

Inventory of Landfill Gas (LFG) potential at 22 Missouri landfills

Excerpted from a presentation by
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LFG inventory - June 2004

- Inventory current LFG use in Missouri
- Estimate potential LFG use in Missouri
 - Identify candidate landfills
 - Determine life cycle of LFG at these landfills
 - Estimate “average” & “minimum” recovery
 - Estimate aggregate LFG potential
 - Total for new and existing LFG projects
 - Compare to other indigenous/renewable energy
 - Estimate greenhouse gas benefits of LFG projects

Current Missouri LFG Energy Use

- Fred Weber Sanitary Landfill
 - Pattonville High School
 - Greenhouse
 - Asphalt Plant
- Onyx Oak Ridge Landfill
 - Daimler Chrysler
- Rumble Sanitary Landfill
 - Greenhouse for Sugar Creek Schools

Table 1. Energy Equivalent Recovery from Existing Projects

Landfill Name	Landfill Gas Recovery - Current		Power Generating Potential	Natural Gas Equivalent
	(cfm)	(mmBTU/hr)	(MW)*	(mm ft ³)
Fred Weber	2,441	74.1	6.7	641
Onyx Oak Ridge	1,600	48.6	4.4	420
Rumble 2	24	0.7	0.1	6
Totals	4,065	123.4	11.2	1,068

*MW power generating potential assumes a heat rate of 11,000 Btu/kW-hr

Source: EPA Landfill Methane Outreach Program

Criteria used to select “Candidate Landfills”

- More than 1 million tons of Waste in Place
- Active or closed less than 10 years

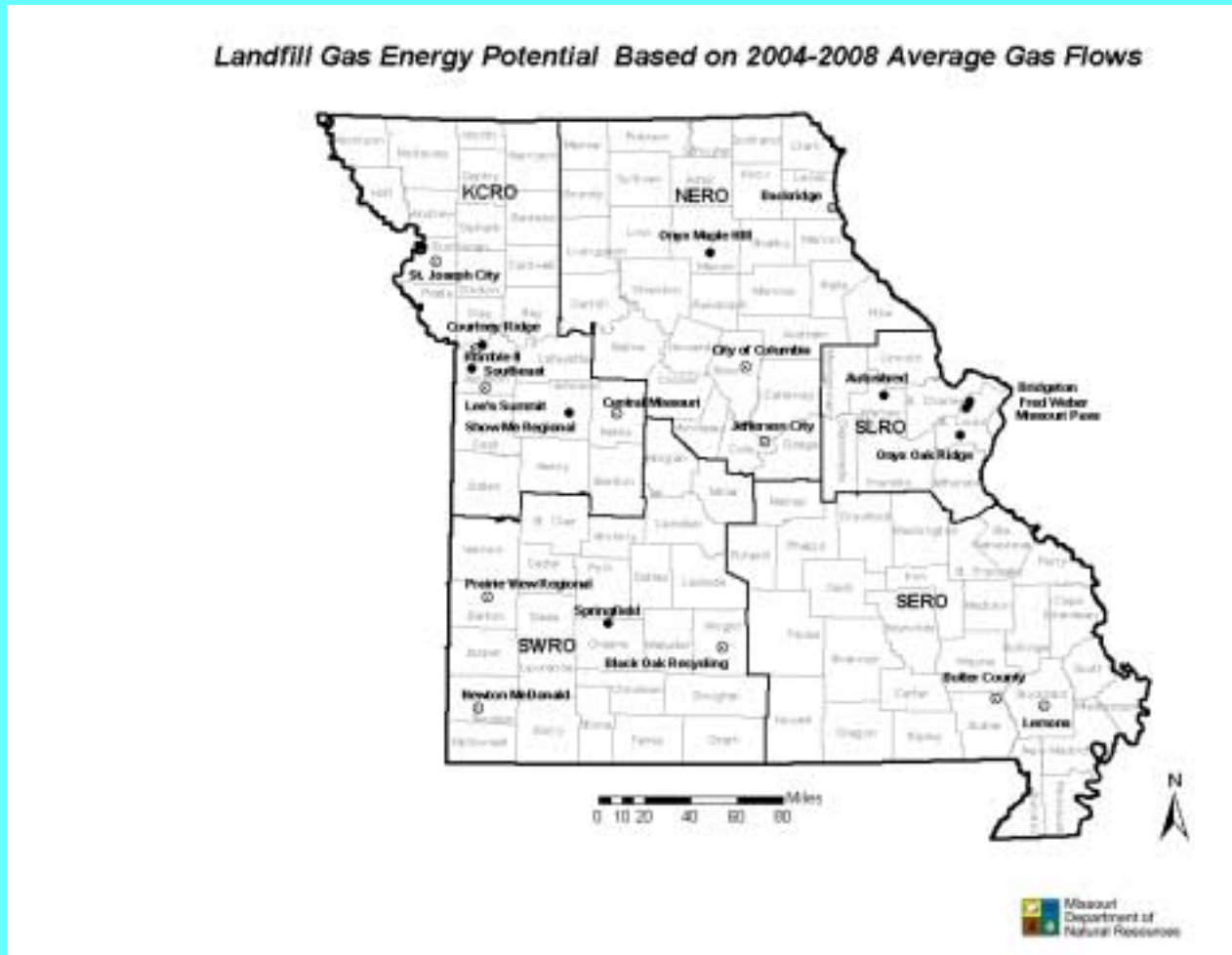
Or

- Has an active landfill gas collection system and flare
- Landfill gas has not deteriorated (LFG composition is still at least 35 percent methane)

22 Candidate Landfills

SLRO	Autoshred	NERO	Backridge
	Bridgeton		Columbia
	Fred Weber		Jefferson City
	Missouri Pass		Onyx Maple Hill
	Onyx Oak Ridge		
SWRO	Black Oak	KCRO	Central Missouri
	Newton McDonald		Courtney Ridge
	Prarieview		Lee's Summit
	Springfield		Rumble II
			Show Me Regional
SERO	Butler County		Southeast
	Lemons East		St. Josephs

Map of candidate landfills



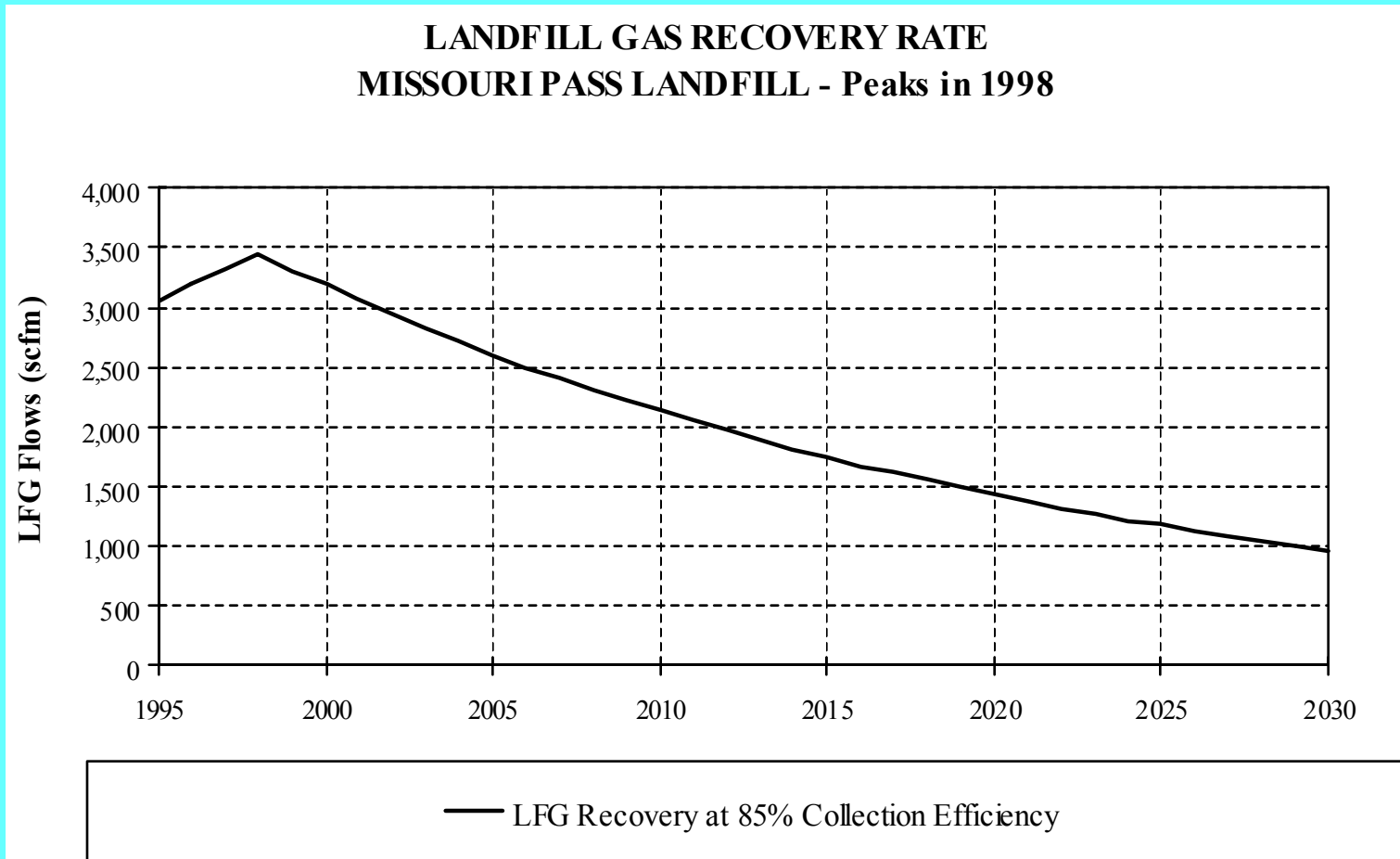
How LFG capture was estimated

- LandGEM model used to estimate LFG flow from 22 landfills
 - EPA's Landfill Gas Generation Model, LandGEM, is the most commonly used model for this purpose
 - Modeling was done by LMOP
- Input annual disposal rates in tons/year
 - Used volume disposal records, opening and closing/projected closing years
 - EC provided data from Missouri DNR's Solid Waste Management Program (SWMP) and Air Pollution Control Program (APCP)

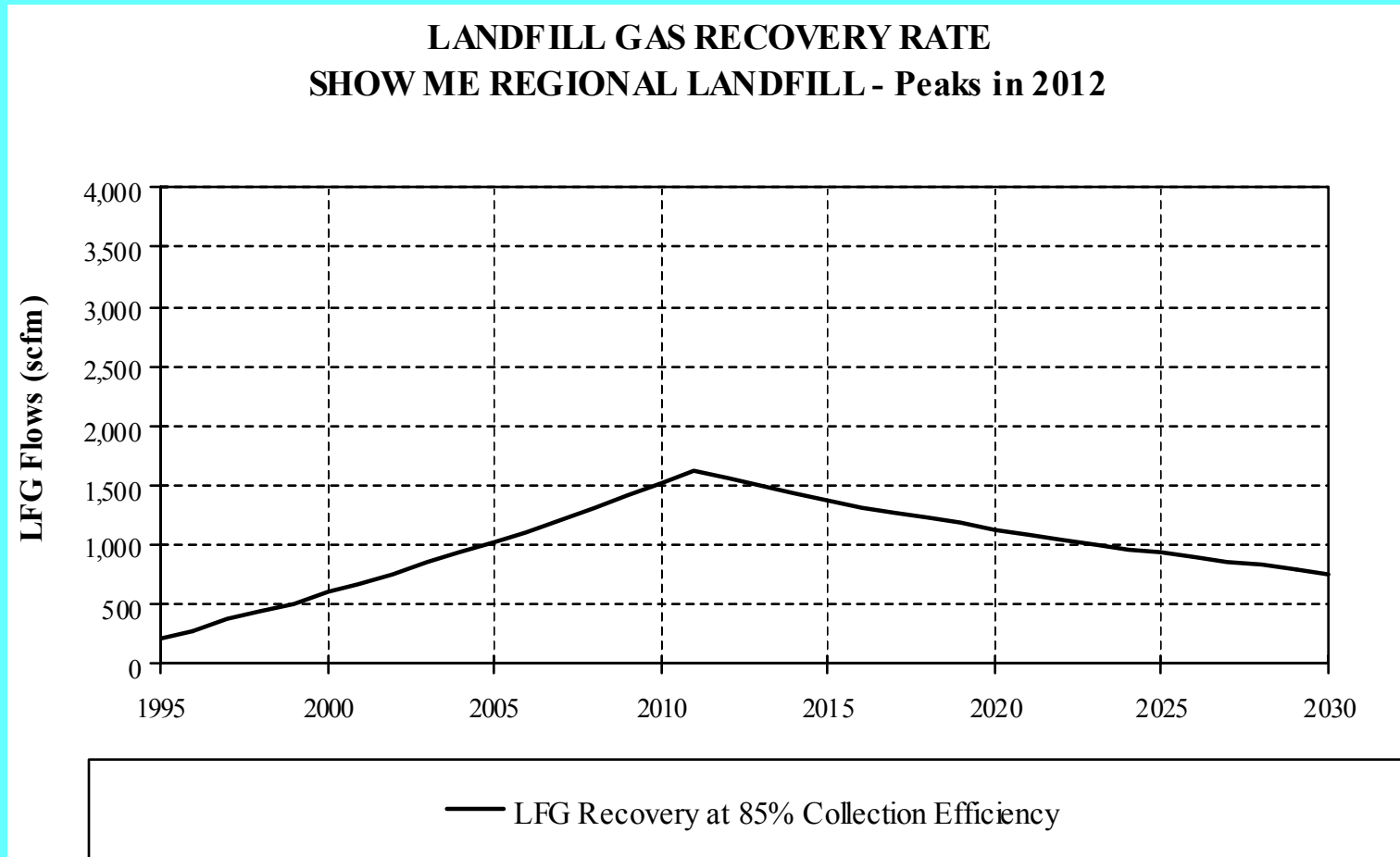
Key modeling assumptions

- Assumptions used to estimate LFG capture
 - Set LandGEM decay rate constant (k) and generation rate constant (Lo) to EPA (AP-42) defaults:
 - $k = 0.04/\text{year}$
 - $Lo = 100 \text{ m}^3/\text{Mg}$ (3,204 ft^3/ton)
 - Collection system assumed to be 85% efficient
- Assumptions used to estimate energy content
 - LFG assumed to be 50% methane with a heat value of 506 Btu per cubic foot
 - Heat rate of 11,000 Btu/kW-hr assumed in estimating power generating potential

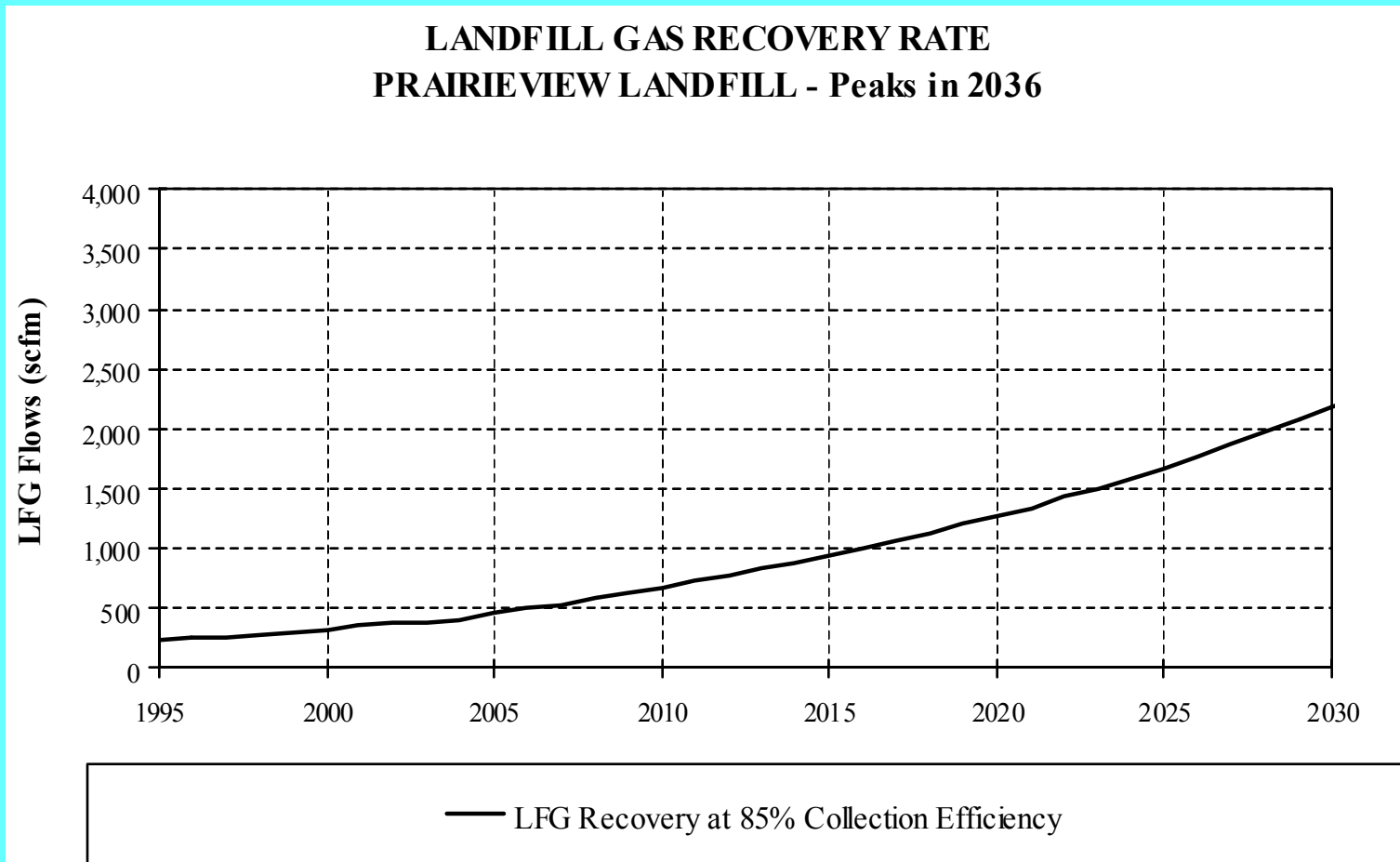
LFG potential curve example #1 - peaking prior to 2005



LFG potential curve example #2 - peaking during 2005 - 2014



LFG potential curve example #3 - peaking after 2014



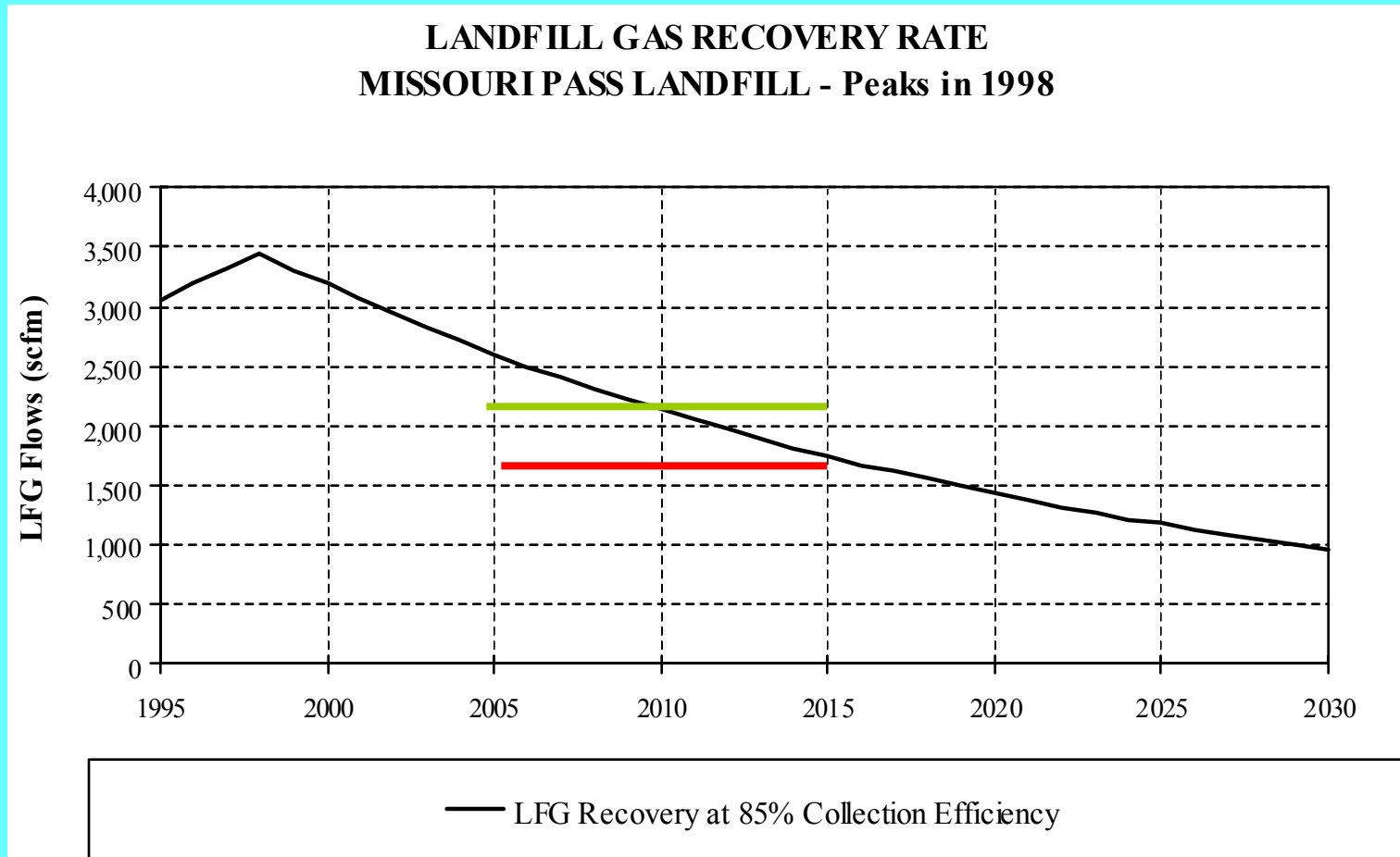
LandGEM Modeling Results

- Tables show potential LFG recovery, energy equivalent, and project size that can be supported based on:
 - Average LFG recovery for 2004-08
 - Minimum LFG recovery for 2005-2014 (flows sufficient to meet capacity for 10 years)
- Energy equivalent indicated two ways
 - Generating potential in megawatts (MW) if the LFG were dedicated to power generation
 - Equivalent volume of natural gas (NG) in millions of cubic feet (Mcf) - assumes LFG has half the heat value of NG

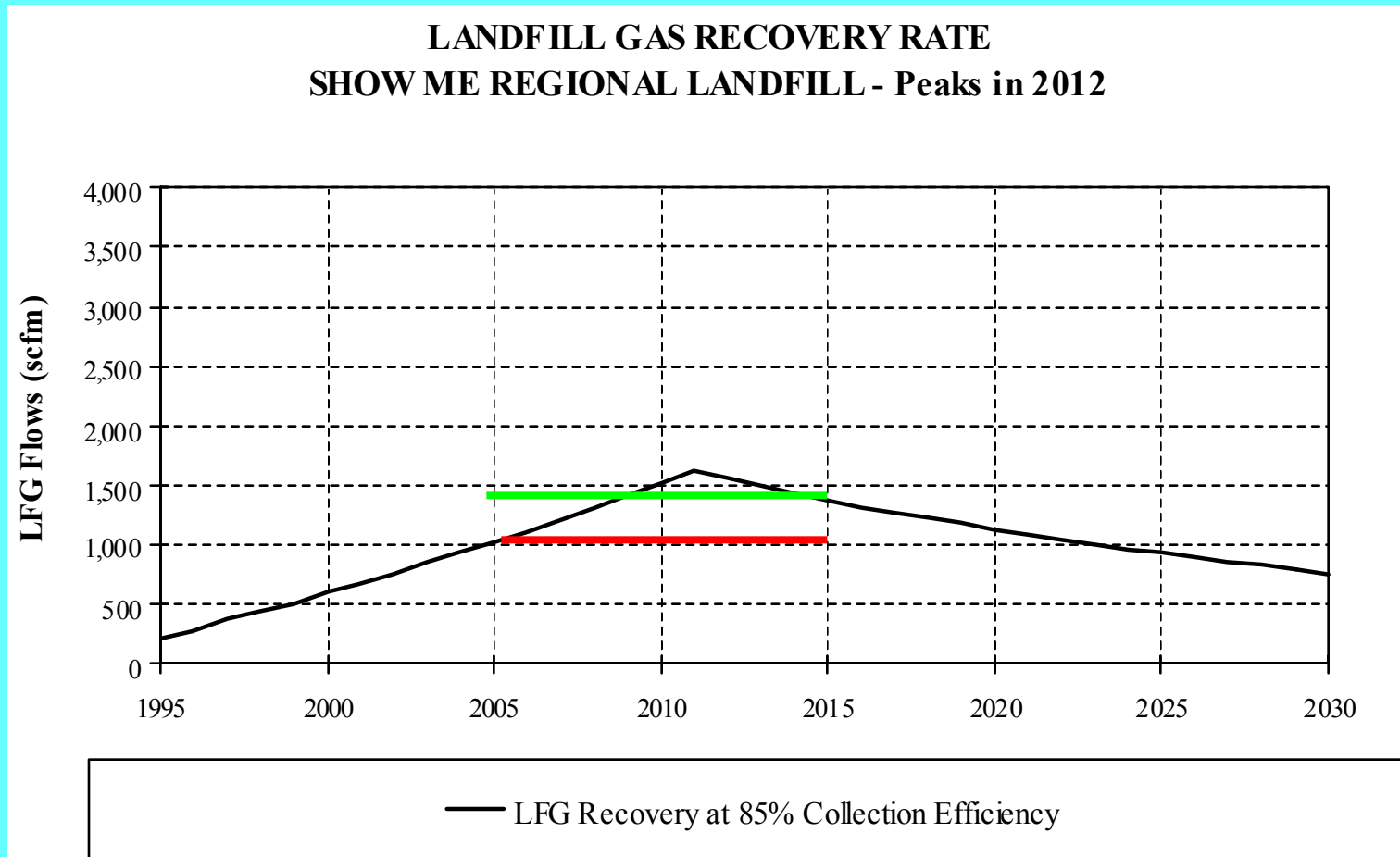
“Minimum” recovery”

- “Average recovery” is the average annual LFG recovery for the 5 years 2004-2008
- “Minimum recovery” indicates LFG project size that can be sustained from 2005-2014 at constant rate of LFG use.
- “Minimum recovery” is estimated because the investor in a LFG project may require a constant supply of LFG for at least 10 years to recover their investment.

LFG potential curve example #1 - average versus minimum recovery



LFG potential curve example #2 - average versus minimum recovery



LFG potential curve example #3 - average versus minimum recovery

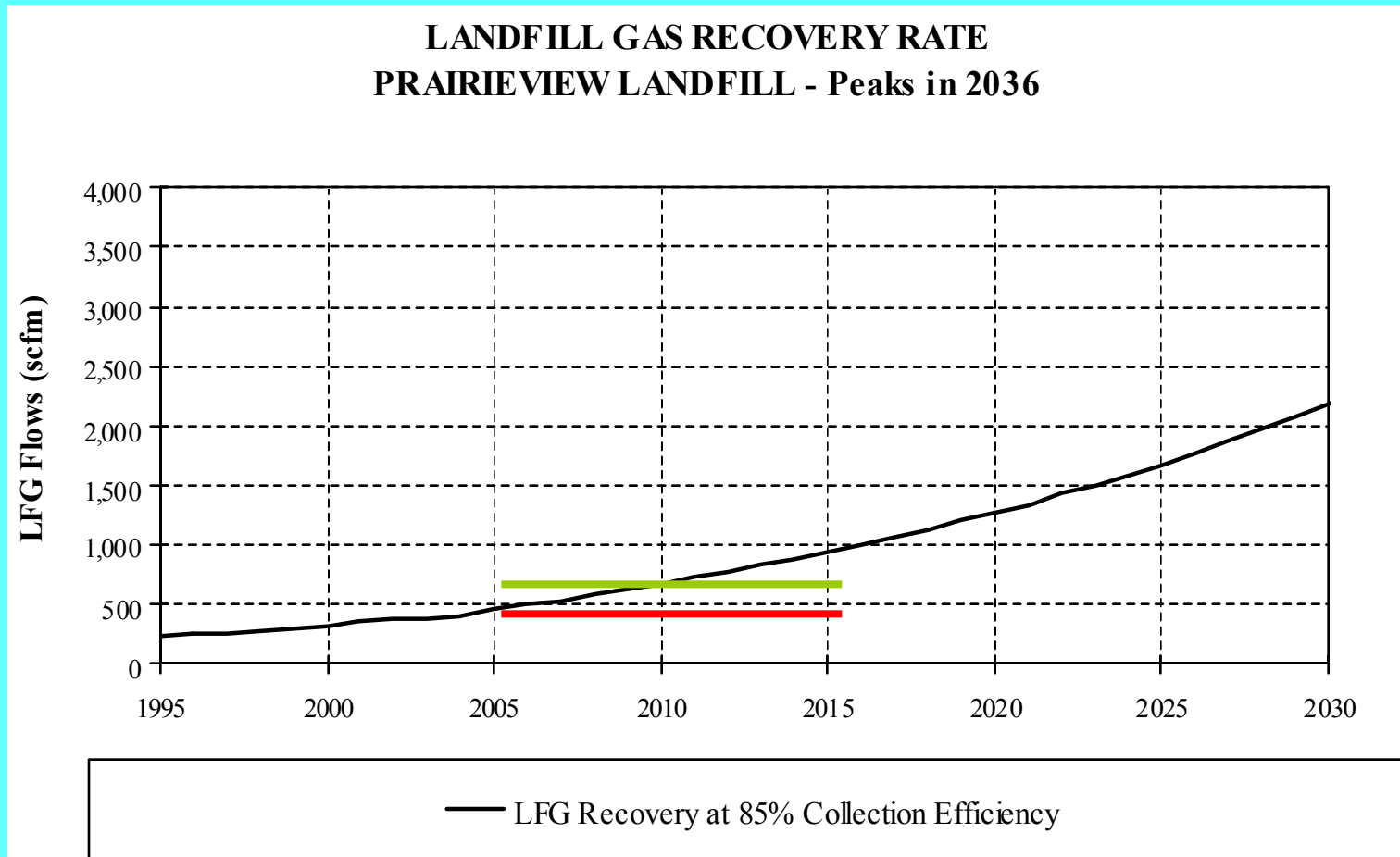


Table 2. Estimated LFG energy potential for nine sites with highest potential - average flow

Landfill Name	Region	Landfill Gas Recovery - 2004-2008 Average		Power Generating Potential	Natural Gas Equivalent
		(cfm)	(mm BTU/hr)	(MW)	(Mcf)
Bridgeton	SLRO	3,826	116.2	10.6	1,005.5
Missouri Pass	SLRO	2,512	76.3	6.9	660.2
Courtney Ridge	KCRO	1,787	54.3	4.9	469.6
Southeast	KCRO	1,744	52.9	4.8	458.3
Autoshred	SLRO	1,200	36.4	3.3	315.4
Show Me Regional	KCRO	1,117	33.9	3.1	293.5
Springfield	SWRO	1,025	31.1	2.8	269.4
Fred Weber	SLRO	966	29.3	2.7	253.9
Onyx Maple Hill	NERO	956	29.0	2.6	251.2
Totals		15,133	459.4	41.8	3,977.0

*MW power generating potential assumes a heat rate of 11,000 Btu/kW-hr

Source: EPA Landfill Methane Outreach Program

Table 3. Estimated LFG energy potential for remaining sites - average flow

Landfill Name	Region	Landfill Gas Recovery - 2004-2008 Average		Power Generating Potential	Natural Gas Equivalent
		(cfm)	(mmBTU/hr)	(MW)	(Mcf)
Rumble 2	KCRO	824	25.0	2.3	216.5
Jefferson City	NERO	779	23.7	2.2	204.7
Lee's Summit	KCRO	772	23.4	2.1	202.9
Central Missouri	KCRO	676	20.5	1.9	177.7
Lemons East	SERO	629	19.1	1.7	165.3
Butler County	SERO	624	18.9	1.7	164.0
Black Oak	SWRO	592	18.0	1.6	155.6
Prarieview	SWRO	495	15.0	1.4	130.1
St. Josephs	KCRO	469	14.2	1.3	123.3
Backridge	NERO	347	10.5	1.0	91.2
Columbia	NERO	341	10.4	0.9	89.6
Onyx Oak Ridge	SLRO	300	9.1	0.8	78.8
Newton McDonald	SWRO	277	8.4	0.8	72.8
Totals		6,825	207.2	18.8	1,793.6

*MW power generating potential assumes a heat rate of 11,000 Btu/kW-hr

Source: EPA Landfill Methane Outreach Program

Map (average flow)

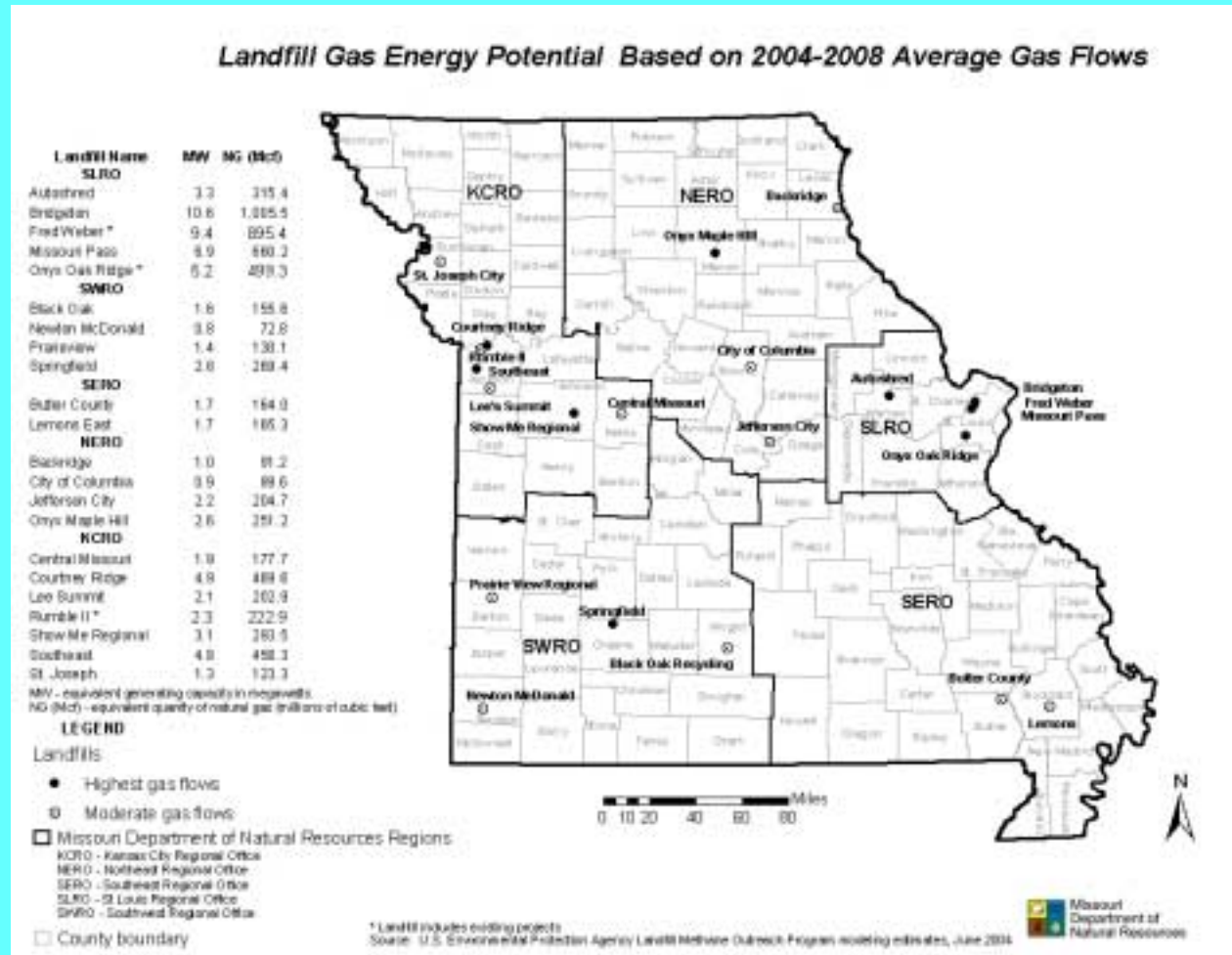


Table 4. Estimated LFG energy potential for nine sites with highest potential - minimum flow

Landfill Name	Region	Landfill Gas Recovery - 2005-2014 Minimum		Power Generating Potential	Natural Gas Equivalent
		(cfm)	mm BTU/hr	(MW)	(Mcf)
Bridgeton	SLRO	3,055	92.7	8.4	802.9
Missouri Pass	SLRO	1,821	55.3	5.0	478.6
Courtney Ridge	KCRO	1,650	50.1	4.6	433.6
Southeast	KCRO	1,264	38.4	3.5	332.2
Show Me Regional	KCRO	1,021	31.0	2.8	268.3
Springfield	SWRO	994	30.2	2.7	261.2
Onyx Maple Hill	NERO	918	27.9	2.5	241.3
Autoshred	SLRO	870	26.4	2.4	228.6
Fred Weber	SLRO	817	24.8	2.3	214.7
Totals		12,410	376.8	34.3	3,261.3

*MW power generating potential assumes a heat rate of 11,000 Btu/kW-hr

Source: EPA Landfill Methane Outreach Program 21

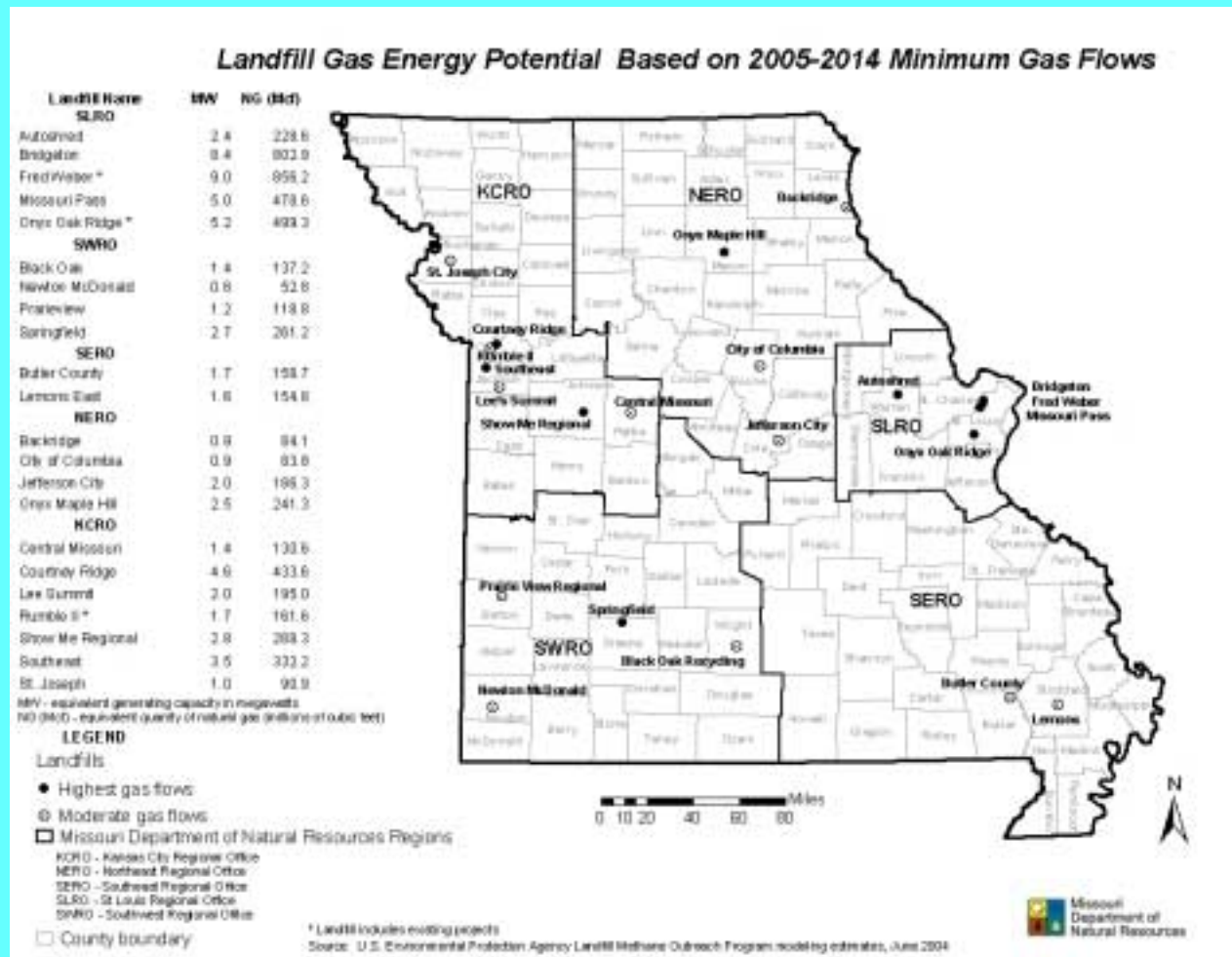
Table 5. Estimated LFG energy potential for remaining sites - minimum flow

Landfill Name		Landfill Gas Recovery - 2005-2014 Minimum		Power Generating Potential	Natural Gas Equivalent
		(cfm)	mmBTU/hr	(MW)	(Mcf)
Lee Summit	KCRO	742	22.5	2.0	195.0
Jefferson City	NERO	709	21.5	2.0	186.3
Butler County	SERO	604	18.3	1.7	158.7
Rumble 2	KCRO	591	17.9	1.6	155.3
Lemons East	SERO	589	17.9	1.6	154.8
Black Oak	SWRO	522	15.8	1.4	137.2
Central Missouri	KCRO	497	15.1	1.4	130.6
Prarieview	SWRO	452	13.7	1.2	118.8
St. Josephs	KCRO	346	10.5	1.0	90.9
Backridge	NERO	320	9.7	0.9	84.1
Columbia	NERO	319	9.7	0.9	83.8
Onyx Oak Ridge	SLRO	300	9.1	0.8	78.8
Newton McDonald	SWRO	201	6.1	0.6	52.8
Totals		5,892	178.9	16.3	1,548.4

*MW power generating potential assumes a heat rate of 11,000 Btu/kW-hr

Source: EPA Landfill Methane Outreach Program

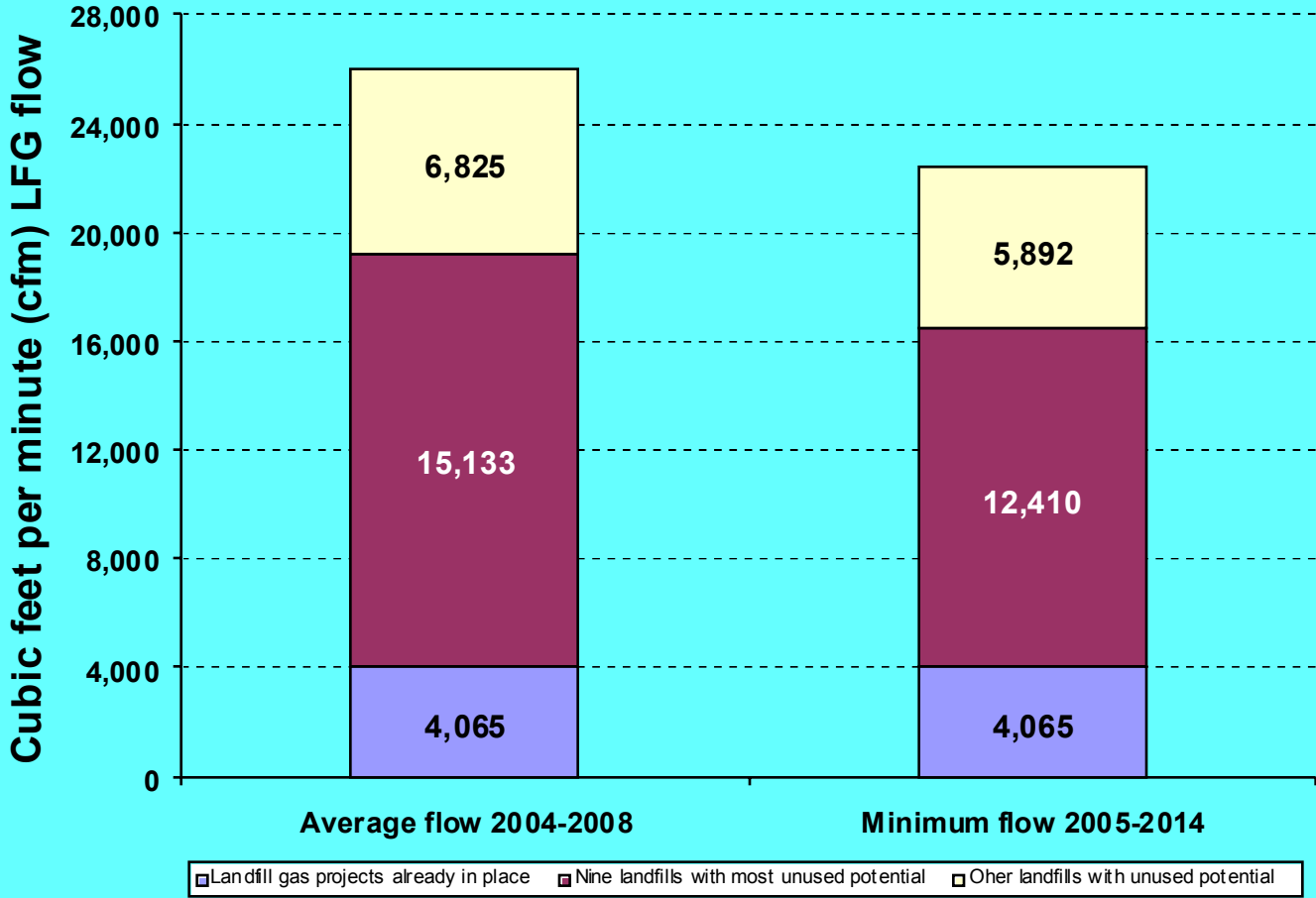
Map (minimum flow)



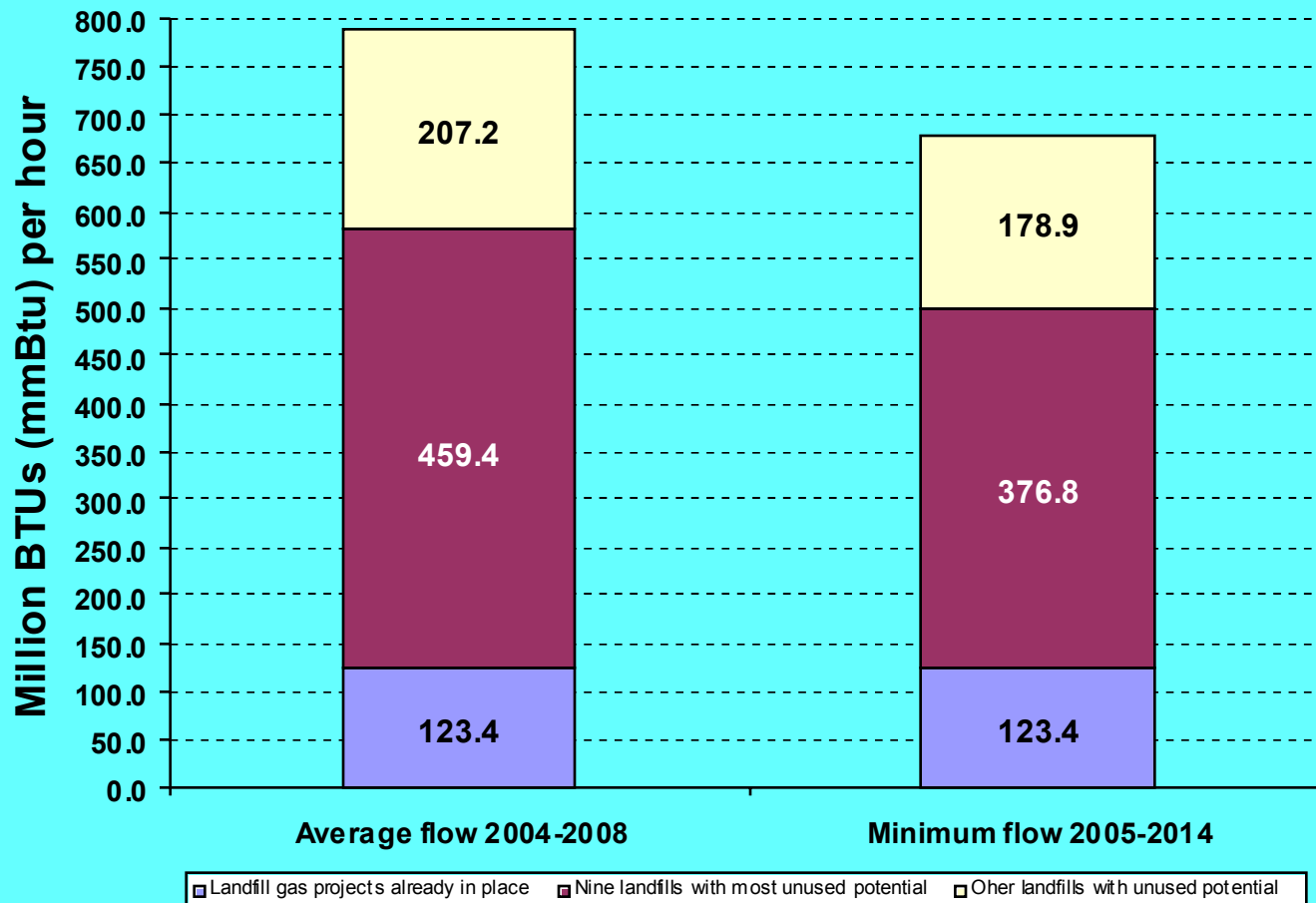
Total LFG energy from existing and potential new projects at 22 landfills

- Existing LFG projects at 3 landfills
 - 123.4 mmBtu/hr
 - 11.2 MW
- Potential (Based on average flow 2004-08)
 - 666.6 mmBtu/hr
 - 60.6 MW
- Potential (Based on minimum flow 2005-14)
 - 555.6 mmBtu/hr
 - 50.5 MW

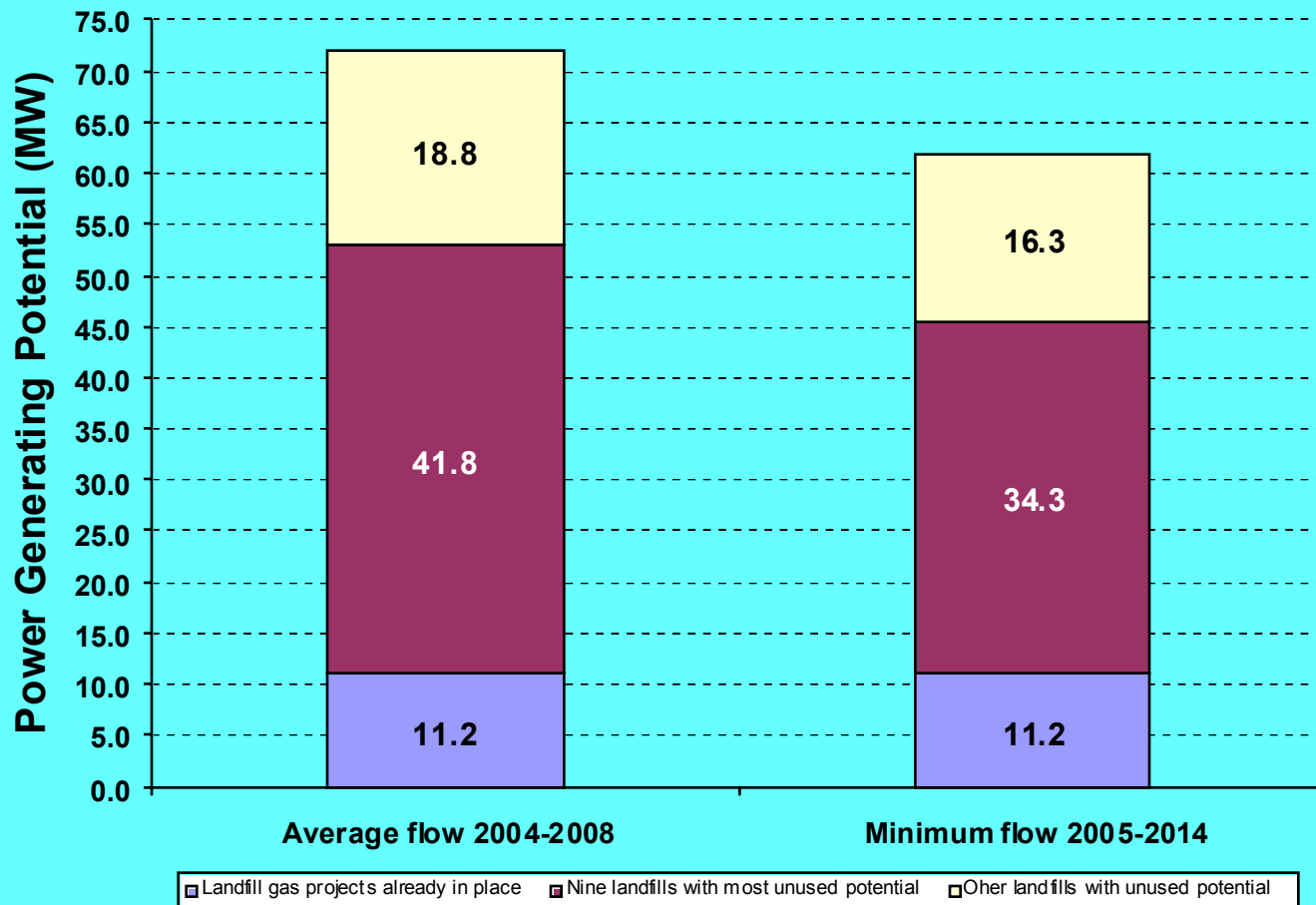
Existing & potential LFG recovery (cfm) at 22 Missouri Landfills



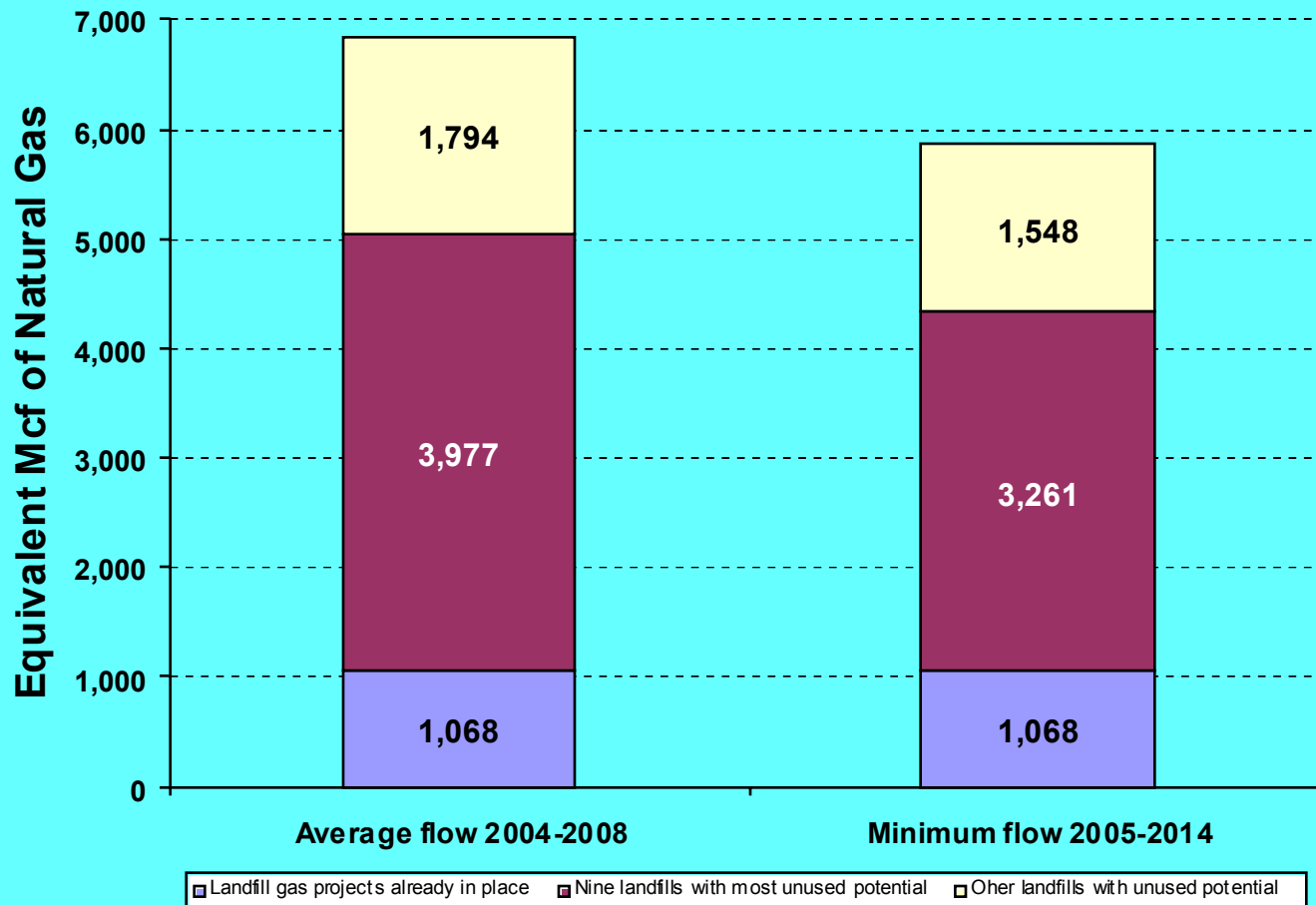
Existing & potential LFG recovery (mmBtu/hr) at 22 Missouri Landfills



Existing & potential LFG recovery as MW of generating potential at 22 Missouri Landfills



Existing & potential LFG recovery as equivalent Mcf of natural gas at 22 Missouri Landfills



Missouri LFG use (trillion BTU) compared to other Missouri energy production and use

