SCS ENGINEERS

Report

LFG Collection System Evaluation
Ontario County Landfill

Presented to:

Ontario County
Thomas P. Harvey, Planning Director
20 Ontario Street
Canandaigua, New York 14424
585-396-4456

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April 17, 2014
File No. 13213027.00

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1.0 INTRODUCTION

1.1 PURPOSE

The purpose of this report is to evaluate the landfill gas (LFG) collection and control system (GCCS) at the Ontario County Landfill, with an emphasis on odor control, and to make recommendations for augmenting GCCS performance. The focus of this report is on the LFG collection side of the GCCS (with a goal of reducing fugitive emissions from the Landfill), though a review of the control system (blowers, flares and engine facility) is also included to confirm that there is sufficient LFG control capacity, and that collected (but uncombusted) LFG is not being discharged to the atmosphere.

1.2 SUMMARY OF BACKGROUND INFORMATION

1.2.1 Landfill

Ontario County (County) owns the Ontario County Landfill (Landfill) and is the permittee on the New York State Department of Environmental Conservation (NYSDEC; Part 360) permit to operate the Landfill. In December 2003, Casella Waste Services of Ontario, LLC (Casella) commenced operation of the Landfill as part of a 25-year Operations, Management and Lease (OML) agreement with Ontario County.

The Landfill is located in the Town of Seneca, New York, approximately five miles west of Geneva, and 11 miles east of Canandaigua, New York. The Landfill is bound to the north and east by roads (New York State Routes 5 and 20, and County Road 5 respectively), and to the south by private property and west by the Town of Seneca property. The present Landfill property encompasses approximately 387 acres.

The Landfill is comprised of three separate waste mounds: Phase I, Phase II/IIA and Phase III landfills. The Phase I and II/IIA landfills are closed. The Phase I landfill is the oldest of the three landfills. The Phase I landfill, which is unlined, was operational between 1974 through 1979 and is approximately 17 acres in size. Although the Phase II and Phase IIA landfills are physically separate landfills, they have historically been referenced as a single landfill. The Phase II/IIA landfill was operational between 1979 through 1991 and utilizes a partial liner and leachate collection system. The Phase II landfill includes a soil cap while the Phase IIA landfill includes a geomembrane cap. The Phase II/IIA landfill was historically classified as a Class 3 Inactive Hazardous Waste Site and encompasses approximately 26 acres.

The Phase III Landfill is an active landfill that has been operational since 1992. The Phase III landfill is approximately 84 acres in size and currently consists of seven separate stages: Stage I, Stage II (A and B), Stage III, Stage IV, Stage V (A and B), Stage VI (A and B), and Stage VII (A and B). A final cover system is installed over the lower half of sideslopes at Stages I, IIA and IIB, and a temporary geomembrane cover is installed over the sideslopes of Stages III, IV, VA, VB, VIA and VIB (it is noted that the eastern sideslope at the southeast corner of Stage VA is not currently covered).

The County is currently involved in a landfill expansion permitting effort, which would add an additional 43 acres to the Phase III landfill footprint, if approved. The Stage VIII ("Wrap-around") expansion will include the construction of new lined landfill cells covering 16.0 acres around the northern and western boundaries of the Phase III landfill. The Stage IX (Eastern) expansion will be located adjacent to the eastern boundary of the Phase III landfill, covering 27.5 acres including the area currently approved as a borrow area for soils.

The Board of Supervisors for the County is the lead agency under the State Environmental Quality Review Act (SEQRA) for the proposed expansion of the Landfill. The County reviewed and made available for public review and comment a Draft Environmental Impact Statement (DEIS), dated December 2011. A public hearing on the DEIS was held on January 26, 2012, and the written comment period for the DEIS concluded on February 21, 2012. The County thereafter engaged in a review of the comments received, and approved the issuance of a Final Environmental Impact Statement (FEIS) on August 23, 2012.

It is noted that, in 2011, residents adjacent to the Landfill and other downwind residents have reported a variety of odors which they believe originate from the Landfill. Numerous public comments were submitted during the DEIS public review period concerning odors. The FEIS noted that *"excessive odors that were observed during 2011 were the result of abnormal atmospheric conditions and landfill operational conditions. During 2011, the region experienced much higher than average rain fall during the late fall, and unseasonably warm winter conditions. Under these conditions, landfill gas production actually increased during the fall and winter, when typically dryer and colder conditions would have slowed landfill gas production. The problem with higher than normal gas production was compounded by the unusually wet surface conditions which prevented heavy equipment from being able to access areas where landfill gas wells were needed in order to control the gas being produced."*

1.2.2 Existing GCCS

1.2.2.1 General

Operation of the GCCS is required in accordance with 40 CFR 60: New Source Performance Standards (NSPS), Subpart WWW: Municipal Solid Waste (MSW) Landfills, and with 6 NYCRR Part 208: Landfill Gas Collection and Control Systems for Certain MSW Landfills. The LFG collection systems in Phases II/IIA and III (there is no LFG collection system in Phase I) are operated by Casella. The LFG control system includes the LFGE Facilities and the blower/flare systems, described below.

1.2.2.2 Phase II/IIA LFG Collection System

The Phase II/IIA LFG collection system is comprised of approximately 28 vertical LFG extraction wells (9 in Phase II, and 19 in Phase IIA). The wells are connected to the main perimeter header systems via a series of sub-header and lateral pipes. Phase II and Phase IIA are each (i.e., separately) surrounded by 4- to 8-inch LFG perimeter header systems, which are manifolded together with 10-inch piping. The combined Phase II/IIA LFG flow is conveyed to the LFG-to-energy (LFGE) facilities (discussed below). Alternatively, the Phase II/IIA LFG flow can be conveyed to the Phase II blower/flare system (discussed below).

1.2.2.3 Phase III LFG Collection System

Based on a review of a March 2014 LFG collection system plan by Casella's environmental engineering consultant, Barton and Loguidice, D.P.C. (B&L), the Phase III LFG collection system is comprised of approximately 93 vertical extraction wells (including approximately 21 vertical wells which are commonly controlled by approximately 8 wellheads), 40 horizontal collectors, 6 LFG vents (with an approximate additional 6 LFG vents not connected to the LFG collection system), and a number of LFG and condensate drainage connections to leachate collection system cleanouts. The LFG collectors are connected to a main perimeter header via a series of sub-header and lateral pipes. The main perimeter header is a 12- to 18-inch diameter pipe located outside the waste footprint, completely surrounding Phase III. The main perimeter header is connected to the LFGE facilities and three blower/flare systems (discussed below).

1.2.2.4 LFGE Facilities

There are two LFGE Facilities at the Landfill, which are owned and operated by Innovative Energy Systems, LLC (IES), and include reciprocating internal combustion engines to generate electricity. The LFGE Facilities function as the primary LFG control devices, and supply vacuum to the LFG wellfield under normal operating conditions. The two LFGE Facilities include eight engines (with a combined capacity of approximately 6.4 MW) and three (larger) engines (with a combined capacity of approximately 5.6 MW), with a total LFGE Facility capacity of approximately 12 MW (facility capacities based on a review of IES's website).

1.2.2.5 LFG Blower/Flare Systems

There are four blower/flare systems at the Landfill: three are located along the Phase III perimeter header near the southeast corner (3,000 scfm utility flare), mid-western side (1,100 scfm utility flare) and northeast corner, adjacent to the LFGE facilities (1,250 scfm enclosed flare); the fourth is located at the northeast corner of the Phase II/IIA mound (500 scfm enclosed flare). These blower/flare stations are operated by Casella when they are notified by IES that there will be extended LFGE Facility offline time. SCS was informed that it is rare for the LFGE Facilities to be offline sufficiently long enough for Casella to operate the blower/flare systems. Operations of these blower/flare stations, when required, appear to be performed on an ad-hoc basis, as there are no specific setpoints established for inlet vacuum at each blower/flare station.

1.3 INFORMATION REVIEWED

SCS received and reviewed the following information provided by the County, Casella or B&L:

- Ontario County annual solid waste reports to NYSDEC for 2010-2012 (including solid waste receipts).
- Email from Jerry Leone of Casella dated February 6, 2014 regarding 2013 waste receipt data.
- Email from Jerry Leone of Casella dated February 12, 2014 regarding approximate annual breakdown of waste placement by Phase III stage.
- Landfill leachate collection system plan, B&L, June 2013.

- Existing LFG collection system plans for Phase II/IIA and Phase III, B&L, December 2013.
- Various LFG collection system expansion plans from 2007-2013, B&L.
- Proposed LFG collection system expansion plan, B&L, March 2014.
- Phase III, Stage VIII and IX Expansion Operations and Maintenance Manual and Odor Management Plan, Casella, September 2013.
- Capping Plan, B&L, no date.
- Typical geomembrane cap detail, B&L, no date.
- Top of Intermediate Cover Plan, B&L, September 2013.
- IES 2003-2013 LFG recovery, operating hours and energy production data.
- Monthly LFG wellfield operating logs from January 2012 – February 2014.
- Letter from Jeffrey Reed of B&L to Lionel MacKenzie of USEPA, Response to Data Request, March 11, 2012 (includes 2003-2012 blower/flare station LFG volumes).
- Email from Jerry Leone of Casella dated February 24, 2014 regarding 2013 LFG flow to blower/flare stations and LFGE facilities.
- Email from Jerry Leone of Casella dated March 26, 2014 regarding depth to stone fill in vertical LFG extraction wells installed by Casella.

2.0 SUMMARY OF FIELD INVESTIGATION

On February 12 and 13, 2014, SCS visited the Landfill to collect LFG data at some wellheads in Phase III (SCS monitored 37 wellheads connected to approximately 54 vertical extraction wells, five horizontal collectors and 8 horizontal collectors), including LFG content (i.e., methane (CH_4), carbon dioxide (CO_2), oxygen (O_2) and balance gas), pressure/vacuum, flow, temperature and other observations. A summary of LFG wellhead readings collected by SCS is included in Appendix A. SCS also collected depth to bottom and depth to water data at 5 vertical LFG extraction wells (i.e., well sounding). A summary of well sounding data is included in Appendix B.

During LFG collector monitoring, SCS observed considerable odors at the following locations:

- The active filling area of Phase III (i.e., Stage VII), particularly at locations down-slope and west of this area.
- Along the access road which crosses Phase III.
- Along the edges of the temporary geomembrane cover installed along the south and southeastern slopes of Phase III, which appeared to be in good condition.

SCS walked over Phase II/IIA to inspect for LFG-related issues (e.g., odors). SCS detected no odors or other notable LFG-related issues at this area. SCS did not have the opportunity to walk over the surface of Phase I. It is noted that, during SCS's site visit, the Landfill was covered with about 1 foot of snow, so observations related to the Landfill surface (e.g., cracks in soil cover, distressed vegetation) were not possible.

While on site, SCS met with Casella's LFG system operations contractor and with a representative from IES to discuss operational issues. In speaking with IES, it was noted that the three-engine LFGE Facility has the ability to increase or decrease load to the engines based on inlet vacuum control. At the time of SCS's site visit, this LFGE Facility was controlled using a high vacuum set point of 87 inches-water column (in-w.c.) and a low vacuum set point of 82 in-w.c., to allow modulation of engine load by approximately 50 kW. However, system vacuum can increase beyond this range if there is insufficient LFG flow from the Landfill (largely based on wellfield tuning) and either the eight-engine LFGE facility or blower/flare systems are operated without appropriate adjustment. Based on conversations with IES, they typically will shut down one of the eight, smaller engines manually if inlet vacuum approaches 100 in-w.c., as one of the vacuum traps can be compromised if inlet vacuum exceeds this amount. Based on discussions with IES, it does not appear that it is a goal for IES to operate the LFG header system at a consistent vacuum, but rather, the vacuum is adjusted as necessary to meet the needs of the LFGE Facilities.

Notably, flow to the LFGE Facilities on February 12, 2014 was approximately 3,780 scfm at 50.6 percent methane (on average) and system vacuum of 76 in-w.c. On February 13, 2014, the LFGE Facilities flow was approximately 3,590 scfm at 53.8 percent methane and system vacuum of 63 in-w.c. It is noted that engine maintenance on February 13, 2014 resulted in reduced

LFGE Facility load and inlet vacuum. No LFG blower/flare stations were operated during this time.

It was also noted that vacuum applied by the LFGE Facilities to the Phase II/IIA header system is controlled by throttling a header valve located near the inlet of the Phase II/IIA blower/flare system.

3.0 LFG RECOVERY PROJECTIONS

3.1 INTRODUCTION

SCS uses the same first-order decay equation as the U.S. Environmental Protection Agency's Landfill Gas Emissions Model (LandGEM). While LandGEM estimates LFG generation, SCS estimates expected LFG recovery. SCS selects values for the potential methane generation capacity (L_o) and methane generation rate (k) that are derived from (1) calibration to LFG flow and methane data, as collected at the landfill being modeled, and (2) adjustments to default values developed by SCS based on a database of over 1,000 years of LFG flow and methane data from over 200 landfills with operational LFG collection systems.

The estimating method used by SCS projects the recovery potential, which is the maximum amount of LFG a fully-comprehensive, efficiently-operated collection system can recover. Expected recovery, adjusted for the limitations of the actual or proposed collection system, is calculated by multiplying the recovery potential by the estimated fraction of LFG that is effectively collected, a measure we call collection system coverage. Collection system coverage is a measure of the efficiency of both the collection system design and performance. Unlike collection efficiency, collection system coverage is a percentage of the LFG recovery potential (i.e., LFG recovery which is achievable), not a percentage of LFG generation (which is unknown and cannot be measured). SCS estimates LFG collection system coverage based on a review of the coverage of the waste and actual LFG recovery versus LFG recovery potential. It is noted that if wells are installed in newer waste over time, the LFG system coverage will generally increase, or at least remain constant.

3.2 WASTE INFORMATION

3.2.1 Waste Composition

Composition data for waste disposed in Phase III was provided by Casella. Based on conversations with Casella regarding actual waste disposed, the waste composition categories provided were sorted into the following broader waste categories for the purpose of LFG modeling:

- Municipal Solid Waste (MSW): Municipal Sludge, Domestic Waste and Industrial Sludge
- Construction and Demolition Waste (C&D): C&D Debris, Exempt C&D and Processed C&D
- Inert: Industrial Waste (composed primarily of ash), Contaminated Soils, Tires, Tire Chips, Auto Shredder Fluff, Asbestos, Rejected Glass and Ash.

Table 1 below summarizes the total amount of each of these categories (i.e., MSW, C&D and Inert), and provides the total annual amount of waste disposed at Phase III.

Table 1. Phase III Waste Summary by Waste Type

Year	Disposed Waste Fraction (tons)			Total Waste (tons)
	MSW	C&D	Inert	
1992	27,777	0	2,686	30,462
1993	43,232	0	2,523	45,755
1994	83,433	13,100	2,581	99,113
1995	99,151	14,663	28,202	142,016
1996	93,334	37,252	29,517	160,102
1997	137,669	47,975	25,527	211,171
1998	183,925	46,906	13,834	244,665
1999	209,626	46,942	15,966	272,534
2000	231,294	24,654	8,494	264,443
2001	256,183	38,321	28,243	322,747
2002	226,926	53,050	70,694	350,669
2003	249,782	36,535	38,247	324,563
2004	468,867	112,678	81,687	663,232
2005	502,135	136,102	62,822	701,060
2006	499,632	114,973	192,736	807,341
2007	469,590	104,401	120,387	694,377
2008	528,964	90,997	337,190	957,150
2009	666,772	67,160	169,613	903,545
2010	799,171	53,120	59,098	911,389
2011	780,245	46,992	57,895	885,132
2012	651,105	61,601	248,867	961,573
2013	641,492	101,743	112,430	855,666

For 2014 and future years (up to at least 2023), SCS assumes the same amounts under each category will be accepted at Phase III. Based on the amounts shown in Table 1, the average breakdown of the waste by these categories is as follows: 72.6 percent MSW, 11.6 percent C&D and 15.8 percent inert. It is noted that Phase II/IIA is also connected to the GCCS, but that waste placed in Phase II/IIA is not included in Table 1 above. The County estimated that approximately 704,000 tons of waste were disposed at the Landfill between 1979 and 1992. Assuming the same average waste breakdown as in Table 1 above, SCS estimated the waste input to Phase II/IIA (between 1979 and 1991) at a flat rate of approximately 37,700 tons/year MSW and 6,000 tons/year C&D.

The LFG model uses the MSW and C&D waste inputs, which represent the decomposable fraction of waste disposed in the Landfill, and which will contribute to LFG production. LFG recovery projections were prepared for these two categories using the LandGEM model with different model input parameters specific to those waste streams. The LFG recovery projections for each category were then summed together to yield overall total LFG recovery projections for the Landfill.

Inert waste is not included in the LFG model, as it does not generally contribute to LFG production. As such, the inert fraction of waste placed is not discussed or included further in this report.

3.3 HISTORICAL LFG COLLECTION DATA

The historical LFG collection system flow data was obtained from Casella and the County, and includes LFG flow delivered to the LFGE Facility and the LFG blower/flare stations. Table 2 presents the data for 2003 to 2013.

Table 2. Historical LFG Recovery Data Summary

Year	LFG Flow @ 50% CH_4 (scfm)
2003	1,423
2004	1,459
2005	1,901
2006	2,214
2007	2,805
2008	2,316
2009	2,282
2010	2,141
2011	2,874
2012	4,615
2013	3,706

3.4 LFG RECOVERY MODELING

LandGEM is a simplistic, first order, single stage model with only two input parameters (L_0, and k) other than waste receipts and LFG composition. It assumes that the LFG production rate is at its peak upon initial waste placement, after a short lag time during which anaerobic conditions are established in the landfill. The gas production rate is then assumed to decrease exponentially (i.e., first order decay) as the organic fraction of the landfill refuse decreases.

The model equation is as follows:

$$Q = \sum_{i=1}^{n} 2kL_0 M_i (e^{-kt_i})$$

where,

Q = Methane generation rate from the landfill in the ith year, cf/yr
k = Methane generation rate constant, 1/yr
L_0 = Methane generation potential, cf/ton
M_i = Mass of refuse in the ith section, ton
t_i = Age of the ith section, yrs
i = Section number

The theoretical value for potential methane generation capacity of refuse, L_0, depends on the type of refuse only. The higher the cellulose content of the refuse, the higher the value of the theoretical methane generation capacity. The theoretical methane generation capacity is determined by a stoichiometric method, which is based on a gross empirical formula representing the chemical composition of composite refuse or individual refuse type. Some researchers have reported "obtainable L_0" which accounts for the nutrient availability, pH, and moisture content within the landfill. The researchers point out that "obtainable L_0" is less than the theoretical L_0. Even though refuse may have a high cellulose content, if the landfill conditions are not hospitable to the methanogens, the potential methane generation capacity of the refuse may never be reached. The "obtainable L_0" is approximated from overall biodegradability of "typical" composite refuse or individual waste components, assuming a conversion efficiency based on landfill conditions.

The methane generation rate constant, *k*, determines how quickly the methane generation rate decreases, once it reaches the peak rate upon placement. The higher the value of *k*, the faster the methane generation rate from each submass decreases over time. The value of *k* is a function of the following major factors: (1) refuse moisture content, (2) availability of the nutrients for methanogens, (3) pH, and (4) temperature. In general, increasing moisture content increases the rate of methane generation.

The input parameters selected for the purpose of preparing the LFG recovery estimates dictate the modeling results. The most important or sensitive parameter that affects the results of the model output is the waste quantity information. Values for *k* and L_0 are also important, and vary depending on the region and climatology of the site location.

Typical values for L_0 and *k* are published by the U.S. EPA's Office of Air Quality Planning and Standards, which develops emission factors for various industries, including landfills. In most cases, emission factors are simply averages of all available data of acceptable quality, and are generally assumed to be representative of long-term averages for all facilities in a particular source category. Emission factors are updated periodically and published in a U.S. EPA document entitled "A Compilation of Air Pollutant Emission Factors", which is commonly referred to by its document number, AP-42. The current AP-42 values (November 1998) for wet MSW landfills (25 inches or more of precipitation per year) are *k* of 0.04 yr^{-1} and a L_0 of 3,200 cubic feet per ton of waste received.

SCS has analyzed LFG recovery (not generation) from over 200 MSW landfill sites across the country. The L_0 values for each landfill were estimated using actual LFG collection rates measured at the sites. The average L_0 value is 3,000 cubic feet per ton. SCS models LFG recovery directly, eliminating the need to multiply LFG generation by an estimated recovery rate. The ultimate methane recovery rate (L_0) used as a model input parameter in the updated projections directly considers both methane generation and estimated recovery rate. As such, a L_0 of 3,000 cubic feet per ton was used for MSW at Phase III.

Similarly, SCS has analyzed LFG recovery from over 200 MSW landfill sites. The *k* values for each of these landfills were estimated using actual collection rates measured at the site, and correlated against annual precipitation. Normal annual precipitation at the Landfill is approximately 34 inches (based on climatological normal values prepared by the National

Oceanic and Atmospheric Administration (NOAA)). At this precipitation rate, the SCS *k* value is 0.06 yr^{-1}. However, use of this *k* value results in model results lower than historic LFG recovery data from the Landfill.

Rainfall data for the vicinity of the Landfill (taken from NOAA databases) indicates significant variability in rainfall over the past 10 years, from approximately 29 to 42 inches per year, with the maximum occurring in 2011, and the minimum in 2012. This high variability in precipitation is aligned with trends in LFG recovery with a one year lag, as the maximum annual average LFG recovery rate (4,615 scfm) was noted in 2012 and was significantly reduced (to 3,706 scfm) in 2013. It is also noted that the arithmetic average of annual precipitation between 2003 and 2013 is approximately 37 inches. At this precipitation rate, the SCS *k* value is 0.072 yr^{-1}, which still yields slightly lower LFG model results than historic LFG recovery data from the Landfill. SCS has increased the *k* value for MSW to 0.08 yr^{-1} to more accurately reflect historic and projected LFG recovery at the Landfill, which is similar to *k* values based on model calibration at other landfills in the Northeast.

Review and adjustment of the *k* and L_0 values as applied to the C&D is necessary. Typical C&D debris consists of bricks, concrete, drywall, wood, dirt, soil and other C&D materials. As noted above, L_0 depends largely on the cellulose content of the refuse. Qualitatively, we expect that C&D debris will have lower cellulose content than MSW. Based on our experience with actual LFG recovery from dedicated C&D debris landfills, we selected a L_0 of 1,500 cubic feet per ton for the C&D waste.

Values for *k* depend on the refuse moisture content and other variables noted above. Qualitatively, we expect that the as-received moisture content of C&D debris and nutrient availability are less than that of the MSW (due to the lack of wet components such as food waste, sludges, etc.). However, both waste types will be exposed to the same levels of precipitation and landfill conditions. Based on the historical LFG recovery rates, we estimate that the *k* value for C&D waste will be less than that for the MSW at the Landfill, and is estimated at 0.06 yr^{-1}.

The LFG recovery model estimates both the LFG recovery potential from the Landfill, which is the rate of recovery achievable with a 100 percent comprehensive GCCS, and the estimated LFG recovery rate, which is the amount expected given the limitations of the actual and planned collection system and equal to the recovery potential times the estimated collection system coverage. The value for collection system coverage is based on engineering judgment, and considers many factors including:

- Closed or active (i.e., cover) status of the landfill area
- Type of well construction and extents of LFG collection system construction
- Status of GCCS operation, including open/closed status of wells, intermediate low points in LFG piping, etc.

The value for collection system coverage ranges between 0 percent (for no recovery) to 100 percent (for a fully comprehensive collection system). The collection system coverage for the Landfill was estimated as follows, based on GCCS expansion drawings provided by Casella and B&L:

Table 3. Collection System Coverage Estimates

Year	Collection System Coverage Value
2007	70%
2008	70%
2009	80%
2010	80%
2011	70%
2012	90%
2013	80%
2014-2023	90%
≥2024	100%

Collection system coverage values in Table 3 for years prior to 2007 were not prepared, due to lack of GCCS drawings for the corresponding years. The collection system coverage value for 2014 and forward was assumed based on expected efforts to expand the LFG collection system with waste placement, based on the March 2014 proposed LFG collection system expansion plan. In the year following Phase III closure (i.e., 2024), collection system coverage is estimated to increase to 100 percent and remain constant thenceforth, reflecting installation of a final cover and final LFG collection system expansion.

3.5 LFG RECOVERY PROJECTIONS SUMMARY

To summarize, SCS prepared the LFG recovery model based on the following input parameters:

- **Refuse Filling History and Projections:** Waste receipt data listed in Table 1 and a total waste input of 708,000 for Phase II/IIA for years 1979 through 1991 were used as model inputs for the Landfill (not including Phase I, which is not connected to the GCCS).

- **Methane Decay Rate Constant (*k*):** *k* values of 0.08 yr^{-1} and 0.06 yr^{-1} were selected for MSW and C&D respectively, based on SCS' database for landfills and calibration of the LFG model to agree with historic LFG recovery.

- **Ultimate Methane Recovery Potential (L_0):** L_0 values of 3,000 ft^3/ton and 1,500 ft^3/ton were used based on SCS's national database for MSW landfills and our experience with C&D.

- **System Coverage:** Historical and future system coverage estimates are based on our engineering judgment, which is in turn based on our review of collection system expansion plans provided by Casella and B&L. Future system coverage is projected to remain constant at 90 percent until final closure of Phase III, and then remain constant at 100 percent thenceforth, as discussed above.

The LFG recovery projections for the Landfill are presented in Appendix C. All LFG flow values are adjusted to 50 percent methane content. Appendix C includes the following information:

- Annual historical and projected future waste disposal rates.
- Annual waste in place values.
- Projected LFG recovery potential, which is the maximum amount of LFG that is recoverable with a fully comprehensive collection system.
- Estimated collection system coverage.
- Projected annual average LFG recovery from the existing and planned system, which is equal to the recovery potential multiplied by the estimated system coverage.

Appendix C also provides the following information in a graph format:

- Projected LFG recovery potential.
- Estimated LFG recovery from system as historically installed.
- Historical LFG recovery rates for 2003 through 2013.
- Annual precipitation.

As shown in Appendix C, annual average LFG recovery potential is projected to be approximately 4,400 scfm in 2014 and increase to a peak of approximately 6,500 scfm in the year following final closure of Phase III, and decline thereafter.

3.6 MODEL LIMITATIONS AND DISCLAIMER

This report has been prepared in accordance with the care and skill generally exercised by reputable LFG professionals, under similar circumstances, in this or similar localities. The LFG recovery projections are based on our engineering judgment as of the date of this report. No warranty, express or implied, is made as to the professional opinions presented herein. Changes in the landfill property use and conditions (for example: variations in rainfall, water levels, landfill operations, final cover systems, or other factors) may affect future gas recovery at the landfill. SCS does not guarantee the quantity or the quality of the available LFG.

This report is prepared exclusively for the use of the County. No other party, known or unknown to SCS is intended as a beneficiary of this report or the information it contains. Third parties use this report at their own risk. SCS assumes no responsibility for the accuracy of information obtained from, or provided by, third-party sources.

4.0 LFG COLLECTION SYSTEM EVALUATION

4.1 GENERAL LFG EVALUATION

Historic LFG recovery from the Landfill was significantly below LFG recovery potential for years 2008 through 2011 (with a significant reduction in LFG flow after 2007). Odor control became a public issue for the Landfill in 2011. In 2012, odors at the Landfill largely came under control, and actual LFG recovery for that year was slightly above estimated LFG recovery potential. Alignment of these facts with the model results serves to validate the model discussed in Section 3 and included in Appendix C. From 2011 through 2013, Casella installed annual expansions to the LFG collection system at minimum, and plans a new expansion in 2014. However, as waste continues to be placed at the Landfill, LFG flows are projected to increase in the future. As such, regular expansions to the LFG collection system need to be continued to maintain odor control. Specifically, in preparation of the future collection system coverage estimates (i.e., 90 percent for 2014 through 2023, and 100 percent thereafter), SCS assumes that LFG collection system expansions will be performed on an annual basis at minimum. **We recommend that the LFG collection system continue to be expanded on an annual basis at minimum. Additional expansions may be necessary, depending on waste quantities and types filled, and specific waste placement methods.**

A plan showing the expected ROI for each LFG collector in Phase III and the boundary of 50-foot waste depth (within Stages III through VII; insufficient liner elevation contour data was available for estimation of the 50-foot waste depth line in Stages I and II) is included in Appendix D. As shown on the drawing, there are gaps in the existing coverage. It is noted that some gaps include areas where existing horizontal collectors are providing some LFG collection. However, these horizontal collectors are generally installed deep in the waste, and are unlikely to be effective at controlling LFG surface emissions. Additionally, vertical LFG wells with little to no current LFG flow are not assigned a ROI (see Phase III LFG Collection System Evaluation below).

During our site visit, we observed considerable odors in the active filling area of Phase III (i.e., Stage VII), particularly at locations down-slope and west of this area. Another area where significant odors were noted is the access road which traverses Phase III. These areas are both adjacent to, or run through, significant LFG collection system gaps identified in the plan included in Appendix D. Also, while the temporary geomembrane cover installed along the south and southeastern slopes of Phase III appeared to be in good condition, it did not appear to be effectively limiting odors in that area. This observation corroborates the LFG collection system gaps noted on the plan in Appendix D.

We recommend that vertical LFG extraction wells be installed in areas of the LFG collection system gaps indicated on the plan in Appendix D to provide better LFG collection system coverage, and resulting improved odor control and increased LFG recovery.

4.2 PHASE I AND II/IIA LFG EVALUATION

Waste in Phase I is generally greater than 35 years old, and waste in Phase II/IIA is greater than 20 years old. While some LFG will continue to be produced from waste in these areas, current LFG flow is estimated to be low (total for Phase I and II/IIA is 60-70 scfm at 50 percent methane in 2014, based on the LFG model in Appendix C) and continues to decline (at approximately 7-8 percent per year). Additionally, the odor potential of LFG from these areas is expected to be negligible, due to waste age. As indicated in Section 2.0, no odors or other significant LFG issues were observed at these two areas during SCS's site visit.

Phase II/IIA includes a relatively comprehensive LFG collection system, considering waste age. A review of LFG collector operational records provided by Casella indicates that vacuum generally appears to be available to LFG wellheads. It is noted that header (system) vacuum ports are either damaged or nonexistent on the wellheads. As such, SCS was unable to evaluate flow through the Phase II/IIA LFG wellheads based on monitoring data (which requires separate system and static vacuum readings). It is noted that not all wellheads in Phase II/IIA were included in January 2014 monitoring data provided by Casella. SCS has not been provided with information indicating which wells, if any, have been decommissioned or abandoned. SCS recommends that all active (i.e., not abandoned or decommissioned) wellheads be monitored every month, in accordance with Part 208 requirements.

Based on our review, there do not appear to be significant issues related to Phase I or operation of the Phase II/IIA LFG collection system that would contribute to off-site odors, though the County should review Phase II/IIA monthly LFG monitoring records to ensure that all active LFG collectors are monitored on a monthly basis at minimum. As such, we do not recommend any changes related to LFG operations at Phase II/IIA, and these two areas of the Landfill are not discussed further in this evaluation.

4.3 PHASE III LFG COLLECTION SYSTEM EVALUATION

4.3.1 LFG Collection System Design Issues

Phase III operations have generally proceeded from Stage I through Stage VII (i.e., in a clockwise fashion around Phase III, starting in Stage I in the northwest corner and progressing to Stage VII on the west side). Relatively new waste (i.e., less than 5 years old) has generally been placed in Stages V through VII. However, few LFG collectors have been installed in Stage VII to date. Casella has already prepared plans (dated March 2014) to expand the LFG collection system into Stages III, V, VI and VII, generally in areas of (or near to) recently-placed waste. The March 2014 proposed collection system expansion includes 8 vertical LFG extraction wells and 5 horizontal LFG collectors.

SCS reviewed the existing LFG collection system plan (including the proposed March 2014 LFG collection system expansion) for gaps in LFG collection system coverage. SCS generally recommends installation of vertical LFG extraction wells in areas with at least 50-foot waste depth. Also, based on experience, field tests and theoretical calculations (which incorporate LFG generation, waste density and waste permeability), a vertical well radius of influence (ROI) of five times the solid pipe length or depth to stone surrounding the solid pipe length (whichever is lower) is usually attainable in a typical LFG collection system.

Similarly, SCS estimates the horizontal and vertical ROIs of a horizontal collector to be approximately 50 feet and 15 feet, respectively, when the horizontal collector is buried in at least 15 feet of waste, and the perforated section of the horizontal collector is located at least 75 feet into the landfill from the nearest sideslope (measured at the elevation at which the horizontal collector was installed).

Most of the vertical LFG extraction wells in Phase III are installed with 20 feet of solid pipe below grade. Perforated pipe is installed below the solid pipe. However, depth to stone fill (which surrounds the perforated pipe) in many wells is only 14.5 feet. For these wells, the ROI was based on the depth to stone fill (i.e., 5 times depth to stone fill, or 72.5 feet).

Some LFG wells were installed with only 5-foot depth to stone fill, 20-foot depth to perforated piping, and were connected in series to a common wellhead. Examples of such series include wells EW-50 to 57, EW-99 to 102, and EW-107 to 110. Generally, these wells were installed in areas that were being filled at the time of well installation, so that all well and piping components would be below grade to avoid damage by filling activities. Final filling over these wells varies from approximately 50 to 70 feet. As such, final depth to stone and perforated piping is 55-75 feet and 70-90 feet, respectively. The effectiveness of such deep wells at collecting LFG for mitigating off-site odors is limited, as barometric conditions and waste placement variables (e.g., compaction) may favor LFG flow to the atmosphere rather than to the deep well. Operations of multiple wells connected to a common wellhead are limited to the weakest collector; all wells connected to a common wellhead must be operated at the same vacuum. This can result in poor LFG collection at wells that would otherwise perform better if equipped with a separate wellhead. For wells such as those described above, SCS assigned a ROI of only 10 feet, to reflect the limited effectiveness of such wells. **We recommend that future vertical wells be installed to achieve 20 feet of solid piping below grade, and 20-foot depth to stone fill, measured from final grades, or from interim grades at which the well will be operated. Additionally, we recommended that future LFG collectors each be connected to a separate wellhead to allow independent control of each LFG collector.**

Further, it is noted that the ROIs discussed above are estimated solely based on the well construction details. Based on monitoring data collected by SCS (included in Appendix A), some of the existing wells have low to no LFG flow, based on little to no difference between vacuum applied to the well (static vacuum) and vacuum available in the LFG header (system vacuum). For wells with no LFG flow as described above (i.e., less than 1 in-w.c. between static and system vacuum), SCS has assigned no ROI. It is also noted that Casella does not typically record system vacuum or wellhead flow in their monitoring logs. **SCS recommends that the County request Casella to collect and record system vacuum measurements at each LFG collector to check for issues related to vacuum availability, and to measure LFG flow using the wellhead flow device, where available. Where system vacuum measurements are not currently possible due to lack of an appropriate wellhead monitoring port, SCS recommends that such a monitoring port be installed.**

Based on a review of available drawings, it appears that horizontal collectors have typically been installed with perforated piping nearly to the edge of the sideslope, which may result in air intrusion. **SCS recommends that future horizontal collectors be installed with at least 75 feet of solid piping horizontally into the landfill from the sideslope to minimize atmospheric intrusion into the horizontal collector and potential leachate breakouts.**

Additionally, the horizontal collectors have been installed along existing and undulating grades, with no apparent considerations for condensate or leachate management along the length of the horizontal collectors. **SCS recommends that future horizontal collectors be installed at uniform grades (i.e., not necessarily following existing grades) to allow the establishment of definite high points and low points along the horizontal collectors, with installation of stone drain pits at the low points, to provide some capacity for condensate and leachate management and to maximize the operational life of the horizontal collectors.**

Based on 2013 LFG recovery rates (approximately 3,700 scfm), the size of the main perimeter header and connection to the LFGE Facilities (i.e., 18 inch diameter) appears to be appropriate for concurrent flow, as compared with SCS's typical LFG pipe sizing standards. However, with countercurrent flow of LFG versus condensate, the flow rate through the main perimeter header may need to be limited to approximately 1,600 scfm, depending on slope. No information regarding the slope of existing LFG header piping was provided. As such, it was not possible to provide a detailed engineering review of condensate management on the LFG header. **We recommend that the piping installation details be reviewed to ascertain if there are any flow limitations, now or to be expected in the future.** Our recommended pipe flow capacities are based on minimizing condensate surging issues and head loss.

Photographs provided by Casella and as taken by SCS during our site visit indicate several headers and laterals installed at grade or only partially below grade. These exposed LFG pipes may be subject to freezing in the winter. **SCS recommends that all LFG header and/or lateral pipes in the Landfill either be buried in a trench or have soil mounded over them to mitigate freezing and movement due to expansion and contraction.**

It is also noted that Casella operates several condensate sumps on the Phase III perimeter LFG, most of which drain by gravity to the leachate collection system (one includes a pneumatically-actuated pump to move condensate to the leachate collection system). There is also a pneumatically-actuated sump at Phase II/IIA. SCS was not provided with sufficient detail to review the designs of these sumps.

4.3.2 LFG System Operational Issues

4.3.2.1 LFG Collection System Monitoring Data Analysis

SCS reviewed Phase III LFG collection system monitoring data for November 2013 through February 2014, provided by Casella. The most significant issue with these monitoring logs is, as discussed above, that Casella does not record system vacuum or wellhead flow (for wellheads equipped with a flow measurement device). Such measurements allow an indication of the productivity of individual collectors, and can indicate where operational issues may exist (e.g., watered-in wells).

A detailed review of the November 2013 through February 2014 monitoring data from Casella, and February 2014 monitoring data from SCS, indicates the following metrics:

Table 4. Phase III LFG Collection System Monitoring Data Summary

Monitoring Data Metric	November 2013	December 2013	January 2014	February 2014
# of Wellheads Monitored	108	109	108	45
# of Wellheads with Methane < 40%	9	16	11	3
# of Wellheads with Methane > 55%	69	64	55	13
Average Wellhead Methane Content (%)	54.3	53.9	52.6	54.2
Average Methane Content at LFGE Facility (%)	n/r	n/r	51.5	51.6
# of Wellheads with Oxygen >2%	15	16	18	4
Average Wellhead Oxygen Content (%)	1.0	1.2	1.2	0.7
Average Oxygen Content at LFGE Facility (%)	n/r	n/r	1.3	1.1
# of Wellheads with Static Pressure >0 in-w.c.[1]	0	0	0	2[2]
Average Wellhead Static Pressure (in-w.c.)	-28.4	-34.3	-18.9	-27.9
# of Wellheads with System Vacuum >10 in-w.c.	n/r	n/r	16[3]	2
Average System Vacuum at Wellheads (in-w.c.)	n/r	n/r	51.9	43.9
Average System Vacuum at LFGE Facility	n/r	n/r	84.8	71.5
# of Wellheads with < 1 in-w.c. difference between static and system vacuum[1]	n/r	n/r	26	11
# of Wellheads with Temperature >120°F	7	2	2	3

Note:

[1] Quantities do not include wellheads where system vacuum measurements were not possible.

[2] Does not include erroneous reading at EW-93.

[3] Several records were noted where system vacuum readings exceeded static vacuum readings. It was assumed that these readings were reversed at these wellheads.

n/r = not recorded

The LFG collection system metrics listed in Table 4 provide information that can be used to identify issues with respect to inadequate LFG collection. The most noteworthy data in this table is that most of the LFG collectors are typically operated at greater than 55 percent methane. A typical methane concentration goal for operation of LFG collection systems for odor control is 45 to 50 percent methane, which represents a balance between limiting air intrusion and adequately recovering LFG. Additionally, most biogas-fueled engine facilities are able to operate with methane concentration in this range. It is also noted that, while the arithmetic average wellhead methane concentration is between approximately 53 and 54 percent, the methane concentration at the LFGE Facilities is between 51 and 52 percent. This change is likely due to mixing LFG collected from Phase III with the same from Phase II/IIA, with the latter yielding generally lower quality LFG (i.e., lower methane and higher oxygen content). **We recommend that the LFG collection system be operated with a goal to achieving approximately 45-50 percent methane, less than 1 percent oxygen and vacuum (or at least**

atmospheric pressure) at all LFG collectors. While meeting all of these criteria is not always possible, most criteria should be met at most wellheads to maintain odor control, and minimize LFG collection system-related issues (e.g., SSO events).

Another issue noted in Table 4 is that, while average system vacuum is generally acceptable (which was also confirmed during SCS's site visit), several wells have low available vacuum, thus limiting the amount of vacuum that can be applied to these wellheads. Based on the last full monitoring round performed by Casella (in February 2014), the following wells were identified with low system vacuum: CO-21, 22, 23, EW-7, 12, 49A, 79, 83, 86, 91, 92, 97, 117, HC 4-15, 20 and 44. **We recommend that system vacuum at these LFG collectors be confirmed, and if system vacuums are low (<10 in-w.c.), check the ports on these wellheads. If, after repairing broken ports, system vacuum continues to be low, we recommend that headers in the vicinity of these LFG collectors be checked for low points, which can cause condensate accumulation and resulting reduced vacuum distribution and LFG flow.**

Table 4 indicates that a number of wells have a low difference between system and static pressure. The difference between system and static pressure is proportional to flow through the wellhead, therefore, a low difference indicates low flow. The plan in Appendix D assigns no ROI to LFG collectors with low difference (i.e., < 1 in-w.c.) between system and static pressure. It is also noted that, of the wellheads monitored with low available vacuum, only 6 of these in January 2014 and 1 of these in February 2014 also had low difference between system and static pressure, indicating that reduced flow at these wellheads was generally not due to limited available vacuum. Generally, reduced flow is a result of LFG collector damage (e.g., pinched/crushed vertical wells/horizontal collectors) or water impacts, which are discussed further below. **We recommend that LFG collectors be evaluated on an ongoing basis for limited difference between static and system vacuum, and where appropriate, such LFG collectors be repaired, replaced or decommissioned/abandoned (in accordance with 6 NYCRR Part 208 provisions).**

It was noted during SCS's site visit that vacuum was generally well distributed across the LFG collector wellheads checked (with the exception of EW-83 and 117). According to Casella, perimeter LFG header condensate sumps are operating correctly, and this was generally confirmed by SCS's monitoring of selected LFG collectors during our site visit, and in review of LFG monitoring data for November 2013 through January 2014. However, as indicated above, Casella's January 2014 LFG monitoring data indicates potential issues with provision of vacuum to the following wellheads: CO-21, 22, 23, EW-7, 12, 49A, 79, 83, 86, 91, 92, 97, 117, HC 4-15, 20 and 44. **As indicated above, we recommend that system vacuum at these LFG collectors be confirmed, and if system vacuum is low (<10 in-w.c.), check the system pressure ports on these wellheads. If, after repairing broken system pressure ports, system vacuum continues to be low, we recommend that headers in the vicinity of these LFG collectors be checked for low points, which can cause condensate accumulation and resulting reduced vacuum distribution and LFG flow.**

In reviewing Casella's January 2014 LFG operations records, they indicate the presence of a subsurface oxidation (SSO) in the vicinity of EW-49A, 58, 91, 92, 121 and CO-21. A SSO event (sometimes referred to as a "landfill fire") can typically be identified by the following observations:

- Elevated LFG temperatures (i.e., >120ºF)
- Elevated carbon monoxide (CO) concentrations (i.e., >100 ppm)
- Smoke emissions at grade
- Significant and localized settlement

SSO is primarily controlled by minimizing air intrusion into the waste mass, typically by reducing vacuum application at nearby LFG collectors. Thus, SSO events can lead to odors, due to reduced application of vacuum and resulting reduced flow from the SSO areas. While SCS has not reviewed any wellhead CO concentration readings, there were no elevated temperatures indicated in monitoring records for wells in the area of the purported SSO event. Vacuum applied to wells was generally low, and methane concentration was high in this area as a result. While it is important to keep potential SSO events under control via reduced applied vacuum to local LFG collectors, it is also important to maintain odor control. It is also noted that a substantial part of the area around this SSO event area has no existing cover. **We recommend that consideration be given to increasing applied vacuum at LFG collectors in the area identified by Casella as a SSO event (i.e., EW-49A, 58, 91, 92, 121 and CO-21), as the SSO event currently appears to be under control.**

In reviewing monitoring data, SCS noted LFG temperatures in excess of 120ºF at wells EW-111 through 115. These elevated temperatures may provide an early indication of a potential SSO event. **We recommend that CO concentrations be monitored at wells EW-111 through 115 to estimate if the area is in the early stages of an SSO event.** Additionally, the County should be aware that Casella may need to reduce vacuum to these wells in order to prevent an SSO event, which may lead to increased LFG surface emissions in this area, and resulting odors.

4.3.2.2 LFG Control Systems

The primary device(s) of the LFG control system are the LFGE Facilities. The control systems for these facilities do not maintain a constant header vacuum (system vacuum) at the facilities inlet. It is noted that, in order to effectively control odors from a landfill, the LFG collection system must be well-tuned. Wellfield tuning is a regular exercise (generally monthly or bi-weekly) involving monitoring at each LFG collector wellhead, and adjusting the wellhead valve to maintain vacuum (or at worst, atmospheric pressure), optimize methane concentration (generally 45-50 percent) and minimize atmospheric intrusion (generally by keeping oxygen concentration at less than 1 percent by volume) at each LFG collector. While meeting all of these criteria is not always possible, most criteria should be met at most wellheads to maintain odor control, and minimize LFG collection system-related issues (e.g., SSO events). In order to reasonably maintain a wellfield in this fashion, the system vacuum must be kept constant; new wellfield tuning must be conducted with every change in system vacuum.

At the Landfill, the LFGE Facilities draw from the LFG collection system whatever LFG flow is needed at the time to optimally operate the engines, though one of the LFGE Facilities is equipped with some level of vacuum control. Operation of the LFGE Facilities in this fashion results in highly variable system vacuum, depending on the operational status of the LFGE Facilities (e.g., variable number of operating engines). Even during the short time of SCS's site visit (only two days), the system vacuum ranged from -76 in-w.c. to -63 in-w.c., with total LFG flows of 3,780 scfm and 3,590 scfm, respectively.

Casella operates and maintains the four LFG blower/flare systems around Phase II/IIA and III at its discretion. The total LFG flow capacity of these systems is 5,850 scfm. While Casella maintains an odor management plan (the most recent revision of which is dated October 2013), this plan does not address in detail the operations of the LFG blower/flare systems. During SCS's site visit, on the second day during which there was a significant reduction in LFGE Facilities inlet vacuum, the LFGE blower/flare systems were not operated. SCS was informed that it is rare for the LFGE Facilities to be offline sufficiently long enough for Casella to operate the blower/flare systems. Operations of these blower/flare stations, when required, appear to be performed on an ad-hoc basis, as there are no specific setpoints established for inlet vacuum at each blower/flare station, and would appear to exclude periods when the LFGE Facilities are operating at partial load (such as that observed during the second day of SCS's site visit).

We recommend that the County establish a system vacuum that must be kept constant. To meet this goal, we recommend that Casella and IES be required to maintain a specifically agreed-upon and constant inlet vacuum to their LFGE Facilities. This may be achieved by having Casella operate (and automate, as necessary) the LFG blower/flare systems to provide additional vacuum when the LFGE Facilities are unable to maintain the specified inlet vacuum, or by having IES independently install and operate a LFG blower/flare system at their LFGE Facilities.

4.3.2.3 Water Impacts

Background

LFG is saturated with water vapor. As the LFG travels through a collector casing (either a vertical well or horizontal collector) during extraction, the LFG will cool to some extent, condensate will form, and the condensate falls by gravity into the collector. Since the collector is slotted and crushed stone surrounds the collector, it may be reasonable to expect that this condensate could flow out of the collector, through the slots and gravel, and percolate into the waste mass. However, if the waste mass is dense and/or saturated with water, the condensate may not drain quickly and it may back up into the collector. This condition may worsen over time as the waste consolidates and silt fills void spaces in the waste and gravel. Additionally, silt may enter the gravel through the application of vacuum.

Compounding this problem, leachate may move horizontally within the landfill, along layers of daily and/or intermediate cover, which, depending on the material used, can exhibit lower permeability than the waste. When the leachate over the daily cover intersects with a well boring, the leachate may drain down through the well stone, partially filling the well. Similar to condensate, the leachate may then be unable to drain out through the bottom of the well boring.

SCS has observed similar conditions at other landfills. Dr. Tim Townsend of University of Florida also noted this condition in his paper, Effect of Perched Water Conditions in MSW Landfills: Considerations for Landfill Operators. Dr. Townsend observed water levels in Florida landfills and noted that the water in LFG wells could rise significantly due in part to acting as a receptacle for perched water within the waste. These higher water levels were not found to be representative of general water levels in the landfills, which were much lower. The normal placement and compaction of waste in horizontal layers tends to impede vertical water movement, in waste, which may have an in-place vertical permeability of approximately $1x10^{-5}$cm/sec. Thus, some horizontal movement of leachate toward LFG collectors is to be expected.

Throughout the Northeast, it is common for landfills to install well dewatering systems as a means to enhance the performance of the LFG collection system, either to improve odor control or energy production. Based on a non-comprehensive survey of landfills in the Northeast, there are at least 20 landfills where well dewatering systems are operational.

The goal of the LFG system is to recover all of the LFG that is generated in the Landfill. Any water in the LFG well casing and/or the stone surrounding the casing will interfere with application of vacuum to the waste mass and in turn, with recovery of the LFG that is generated. The goal of a dewatering system is to lower the water level in the well casing such that the slots are above the water level and vacuum can be applied to the unsaturated waste mass. Concurrent with lowering the water level, increased LFG flow is needed to justify the cost and expense of the dewatering system.

At other landfills, SCS conducted tests as to whether periodic pumping or permanent pumping is warranted. The data indicated that periodic pumping will not be effective. As such, permanent pumps should be considered, if any.

Site-Specific Discussion

SCS performed LFG vertical extraction well sounding measurements at 5 wells (i.e., measurements of depth to well bottom and to static water level). Well sounding data is provided in Appendix B. Wells sounded include EW-104, 114, 124, 127 and 129, and are generally located in the southwestern quadrant of Phase III (except for EW-104, which is located in the southeastern quadrant). The well sounding data indicates that water levels are relatively high in these 5 wells, particularly EW-104, 114 and 124. In comparing the well sounding data with the LFG monitoring data in Appendix A, these wells (except EW-124) had high methane content (>57 percent). The wellhead valves for wells EW-127 and 129 were both noted as fully open, with no flow through the wellhead. Additionally, the difference between static and system vacuum in wells EW-104 and 114 was minimal. It is, however, difficult to draw conclusions from such a limited well sounding investigation.

Capital and operating costs for dewatering systems are significant. Enhanced performance of the LFG system is needed to justify the cost and expense of the dewatering system. This report includes only a limited collection and review of well sounding data, and does not assess the capital and operating costs of the dewatering system nor the relative value of the system as it pertains to enhanced LFG system performance. **We recommend that a full round of LFG well sounding be performed to more fully assess water impacts upon LFG collection at Phase III. Based on the results of this well sounding effort, Casella should review the appropriateness of installing and operating a LFG well dewatering system.**

5.0 FINDINGS AND RECOMMENDATIONS

5.1 FINDINGS

Based on the above evaluation, SCS' findings are as follows:

- The LFG system has historically not extracted sufficient LFG from the Landfill to maintain odor control. While recent efforts have mitigated this issue, continued waste placement will cause LFG generation to increase (to approximately 4,400 scfm in 2014 and a peak of 6,500 scfm in 2024), requiring annual LFG collection system expansions at minimum.

- The existing LFG collection system has significant gaps, as shown on the plan in Appendix D.

- There are several LFG collection system design issues which limit the effectiveness of the LFG collection system.

- Some LFG operational issues include:

    - Records of system vacuum are generally not maintained, though low system vacuum was noted at 16 LFG collectors, indicating possible issues with monitoring ports or the LFG header.

    - The majority of LFG collectors are operated at a methane content significantly higher than 50 percent, indicating that insufficient vacuum is applied to these wells.

    - Low to no difference between static and system vacuum was noted at several LFG collectors, indicating low to now flow at these LFG collectors.

    - The LFGE Facilities and LFG blower/flare systems are not operated to maintain a constant system vacuum.

- Odors were observed during a site visit, primarily near the active filling area of Phase III.

- In January 2014 monitoring records, Casella identified an SSO event on the east side of the Landfill in the vicinity of Stage III, but it generally appears to be under control, though vacuum is still reduced to the LFG collectors in this area.

- There is risk of a new SSO event in the vicinity of wells EW-111 through 115.

- High water levels in some wells may be having an impact on LFG recovery.

5.2 RECOMMENDATIONS

Based on this evaluation, SCS recommends the following actions:

1. Continue to expand the LFG collection system on an annual basis at minimum. Additional expansions may be necessary, depending on waste quantities and types filled, and specific waste placement methods.

2. Install vertical LFG extraction wells in areas of the LFG collection system gaps indicated on the plan in Appendix D to provide better LFG collection system coverage, and improved odor control (both on-site and off-site) and increased LFG recovery.

3. Install future vertical wells to achieve 20 feet of solid piping below grade, and 20-foot depth to stone fill, measured from final grades, or from interim grades at which the well will be operated. Additionally, individually connect future LFG collectors to separate wellheads to allow independent control of each LFG collector.

4. Request that Casella collect and record system vacuum measurements at each LFG collector to check for issues related to vacuum availability, and to allow measurements of LFG flow using the wellhead flow device, where available. Where system vacuum measurements are not currently possible due to lack of an appropriate wellhead monitoring port, a new monitoring port should be installed.

5. Install future horizontal collectors with at least 75 feet of solid piping horizontally into the landfill from the sideslope to minimize atmospheric intrusion into the horizontal collector and potential leachate breakouts.

6. Install future horizontal collectors at uniform grades (i.e., not necessarily following existing grades) to allow the establishment of definite high points and low points along the horizontal collectors, with stone drain pits at the low points, to provide some capacity for condensate and leachate management and to maximize the operational life of the horizontal collectors.

7. Review LFG header and lateral piping installation details to ascertain if there are any flow limitations, now or to be expected in the future.

8. Bury all LFG header and/or lateral pipes in the Landfill in a trench or have soil mounded over them to mitigate freezing and movement due to expansion and contraction.

9. Operate the LFG collection system with a goal to achieving approximately 45-50 percent methane, less than 1 percent oxygen and vacuum (or at least atmospheric pressure) at all LFG collectors. While meeting all of these criteria is not always possible, most criteria should be met at most wellheads to maintain odor control, and minimize LFG collection system-related issues (e.g., SSO events).

10. Confirm system vacuum at CO-21, 22, 23, EW-7, 12, 49A, 79, 83, 86, 91, 92, 97, 117, HC 4-15, 20 and 44, and if system vacuum is low (<10 in-w.c.), check the system vacuum ports on these wellheads. If, after repairing broken system pressure ports, system vacuum continues to be low, we recommend that headers in the vicinity of these LFG collectors be checked for low points, which will result in condensate accumulation and resulting reduced vacuum distribution and LFG flow.

11. Evaluate LFG collectors on an ongoing basis for reduced difference between static and system vacuum, and where appropriate, repair, replace or decommission/abandon (in accordance with NSPS provisions) such LFG collectors.

12. Give consideration to increasing applied vacuum at LFG collectors in the area identified by Casella as a SSO event (i.e., EW-49A, 58, 91, 92, 121 and CO-21), as the SSO event currently appears to be under control.

13. Monitor CO concentrations at wells EW-111 through 115 to estimate if the area is in the early stages of an SSO event.

14. Establish a system vacuum that must be kept constant. To meet this goal, Casella and IES should be required to maintain a specifically agreed-upon and constant inlet vacuum to their LFGE Facilities. This may be achieved by having Casella operate (and automate, as necessary) the LFG blower/flare systems to provide additional vacuum when the LFGE Facilities are unable to maintain the specified inlet vacuum, or by having IES independently install and operate a LFG blower/flare system at their LFGE Facilities.

15. Perform a full round of LFG well sounding to more fully assess water impacts upon LFG collection at Phase III. Based on the results of this well sounding effort, review the appropriateness of installing and operating a LFG well dewatering system.

16. Include surface emission monitoring (SEM) scans as a part of future LFG system evaluations, to provide surface emissions data for corroboration of other data collected (e.g., LFG collection system monitoring) and engineering considerations made (e.g., LFG collector ROI).

Appendix A

LFG Wellhead Readings Collected by SCS

Device ID	Date/Time	CH4	CO2	O2	Balance	Adj. Static Press.	Adj. Gas Temp.	Adj. Flow	Sys. Vacuum	Comments
GEM™5000		%	%	%	%	inches H2O	DegF	SCFM	inches H2O	
LFGE	2/12/2014 8:34	48.6	34.8	1.7	14.9	-77.86	34	0	-77.85	,,,,,,,
LFGE	2/12/2014 15:44	52.5	36.2	0.9	10.4	-73.44	36	0	-73.42	,,,,,,,
LFGE	2/13/2014 7:49	53.8	36.6	0.7	8.9	-63.26	34	0	-63.22	,,,,,,,
EW----31	2/13/2014 11:46	58.6	41.3	0	0.1	-5.89	110	3.6	-59.2	,,,,,,,
EW----43	2/13/2014 11:49	58.3	41.7	0	0	-58.9	60	3.5	-58.97	FULLY OPEN,,,,,,,
EW----49	2/13/2014 11:51	59.6	40.4	0	0	-59.07	32	3.6	-58.86	,,,,,,,
EW-50-53	2/13/2014 9:49	45.8	33	4.8	16.4	-46.57	23	0	N/A	,,,,,,,
EW-54-57	2/13/2014 10:16	55.6	44.4	0	0	-53.29	0	0	N/A	FULLY OPEN,,,,,,,
EW-59-65	2/13/2014 10:09	58.9	38.1	0	3	-45.53	65	0	N/A	FULLY OPEN,,,,,,,
EW-66-69	2/13/2014 10:42	44.2	33.5	0.2	22.1	-62.34	0	0	N/A	,,,,,,,
EW----70	2/13/2014 9:10	60.8	39.1	0	0.1	1.9	12	0	N/A	FULLY OPEN,,,,,,,
EW-71-72	2/13/2014 9:31	43.4	31.2	4.7	20.7	-44.87	16	0	N/A	,,,,,,,
EW----82	2/12/2014 14:24	59.5	40.4	0	0.1	-34.28	111	50.8	-50.46	FULLY OPEN,,,,,,,
EW----83	2/12/2014 14:18	58.9	38.1	0.5	2.5	-1.67	111	35	-3.2	,,,,,,,
EW----85	2/12/2014 14:04	59.2	40.8	0	0	-42.99	119	N/A	-42.95	,,,,,,,
EW----86	2/13/2014 11:54	59.5	40.5	0	0	-2.62	60	0	N/A	FULLY OPEN,,,,,,,
EW----87	2/12/2014 15:14	57.2	38	0	4.8	-51.8	46	0	N/A	,,,,,,,
EW----89	2/12/2014 15:03	52	35.4	0	12.6	-47.28	106	0	N/A	FULLY OPEN,,,,,,,
EW----93	2/13/2014 9:35	60.8	39.2	0	0	57.07	22	0	N/A	,,,,,,,
EW----97	2/13/2014 10:59	60.1	39.5	0	0.4	0.62	32	0	N/A	,,,,,,,
EW----98	2/13/2014 11:08	63.3	36.7	0	0	-55.91	36	0	N/A	SURGING WELL SIDE,,,,,,,
EW---103	2/12/2014 14:43	59.4	40.6	0	0	-52.15	118	25.8	-52.82	FULLY OPEN,,,,,,,
EW---104	2/12/2014 14:52	60.2	39.8	0	0	-52.25	117	16.1	-52.62	,,,,,,,
EW---111	2/12/2014 13:21	46.3	36.2	0	17.5	-14.12	119	48.2	-52.03	FULLY OPEN,,,,,,,
EW---112	2/13/2014 11:14	34.3	32	3.2	30.5	-48.95	133	N/A	-48.95	,,,,,,,
EW---113	2/12/2014 13:09	57.8	42.2	0	0	-48.67	100	20.5	-43.03	FULLY OPEN,,,,,,,
EW---114	2/12/2014 13:12	57.7	42.2	0	0.1	-49.43	111	23.8	-50.08	,,,,,,,
EW---115	2/12/2014 13:04	59.6	40.4	0	0	-50.52	125	10.9	-50.62	,,,,,,,
EW---116	2/12/2014 12:47	58.7	41.3	0	0	-41.89	90	91.1	-49.84	,,,,,,,
EW---117	2/12/2014 14:11	58.3	41.7	0	0	-2.31	60	15.5	-3.3	,,,,,,,
EW---118	2/12/2014 14:36	59.1	38.7	0	2.2	-36.2	111	72.2	-41.3	,,,,,,,
EW---120	2/12/2014 15:17	61.2	38.8	0	0	-55.01	32	6.5	-55.15	,,,,,,,
EW---123	2/12/2014 13:55	59.7	40.3	0	0	-15.21	111	0	-51.27	FULLY OPEN,,,,,,,
EW---124	2/12/2014 13:49	47.8	37.2	0.1	14.9	-11.53	110	0	-50.91	,,,,,,,
EW---125	2/12/2014 13:43	41.3	33.6	0	25.1	-5.36	121	0	-51.01	FULLY OPEN,,,,,,,
EW---126	2/12/2014 13:36	47	37.2	0	15.8	-12.94	109	0	-50.25	,,,,,,,
EW---127	2/12/2014 13:28	58.8	41.2	0	0	-2.77	100	0	-50.88	FULLY OPEN,,,,,,,
EW---128	2/12/2014 12:51	59.6	40.3	0	0.1	-3.13	112	0	-51.99	FULLY OPEN,,,,,,,
EW---129	2/12/2014 12:43	58.3	41.6	0	0.1	-3.17	119	0	-51.9	FULLY OPEN,,,,,,,
EW--129A	2/12/2014 12:38	39.4	33.2	0.1	27.3	-1.86	84	0	-54.53	,,,,,,,
WHC---28	2/13/2014 9:45	60.5	39.4	0	0.1	-46.25	30	0	N/A	FULLY OPEN,,,,,,,
WHC---32	2/13/2014 11:04	59.1	38.1	0	2.8	-2.1	100	52.1	-56.62	,,,,,,,
WHC---33	2/13/2014 11:11	61.3	38.6	0	0.1	-10.68	100	95.3	-53.36	,,,,,,,
HC----40	2/13/2014 11:18	56.2	43.3	0	0.5	-34.03	90	0	-53.89	,,,,,,,
HC----41	2/13/2014 11:25	46.4	42.4	0.3	10.9	-35.19	120	0	-52.8	FULLY OPEN,,,,,,,
HC----42	2/13/2014 11:34	55.9	44.1	0	0	-53.09	47	0	-53.29	,,,,,,,
HC----43	2/13/2014 11:38	57.3	42.5	0	0.2	-20.23	78	0	-59.89	FULLY CLOSED,,,,,,,
HC----44	2/13/2014 11:42	0.7	4.9	19.4	75	-0.52	33	0	-56.04	,,,,,,,
Wellhead Metrics:										
	Average:	54.2	38.3	0.74	6.8	-28.07	79	13.4	-49.13	
	Maximum:	63.3	44.4	19.4	75	57.07	133	95.3	-3.20	
	Minimum:	0.7	4.9	0	0	-62.34	0	0.0	-59.89	
LFGE Header Metrics:										
	Average:	51.6	35.9	1.1	11.4	-71.52	35	0.0	-71.50	
	Maximum:	53.8	36.6	1.7	14.9	-63.26	36	0.0	-63.22	
	Minimum:	48.6	34.8	0.7	8.9	-77.86	34	0.0	-77.85	

Appendix B

LFG Well Sounding Data Collected by SCS

Ontario County Well Sounding Data

Collected by SCS Engineers
Technician: Brian Basconi
Date: February 13, 2014

Well ID	Well Construction Data					Well Sounding Data			
	Year Installed	Well Depth	Solid Pipe Length	Screen Length	Grade at Installation	Well Depth	Depth to Water	Current Grade	% Screen Open
EW-104	2012	144	20	124	979.5	138	47.6	~975	23%
EW-114	2012	82	20	62	926.8	52.1	36.75	~930	52%
EW-124	2013	Unknown	21	Unknown	~956	97	45.8	~974	33%
EW-127	2013	Unknown	21	Unknown	~953	87	62.1	~968	62%
EW-129	2013	Unknown	21	Unknown	~968	71	53.1	~970	64%

Notes:

1. Grades at installation based on review of applicable LFG Collection System Expansion Plan. Because no well schedule was included on the 2013 plan, grades at installation were estimated based on review of surface grade contours.

2. Current grades estimated based on review of surface grade contours from November 14, 2013 aerial survey.

Appendix C

LFG Recovery Projections

EXHIBIT 1A. LFG RECOVERY PROJECTION FROM MSW
ONTARIO COUNTY LANDFILL, CANANDAIGUA, NY

	Disposal Rate	Refuse In-Place	LFG Recovery Potential			LFG System Coverage	LFG Recovery from Planned System		
Year	(tons/yr)	(tons)	(scfm)	(mmcf/day)	(mmBtu/yr)	(%)	(scfm)	(mmcf/day)	(mmBtu/yr)
1979	37,721	37,721	0	0.00	0				
1980	37,721	75,442	33	0.05	8,858				
1981	37,721	113,163	64	0.09	17,035				
1982	37,721	150,885	92	0.13	24,583				
1983	37,721	188,606	119	0.17	31,551				
1984	37,721	226,327	143	0.21	37,983				
1985	37,721	264,048	165	0.24	43,920				
1986	37,721	301,769	186	0.27	49,402				
1987	37,721	339,490	205	0.29	54,461				
1988	37,721	377,212	222	0.32	59,132				
1989	37,721	414,933	239	0.34	63,443				
1990	37,721	452,654	254	0.37	67,424				
1991	37,721	490,375	267	0.38	71,098				
1992	27,777	518,152	280	0.40	74,489				
1993	43,232	561,384	283	0.41	75,285				
1994	83,433	644,816	299	0.43	79,649				
1995	99,151	743,967	350	0.50	93,117				
1996	93,334	837,301	411	0.59	109,241				
1997	137,669	974,970	462	0.66	122,759				
1998	183,925	1,158,895	548	0.79	145,649				
1999	209,626	1,368,521	668	0.96	177,641				
2000	231,294	1,599,815	802	1.15	213,209				
2001	256,183	1,855,998	944	1.36	251,130				
2002	226,926	2,082,924	1,098	1.58	291,980				
2003	249,782	2,332,705	1,214	1.75	322,820				
2004	468,867	2,801,572	1,341	1.93	356,655				
2005	502,135	3,303,707	1,652	2.38	439,336				
2006	499,632	3,803,339	1,968	2.83	523,472				
2007	469,590	4,272,929	2,258	3.25	600,551	70%	1,581	2.28	420,386
2008	528,964	4,801,893	2,499	3.60	664,650	70%	1,749	2.52	465,255
2009	666,772	5,468,665	2,774	3.99	737,763	80%	2,219	3.20	590,210
2010	799,171	6,267,836	3,149	4.54	837,616	80%	2,520	3.63	670,093
2011	780,245	7,048,081	3,613	5.20	960,882	70%	2,529	3.64	672,617
2012	651,105	7,699,186	4,024	5.79	1,070,227	90%	3,622	5.22	963,204
2013	641,492	8,340,678	4,290	6.18	1,140,839	80%	3,432	4.94	912,671
2014	641,492	8,982,170	4,526	6.52	1,203,766	90%	4,074	5.87	1,083,389
2015	641,492	9,623,663	4,745	6.83	1,261,854	90%	4,270	6.15	1,135,669
2016	641,492	10,265,155	4,946	7.12	1,315,476	90%	4,452	6.41	1,183,929
2017	641,492	10,906,647	5,132	7.39	1,364,976	90%	4,619	6.65	1,228,478
2018	641,492	11,548,140	5,304	7.64	1,410,670	90%	4,774	6.87	1,269,603
2019	641,492	12,189,632	5,463	7.87	1,452,851	90%	4,917	7.08	1,307,566
2020	641,492	12,831,124	5,609	8.08	1,491,788	90%	5,048	7.27	1,342,610
2021	641,492	13,472,617	5,744	8.27	1,527,733	90%	5,170	7.44	1,374,959
2022	641,492	14,114,109	5,869	8.45	1,560,913	90%	5,282	7.61	1,404,822
2023	641,492	14,755,601	5,984	8.62	1,591,543	90%	5,386	7.76	1,432,388
2024	0	14,755,601	6,091	8.77	1,619,817	100%	6,091	8.77	1,619,817
2025	0	14,755,601	5,622	8.10	1,495,280	100%	5,622	8.10	1,495,280
2026	0	14,755,601	5,190	7.47	1,380,317	100%	5,190	7.47	1,380,317
2027	0	14,755,601	4,791	6.90	1,274,194	100%	4,791	6.90	1,274,194
2028	0	14,755,601	4,423	6.37	1,176,229	100%	4,423	6.37	1,176,229
2029	0	14,755,601	4,083	5.88	1,085,796	100%	4,083	5.88	1,085,796
2030	0	14,755,601	3,769	5.43	1,002,316	100%	3,769	5.43	1,002,316

Methane Content of LFG Adjusted to:	50%
Selected Decay Rate Constant (k):	0.080
Selected Ultimate Methane Recovery Rate (Lo):	3,000 cu ft/ton

Notes:

1. Waste projections (2014-2023) based on phone message from J. Leone of Casella, indicating that 2013 waste acceptance rate will remain constant for foreseeable future.
2. 1979-1991 waste to Phase II estimated based on total Phase II waste amount (from J. Leone email dated 02/07/2014) less 1992 waste amount (to Phase II), multiplied by MSW waste fraction (estimated at 88% based on 1992-2013 waste records) and spread evenly between 1979 through 1991.

EXHIBIT 1B. LFG RECOVERY PROJECTION FROM C&D
ONTARIO COUNTY LANDFILL, CANANDAIGUA, NY

Year	Disposal Rate (tons/yr)	Refuse In-Place (tons)	LFG Recovery Potential (scfm)	LFG Recovery Potential (mmcf/day)	LFG Recovery Potential (mmBtu/yr)	LFG System Coverage (%)	LFG Recovery from Planned System (scfm)	LFG Recovery from Planned System (mmcf/day)	LFG Recovery from Planned System (mmBtu/yr)
1979	6,002	6,002	0	0.00	0				
1980	6,002	12,005	2	0.00	533				
1981	6,002	18,007	4	0.01	1,035				
1982	6,002	24,009	6	0.01	1,508				
1983	6,002	30,012	7	0.01	1,954				
1984	6,002	36,014	9	0.01	2,373				
1985	6,002	42,016	10	0.01	2,768				
1986	6,002	48,019	12	0.02	3,141				
1987	6,002	54,021	13	0.02	3,491				
1988	6,002	60,023	14	0.02	3,821				
1989	6,002	66,026	16	0.02	4,132				
1990	6,002	72,028	17	0.02	4,424				
1991	6,002	78,030	18	0.03	4,700				
1992	0	78,030	19	0.03	4,960				
1993	0	78,030	18	0.03	4,671				
1994	13,100	91,130	17	0.02	4,399				
1995	14,663	105,794	20	0.03	5,306				
1996	37,252	143,045	24	0.03	6,300				
1997	47,975	191,021	35	0.05	9,243				
1998	46,906	237,927	49	0.07	12,967				
1999	46,942	284,869	62	0.09	16,379				
2000	24,654	309,523	74	0.11	19,596				
2001	38,321	347,844	78	0.11	20,645				
2002	53,050	400,894	86	0.12	22,848				
2003	36,535	437,429	99	0.14	26,230				
2004	112,678	550,107	105	0.15	27,949				
2005	136,102	686,209	137	0.20	36,332				
2006	114,973	801,182	174	0.25	46,308				
2007	104,401	905,583	202	0.29	53,826	70%	142	0.20	37,678
2008	90,997	996,580	225	0.32	59,967	70%	158	0.23	41,977
2009	67,160	1,063,740	243	0.35	64,559	80%	194	0.28	51,648
2010	53,120	1,116,860	251	0.36	66,767	80%	201	0.29	53,413
2011	46,992	1,163,852	254	0.37	67,598	70%	178	0.26	47,319
2012	61,601	1,225,454	255	0.37	67,836	90%	230	0.33	61,053
2013	101,743	1,327,197	261	0.38	69,359	80%	209	0.30	55,487
2014	101,743	1,428,941	280	0.40	74,359	90%	252	0.36	66,923
2015	101,743	1,530,684	297	0.43	79,068	90%	268	0.39	71,161
2016	101,743	1,632,428	314	0.45	83,503	90%	283	0.41	75,153
2017	101,743	1,734,171	330	0.47	87,680	90%	297	0.43	78,912
2018	101,743	1,835,914	344	0.50	91,613	90%	310	0.45	82,452
2019	101,743	1,937,658	358	0.52	95,317	90%	323	0.46	85,786
2020	101,743	2,039,401	372	0.53	98,806	90%	334	0.48	88,925
2021	101,743	2,141,145	384	0.55	102,091	90%	345	0.50	91,882
2022	101,743	2,242,888	396	0.57	105,185	90%	356	0.51	94,667
2023	101,743	2,344,632	406	0.59	108,099	90%	366	0.53	97,289
2024	0	2,344,632	417	0.60	110,843	100%	417	0.60	110,843
2025	0	2,344,632	393	0.57	104,388	100%	393	0.57	104,388
2026	0	2,344,632	370	0.53	98,309	100%	370	0.53	98,309
2027	0	2,344,632	348	0.50	92,584	100%	348	0.50	92,584
2028	0	2,344,632	328	0.47	87,193	100%	328	0.47	87,193
2029	0	2,344,632	309	0.44	82,115	100%	309	0.44	82,115
2030	0	2,344,632	291	0.42	77,333	100%	291	0.42	77,333
2031	0	2,344,632	274	0.39	72,829	100%	274	0.39	72,829
2032	0	2,344,632	258	0.37	68,588	100%	258	0.37	68,588
2033	0	2,344,632	243	0.35	64,594	100%	243	0.35	64,594
2034	0	2,344,632	229	0.33	60,832	100%	229	0.33	60,832
2035	0	2,344,632	215	0.31	57,290	100%	215	0.31	57,290

Methane Content of LFG Adjusted to: 50%
Selected Decay Rate Constant (k): 0.060
Selected Ultimate Methane Recovery Rate (Lo): 1,500 cu ft/ton

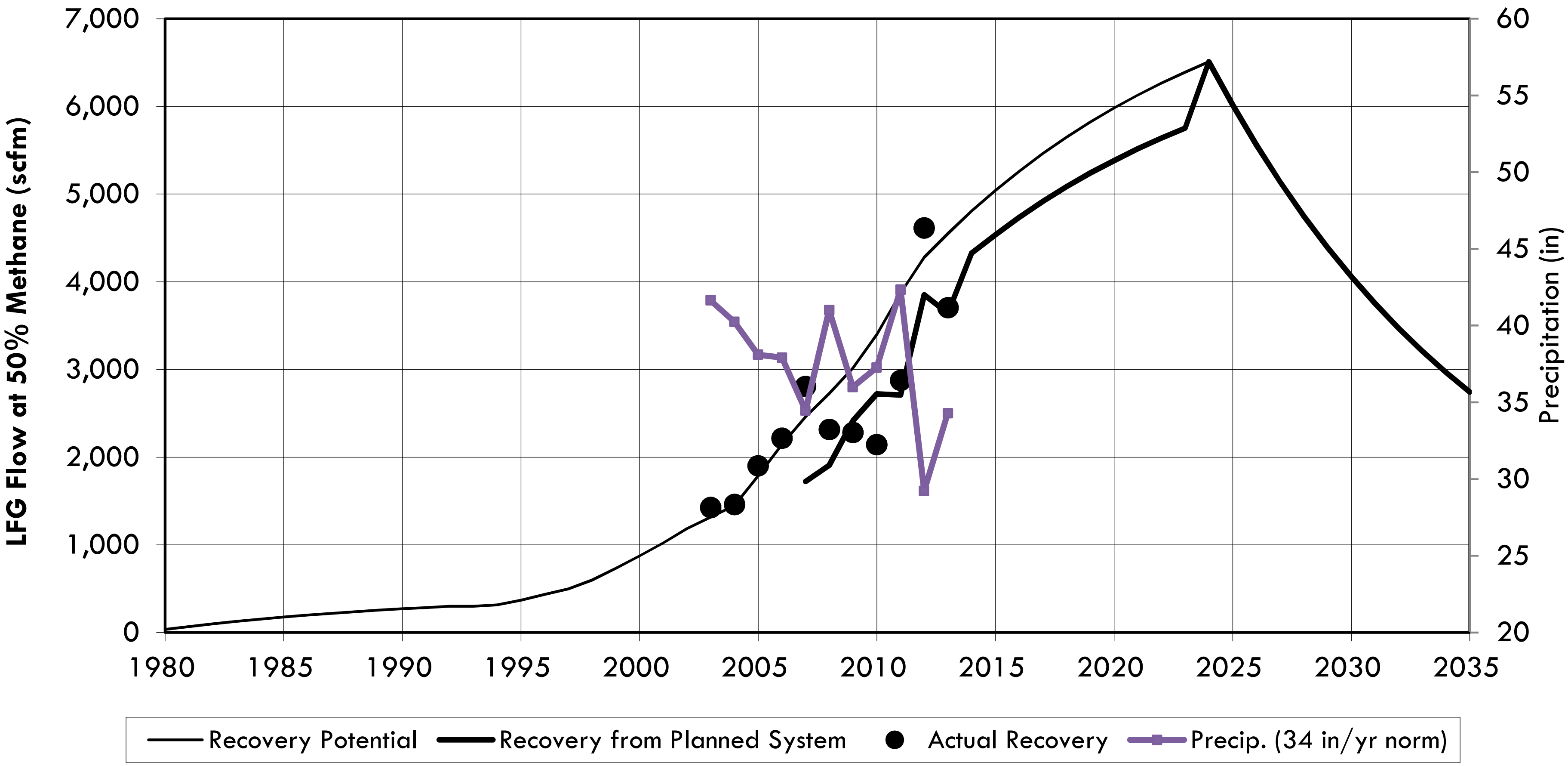
Notes:
1. Waste projections (2014-2023) based on phone message from J. Leone of Casella, indicating that 2013 waste acceptance rate will remain constant for foreseeable future.
2. 1979-1991 waste to Phase II estimated based on total Phase II waste amount (from J. Leone email dated 02/07/2014) less 1992 waste amount (to Phase II), multiplied by C&D waste fraction (estimated at 12% based on 1992-2013 waste records) and spread evenly between 1979 through 1991.

EXHIBIT 1C. LFG RECOVERY PROJECTION SUMMARY
ONTARIO COUNTY LANDFILL, CANANDAIGUA, NY

Year	Disposal Rate (tons/yr)	Refuse In-Place (tons)	LFG Recovery Potential (scfm)	LFG Recovery Potential (mmcf/day)	LFG Recovery Potential (mmBtu/yr)	LFG System Coverage (%)	LFG Recovery from Planned System (scfm)	LFG Recovery from Planned System (mmcf/day)	LFG Recovery from Planned System (mmBtu/yr)
1979	43,723	43,723	0	0.00	0	0%			
1980	43,723	87,447	35	0.05	9,391	0%			
1981	43,723	131,170	68	0.10	18,070	0%			
1982	43,723	174,894	98	0.14	26,091	0%			
1983	43,723	218,617	126	0.18	33,505	0%			
1984	43,723	262,341	152	0.22	40,356	0%			
1985	43,723	306,064	176	0.25	46,689	0%			
1986	43,723	349,788	198	0.28	52,542	0%			
1987	43,723	393,511	218	0.31	57,952	0%			
1988	43,723	437,235	237	0.34	62,953	0%			
1989	43,723	480,958	254	0.37	67,575	0%			
1990	43,723	524,682	270	0.39	71,848	0%			
1991	43,723	568,405	285	0.41	75,798	0%			
1992	27,777	596,182	299	0.43	79,449	0%			
1993	43,232	639,414	301	0.43	79,956	0%			
1994	96,533	735,947	316	0.46	84,047	0%			
1995	113,815	849,761	370	0.53	98,423	0%			
1996	130,586	980,347	434	0.63	115,541	0%			
1997	185,644	1,165,991	496	0.71	132,002	0%			
1998	230,831	1,396,821	596	0.86	158,616	0%			
1999	256,568	1,653,390	730	1.05	194,020	0%			
2000	255,948	1,909,338	875	1.26	232,805	0%			
2001	294,504	2,203,842	1,022	1.47	271,775	0%			
2002	279,975	2,483,818	1,184	1.70	314,828	0%			
2003	286,316	2,770,134	1,312	1.89	349,050	0%			
2004	581,545	3,351,679	1,446	2.08	384,604	0%			
2005	638,238	3,989,917	1,789	2.58	475,667	0%			
2006	614,605	4,604,522	2,142	3.09	569,780	0%			
2007	573,990	5,178,512	2,460	3.54	654,377	70%	1,722	2.48	458,064
2008	619,960	5,798,473	2,725	3.92	724,617	70%	1,907	2.75	507,232
2009	733,932	6,532,405	3,017	4.34	802,322	80%	2,413	3.48	641,858
2010	852,292	7,384,696	3,401	4.90	904,382	80%	2,720	3.92	723,506
2011	827,237	8,211,933	3,867	5.57	1,028,480	70%	2,707	3.90	719,936
2012	712,706	8,924,639	4,279	6.16	1,138,063	90%	3,851	5.55	1,024,257
2013	743,236	9,667,875	4,550	6.55	1,210,198	80%	3,640	5.24	968,158
2014	743,236	10,411,111	4,806	6.92	1,278,125	90%	4,325	6.23	1,150,312
2015	743,236	11,154,347	5,042	7.26	1,340,922	90%	4,538	6.53	1,206,830
2016	743,236	11,897,583	5,260	7.57	1,398,979	90%	4,734	6.82	1,259,081
2017	743,236	12,640,818	5,462	7.87	1,452,656	90%	4,916	7.08	1,307,390
2018	743,236	13,384,054	5,649	8.13	1,502,283	90%	5,084	7.32	1,352,055
2019	743,236	14,127,290	5,821	8.38	1,548,168	90%	5,239	7.54	1,393,351
2020	743,236	14,870,526	5,981	8.61	1,590,594	90%	5,383	7.75	1,431,535
2021	743,236	15,613,762	6,128	8.82	1,629,824	90%	5,515	7.94	1,466,841
2022	743,236	16,356,997	6,265	9.02	1,666,099	90%	5,638	8.12	1,499,489
2023	743,236	17,100,233	6,391	9.20	1,699,642	90%	5,752	8.28	1,529,678
2024	0	17,100,233	6,507	9.37	1,730,661	100%	6,507	9.37	1,730,661
2025	0	17,100,233	6,015	8.66	1,599,668	100%	6,015	8.66	1,599,668
2026	0	17,100,233	5,560	8.01	1,478,627	100%	5,560	8.01	1,478,627
2027	0	17,100,233	5,139	7.40	1,366,778	100%	5,139	7.40	1,366,778
2028	0	17,100,233	4,751	6.84	1,263,421	100%	4,751	6.84	1,263,421
2029	0	17,100,233	4,391	6.32	1,167,911	100%	4,391	6.32	1,167,911
2030	0	17,100,233	4,060	5.85	1,079,649	100%	4,060	5.85	1,079,649
2031	0	17,100,233	3,479	5.01	925,254	100%	3,753	5.01	925,254
2032	0	17,100,233	3,212	4.62	854,117	100%	3,469	4.62	854,117
2033	0	17,100,233	2,965	4.27	788,450	100%	3,207	4.27	788,450
2034	0	17,100,233	2,737	3.94	727,831	100%	2,965	3.94	727,831
2035	0	17,100,233	2,526	3.64	671,873	100%	2,742	3.64	671,873

Methane Content of LFG Adjusted to: 50%
Selected Decay Rate Constant (k) for MSW: 0.080
Selected Ultimate Methane Recovery Rate (Lo) for MSW: 3,000 cu ft/ton
Selected k for C&D: 0.06
Selected L_o for C&D: 1500 cu ft/ton

Exhibit 2. LFG Recovery Projection
Ontario County Landfill, Canandaigua, NY



Appendix D

LFG Collection System ROI Plan

LEGEND:

- ELEVATION CONTOUR LINE
- BRUSH/WOODS
- FENCE
- EXISTING STREAM LIMITS
- EXISTING HORIZONTAL COLLECTOR TRENCH
- CO — EXISTING CLEANOUT
- K-1 — EXISTING CONDENSATE KNOCKOUT
- EXISTING BUTTERFLY VALVE
- EXISTING CONDENSATE TRAP
- LFG — EXISTING PERIMETER GAS COLLECTION HEADER
- EXISTING HDPE END CAP
- EXISTING LFG PIPING
- GV-11 — EXISTING GAS VENT
- EW-128 — EXISTING VERTICAL EXTRACTION WELL WITH WELLHEAD
- EW-103 — EXISTING BELOW GRADE EXTRACTION WELL WITHOUT WELLHEAD
- HC-15 — EXISTING HORIZONTAL COLLECTOR WELLHEAD
- 88 — EXISTING REMOTE WELLHEAD
- EW-99 — DECOMMISSIONED VERTICAL EXTRACTION WELLHEAD
- HC-34 — DECOMMISSIONED HORIZONTAL COLLECTION WELLHEAD
- EXISTING EXPOSED CAP AREA
- EXISTING FINAL CAP AREA
- HC-47 — PROPOSED HORIZONTAL COLLECTION WELLHEAD
- PROPOSED HORIZONTAL COLLECTION TRENCH
- PROPOSED LFG PIPING
- EW-130 — PROPOSED VERTICAL EXTRACTION WELL WITH WELLHEAD
- LFG COLLECTOR ROI
- LFG COLLECTION SYSTEM GAP
- 50' WASTE LINE

NOTES:

1. BASE MAP TOPOGRAPHY HAS BEEN COMPLIED FROM AERIAL PHOTOGRAPHY ON NOVEMBER 14, 2013 BY AERO-METRIC.
2. EXISTING LFG COLLECTION SYSTEM AND PROPOSED LFG SYSTEM EXPANSION FROM LFG PLAN DATED MARCH 2014 BY BARTON AND LONGUIDICE, D.P.C.
3. NO RADIUS OF INFLUENCE (ROI) ASSIGNED FOR HORIZONTAL COLLECTORS AT ESTIMATED DEPTH OF 40 FEET OR GREATER BELOW EXISTING GRADE OR FOR ACTIVE VERTICAL WELLS WITH LITTLE TO NO FLOW BASED ON MONITORING RECORDS.

NO.	REVISION	DATE

SHEET TITLE: PHASE III LFG COLLECTION SYSTEM RADIUS OF INFLUENCE PLAN

PROJECT TITLE: LFG SYSTEM EVALUATION ONTARIO COUNTY LANDFILL

CLIENT: PLANNING DEPARTMENT ONTARIO COUNTY 20 ONATRIO STREET, 3RD FLOOR, SUITE 319 CANANDAIGUA, NEW YORK 14424

SCS ENGINEERS
STEARNS, CONRAD AND SCHMIDT CONSULTING ENGINEERS, INC.
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PH. (845) 357-1510 FAX. (845) 357-1049

PROJ. NO. 13213027.00 | DWN. BY: SHY | Q/A RVW BY: GPM
DSN. BY: MMS | CHK. BY: MMS | APP. BY: GPM

CADD FILE: 13213027.00

DATE: 04/04/2014

SCALE: 1'=100'

DRAWING NO. 1 of 1