure connection at the opposite end of the pitot and then, through connecting tubing, to the low or negative pressure side of a manometer. When the total pressure tube is connected to the high-pressure side of the manometer, velocity pressure is indicated directly. See the figure below. To insure accurate velocity pressure readings, the pitot tube tip is pointed directly into and parallel with a laminar portion of the gas stream.

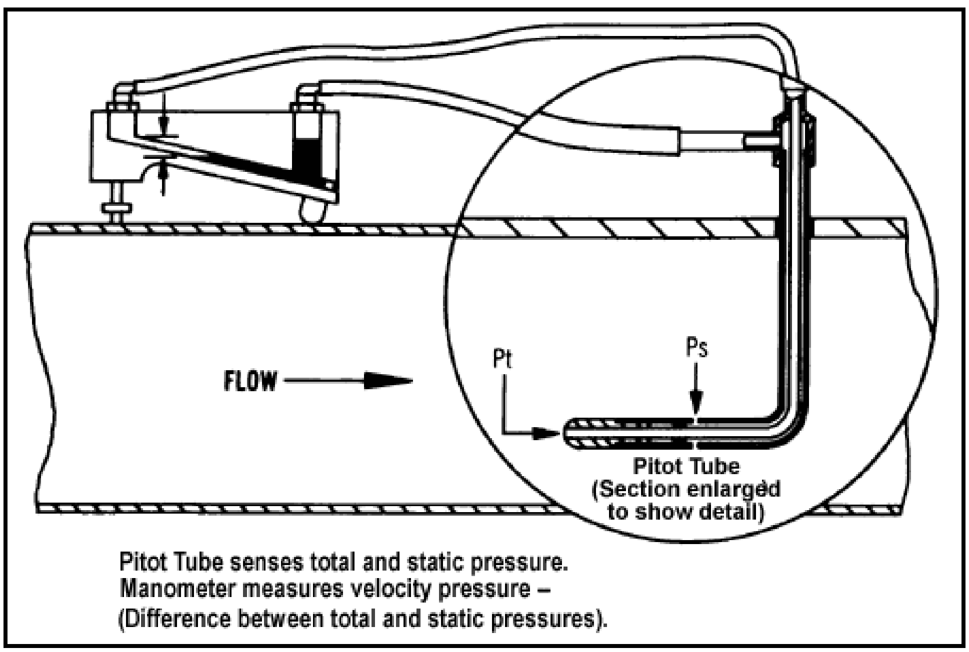


Figure 3: Pitot Tube

The measured data is used to calculate scfm as shown in Appendix V, the flow meter calibration records. The meter is manually adjusted to correspond to the calculated acfm. Typically, the

primary meter has been found to be accurate to +/- five percent, and therefore only minor calibrations have been made.

The methane concentration measured by the California Instruments NDIR Analyzer is calibrated each week, and any hand-held instrument such as a GEM-500 or equivalent, prior to its use. The instrument is calibrated using fifty-percent methane content gas from a standard gas cylinder and zero methane content from ambient air. See Appendix V for samples of the calibrations.

4.3 Quality control (QC)

The following quality control procedures will be followed:

- The recording and archiving of daily gas flow and methane concentration monitoring records
- The maintenance of a daily log book for Project operating conditions
- The regular calibration of measurement equipment, as specified above and in Appendix I
- The implementation of corrective actions when problems are identified and the reporting of those problems to ERT when they occur
- The establishment of routine reminders for site technicians to perform calibration and other QC procedures

This MRV Guideline will be available for review and comment. The feedback and comments received will be considered in future revisions.

5 Uncertainties

There are a number of uncertainties related to estimates of methane emission reductions from landfill gas capture projects. Some of these uncertainties are more easily quantified than others. Sources and magnitude of uncertainties (and changes thereof) should be explicitly addressed and discussed as part of the GHG emissions calculation and reporting process.

Unless otherwise specified during the GHG emissions reporting process, uncertainties are as described below.

The accuracy and precision of measurement equipment, such as the flow meter and gas analyzer, is easily quantified and considered to be quite low. The extrapolation of gas composition measurements to the total flow of landfill gas can introduce significant errors, depending upon the variability of the methane content of the landfill gas and the frequency of samples taken. The actual methane content of pure landfill gas does not vary significantly each week as shown by past measurements. The frequency of samples to be taken for LFG to the engines are each minute and recorded each hour, which accounts for nearly all LFG collected from the Landfill. The frequency of samples to be taken for LFG to the flare will be at least weekly and the variability is expected to be low for little LFG.

The variation in the efficiency due to environmental influences or operating practices may also contribute to the overall uncertainty. Operating malfunctions of the Project are recorded, if and

when they occur, though, the contribution of this variation to the overall uncertainty is not expected to be large. During normal operations, the Project is expected to destroy all or nearly all the methane gas contained within the LFG. During normal operations of the District flare, the combustion temperature and residence time are sufficient to completely destroy all methane gas contained within the LFG (e.g. 99+ percent).

An additional source of uncertainty relates to the assumed baseline for this landfill gas capture project. In the absence of a landfill gas collection system, a fraction of the methane would have oxidized as it percolated through the Landfill strata, thereby lowering the implicit baseline emissions for the Project and also the estimated emission reductions. The U.N. Framework Convention on Climate Change (UNFCCC) CDM Executive Board requested at its 12th meeting (November 2003) that the UNFCCC Secretariat prepare a technical paper on the impact of oxidation of biogas in the calculation of methane emission reductions for landfill gas projects. This MRV Guideline may require revision if and when a scientifically valid methodology for correcting baseline emission calculation for landfill gas capture projects is available from the UNFCCC.

6 Reporting and Documentation

All records and logs should be maintained such that they can be audited by an independent third party verifier.

An annual emissions reduction report should be submitted to ERT with data as specified in this MRV guideline.

CNBE will utilize an excel worksheet to provide emissions calculation data and results to ERT, utilizing the template worksheet called “CHNB calculations.xls”, jointly developed by ERT and CNBE and based on the methodology described in section 3 above. The figures below are extracts from the template and illustrate the inputs formats and calculation steps performed

CommonWealth New Bedford Energy LLC							
Calculation of Verified Emission Reduction in CO2 equivalent tons per the TGNB Protocol, 2005							
Emission Reductions from methane oxidation during energy generation							
Begin period - date	**End period - date**	**Totalizer reading end period**	**Totalizer reading start period**	**Methane content end period**	**Methane content start period**	**Methane delivered to flare**	**Methane delivered cumulative**
mm/dd/yy	*mm/dd/yy*	*scf*	*scf*	*%*	*%*	*scf*	*scf*
22-Dec-04	22-Dec-04	86,972,050	86,972,050	36.0%	36.0%	-	-
22-Dec-04	29-Dec-04	113,716,100	86,972,050	36.0%	36.0%	9,627,858	9,627,858
29-Dec-04	5-Jan-05	156,000,000	113,716,100	36.0%	36.0%	15,222,204	24,850,062
5-Jan-05	12-Jan-05	190,000,000	156,000,000	36.0%	36.0%	12,240,000	37,090,062
12-Jan-05	19-Jan-05	200,000,000	190,000,000	36.0%	36.0%	3,600,000	40,690,062
19-Jan-05	26-Jan-05	200,000,000	200,000,000	36.0%	36.0%	-	40,690,062
26-Jan-05	2-Feb-05	200,000,000	200,000,000	36.0%	36.0%	-	40,690,062
2-Feb-05	9-Feb-05	200,000,000	200,000,000	36.0%	36.0%	-	40,690,062

Figure 4: Emissions calculations worksheet – extract 1 LFG totalizer inputs, methane content inputs and

calculations of methane delivered for methane oxidation from energy generation

Methane oxidation efficiency	Molar weight methane	Pounds to metric tons conversion	Gas constant	Mass methane destroyed in the period	Mass methane destroyed cumulative	Global warming potential methane	Emission reduction	Emission reduction cumulative
%	*Pounds per mole*	*Pounds per ton*	*scf per pound mole*	*metric tons*	*metric tons*	*tons CO2 equivalent per ton methane*	*CO2 equivalent tons*	*CO2 equivalent tons*
99.9%	16	2,205	385	0	0	21	-	-
99.9%	16	2,205	385	181	181	21	3,807	3,807
99.9%	16	2,205	385	287	468	21	6,019	9,826
99.9%	16	2,205	385	230	698	21	4,840	14,665
99.9%	16	2,205	385	68	766	21	1,423	16,089
99.9%	16	2,205	385	0	766	21	-	16,089
99.9%	16	2,205	385	0	766	21	-	16,089
99.9%	16	2,205	385	0	766	21	-	16,089

Figure 5: Emissions calculations worksheet extract 2 – input parameters for calculation and calculations of methane destroyed and resulting GHG emission reductions from energy generation

7 Attestation statement

The attestation statement in Appendix II must be signed by management of CNBE and submitted annually to ERT, along with the Project report, by March 31 following each year of the Project's lifetime, or upon submittal of periodic emission reduction documentation for verification and registration.

8 Verification and registration

ERT will conduct a site visit to the Landfill to verify the operating conditions of this Project. The reductions will be verified by ERT and registered in CNBE/CRMC's account in ERT's GHG Registry.

ERT will annually verify and apply audit-sampling methods. Once verified following the provision of the annual emissions reduction report and complete supporting documentation, ERT will register emission reductions in the account of CNBE/CRMC for the preceding year's vintage of emission reductions. A Project Verification Statement will be produced for each registration of emission reductions cycle.

9 References

Helping Landfill Owners Achieve Effective, Low-Cost Compliance with Federal Landfill Gas Regulations, U.S. Environmental Protection Agency**,** Landfill Methane Outreach Program, Washington, DC, prepared by SCS Engineers under EPA Contract No. 68-W6-0004, <http://www.epa.gov/lmop/pdf/booklet8.pdf>

10 Appendices

Appendix I: Factors, Variables, and QC procedures summary
Appendix II: Attestation statement
Appendix III: Map of Landfill site
Appendix IV: Map of LFG utilization Project
Appendix V: Results from methane component analysis
Appendix VI: Copy of flow meter calibration records
Appendix VII: Copy of generator operation logs (future)

Appendix I: Factors, Variables, and QC procedures summary

Factor Used for Converting Methane to Carbon Dioxide Equivalents

Global Warming Potential	Reference
21	*Climate Change 1995: The Science of Climate Change*, IPCC (1996)

Conversion Factors

Description	Factor	Units	Description
Methane energy content	50.0 39.6 1012 911	GJ/Mg MJ/m^3 BTU/scf BTU/scf	Net calorific value per unit mass Net calorific value per unit volume (STP) Gross heat content (higher heating value) Net heat content (lower heating value)
Methane density	677	g/m^3 (288°K)	Density should be corrected for local climate and altitude

Data to be collected or used to monitor emissions from the Project activity, and how this data will be archived

Variable	Description	Data unit	Measured, calculated or estimated	Recording Frequency	Proportion of data to be monitored	How are data archived?	Comments
LFG	Amount of landfill gas to Project	$Feet^3$	Measured	Continuous	100%	Electronic	Measured by a flow meter. Data will be aggregated monthly and yearly.
EG	Amount of electricity generated	MWh	Measured	Continuous	100%	Electronic	Measured by a kWh meter. Data will be aggregated monthly and yearly
HR	Heat rate of the generator	GJ/MWh	Measured & calculated	Semi-annual, monthly if unstable	NA	Electronic	Data will be used to test and, if necessary, correct the generator's name plate heat rate.
FE	Combustion efficiency	%	Measured & calculated	Semi-annual, monthly if unstable	NA	Electronic	Methane content of exhaust gases.
F_{CH4}	Methane fraction in landfill gas	%	Measured & calculated	Daily	100%	Electronic	Measured by gas quality analyzer.

Quality control (QC) procedures are needed for the monitoring equipment and the data collected

Data	Uncertainty (High/Medium/Low)	Explanation
LFG	Low	Flow meters will be subject to a regular maintenance and testing regime to ensure accuracy.
EG	Low	Electricity meters will be subject to a regular maintenance and testing regime to ensure accuracy. Their readings will be checked by the electricity distribution company.
HR	Low	Regular maintenance will ensure optimal operation of engines and generators. The heat rate will be checked semi-annually, with monthly checks if the heat rate shows significant deviations from previous values.
FE	Low	Regular maintenance will ensure optimal operation of flares. Flare efficiency will be checked semi-annually, with monthly checks if the efficiency shows significant deviations from previous values.
F_{CH4}	Low	The gas analyzer will be subject to a regular maintenance and testing regime to ensure accuracy.

Appendix II: Attestation Statement

As an officer of CommonWealth New Bedford Energy LLC (CNBE) I hereby certify that the emissions reductions reported in connection with methane capture and combustion have been calculated according to the methods and procedures as outlined and described in this MRV Guideline and are a true representation of the emission performance of the Project.

____
Verification Statement Reference Number

____
Name

____
Title

____
Signature Date

Appendix III: Maps of Landfill site

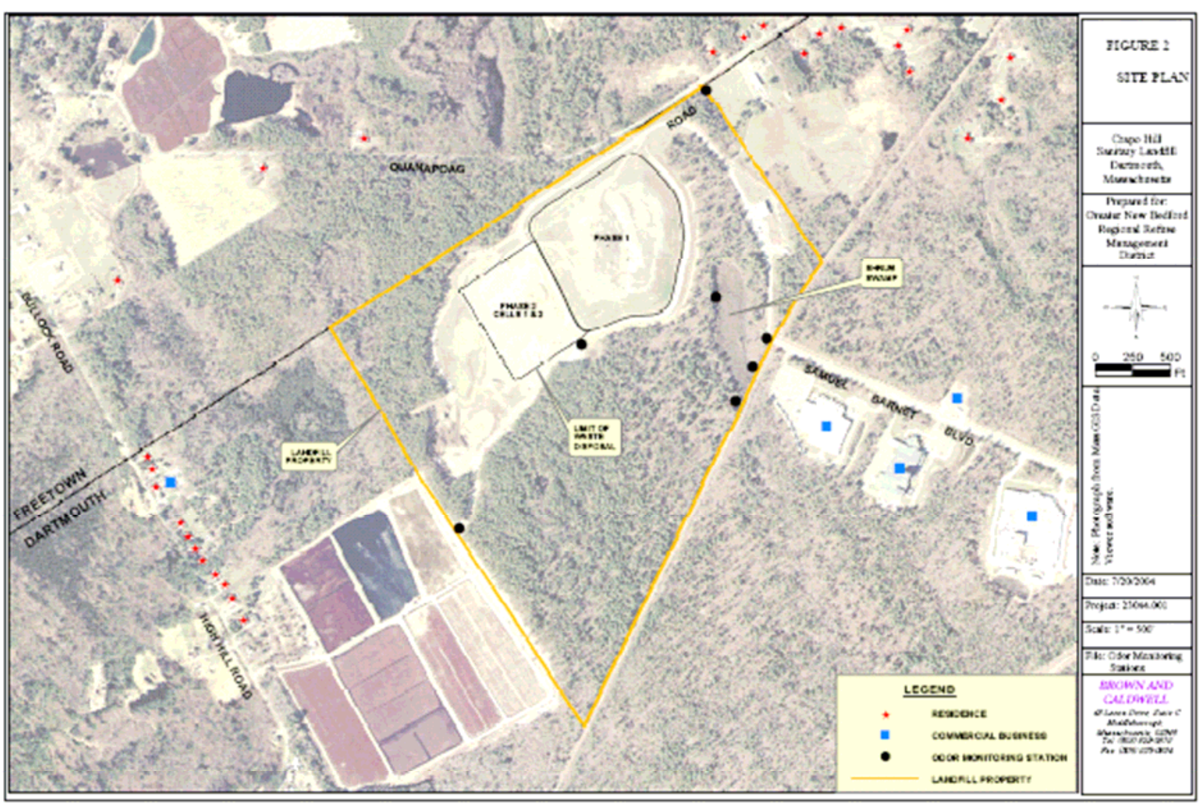
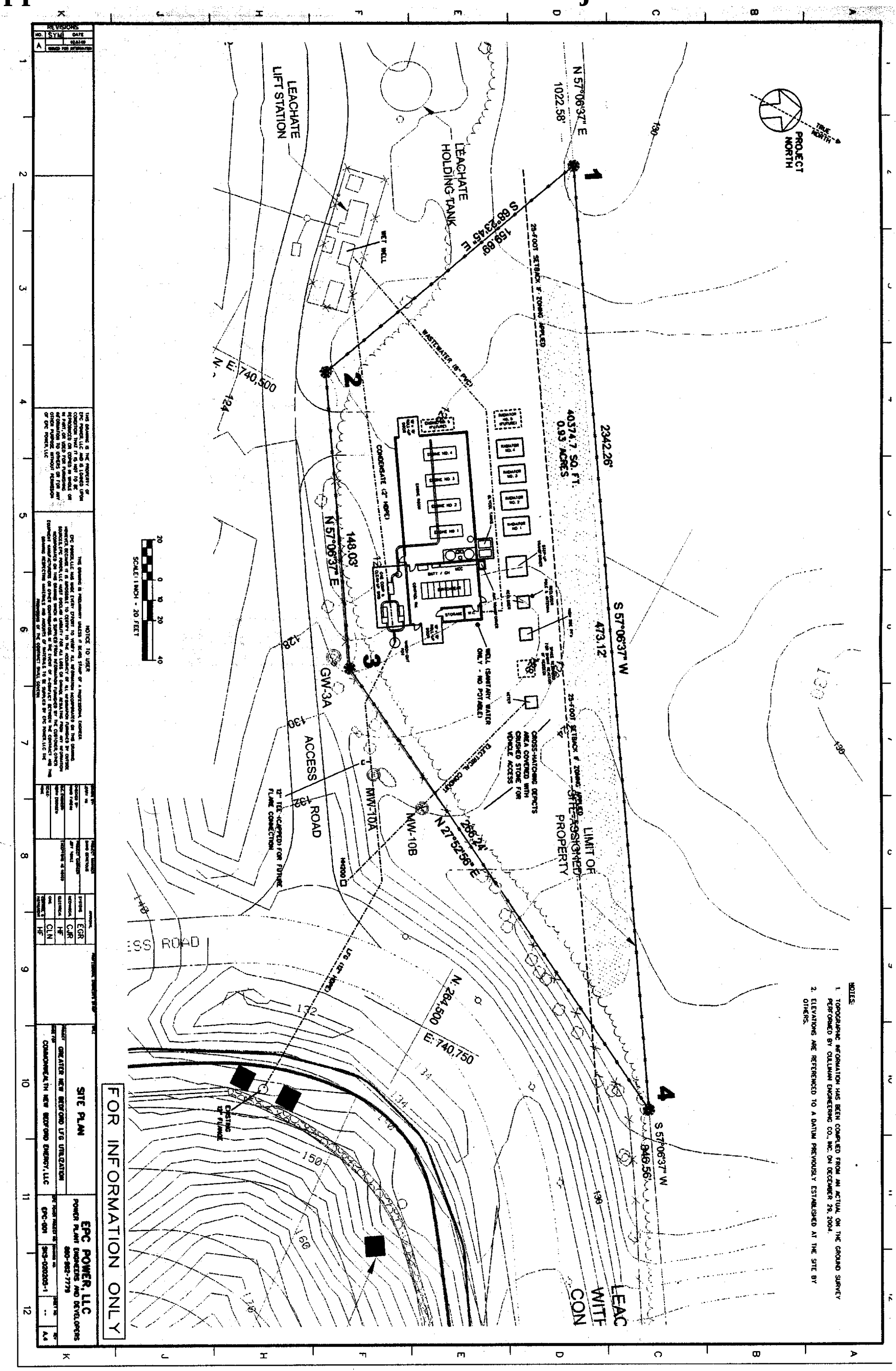


Figure 6: Aerial Site Plan

Appendix IV: Bedford LFG utilization Project



Appendix V: Results from methane component analysis

YEAR 2004 LFG Production Report Data

CRAPO HILL LANDFILL		Methane heat value Btu/s	1012													
														Corrected		Flow at
		Date	Time	CH4	CO2	O2	Bal	Temp F	aP	dP	sP	Flow in	Flow in	Flow	Flow	50% methane
YEAR	MONTH			%	%	%	%		in H2O	in H2O	in H2O	M3/Hr	CFM	CFM, 1	SCFM	SCFM
2004	January	1/7/2004	3:18:54	54	40	0.8	5.2	97	411	1.5	7	1,840	1,082	1,175	1,114	**1,203**
		1/21/2004	2:43:09	49.5	40	0.8	9.7	91	407	1.81	7	2,027	1,192	1,295	1,241	**1,228**
		1/29/2004	10:29:26	52	37	1	10	88	406	1.34	7	1,763	1,037	1,126	1,085	**1,128**
		1/30/2004	12:47:57	53	39	0.4	7.6	88	404	1.24	7	1,696	998	1,083	1,044	**1,106**
	February	2/2/2004	9:01:27	54	39	0.8	6.2	104	417	1.37	7	1,802	1,060	1,151	1,077	**1,164**
		2/3/2004	13:24:40	53	40	0.9	6.1	98	415	1.33	6	1,719	1,011	1,098	1,039	**1,101**
		2/5/2004	11:13:10	51	37	1.2	10.8	97	417	1.31	6	1,747	1,028	1,116	1,058	**1,079**
		2/6/2004	8:40:23	55	39	0.2	5.8	96	415	1.04	5	1,552	913	991	941	**1,035**
		2/10/2004	10:23:55	55	40	0.2	4.8	98	409	1.08	6	1,577	928	1,007	953	**1,048**
		2/12/2004	10:23:44	55	38	0.3	6.7	93	413	1.09	6	1,594	938	1,018	972	**1,069**
		2/12/2004	10:34:39	55	38	0.4	6.6	93	413	1.09	6	1,594	938	1,018	972	**1,069**
		2/17/2004	7:41:31	53	37	0.6	9.4	93	419	1.16	6	1,639	964	1,047	999	**1,059**
		2/20/2004	14:05:43	55	39	0.1	5.9	95	409	1.05	5	1,577	928	1,007	958	**1,054**
		2/20/2004	11:01:18	54	40	0.3	5.7	100	409	1.01	5	1,571	924	1,003	946	**1,022**
		2/23/2004	13:54:24	55	40	0.2	4.8	95	411	1.07	5	1,565	921	1,000	951	**1,046**
		2/27/2004	13:06:12	56	39	0.1	4.9	101	412	1.09	5	1,597	939	1,020	960	**1,075**
	March	3/4/2004	13:25:18	54	40	0.3	5.7	95	412	1.13	6	1,602	942	1,023	973	**1,051**
		3/5/2004	14:41:52	53	40	0.3	6.7	97	413	1.13	6	1,628	958	1,040	986	**1,045**
		3/9/2004	11:55:04	53	45	0.3	1.7	97	411	1.11	5	1,585	932	1,012	960	**1,017**
		3/19/2004	13:25:21	54	39	0.3	6.7	92	413	1.09	5	1,598	940	1,021	976	**1,054**
		3/23/2004	10:54:44	55	40	0.2	4.8	95	414	1.08	5	1,590	935	1,016	966	**1,063**
		3/25/2004	7:29:52	56	39	0.3	4.7	97	417	1.01	5	1,519	894	970	920	**1,030**
	April	4/16/2004	7:39:11	56	39	0.2	4.8	105	412	1.18	5	1,661	977	1,061	991	**1,110**
		4/29/2004	9:24:51	55	39	0.2	5.8	107	414	0.93	4	1,484	873	948	883	**971**
		4/30/2004	9:20:50	56	38	0.3	5.7	113	413	0.92	4	1,460	859	932	859	**962**
	May	5/14/2004	7:38:29	55	40	0.3	4.7	109	413	0.9	4	1,456	856	930	863	**949**
		5/15/2004	12:35:59	55	40	0.3	4.7	113	411	0.72	4	1,298	764	829	764	**840**
		5/26/2004	8:42:51	55	40	0.1	4.9	110	407	0.86	4	1,444	849	922	854	**940**
		5/29/2004	12:55:34	57	39	0	4	113	408	1.04	5	1,597	939	1,020	940	**1,071**
	June	6/7/2004	13:11:56	57	39	0.1	3.9	119	412	1.08	5	1,554	914	993	905	**1,032**
		6/21/2004	10:35:30	56	39	0.1	4.9	122	410	1	5	1,484	873	948	860	**963**
		6/29/2004	8:43:51	57	39	0	4	124	411	0.96	5	1,454	855	**929**	840	**957**
	September	9/27/2004	14:29:45	55	40	0.1	4.9	123	413	1.22	6	1907	1122	1,122	1,016	**1,118**
	October	10/1/2004	14:39:29	58	38	0.1	3.9	125	414	1.21	6	1917	1128	1,128	1,018	**1,181**
		10/4/2004	11:42:31	58	40	0	2	122	412	1.24	6	1984	1167	1,167	1,059	**1,228**
		10/4/2004	14:25:38	58	40	0	2	122	412	1.38	7	2025	1191	1,191	1,081	**1,254**
		10/20/2004	10:49:01	55	39	0.2	5.8	113	413	1.28	6	1954	1149	1,149	1,059	**1,165**
		10/25/2004	13:20:24	56	40	0.1	3.9	113	411	1.26	6	1927	1134	1,134	1,045	**1,170**
		10/30/2004	10:57:42	55	40	0.3	4.7	115	410	1.26	6	1937	1139	1,139	1,046	**1,151**
	November	11/6/2004	12:28:56	57	37	0	6	105	406	1.22	6	1961	1154	1,154	1,078	**1,229**
		11/17/2004	13:21:12	55	37	0.8	7.2	111	415	1.44	7	2076	1,221	1,221	1,129	**1,242**
		11/18/2004	8:48:01	54	40	1	5	107	413	1.33	6	2012	1,184	1,184	1,102	**1,190**
		11/18/2004	11:50:48	54	45	0.1	0.9	107	412	1.26	6	1899	1,117	1,117	1,040	**1,123**
		11/30/2004	8:59:59	56	38	0.2	5.8	107	414	1.22	6	1938	1,140	1,140	1,062	**1,189**
	December	12/3/2004	14:54:08	58	38	0	4	105	405	1.22	6	1971	1,159	1,159	1,083	**1,257**
		12/10/2004	11:38:45	57	40	0	3	104	408	1.23	6	1899	1,117	1,117	1,046	**1,192**
		12/16/2004	12:35:59	54	39	0.3	6.7	101	415	1.24	6	1881	1106	1,106	1,041	**1,125**
		12/21/2004	8:42:51	52	37	0.3	10.7	87	413	1.09	6	1839	1082	1,082	1,044	**1,086**
		12/22/2004	12:55:34	54	40	0.1	5.9	108	413	1.08	5	1763	1037	1,037	964	**1,041**
		12/22/2004	13:11:56	52	39	0.4	8.6	108	415	1.2	6	1887	1110	1,110	1,032	**1,073**
		12/23/2004	10:35:30	55	40	0	5	108	413	1.07	5	1796	1056	1,056	982	**1,080**

Appendix VI: Copy of flow meter calibration records

Landfill Gas Flow Calibration 1 of 2

Crapo Hill Landfill, New Bedford/Dartmouth, Massachusetts

Note: Calculation of volumetric flow of LFG through a pipe using a pitot tube and manometer.

MEASURING INSTRUMENT:	Pitot Tube:	160	160	160	160	160	160	160
	Manometer:	Dwyer Mark II	Dwyer Mark II	Dwyer Mark II	Dwyer Mark II	Dwyer Mark II	Dwyer Mark II	Dwyer Mark II
DATE OF MEASUREMENT:		22-Nov-00	11-Jun-01	7-Jan-02	18-Apr-02	13-Nov-02	23-Feb-04	July 6,2004
TIME OF MEASUREMENT:								
PARAMETERS	UNITS	VALUES	VALUES	VALUES	VALUES	VALUES	VALUES	VALUES
Pipe dimensions								
Inside Diameter	inches	**10.420**	**10.420**	**10.420**	**10.420**	**10.420**	**10.420**	**10.420**
Area of cross section	square feet	0.5922	0.5922	0.5922	0.5922	0.5922	0.5922	0.5922
Flow Calculation								
Kp pitot tube constant	ft/sec[(lb/lb-mole)(in. Hg)/(R)(in H20)]^1/2	85.49	85.49	85.49	85.49	85.49	85.49	85.49
Cp Pitot tube coefficient	dimensionless	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	1.00	1.00
dP Average velocity pressure of stack gas	in H20	**0.080**	**0.108**	**0.091**	**0.234**	**0.268**	**0.178**	**0.160**
Ts Stack temperature	Degrees Fahrenheit	**100**	**117**	**94**	**116**	**106**	**94**	**126**
	Degrees Rankine	560	577	554	576	566	554	586
Pg Stack static pressure	inch H20	**5.5**	**7.4**	**6.2**	**7.7**	**8.4**	**5.0**	**5.1**
	inch Hg	0.40	0.54	0.46	0.57	0.62	0.37	0.38
Pbar Barometric pressure	inch Hg	**29.74**	**29.71**	**29.20**	**29.78**	**28.99**	**30.23**	**29.28**
Ps Absolute stack gas pressure	inch Hg	30.14	30.25	29.66	30.35	29.61	30.60	29.66
Ms Molecular weight of stack gas, wet	lb/lb-mole	29.46	29.46	29.46	29.46	29.46	29.46	29.46
Vs Average stack gas velocity	feet per second	19.2	22.6	20.6	33.2	35.6	28.2	28.0
Qact Volumetric Flow	actual cubic feet per minute	682	803	731	1,179	1,267	1,003	995
Qstd Volumetric Flow at actual methane content	standard cubic feet per minute *	648	743	691	1,096	1,169	978	889
Qstd Volumetric Flow at 50% methane	standard cubic feet per minute **		774	746	1,184	1,286	1,076	977
Methane Content	%, vol/vol		52.1%	54.0%	54.0%	55.0%	55.0%	55.0%
Orifice Reading	cfm			677	1,056	1,162	922	880

* Standard conditions are corrected to 68 degrees F and 29.92 in Hg at actual methane content.

** Standard conditions corrected to 50 % methane content.

Input values are in blue or bold.

Calculated output values are in black or not bold.

Calculation Formulas:

Vs = Kp*Cp*(sqrt dP) * sqrt (Ts/(Ps*Ms))

Qact = Vs * A * 60

Qstd = Qact * Tstd/ Ts * Ps/Pstd

Conversions and constants

13.9 in H2O/In Hg

Tstd = 528 degrees R

Pstd = 29.92 in Hg

Landfill Gas Flow Calibration 2 of 2
Crapo Hill Landfill, New Bedford/Dartmouth, Massachusetts

Measurements by	Tom Yeransian	Tom Yeransian	Tom Yeransian	Tom Yeransiar	Tom Yeransian	Tom Yeransian	Tom Yeransian	
Date	22-Nov-00	11-Jun-01	7-Jan-02	18-Apr-02	13-Nov-02	February 23,2004	6-Jul-04	
LFG Blower	1	1	2	1 and 2	1 and 2	1 and 2	1 and 2	
Drive Speed (1 to 10)	Max . Constant	Max . Constant	Max . Constant	Max . Constar	Max . Constan	Max . Constant	Max . Constant	
Flow valve	60%	60%	50%	50%	50%	60%	60%	
Pipe inside diameter, inches	10.42	10.42	10.42	10.42	10.42	10.42	10.42	
Orifice measurement, cfm	600	730	677	1056	1162	922	880	
Ambient Temperature, F	50	79	35	80	50	28	90	
Barometric Pressure, In Hg	29.74	29.71	29.20	29.78	28.99	30.23	29.28	
Blower Inlet Temperature, F	80	90	65	80	78	68	96	
Blower Outlet Temperature, F	100	117	94	116	106	94	126	
Blower Inlet Pressure (SP), In H20	-32	-32	-36	-30	-30	-38	-38	
Blower Outlet Pressure, In H20	5.5	7.4	6.2	7.7	8.4	5	5.1	Static Pressure (SP)
Measurement	1	1	1					
Manometer	Dwyer Mark II	Dwyer Mark II	Dwyer Mark II					
Pitot Tube	Dwyer 166-6, 1/8"	Dwyer 166-6, 1/8"	Dwyer 166-6, 1/8"					
Velocity Pressure (dP)								Point
Point								distance, inches
1	0.08	0.11	0.09	0.19	0.25	0.16	0.16	2
2	0.08	0.105	0.095	0.2	0.27	0.18	0.17	3
3	0.09	0.11	0.09	0.22	0.27	0.19	0.17	4
4	0.09	0.11	0.095	0.24	0.28	0.19	0.17	5
5	0.08	0.11	0.09	0.25	0.27	0.19	0.16	6
6	0.08	0.105	0.09	0.25	0.27	0.18	0.15	7
7	0.07	0.11	0.09	0.26	0.27	0.17	0.14	8
8	0.07	0.105		0.26	0.26	0.16		9
Average	0.080	0.108	0.091	0.234	0.268	0.178	0.160	
Gas Composition								
Compound								
CH4		52.1%	54.0%	54.0%	55.0%	55.0%	55.0%	
CO2		39.3%	40.0%	40.0%	45.0%	40.0%	40.0%	
O2		0.0%	0.0%	0.2%	0.0%	0.2%	0.1%	
N2		8.5%	6.0%	5.8%	0.0%	4.8%	4.9%	
Total		100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	

Appendix VII: Copy of generator operation logs