

LandGEM and Non-Methane Organic Compounds Rate Update Report

Landfill Gas Collection and Control System

Cinder Lake Landfill Flagstaff, Arizona

November 2017

Prepared for:
City of Flagstaff.
6770E. Landfill Road
Flagstaff, AZ 86004



TABLE OF CONTENTS

1	STAGE I – INITIAL REVIEW	4
2	STAGE II – 2006 TO 2008 REVIEW	5
3	STAGE II – 2006 TO 2008 REVIEW	6
	LIMITATIONS.....	8
APPENDICES		
	APPENDIX A REVISED 2006 – 2016 REVISED DEPOSITED MUNICIPAL SOLID WASTE, PAPER MILLINGS RECEIVED, & ADC	
	APPENDIX B REVISED 2017 CLL OPERATIONS WORKSHEETS (EMAIL)	
	APPENDIX C REVISED 2017 LANDGEM REPORT	

November 14, 2017

Mr. Mathew Morales
Senior Project Manager
City of Flagstaff – Cinder Lake Landfill
6770 E. Landfill Road
Flagstaff, Arizona 86004

Re: Cinder Lake Landfill LandGEM & Non Methane Organic Compound Rate Updates

Dear Mr. Morales:

This report pertains to the update of the LandGEM and Non-methane organic compounds (NMOC) rate for the City of Flagstaff, Public Works Department, Solid Waste Section – Cinder Lake Landfill (Cinder Lake) located in Flagstaff, Arizona. The report was compiled by Cornerstone Environmental Group, a Tetra Tech Company (Cornerstone) to revise the LandGEM model and NMOC emission rate. The report will cover the three stages, as approved by Cinder Lake, in which the updates were accomplished.

The affected years are from 2006 through 2016 and changes to the projected future intake rates for paper sludge as an alternative daily cover material beginning in mid-2017.

Cornerstone's services included:

- Review of the revised disposal rates from 2006 – 2016 in the worksheet "CLOSURE-CELL-D&E" and related values in the "CLOSURE-CELL-ABC";
- Revision of the disposal tonnage to include paper sludge/millings as Alternative Daily Cover (ADC);
- Verifying that the spreadsheet is accurate based on removal of paper sludge/millings as ADC tonnage in the intake rates from 2017 and the proceeding years, and;
- Preparation of this final report of Cornerstone's review, results of the NMOC rate (including the projected year that the model predicts the landfill will exceed 34 Mg/yr NMOC) and parameters used for LandGEM model.


Should you have any questions regarding the above information, do not hesitate to contact us.

Sincerely,

Cornerstone Environmental Group, LLC



Mukonde Chama, P.E.
Project Manager



Garth R. Bowers, P.E.
Senior Operations Director

Attachments: Revised 2006 – 2016 Tonnages
Revised 2006 – 2016 Paper Millings as ADC
Revised LandGEM and Predicted Year for 34 Mg/yr NMOC threshold

1 STAGE I – INITIAL REVIEW

Cornerstone's initial assistance, approved on April 7, 2017 by Purchase Order 17-000950, included a revised 2017 LandGEM model and NMOC emission rates summaries.

Cornerstone prepared an adjusted tonnages report for the 2009 - 2016 period including revised Emissions Inventory (EI) values for Volatile Organic Compounds (VOC) and Hazardous Air Pollutants (HAPs). The revised 2017 LandGEM model included future projections with a 3% increase in deposited waste until closure.

Cornerstone reviewed the previous Tier II reports (2008 and 2013) prepared for Cinder Lake, disposal rates for the period, and records of daily waste accepted and placed in the landfill. Cornerstone and Cinder Lake discussed the possibility of including only the portion of paper millings that were used as alternative daily cover (ADC).

On April 26, 2017, Cornerstone submitted, by email, the revised tonnages and LandGEM to Cinder Lake for review. Upon approval of the revised data, Cornerstone was to produce a report for submittal to the Arizona Department of Environmental Quality (ADEQ) revising the waste numbers, HAPs and VOCs for the 2009 - 2016 period. The final report was postponed due to a revised scope as outlined in Stage 2.

The revised LandGEM model indicated that the landfill would reach the NMOC threshold of 34 MG/yr in the year 2020.

2 STAGE II – 2006 TO 2008 REVIEW

On May 3, 2017, during Cinder Lake's review of Cornerstone's tonnages and LandGEM reports, Cornerstone was informed by email of a possible need to add the 2006 – 2008 years to the analysis if reconstruction debris could be excluded as a non-NMOC contributor. Upon evaluation and internal Cornerstone discussions, it was agreed that if the reconstruction debris contained only inert construction-related products, it could be excluded as a product that was not likely to emit NMOC's. These construction-related products are disposed of and landfilled on site separate from the rest of the MSW.

On June 1, 2017, Cornerstone relayed this by email to Cinder Lake and further discussed the data to be analyzed and included. Cornerstone was requested to submit a revised scope to incorporate the Stage II review (2006-08) information into the information previously analyzed in Stage I (2009-16). On June 7, 2017, Cornerstone submitted the revised scope and requested approval by email to proceed with the revised scope and revise estimates for deposited waste, actual paper millings used as ADC and LandGEM/NMOC updates. Upon Cinder Lake's approval, Cornerstone revised Cinder Lake's waste tracking spreadsheet sent June 6, 2017 by email to include the waste deposited numbers for the 2006 – 2016 years.

Similar to the Stage I process, Cornerstone reviewed the disposal rates for the 2006 – 2008 period, records of daily waste accepted and placed in the landfill. Cornerstone continued to account for inert waste (construction-related products) to be excluded from the biodegradable fraction of waste that is deposited as MSW in the landfill per the approved revised scope. Additionally, Cornerstone included the ADC as solid waste as there was no verification or chemical analysis data showing that the paper millings were inert and did not contribute to the NMOC emission rate.

On June 26, 2017, Cornerstone submitted the revised 2006 – 2016 tonnages as well as the revised LandGEM report to Cinder Lake for review. The revised 2017 LandGEM model included future projections with a 3% increase in deposited waste until closure. The final step upon approval was to produce a report for submittal to the Arizona Department of Environmental Quality (ADEQ) revising the waste numbers, HAPs and VOCs for the 2006 – 2016 period. The final report was postponed due to a revised scope as outlined in Stage III.

The revised LandGEM model indicated that the landfill would now reach the NMOC threshold of 34 MG/yr in the year 2022 extending the timeframe another 2 years.

3 STAGE III – UPDATE 2017 AND FUTURE PAPER MILLINGS DISPOSAL RATES

On July 11, 2017, Cinder Lake informed Cornerstone that the paper plant that supplied the paper millings to the landfill would no longer be in operation through the foreseeable future. The projections for paper sludge received (Tons and Cubic Yards) in the tracking spreadsheet would need to be revised. The amount of paper millings that had been disposed of from January 1, 2017 thru June 13, 2017 was 20,025 tons. Cinder Lake adjusted this value on the spreadsheet provided by Cornerstone on June 26, 2017. Cinder Lake also deleted all future projections of incoming paper millings from the tracking spreadsheets and equations and requested a re-evaluation of the tonnages, LandGEM and future projections. Cornerstone submitted a change of scope on July 20, 2017 that was approved on August 2, 2017.

Cinder Lake personnel forwarded corrections to the deposit rates initially supplied to Cornerstone. Cornerstone re-reviewed the disposal rates for the 2006 – 2016 period, records of daily waste accepted and placed in the landfill. On August 15, 2017, Cornerstone submitted the revised 2006 – 2016 tonnages, including the paper millings received across the scale through June 2017 as well as the revised LandGEM report to Cinder Lake for review. The revised 2017 LandGEM model includes future projections with a 3% increase in deposited waste until closure. Cinder Lake personnel projects paper millings as ADC through the year 2022. This is conveyed as paper sludge as cover in Appendix A.

The revised LandGEM model indicated that the landfill would still reach the NMOC threshold of 34 MG/yr in the year 2022.

The final step upon approval will be to produce a report for submittal to the Arizona Department of Environmental Quality (ADEQ) revising the waste numbers, HAPs and VOCs for the 2006 – 2016 period. The final report to ADEQ will be sent by Cinder Lake upon approval of the project report.

CONCLUSION

Cornerstone revised disposal rates as requested by Cinder Lake in the three stages as described above. The data for the years revised, 2006 – 2016, were based on revised (more accurate actual deposited) rates as supplied by Cinder Lake taking into consideration actual paper millings deposited as ADC in the landfill rather than paper millings received by the landfill and stored for later use as ADC.

For the years given above, the paper millings used as ADC was included up until July 2017 when paper millings were no longer received by Cinder Lake. Cornerstone reviewed and updated the tracking spreadsheet utilized by Cinder Lake. ADC is no longer received by the landfill, beginning August 2017.

Cornerstone recalculated the NMOC emission rate for the landfill using EPA's LandGEM model based on the requested changes. The NMOC emission rate recalculation by the LandGEM shows that the predicted year that NMOC emissions will exceed the new 34 Mg/Yr NMOC emission rate limit for landfills is during the year 2022. LandGEM predicts that the NMOC emission rate in 2022 will be 34.48 Mg/yr.

In order to provide a more accurate assessment of the actual NMOC emission rate, Cornerstone recommends that a new Tier 2 analysis be completed no later than 5 years since the last Tier 2 was completed.

If you have any questions about the contents of this report, please contact Cornerstone at 630-633-5840.

LIMITATIONS

The services described in this report were performed consistent with generally accepted professional consulting principles and practices. No other warranty, express or implied, is made. These services were performed consistent with our agreement with our client. This report is solely for the use and information of our client unless otherwise noted. Any reliance on this report by a third party is at such party's sole risk.

Opinions and recommendations contained in this report apply to conditions existing when services were performed and are intended only for the client, purposes, locations, time frames, and project parameters indicated. We are not responsible for the impacts of any changes in environmental standards, practices, or regulations subsequent to performance of services. We do not warrant the accuracy of information supplied by others, nor the use of segregated portions of this report.

APPENDIX A

**REVISED 2006 – 2016 REVISED DEPOSITED MUNICIPAL
SOLID WASTE, PAPER MILLINGS RECEIVED, & ADC**

Adjusted Totals of Waste Since 2006

YEAR	Current LandGEM Posted Tonnage	Total Paper Milling Acceptance Rate (tons)
2006	152,234	39,440
2007	157,408	39,653
2008	155,470	39,714
2009	126,990	28,266
2010	136,162	32,395
2011	134,743	43,742
2012	136,947	42,488
2013	141,055	44,003
2014	145,287	40,782
2015	149,646	45,152
2016	154,135	51,273
2017		
Total	1,590,077	

Actual Landfilled Waste (tons)	Paper Millings Used as Cover (tons)	Total Adjusted (tons)
104,445	26,406	130,851
115,935	24,495	140,430
106,117	26,224	132,341
98,750	18,770	117,520
101,409	15,039	116,448
88,572	16,636	105,208
89,366	19,440	108,806
81,359	18,421	99,780
85,473	18,718	104,191
86,691	17,817	104,508
91,150	13,175	104,325
Adjusted Total		1,264,408

APPENDIX B

REVISED 2017 CLL OPERATIONS WORKSHEETS (EMAIL)

CLOSURE OF CINDER LAKE LANDFILL WITH 1350 LB/CY

In-Place Density ton/cu.yd = 0.68
 Refuse/Cover Ratio vol/total vol = 0.75
 Refuse Growth Rate %/year = **3.00%**

All disposal rates up to 2006 were taken from the documented disposal rates taken from "Estimate of in place MSW.xls"

Estimated remaining landfill fill capacity (after 12/31/97) 25,256,711 (Cu. Yd)
 Estimated remaining refuse capacity (after 12/31/97) 18,942,533 (Cu. Yd)
 Estimated remaining refuse capacity (after 01/19/2017) 19,372,524 (Cu. Yd)⁵

Year	Disposal Tonnage (Tons) ¹	Compacted Disposal Volume (Cu. Yd) ¹	Paper Sludge Tons	Paper Sludge ⁴ (Cu.Yd.)	Paper Sludge as Cover (Tons)	Paper Sludge as Cover ⁷ (Cu.Yd.)	Tonnage with Cover Sludge (Tons)	Tonnage after Sludge (Tons)	Volume After Sludge (Cu.Yd.) ²	Total Remaining Capacity (Tons) ³	Total Remaining Capacity (Cu. Yd.) ³	Remaining Refuse Capacity (Tons) ²	Remaining Refuse Capacity (Cu. Yd.) ²
1997										17,048,280	25,256,711	12,786,210	18,942,533
1998	139,477	206,633	6,636	11,305				132,841	195,328	16,862,311	24,981,201	12,646,733	18,735,901
1999	140,502	208,151	29,589	50,407				110,913	157,744	16,674,975	24,703,666	12,506,231	18,527,750
2000	117,597	174,218	26,727	45,532				90,870	128,686	16,518,179	24,471,376	12,388,634	18,353,532
2001	109,835	162,719	28,739	48,959				81,096	113,759	16,371,732	24,254,418	12,278,799	18,190,813
2002	126,650	187,629	28,686	48,869				97,964	138,761	16,202,865	24,004,245	12,152,149	18,003,184
2003	117,880	174,637	28,267	48,155				89,613	126,482	16,045,692	23,771,396	12,034,269	17,828,547
2004	134,367	199,062	32,332	55,080				102,035	143,982	15,866,536	23,505,980	11,899,902	17,629,485
2005	151,188	223,982	35,402	60,310				115,786	163,672	15,664,952	23,207,337	11,748,714	17,405,502
2006	104,445	154,733	39,440	33,460	26,406	65,220	130,851	65,005	121,273	15,525,692	23,001,026	11,644,269	17,250,769
2007	115,935	171,756	39,653	36,780	24,495	60,500	140,430	76,282	134,976	15,371,112	22,772,018	11,528,334	17,079,014
2008	106,116	157,209	39,714	40,360	26,224	64,769	132,340	66,402	116,849	15,229,624	22,562,406	11,422,218	16,921,805
2009	98,750	146,296	28,266	27,000	18,770	46,360	117,520	70,484	119,296	15,097,958	22,367,345	10,818,965	16,028,096
2010	101,409	150,236	32,395	30,580	15,039	37,145	116,448	69,014	119,656	14,962,746	22,167,030	11,222,059	16,625,273
2011	88,572	131,218	43,742	41,720	16,636	41,090	105,208	44,830	89,498	14,844,650	21,992,073	11,133,487	16,494,055
2012	89,366	132,394	42,488	40,680	19,440	48,015	108,806	46,878	90,674	14,725,495	21,815,548	11,044,121	16,361,661
2013	81,359	120,532	44,003	43,720	18,421	45,497	99,780	37,356	76,812	14,617,016	21,654,839	10,962,762	16,241,129
2014	85,473	126,627	40,782	40,360	18,718	46,230	104,191	44,691	86,267	14,503,052	21,486,003	10,877,289	16,114,502
2015	86,691	128,431	45,152	45,080	17,817	44,005	104,508	41,539	83,351	14,387,464	21,314,762	10,790,598	15,986,071
2016	91,150	135,037	51,273	48,540	13,175	32,540	104,325	39,877	86,497	13,076,454	19,372,524	9,807,340	14,529,393
2017	93,885	139,088	20,025	19,820	13,310	32,865	107,195	73,860	119,268	12,951,274	19,187,073	9,713,456	14,390,305
2018	96,701	143,261	0	0	13,444	33,194	110,145	96,701	143,261	12,822,340	18,996,059	9,616,755	14,247,044
2019	99,602	147,559	0	0	13,578	33,526	113,180	99,602	147,559	12,689,537	18,799,314	9,517,153	14,099,485
2020	102,590	151,985	0	0	13,714	33,861	116,304	102,590	151,985	12,552,750	18,596,667	9,414,563	13,947,500
2021	105,668	156,545	0	0	13,851	34,200	119,519	105,668	156,545	12,411,860	18,387,940	9,308,895	13,790,955
2022	108,838	161,241	0	0	13,989	34,542	122,827	108,838	161,241	12,266,742	18,172,952	9,200,057	13,629,714
2023	112,103	166,079	0	0				112,103	166,079	12,117,272	17,951,514	9,087,954	13,463,635
2024	115,466	171,061	0	0				115,466	171,061	11,963,317	17,723,433	8,972,488	13,292,574
2025	118,930	176,193	0	0				118,930	176,193	11,804,744	17,488,509	8,853,558	13,116,382
2026	122,498	181,478	0	0				122,498	181,478	11,641,413	17,246,538	8,731,060	12,934,903
2027	126,173	186,923	0	0				126,173	186,923	11,473,182	16,997,307	8,604,887	12,747,980
2028	129,958	192,531	0	0				129,958	192,531	11,299,905	16,740,600	8,474,929	12,555,450
2029	133,857	198,306	0	0				133,857	198,306	11,121,429	16,476,191	8,341,072	12,357,143
2030	137,873	204,256	0	0				137,873	204,256	10,937,599	16,203,850	8,203,199	12,152,888
2031	142,009	210,383	0	0				142,009	210,383	10,748,254	15,923,339	8,061,191	11,940,834
2032	146,269	216,695	0	0				146,269	216,695	10,553,229	15,634,413	7,914,922	11,725,810
2033	150,657	223,196	0	0				150,657	223,196	10,352,353	15,336,819	7,764,264	11,502,614
2034	155,177	229,892	0	0				155,177	229,892	10,145,450	15,030,297	7,609,088	11,272,723
2035	159,832	236,788	0	0				159,832	236,788	9,932,341	14,714,579	7,449,256	11,035,934
2036	164,627	243,892	0	0				164,627	243,892	9,712,838	14,389,390	7,284,629	10,792,042
2037	169,566	251,209	0	0				169,566	251,209	9,486,750	14,054,445	7,115,063	10,540,834
2038	174,653	258,745	0	0				174,653	258,745	9,253,880	13,709,452	6,940,410	10,282,089
2039	179,892	266,507	0	0				179,892	266,507	9,014,023	13,354,109	6,760,518	10,015,582
2040	185,289	274,502	0	0				185,289	274,502	8,766,971	12,988,105	6,575,228	9,741,079
2041	190,848	282,738	0	0				190,848	282,738	8,512,507	12,611,122	6,384,380	9,458,341
2042	196,573	291,220	0	0				196,573	291,220	8,250,410	12,222,829	6,187,807	9,167,122
2043	202,470	299,956	0	0				202,470	299,956	7,980,449	11,822,887	5,985,337	8,867,165
2044	208,545	308,955	0	0				208,545	308,955	7,702,389	11,410,947	5,776,792	8,558,210
2045	214,801	318,224	0	0				214,801	318,224	7,415,988	10,986,649	5,561,991	8,239,987
2046	221,245	327,770	0	0				221,245	327,770	7,120,995	10,549,622	5,340,746	7,912,217
2047	227,882	337,603	0	0				227,882	337,603	6,817,152	10,099,484	5,112,864	7,574,613
2048	234,719	347,732	0	0				234,719	347,732	6,504,193	9,635,842	4,878,145	7,226,882
2049	241,760	358,163	0	0				241,760	358,163	6,181,846	9,158,291	4,636,385	6,868,718
2050	249,013	368,908	0	0				249,013	368,908	5,849,829	8,666,413	4,387,372	6,499,810
2051	256,484	379,976	0	0				256,484	379,976	5,507,851	8,159,779	4,130,888	6,119,834
2052	264,178	391,375	0	0				264,178	391,375	5,155,613	7,637,945	3,866,710	5,728,459
2053	272,103	403,116	0	0				272,103	403,116	4,792,809	7,100,457	3,594,606	5,325,343
2054	280,267	415,210	0	0				280,267	415,210	4,419,120	6,546,844	3,314,340	4,910,133
2055	288,675	427,666	0	0				288,675	427,666	4,034,221	5,976,623	3,025,665	4,482,467
2056	297,335	440,496	0	0				297,335	440,496	3,637,774	5,389,295	2,728,331	4,041,971
2057	306,255	453,711	0	0				306,255	453,711	3,229,435	4,784,347	2,422,076	3,588,261
2058	315,442	467,322	0	0				315,442	467,322	2,808,845	4,161,251	2,106,633	3,120,939
2059	324,906	481,342	0	0				324,906	481,342	2,375,637	3,519,462	1,781,728	2,639,597

- (1) Actual values are from 1999-2007. Projected values are from 2008 thru 2048.
- (2) Assume an in-place density for solid waste of 1,350 lb/cy and a waste to soil cover ratio of 3:1.
- (3) Combined waste and cover material capacity.
- (4) Paper millings data from scale house software. Volume assumes each incoming load is 20 cubic yards.
- (5) Calculation of available airspace performed with CAD using existing contours as of 1/19/2017 and WWC final design contours.
- (6) Paper millings recorded and used as cover in the landfill. Balance of paper millings in storage.
- (7) Compacted volume is the ratio of uncompacted millings (810 lb/cy) to compacted millings (1053 lb/cy) multiplied times a conversion factor (1053 lb/cy/2000 lb/ton).

Assumptions:

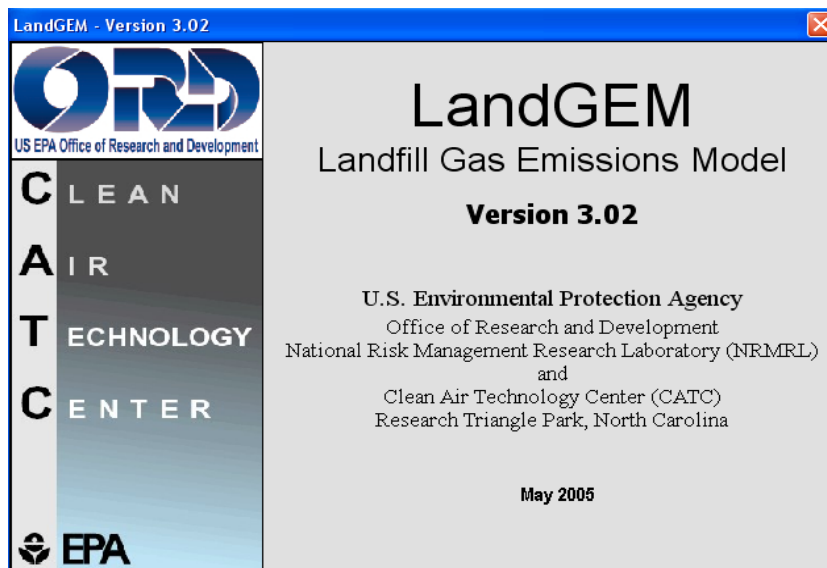
In-Place Density	0.68
New Compaction Equipment In-Place Density	0.75
Refuse/Cover Ratio	0.75
Refuse Growth Rate	3.00%

Estimated remaining Cell A,B,C fill capacity (after 06/30/11)	4,590,010 (Cu. Yd)
Estimated remaining Cell A,B,C refuse capacity (after 06/30/2011)	3,442,508 (Cu. Yd)
Estimated remaining Cell A,B,C refuse capacity (after 01/19/2017)	3,077,416 (Cu. Yd)⁵

Fiscal Year	Disposal Tonnage (Tons) ¹	Disposal Volume (Cu. Yd) ¹	Paper Sludge Received Tons	Paper Sludge Received ⁴ (Cu.Yd.)	Paper Sludge as Cover ⁶ (Tons)	Paper Sludge as Cover ⁷ (Cu.Yd.)	Tonnage with Cover Sludge (Tons)	Volume after Sludge (Cu.Yd.) ²	Total Remaining Capacity (Tons) ³	Total Remaining Capacity (Cu. Yd) ³	Remaining Refuse Capacity (Tons) ²	Remaining Refuse Capacity (Cu. Yd) ²
2006	104,445	154,733	39,440	33,460	26,406	65,220	130,851	121,273	2,323,693	3,442,508	1,742,769	2,581,881
2007	115,935	171,756	39,653	36,780	24,495	60,500	140,430	134,976	2,169,113	3,213,500	1,626,834	2,410,125
2008	106,116	157,209	39,714	40,360	26,224	64,769	132,340	116,849	2,027,625	3,003,888	1,520,718	2,252,916
2009	98,750	146,296	28,266	27,000	18,770	46,360	117,520	119,296	1,895,958	2,808,827	1,421,968	2,106,620
2010	101,409	150,236	32,395	30,580	15,039	37,145	116,448	119,656	1,760,746	2,608,512	1,320,559	1,956,384
2011	88,572	131,218	43,742	41,720	16,636	41,090	105,208	89,498	3,098,257	4,590,010	2,323,693	3,442,508
2012	89,366	132,394	42,488	40,680	19,440	48,015	108,806	91,714	2,979,102	4,413,485	2,234,327	3,310,113
2013	81,359	108,479	44,003	43,720	18,421	45,497	99,780	64,759	3,201,635	4,268,846	2,401,226	3,201,635
2014	85,473	113,964	40,782	40,360	18,718	46,230	104,191	73,604	3,087,671	4,116,894	2,315,753	3,087,671
2015	86,691	115,588	45,152	45,080	17,817	44,005	104,508	70,508	2,972,083	3,962,777	2,229,062	2,972,083
2016	91,150	121,533	51,273	48,540	13,175	32,540	104,325	72,993	2,308,062	3,077,416	1,731,047	2,308,062
2017	93,885	125,179	20,025	19,820	13,310	32,865	107,195	105,359	2,182,883	2,910,510	1,637,162	2,182,883
2018	96,701	128,935	0	0	13,444	33,194	110,145	128,935	2,053,948	2,738,597	1,540,461	2,053,948
2019	99,602	132,803	0	0	13,578	33,526	113,180	132,803	1,921,145	2,561,527	1,440,859	1,921,145
2020	102,590	136,787	0	0	13,714	33,861	116,304	136,787	1,784,358	2,379,144	1,338,269	1,784,358
2021	105,668	140,890	0	0	13,851	34,200	119,519	140,890	1,643,468	2,191,291	1,232,601	1,643,468
2022	108,838	145,117	0	0	13,989	34,542	122,827	145,117	1,498,351	1,997,801	1,123,763	1,498,351
2023	112,103	149,471	0	0	0	0	112,103	149,471	1,348,880	1,798,507	1,011,660	1,348,880
2024	115,466	153,955	0	0	0	0	115,466	153,955	1,194,925	1,593,234	896,194	1,194,925
2025	118,930	158,573	0	0	0	0	118,930	158,573	1,036,352	1,381,802	777,264	1,036,352
2026	122,498	163,331	0	0	0	0	122,498	163,331	873,021	1,164,028	654,766	873,021
2027	126,173	168,231	0	0	0	0	126,173	168,231	704,791	939,721	528,593	704,791
2028	129,958	173,277	0	0	0	0	129,958	173,277	531,513	708,684	398,635	531,513
2029	133,857	178,476	0	0	0	0	133,857	178,476	353,037	470,717	264,778	353,037
2030	137,873	183,830	0	0	0	0	137,873	183,830	169,207	225,610	126,905	169,207
2031	142,009	189,345	0	0	0	0	142,009	189,345	-20,138	-26,850	-15,103	-20,138
2032	146,269	195,025	0	0	0	0	146,269	195,025	-215,163	-286,884	-161,372	-215,163

- (1) Used actual landfilled waste as tonnage. Projected disposable rates begin in 2017.
- (2) Assume an in-place density for solid waste of 1,350 lb/cy and a waste to soil cover ratio of 3:1. Newer compaction equipment was added to the landfill in July of 2012 with an in-place density of 1,500 lb/cy.
- (3) Combined waste and cover material capacity.
- (4) Paper millings data from scale house software. Volume assumes each incoming load is 20 cubic yards.
- (5) Calculation of available airspace performed with CAD using existing contours as of 1/19/2017 and WWC final design contours.
- (6) Paper millings recorded and used as cover in the landfill. Balance of paper millings in storage.
- (7) Compacted volume is the ratio of uncompacted millings (810 lb/cy) to compacted millings (1053 lb/cy) multiplied times a conversion factor (1053 lb/cy/2000 lb/ton).

APPENDIX C
REVISED 2017 LANDGEM REPORT



Summary Report

Landfill Name or Identifier: City of Flagstaff - Cinder Lake Landfill

Date: Tuesday, November 7, 2017

Description/Comments:

About LandGEM:

First-Order Decomposition Rate Equation:

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

Where,

Q_{CH_4} = annual methane generation in the year of the calculation ($m^3/year$)

i = 1-year time increment

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

j = 0.1-year time increment

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

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

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

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

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

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

Input Review

LANDFILL CHARACTERISTICS

Landfill Open Year **1965**
 Landfill Closure Year (with 80-year limit) **2044**
 Actual Closure Year (without limit) **2044**
 Have Model Calculate Closure Year? **No**
 Waste Design Capacity **11,205,770** megagrams

MODEL PARAMETERS

Methane Generation Rate, k **0.020** year⁻¹
 Potential Methane Generation Capacity, L₀ **170** m³/Mg
 NMOC Concentration **433** ppmv as hexane
 Methane Content **50** % by volume

GASES / POLLUTANTS SELECTED

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

WASTE ACCEPTANCE RATES

Year	Waste Accepted		Waste-In-Place	
	(Mg/year)	(short tons/year)	(Mg)	(short tons)
1965	12,976	14,274	0	0
1966	15,781	17,359	12,976	14,274
1967	18,626	20,489	28,757	31,633
1968	21,515	23,666	47,384	52,122
1969	24,448	26,892	68,898	75,788
1970	27,425	30,168	93,346	102,681
1971	30,166	33,182	120,772	132,849
1972	32,937	36,230	150,937	166,031
1973	35,739	39,313	183,874	202,261
1974	38,574	42,432	219,613	241,575
1975	41,442	45,587	258,188	284,006
1976	47,114	51,826	299,630	329,593
1977	52,821	58,103	346,744	381,419
1978	58,564	64,420	399,565	439,521
1979	64,344	70,779	458,129	503,942
1980	70,187	77,206	522,473	574,720
1981	76,007	83,608	592,660	651,926
1982	81,865	90,052	668,667	735,534
1983	87,764	96,540	750,533	825,586
1984	93,703	103,073	838,297	922,126
1985	102,006	112,207	931,999	1,025,199
1986	134,135	147,549	1,034,006	1,137,406
1987	102,182	112,400	1,168,141	1,284,955
1988	105,853	116,438	1,270,323	1,397,355
1989	107,013	117,714	1,376,176	1,513,793
1990	116,026	127,629	1,483,188	1,631,507
1991	135,455	149,000	1,599,215	1,759,136
1992	155,407	170,948	1,734,669	1,908,136
1993	69,013	75,915	1,890,077	2,079,084
1994	114,222	125,644	1,959,090	2,154,999
1995	108,284	119,112	2,073,312	2,280,643
1996	135,665	149,232	2,181,595	2,399,755
1997	120,230	132,253	2,317,261	2,548,987
1998	126,797	139,477	2,437,490	2,681,240
1999	127,729	140,502	2,564,287	2,820,716
2000	106,906	117,597	2,692,016	2,961,218
2001	99,850	109,835	2,798,923	3,078,815
2002	115,136	126,650	2,898,773	3,188,650
2003	107,164	117,880	3,013,909	3,315,300
2004	122,152	134,367	3,121,073	3,433,180

WASTE ACCEPTANCE RATES (Continued)

Year	Waste Accepted		Waste-In-Place	
	(Mg/year)	(short tons/year)	(Mg)	(short tons)
2005	137,444	151,188	3,243,224	3,567,547
2006	118,955	130,851	3,380,668	3,718,735
2007	127,664	140,430	3,499,623	3,849,586
2008	120,309	132,340	3,627,287	3,990,016
2009	106,836	117,520	3,747,596	4,122,356
2010	105,862	116,448	3,854,433	4,239,876
2011	95,644	105,208	3,960,294	4,356,324
2012	98,915	108,806	4,055,938	4,461,532
2013	90,709	99,780	4,154,853	4,570,338
2014	94,719	104,191	4,245,562	4,670,118
2015	95,007	104,508	4,340,281	4,774,309
2016	94,841	104,325	4,435,288	4,878,817
2017	97,686	107,455	4,530,129	4,983,142
2018	100,617	110,678	4,627,815	5,090,597
2019	103,635	113,999	4,728,432	5,201,275
2020	106,744	117,419	4,832,067	5,315,274
2021	109,947	120,941	4,938,811	5,432,692
2022	113,245	124,570	5,048,758	5,553,634
2023	116,642	128,307	5,162,003	5,678,203
2024	120,142	132,156	5,278,645	5,806,510
2025	123,746	136,120	5,398,787	5,938,666
2026	127,458	140,204	5,522,533	6,074,786
2027	131,282	144,410	5,649,991	6,214,990
2028	135,220	148,743	5,781,273	6,359,400
2029	139,277	153,205	5,916,493	6,508,143
2030	143,455	157,801	6,055,771	6,661,348
2031	147,759	162,535	6,199,226	6,819,148
2032	152,192	167,411	6,346,985	6,981,683
2033	156,758	172,433	6,499,177	7,149,094
2034	161,460	177,606	6,655,934	7,321,528
2035	166,304	182,935	6,817,395	7,499,134
2036	171,293	188,423	6,983,699	7,682,069
2037	176,432	194,075	7,154,992	7,870,491
2038	181,725	199,897	7,331,424	8,064,566
2039	187,177	205,894	7,513,149	8,264,464
2040	192,792	212,071	7,700,326	8,470,358
2041	198,576	218,433	7,893,118	8,682,430
2042	204,533	224,986	8,091,694	8,900,863
2043	210,669	231,736	8,296,227	9,125,849
2044	216,989	238,688	8,506,896	9,357,585

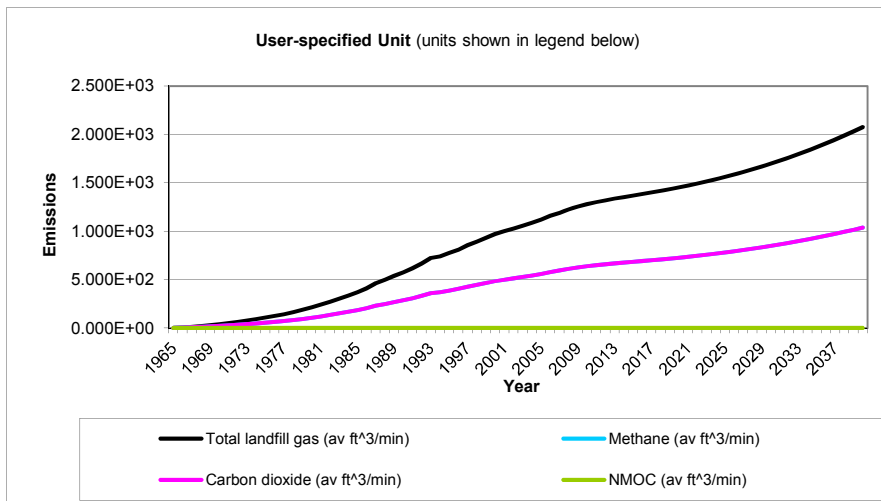
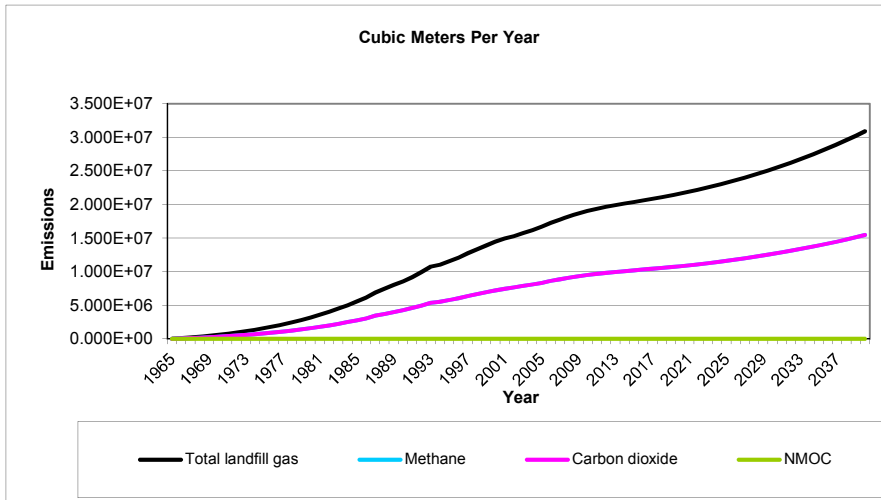
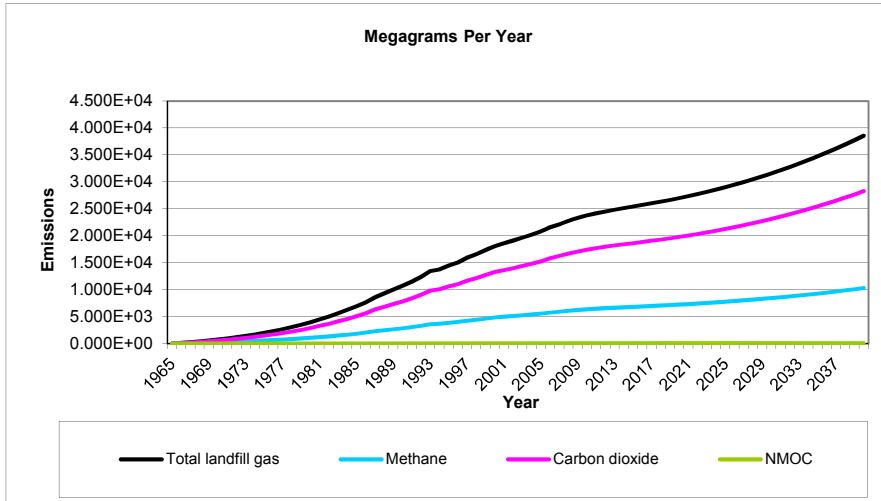
Pollutant Parameters

<i>Gas / Pollutant Default Parameters:</i>				<i>User-specified Pollutant Parameters:</i>	
	Compound	Concentration (ppmv)	Molecular Weight	Concentration (ppmv)	Molecular Weight
Gases	Total landfill gas		0.00		
	Methane		16.04		
	Carbon dioxide		44.01		
	NMOC	4,000	86.18		
Pollutants	1,1,1-Trichloroethane (methyl chloroform) - HAP	0.48	133.41		
	1,1,1,2-Tetrachloroethane - HAP/VOC	1.1	167.85	1.11	
	1,1-Dichloroethane (ethylidene dichloride) - HAP/VOC	2.4	98.97	2.35	
	1,1-Dichloroethene (vinylidene chloride) - HAP/VOC	0.20	96.94		
	1,2-Dichloroethane (ethylene dichloride) - HAP/VOC	0.41	98.96		
	1,2-Dichloropropane (propylene dichloride) - HAP/VOC	0.18	112.99		
	2-Propanol (isopropyl alcohol) - VOC	50	60.11	50.10	
	Acetone	7.0	58.08	7.01	
	Acrylonitrile - HAP/VOC	6.3	53.06	6.33	
	Benzene - No or Unknown Co-disposal - HAP/VOC	1.9	78.11	1.91	
	Benzene - Co-disposal - HAP/VOC	11	78.11		
	Bromodichloromethane - VOC	3.1	163.83	3.13	
	Butane - VOC	5.0	58.12		
	Carbon disulfide - HAP/VOC	0.58	76.13		
	Carbon monoxide	140	28.01		
	Carbon tetrachloride - HAP/VOC	4.0E-03	153.84		
	Carbonyl sulfide - HAP/VOC	0.49	60.07		
	Chlorobenzene - HAP/VOC	0.25	112.56		
	Chlorodifluoromethane	1.3	86.47		
	Chloroethane (ethyl chloride) - HAP/VOC	1.3	64.52	1.25	
	Chloroform - HAP/VOC	0.03	119.39		
	Chloromethane - VOC	1.2	50.49		
	Dichlorobenzene - (HAP for para isomer/VOC)	0.21	147		
	Dichlorodifluoromethane	16	120.91		
	Dichlorofluoromethane - VOC	2.6	102.92		
	Dichloromethane (methylene chloride) - HAP	14	84.94	14.30	
	Dimethyl sulfide (methyl sulfide) - VOC	7.8	62.13		
	Ethane	890	30.07		
	Ethanol - VOC	27	46.08	27.20	

Pollutant Parameters (Continued)

<i>Gas / Pollutant Default Parameters:</i>				<i>User-specified Pollutant Parameters:</i>	
	Compound	Concentration (ppmv)	Molecular Weight	Concentration (ppmv)	Molecular Weight
Pollutants	Ethyl mercaptan (ethanethiol) - VOC	2.3	62.13		
	Ethylbenzene - HAP/VOC	4.6	106.16	4.61	
	Ethylene dibromide - HAP/VOC	1.0E-03	187.88		
	Fluorotrichloromethane - VOC	0.76	137.38		
	Hexane - HAP/VOC	6.6	86.18	6.57	
	Hydrogen sulfide	36	34.08		
	Mercury (total) - HAP	2.9E-04	200.61		
	Methyl ethyl ketone - HAP/VOC	7.1	72.11	7.09	
	Methyl isobutyl ketone - HAP/VOC	1.9	100.16	1.87	
	Methyl mercaptan - VOC	2.5	48.11		
	Pentane - VOC	3.3	72.15	3.29	
	Perchloroethylene (tetrachloroethylene) - HAP	3.7	165.83		
	Propane - VOC	11	44.09		
	t-1,2-Dichloroethene - VOC	2.8	96.94	2.84	
	Toluene - No or Unknown Co-disposal - HAP/VOC	39	92.13	39.30	
	Toluene - Co-disposal - HAP/VOC	170	92.13		
	Trichloroethylene (trichloroethene) - HAP/VOC	2.8	131.40	2.82	
	Vinyl chloride - HAP/VOC	7.3	62.50	7.34	
	Xylenes - HAP/VOC	12	106.16	12.10	

Graphs



Results

Year	Total landfill gas			Methane		
	(Mg/year)	(m ³ /year)	(av ft ³ /min)	(Mg/year)	(m ³ /year)	(av ft ³ /min)
1965	0	0	0	0	0	0
1966	1.092E+02	8.745E+04	5.876E+00	2.917E+01	4.373E+04	2.938E+00
1967	2.399E+02	1.921E+05	1.291E+01	6.407E+01	9.603E+04	6.453E+00
1968	3.919E+02	3.138E+05	2.108E+01	1.047E+02	1.569E+05	1.054E+01
1969	5.652E+02	4.526E+05	3.041E+01	1.510E+02	2.263E+05	1.520E+01
1970	7.597E+02	6.084E+05	4.088E+01	2.029E+02	3.042E+05	2.044E+01
1971	9.755E+02	7.811E+05	5.249E+01	2.606E+02	3.906E+05	2.624E+01
1972	1.210E+03	9.690E+05	6.510E+01	3.232E+02	4.845E+05	3.255E+01
1973	1.463E+03	1.172E+06	7.873E+01	3.909E+02	5.859E+05	3.936E+01
1974	1.735E+03	1.389E+06	9.335E+01	4.635E+02	6.947E+05	4.668E+01
1975	2.025E+03	1.622E+06	1.090E+02	5.410E+02	8.109E+05	5.449E+01
1976	2.334E+03	1.869E+06	1.256E+02	6.235E+02	9.345E+05	6.279E+01
1977	2.684E+03	2.150E+06	1.444E+02	7.170E+02	1.075E+06	7.221E+01
1978	3.076E+03	2.463E+06	1.655E+02	8.216E+02	1.231E+06	8.274E+01
1979	3.508E+03	2.809E+06	1.887E+02	9.370E+02	1.404E+06	9.436E+01
1980	3.980E+03	3.187E+06	2.141E+02	1.063E+03	1.593E+06	1.071E+02
1981	4.492E+03	3.597E+06	2.417E+02	1.200E+03	1.798E+06	1.208E+02
1982	5.042E+03	4.038E+06	2.713E+02	1.347E+03	2.019E+06	1.356E+02
1983	5.632E+03	4.510E+06	3.030E+02	1.504E+03	2.255E+06	1.515E+02
1984	6.259E+03	5.012E+06	3.367E+02	1.672E+03	2.506E+06	1.684E+02
1985	6.923E+03	5.544E+06	3.725E+02	1.849E+03	2.772E+06	1.862E+02
1986	7.645E+03	6.122E+06	4.113E+02	2.042E+03	3.061E+06	2.057E+02
1987	8.622E+03	6.904E+06	4.639E+02	2.303E+03	3.452E+06	2.320E+02
1988	9.312E+03	7.456E+06	5.010E+02	2.487E+03	3.728E+06	2.505E+02
1989	1.002E+04	8.022E+06	5.390E+02	2.676E+03	4.011E+06	2.695E+02
1990	1.072E+04	8.584E+06	5.768E+02	2.863E+03	4.292E+06	2.884E+02
1991	1.148E+04	9.196E+06	6.179E+02	3.068E+03	4.598E+06	3.089E+02
1992	1.240E+04	9.927E+06	6.670E+02	3.311E+03	4.963E+06	3.335E+02
1993	1.346E+04	1.078E+07	7.242E+02	3.595E+03	5.389E+06	3.621E+02
1994	1.377E+04	1.103E+07	7.411E+02	3.679E+03	5.515E+06	3.705E+02
1995	1.446E+04	1.158E+07	7.781E+02	3.863E+03	5.790E+06	3.891E+02
1996	1.509E+04	1.208E+07	8.117E+02	4.030E+03	6.041E+06	4.059E+02
1997	1.593E+04	1.276E+07	8.571E+02	4.255E+03	6.378E+06	4.285E+02
1998	1.663E+04	1.331E+07	8.946E+02	4.441E+03	6.657E+06	4.473E+02
1999	1.736E+04	1.390E+07	9.343E+02	4.638E+03	6.952E+06	4.671E+02
2000	1.810E+04	1.449E+07	9.736E+02	4.834E+03	7.245E+06	4.868E+02
2001	1.864E+04	1.492E+07	1.003E+03	4.978E+03	7.462E+06	5.014E+02
2002	1.911E+04	1.530E+07	1.028E+03	5.104E+03	7.651E+06	5.140E+02
2003	1.970E+04	1.577E+07	1.060E+03	5.262E+03	7.887E+06	5.299E+02
2004	2.021E+04	1.618E+07	1.087E+03	5.399E+03	8.092E+06	5.437E+02
2005	2.084E+04	1.669E+07	1.121E+03	5.566E+03	8.343E+06	5.606E+02
2006	2.158E+04	1.728E+07	1.161E+03	5.765E+03	8.641E+06	5.806E+02
2007	2.216E+04	1.774E+07	1.192E+03	5.918E+03	8.871E+06	5.960E+02
2008	2.279E+04	1.825E+07	1.226E+03	6.088E+03	9.126E+06	6.131E+02
2009	2.335E+04	1.870E+07	1.256E+03	6.238E+03	9.350E+06	6.282E+02
2010	2.379E+04	1.905E+07	1.280E+03	6.355E+03	9.525E+06	6.400E+02
2011	2.421E+04	1.939E+07	1.303E+03	6.467E+03	9.693E+06	6.513E+02
2012	2.454E+04	1.965E+07	1.320E+03	6.554E+03	9.824E+06	6.600E+02
2013	2.488E+04	1.992E+07	1.339E+03	6.646E+03	9.962E+06	6.694E+02
2014	2.515E+04	2.014E+07	1.353E+03	6.719E+03	1.007E+07	6.766E+02

Results (Continued)

Year	Total landfill gas			Methane		
	(Mg/year)	(m ³ /year)	(av ft ³ /min)	(Mg/year)	(m ³ /year)	(av ft ³ /min)
2015	2.545E+04	2.038E+07	1.369E+03	6.799E+03	1.019E+07	6.847E+02
2016	2.575E+04	2.062E+07	1.385E+03	6.877E+03	1.031E+07	6.926E+02
2017	2.604E+04	2.085E+07	1.401E+03	6.955E+03	1.042E+07	7.004E+02
2018	2.634E+04	2.109E+07	1.417E+03	7.036E+03	1.055E+07	7.086E+02
2019	2.667E+04	2.135E+07	1.435E+03	7.123E+03	1.068E+07	7.174E+02
2020	2.701E+04	2.163E+07	1.453E+03	7.215E+03	1.081E+07	7.267E+02
2021	2.738E+04	2.192E+07	1.473E+03	7.312E+03	1.096E+07	7.364E+02
2022	2.776E+04	2.223E+07	1.493E+03	7.415E+03	1.111E+07	7.467E+02
2023	2.816E+04	2.255E+07	1.515E+03	7.522E+03	1.128E+07	7.576E+02
2024	2.859E+04	2.289E+07	1.538E+03	7.636E+03	1.145E+07	7.690E+02
2025	2.903E+04	2.325E+07	1.562E+03	7.755E+03	1.162E+07	7.810E+02
2026	2.950E+04	2.362E+07	1.587E+03	7.879E+03	1.181E+07	7.935E+02
2027	2.999E+04	2.401E+07	1.613E+03	8.010E+03	1.201E+07	8.067E+02
2028	3.050E+04	2.442E+07	1.641E+03	8.146E+03	1.221E+07	8.204E+02
2029	3.103E+04	2.485E+07	1.670E+03	8.289E+03	1.242E+07	8.348E+02
2030	3.159E+04	2.530E+07	1.700E+03	8.438E+03	1.265E+07	8.498E+02
2031	3.217E+04	2.576E+07	1.731E+03	8.593E+03	1.288E+07	8.654E+02
2032	3.278E+04	2.625E+07	1.764E+03	8.755E+03	1.312E+07	8.818E+02
2033	3.341E+04	2.675E+07	1.798E+03	8.924E+03	1.338E+07	8.988E+02
2034	3.407E+04	2.728E+07	1.833E+03	9.100E+03	1.364E+07	9.165E+02
2035	3.475E+04	2.783E+07	1.870E+03	9.282E+03	1.391E+07	9.349E+02
2036	3.546E+04	2.840E+07	1.908E+03	9.473E+03	1.420E+07	9.540E+02
2037	3.620E+04	2.899E+07	1.948E+03	9.670E+03	1.449E+07	9.739E+02
2038	3.697E+04	2.960E+07	1.989E+03	9.875E+03	1.480E+07	9.946E+02
2039	3.777E+04	3.024E+07	2.032E+03	1.009E+04	1.512E+07	1.016E+03
2040	3.860E+04	3.091E+07	2.077E+03	1.031E+04	1.545E+07	1.038E+03
2041	3.945E+04	3.159E+07	2.123E+03	1.054E+04	1.580E+07	1.061E+03
2042	4.034E+04	3.231E+07	2.171E+03	1.078E+04	1.615E+07	1.085E+03
2043	4.127E+04	3.304E+07	2.220E+03	1.102E+04	1.652E+07	1.110E+03
2044	4.222E+04	3.381E+07	2.272E+03	1.128E+04	1.690E+07	1.136E+03
2045	4.321E+04	3.460E+07	2.325E+03	1.154E+04	1.730E+07	1.162E+03
2046	4.236E+04	3.392E+07	2.279E+03	1.131E+04	1.696E+07	1.139E+03
2047	4.152E+04	3.325E+07	2.234E+03	1.109E+04	1.662E+07	1.117E+03
2048	4.070E+04	3.259E+07	2.190E+03	1.087E+04	1.629E+07	1.095E+03
2049	3.989E+04	3.194E+07	2.146E+03	1.065E+04	1.597E+07	1.073E+03
2050	3.910E+04	3.131E+07	2.104E+03	1.044E+04	1.565E+07	1.052E+03
2051	3.833E+04	3.069E+07	2.062E+03	1.024E+04	1.534E+07	1.031E+03
2052	3.757E+04	3.008E+07	2.021E+03	1.003E+04	1.504E+07	1.011E+03
2053	3.682E+04	2.949E+07	1.981E+03	9.836E+03	1.474E+07	9.906E+02
2054	3.609E+04	2.890E+07	1.942E+03	9.641E+03	1.445E+07	9.710E+02
2055	3.538E+04	2.833E+07	1.903E+03	9.450E+03	1.416E+07	9.517E+02
2056	3.468E+04	2.777E+07	1.866E+03	9.263E+03	1.388E+07	9.329E+02
2057	3.399E+04	2.722E+07	1.829E+03	9.080E+03	1.361E+07	9.144E+02
2058	3.332E+04	2.668E+07	1.793E+03	8.900E+03	1.334E+07	8.963E+02
2059	3.266E+04	2.615E+07	1.757E+03	8.724E+03	1.308E+07	8.786E+02
2060	3.201E+04	2.563E+07	1.722E+03	8.551E+03	1.282E+07	8.612E+02
2061	3.138E+04	2.513E+07	1.688E+03	8.381E+03	1.256E+07	8.441E+02
2062	3.076E+04	2.463E+07	1.655E+03	8.216E+03	1.231E+07	8.274E+02
2063	3.015E+04	2.414E+07	1.622E+03	8.053E+03	1.207E+07	8.110E+02
2064	2.955E+04	2.366E+07	1.590E+03	7.893E+03	1.183E+07	7.950E+02
2065	2.897E+04	2.319E+07	1.558E+03	7.737E+03	1.160E+07	7.792E+02

Results (Continued)

Year	Total landfill gas			Methane		
	(Mg/year)	(m ³ /year)	(av ft ³ /min)	(Mg/year)	(m ³ /year)	(av ft ³ /min)
2066	2.839E+04	2.274E+07	1.528E+03	7.584E+03	1.137E+07	7.638E+02
2067	2.783E+04	2.229E+07	1.497E+03	7.434E+03	1.114E+07	7.487E+02
2068	2.728E+04	2.184E+07	1.468E+03	7.287E+03	1.092E+07	7.338E+02
2069	2.674E+04	2.141E+07	1.439E+03	7.142E+03	1.071E+07	7.193E+02
2070	2.621E+04	2.099E+07	1.410E+03	7.001E+03	1.049E+07	7.051E+02
2071	2.569E+04	2.057E+07	1.382E+03	6.862E+03	1.029E+07	6.911E+02
2072	2.518E+04	2.016E+07	1.355E+03	6.726E+03	1.008E+07	6.774E+02
2073	2.468E+04	1.977E+07	1.328E+03	6.593E+03	9.883E+06	6.640E+02
2074	2.419E+04	1.937E+07	1.302E+03	6.463E+03	9.687E+06	6.509E+02
2075	2.372E+04	1.899E+07	1.276E+03	6.335E+03	9.495E+06	6.380E+02
2076	2.325E+04	1.861E+07	1.251E+03	6.209E+03	9.307E+06	6.253E+02
2077	2.279E+04	1.825E+07	1.226E+03	6.086E+03	9.123E+06	6.130E+02
2078	2.233E+04	1.788E+07	1.202E+03	5.966E+03	8.942E+06	6.008E+02
2079	2.189E+04	1.753E+07	1.178E+03	5.848E+03	8.765E+06	5.889E+02
2080	2.146E+04	1.718E+07	1.155E+03	5.732E+03	8.591E+06	5.773E+02
2081	2.103E+04	1.684E+07	1.132E+03	5.618E+03	8.421E+06	5.658E+02
2082	2.062E+04	1.651E+07	1.109E+03	5.507E+03	8.255E+06	5.546E+02
2083	2.021E+04	1.618E+07	1.087E+03	5.398E+03	8.091E+06	5.436E+02
2084	1.981E+04	1.586E+07	1.066E+03	5.291E+03	7.931E+06	5.329E+02
2085	1.942E+04	1.555E+07	1.045E+03	5.186E+03	7.774E+06	5.223E+02
2086	1.903E+04	1.524E+07	1.024E+03	5.084E+03	7.620E+06	5.120E+02
2087	1.866E+04	1.494E+07	1.004E+03	4.983E+03	7.469E+06	5.018E+02
2088	1.829E+04	1.464E+07	9.838E+02	4.884E+03	7.321E+06	4.919E+02
2089	1.792E+04	1.435E+07	9.643E+02	4.788E+03	7.176E+06	4.822E+02
2090	1.757E+04	1.407E+07	9.452E+02	4.693E+03	7.034E+06	4.726E+02
2091	1.722E+04	1.379E+07	9.265E+02	4.600E+03	6.895E+06	4.633E+02
2092	1.688E+04	1.352E+07	9.082E+02	4.509E+03	6.758E+06	4.541E+02
2093	1.655E+04	1.325E+07	8.902E+02	4.419E+03	6.624E+06	4.451E+02
2094	1.622E+04	1.299E+07	8.726E+02	4.332E+03	6.493E+06	4.363E+02
2095	1.590E+04	1.273E+07	8.553E+02	4.246E+03	6.365E+06	4.276E+02
2096	1.558E+04	1.248E+07	8.384E+02	4.162E+03	6.239E+06	4.192E+02
2097	1.527E+04	1.223E+07	8.218E+02	4.080E+03	6.115E+06	4.109E+02
2098	1.497E+04	1.199E+07	8.055E+02	3.999E+03	5.994E+06	4.027E+02
2099	1.467E+04	1.175E+07	7.895E+02	3.920E+03	5.875E+06	3.948E+02
2100	1.438E+04	1.152E+07	7.739E+02	3.842E+03	5.759E+06	3.869E+02
2101	1.410E+04	1.129E+07	7.586E+02	3.766E+03	5.645E+06	3.793E+02
2102	1.382E+04	1.107E+07	7.436E+02	3.691E+03	5.533E+06	3.718E+02
2103	1.355E+04	1.085E+07	7.288E+02	3.618E+03	5.424E+06	3.644E+02
2104	1.328E+04	1.063E+07	7.144E+02	3.547E+03	5.316E+06	3.572E+02
2105	1.302E+04	1.042E+07	7.003E+02	3.477E+03	5.211E+06	3.501E+02

Results (Continued)

Year	Carbon dioxide			NMOC		
	(Mg/year)	(m ³ /year)	(av ft ³ /min)	(Mg/year)	(m ³ /year)	(av ft ³ /min)
1965	0	0	0	0	0	0
1966	8.004E+01	4.373E+04	2.938E+00	1.356E-01	3.784E+01	2.542E-03
1967	1.758E+02	9.603E+04	6.453E+00	2.979E-01	8.311E+01	5.584E-03
1968	2.872E+02	1.569E+05	1.054E+01	4.867E-01	1.358E+02	9.123E-03
1969	4.142E+02	2.263E+05	1.520E+01	7.019E-01	1.958E+02	1.316E-02
1970	5.568E+02	3.042E+05	2.044E+01	9.436E-01	2.632E+02	1.769E-02
1971	7.149E+02	3.906E+05	2.624E+01	1.212E+00	3.380E+02	2.271E-02
1972	8.868E+02	4.845E+05	3.255E+01	1.503E+00	4.193E+02	2.817E-02
1973	1.072E+03	5.859E+05	3.936E+01	1.817E+00	5.070E+02	3.407E-02
1974	1.272E+03	6.947E+05	4.668E+01	2.155E+00	6.012E+02	4.039E-02
1975	1.484E+03	8.109E+05	5.449E+01	2.515E+00	7.018E+02	4.715E-02
1976	1.711E+03	9.345E+05	6.279E+01	2.899E+00	8.087E+02	5.434E-02
1977	1.967E+03	1.075E+06	7.221E+01	3.334E+00	9.301E+02	6.249E-02
1978	2.254E+03	1.231E+06	8.274E+01	3.820E+00	1.066E+03	7.160E-02
1979	2.571E+03	1.404E+06	9.436E+01	4.356E+00	1.215E+03	8.166E-02
1980	2.917E+03	1.593E+06	1.071E+02	4.943E+00	1.379E+03	9.265E-02
1981	3.292E+03	1.798E+06	1.208E+02	5.579E+00	1.556E+03	1.046E-01
1982	3.696E+03	2.019E+06	1.356E+02	6.263E+00	1.747E+03	1.174E-01
1983	4.127E+03	2.255E+06	1.515E+02	6.994E+00	1.951E+03	1.311E-01
1984	4.587E+03	2.506E+06	1.684E+02	7.773E+00	2.169E+03	1.457E-01
1985	5.074E+03	2.772E+06	1.862E+02	8.599E+00	2.399E+03	1.612E-01
1986	5.603E+03	3.061E+06	2.057E+02	9.495E+00	2.649E+03	1.780E-01
1987	6.319E+03	3.452E+06	2.320E+02	1.071E+01	2.987E+03	2.007E-01
1988	6.824E+03	3.728E+06	2.505E+02	1.156E+01	3.226E+03	2.168E-01
1989	7.342E+03	4.011E+06	2.695E+02	1.244E+01	3.471E+03	2.332E-01
1990	7.857E+03	4.292E+06	2.884E+02	1.331E+01	3.714E+03	2.496E-01
1991	8.417E+03	4.598E+06	3.089E+02	1.426E+01	3.979E+03	2.674E-01
1992	9.086E+03	4.963E+06	3.335E+02	1.540E+01	4.295E+03	2.886E-01
1993	9.864E+03	5.389E+06	3.621E+02	1.672E+01	4.664E+03	3.133E-01
1994	1.009E+04	5.515E+06	3.705E+02	1.711E+01	4.772E+03	3.207E-01
1995	1.060E+04	5.790E+06	3.891E+02	1.796E+01	5.011E+03	3.367E-01
1996	1.106E+04	6.041E+06	4.059E+02	1.874E+01	5.228E+03	3.512E-01
1997	1.168E+04	6.378E+06	4.285E+02	1.978E+01	5.520E+03	3.709E-01
1998	1.219E+04	6.657E+06	4.473E+02	2.065E+01	5.761E+03	3.871E-01
1999	1.273E+04	6.952E+06	4.671E+02	2.157E+01	6.017E+03	4.043E-01
2000	1.326E+04	7.245E+06	4.868E+02	2.247E+01	6.270E+03	4.213E-01
2001	1.366E+04	7.462E+06	5.014E+02	2.315E+01	6.458E+03	4.339E-01
2002	1.400E+04	7.651E+06	5.140E+02	2.373E+01	6.621E+03	4.449E-01
2003	1.444E+04	7.887E+06	5.299E+02	2.447E+01	6.825E+03	4.586E-01
2004	1.481E+04	8.092E+06	5.437E+02	2.510E+01	7.003E+03	4.705E-01
2005	1.527E+04	8.343E+06	5.606E+02	2.588E+01	7.220E+03	4.851E-01
2006	1.582E+04	8.641E+06	5.806E+02	2.681E+01	7.478E+03	5.025E-01
2007	1.624E+04	8.871E+06	5.960E+02	2.752E+01	7.677E+03	5.158E-01
2008	1.670E+04	9.126E+06	6.131E+02	2.831E+01	7.897E+03	5.306E-01
2009	1.712E+04	9.350E+06	6.282E+02	2.900E+01	8.092E+03	5.437E-01
2010	1.744E+04	9.525E+06	6.400E+02	2.955E+01	8.243E+03	5.538E-01
2011	1.774E+04	9.693E+06	6.513E+02	3.007E+01	8.388E+03	5.636E-01
2012	1.798E+04	9.824E+06	6.600E+02	3.047E+01	8.501E+03	5.712E-01
2013	1.824E+04	9.962E+06	6.694E+02	3.090E+01	8.621E+03	5.793E-01
2014	1.843E+04	1.007E+07	6.766E+02	3.124E+01	8.715E+03	5.856E-01

Results (Continued)

Year	Carbon dioxide			NMOC		
	(Mg/year)	(m ³ /year)	(av ft ³ /min)	(Mg/year)	(m ³ /year)	(av ft ³ /min)
2015	1.865E+04	1.019E+07	6.847E+02	3.161E+01	8.819E+03	5.925E-01
2016	1.887E+04	1.031E+07	6.926E+02	3.198E+01	8.921E+03	5.994E-01
2017	1.908E+04	1.042E+07	7.004E+02	3.234E+01	9.021E+03	6.061E-01
2018	1.931E+04	1.055E+07	7.086E+02	3.272E+01	9.127E+03	6.133E-01
2019	1.954E+04	1.068E+07	7.174E+02	3.312E+01	9.240E+03	6.208E-01
2020	1.980E+04	1.081E+07	7.267E+02	3.355E+01	9.359E+03	6.288E-01
2021	2.006E+04	1.096E+07	7.364E+02	3.400E+01	9.485E+03	6.373E-01
2022	2.034E+04	1.111E+07	7.467E+02	3.448E+01	9.618E+03	6.462E-01
2023	2.064E+04	1.128E+07	7.576E+02	3.498E+01	9.758E+03	6.556E-01
2024	2.095E+04	1.145E+07	7.690E+02	3.550E+01	9.905E+03	6.655E-01
2025	2.128E+04	1.162E+07	7.810E+02	3.606E+01	1.006E+04	6.759E-01
2026	2.162E+04	1.181E+07	7.935E+02	3.664E+01	1.022E+04	6.867E-01
2027	2.198E+04	1.201E+07	8.067E+02	3.724E+01	1.039E+04	6.981E-01
2028	2.235E+04	1.221E+07	8.204E+02	3.788E+01	1.057E+04	7.100E-01
2029	2.274E+04	1.242E+07	8.348E+02	3.854E+01	1.075E+04	7.224E-01
2030	2.315E+04	1.265E+07	8.498E+02	3.923E+01	1.095E+04	7.354E-01
2031	2.358E+04	1.288E+07	8.654E+02	3.996E+01	1.115E+04	7.490E-01
2032	2.402E+04	1.312E+07	8.818E+02	4.071E+01	1.136E+04	7.631E-01
2033	2.449E+04	1.338E+07	8.988E+02	4.149E+01	1.158E+04	7.778E-01
2034	2.497E+04	1.364E+07	9.165E+02	4.231E+01	1.180E+04	7.931E-01
2035	2.547E+04	1.391E+07	9.349E+02	4.316E+01	1.204E+04	8.090E-01
2036	2.599E+04	1.420E+07	9.540E+02	4.404E+01	1.229E+04	8.256E-01
2037	2.653E+04	1.449E+07	9.739E+02	4.496E+01	1.254E+04	8.428E-01
2038	2.710E+04	1.480E+07	9.946E+02	4.592E+01	1.281E+04	8.607E-01
2039	2.768E+04	1.512E+07	1.016E+03	4.691E+01	1.309E+04	8.792E-01
2040	2.829E+04	1.545E+07	1.038E+03	4.793E+01	1.337E+04	8.985E-01
2041	2.892E+04	1.580E+07	1.061E+03	4.900E+01	1.367E+04	9.185E-01
2042	2.957E+04	1.615E+07	1.085E+03	5.011E+01	1.398E+04	9.392E-01
2043	3.024E+04	1.652E+07	1.110E+03	5.125E+01	1.430E+04	9.607E-01
2044	3.094E+04	1.690E+07	1.136E+03	5.244E+01	1.463E+04	9.829E-01
2045	3.167E+04	1.730E+07	1.162E+03	5.367E+01	1.497E+04	1.006E+00
2046	3.104E+04	1.696E+07	1.139E+03	5.261E+01	1.468E+04	9.861E-01
2047	3.043E+04	1.662E+07	1.117E+03	5.156E+01	1.439E+04	9.665E-01
2048	2.983E+04	1.629E+07	1.095E+03	5.054E+01	1.410E+04	9.474E-01
2049	2.923E+04	1.597E+07	1.073E+03	4.954E+01	1.382E+04	9.286E-01
2050	2.866E+04	1.565E+07	1.052E+03	4.856E+01	1.355E+04	9.103E-01
2051	2.809E+04	1.534E+07	1.031E+03	4.760E+01	1.328E+04	8.922E-01
2052	2.753E+04	1.504E+07	1.011E+03	4.666E+01	1.302E+04	8.746E-01
2053	2.699E+04	1.474E+07	9.906E+02	4.573E+01	1.276E+04	8.572E-01
2054	2.645E+04	1.445E+07	9.710E+02	4.483E+01	1.251E+04	8.403E-01
2055	2.593E+04	1.416E+07	9.517E+02	4.394E+01	1.226E+04	8.236E-01
2056	2.542E+04	1.388E+07	9.329E+02	4.307E+01	1.202E+04	8.073E-01
2057	2.491E+04	1.361E+07	9.144E+02	4.222E+01	1.178E+04	7.913E-01
2058	2.442E+04	1.334E+07	8.963E+02	4.138E+01	1.154E+04	7.757E-01
2059	2.394E+04	1.308E+07	8.786E+02	4.056E+01	1.132E+04	7.603E-01
2060	2.346E+04	1.282E+07	8.612E+02	3.976E+01	1.109E+04	7.453E-01
2061	2.300E+04	1.256E+07	8.441E+02	3.897E+01	1.087E+04	7.305E-01
2062	2.254E+04	1.231E+07	8.274E+02	3.820E+01	1.066E+04	7.160E-01
2063	2.210E+04	1.207E+07	8.110E+02	3.744E+01	1.045E+04	7.019E-01
2064	2.166E+04	1.183E+07	7.950E+02	3.670E+01	1.024E+04	6.880E-01
2065	2.123E+04	1.160E+07	7.792E+02	3.597E+01	1.004E+04	6.743E-01

Results (Continued)

Year	Carbon dioxide			NMOC		
	(Mg/year)	(m ³ /year)	(av ft ³ /min)	(Mg/year)	(m ³ /year)	(av ft ³ /min)
2066	2.081E+04	1.137E+07	7.638E+02	3.526E+01	9.838E+03	6.610E-01
2067	2.040E+04	1.114E+07	7.487E+02	3.456E+01	9.643E+03	6.479E-01
2068	1.999E+04	1.092E+07	7.338E+02	3.388E+01	9.452E+03	6.351E-01
2069	1.960E+04	1.071E+07	7.193E+02	3.321E+01	9.265E+03	6.225E-01
2070	1.921E+04	1.049E+07	7.051E+02	3.255E+01	9.081E+03	6.102E-01
2071	1.883E+04	1.029E+07	6.911E+02	3.191E+01	8.901E+03	5.981E-01
2072	1.846E+04	1.008E+07	6.774E+02	3.127E+01	8.725E+03	5.862E-01
2073	1.809E+04	9.883E+06	6.640E+02	3.066E+01	8.552E+03	5.746E-01
2074	1.773E+04	9.687E+06	6.509E+02	3.005E+01	8.383E+03	5.633E-01
2075	1.738E+04	9.495E+06	6.380E+02	2.945E+01	8.217E+03	5.521E-01
2076	1.704E+04	9.307E+06	6.253E+02	2.887E+01	8.054E+03	5.412E-01
2077	1.670E+04	9.123E+06	6.130E+02	2.830E+01	7.895E+03	5.305E-01
2078	1.637E+04	8.942E+06	6.008E+02	2.774E+01	7.738E+03	5.199E-01
2079	1.604E+04	8.765E+06	5.889E+02	2.719E+01	7.585E+03	5.097E-01
2080	1.573E+04	8.591E+06	5.773E+02	2.665E+01	7.435E+03	4.996E-01
2081	1.542E+04	8.421E+06	5.658E+02	2.612E+01	7.288E+03	4.897E-01
2082	1.511E+04	8.255E+06	5.546E+02	2.561E+01	7.144E+03	4.800E-01
2083	1.481E+04	8.091E+06	5.436E+02	2.510E+01	7.002E+03	4.705E-01
2084	1.452E+04	7.931E+06	5.329E+02	2.460E+01	6.863E+03	4.612E-01
2085	1.423E+04	7.774E+06	5.223E+02	2.411E+01	6.728E+03	4.520E-01
2086	1.395E+04	7.620E+06	5.120E+02	2.364E+01	6.594E+03	4.431E-01
2087	1.367E+04	7.469E+06	5.018E+02	2.317E+01	6.464E+03	4.343E-01
2088	1.340E+04	7.321E+06	4.919E+02	2.271E+01	6.336E+03	4.257E-01
2089	1.314E+04	7.176E+06	4.822E+02	2.226E+01	6.210E+03	4.173E-01
2090	1.288E+04	7.034E+06	4.726E+02	2.182E+01	6.087E+03	4.090E-01
2091	1.262E+04	6.895E+06	4.633E+02	2.139E+01	5.967E+03	4.009E-01
2092	1.237E+04	6.758E+06	4.541E+02	2.096E+01	5.849E+03	3.930E-01
2093	1.213E+04	6.624E+06	4.451E+02	2.055E+01	5.733E+03	3.852E-01
2094	1.189E+04	6.493E+06	4.363E+02	2.014E+01	5.619E+03	3.776E-01
2095	1.165E+04	6.365E+06	4.276E+02	1.974E+01	5.508E+03	3.701E-01
2096	1.142E+04	6.239E+06	4.192E+02	1.935E+01	5.399E+03	3.628E-01
2097	1.119E+04	6.115E+06	4.109E+02	1.897E+01	5.292E+03	3.556E-01
2098	1.097E+04	5.994E+06	4.027E+02	1.859E+01	5.187E+03	3.485E-01
2099	1.075E+04	5.875E+06	3.948E+02	1.823E+01	5.085E+03	3.416E-01
2100	1.054E+04	5.759E+06	3.869E+02	1.786E+01	4.984E+03	3.349E-01
2101	1.033E+04	5.645E+06	3.793E+02	1.751E+01	4.885E+03	3.282E-01
2102	1.013E+04	5.533E+06	3.718E+02	1.716E+01	4.788E+03	3.217E-01
2103	9.928E+03	5.424E+06	3.644E+02	1.682E+01	4.694E+03	3.154E-01
2104	9.731E+03	5.316E+06	3.572E+02	1.649E+01	4.601E+03	3.091E-01
2105	9.539E+03	5.211E+06	3.501E+02	1.616E+01	4.510E+03	3.030E-01