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Landfill Gas Potential using the Philippine Landfill Gas Model

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Introduction

- The landfill started approximately in the early 1940s. The Dump was the primary solid waste disposal facility for the residents until waste acceptance ceased in August 2011.
- Documentation of the type, size, location, and duration of fires is mostly unavailable. However, observations of certain test pits in the northwest corner indicate that open burning of trash occurred, and neighbors have reported that burning of the waste was a standard practice for a period of time.

Philippine Model

- In 2009, the Landfill Methane Outreach Program (LMOP) of the USEPA developed a version of the LandGEM Model for the Philippine Islands.
- The Philippines LandGEM provides a more developed gas generation calculation, and a more developed estimate of the fraction of LFG available for capture, than does the “Standard” LandGEM.
- The Philippine Model provides recommended values for input variables based on climatological data, landfill configurations, landfill operations practices, observable leachate characteristics, waste characteristics specific to the Philippines, and the estimated effect of these conditions on the amounts and rates of LFG generation.

Why The Philippine Model?

The Philippines	Project
• Tropical location in the western Pacific .	• Tropical location in the western Pacific
• Annual temperature of 80 degrees Fahrenheit	• Annual temperature of 81 degrees Fahrenheit
• Mean annual rainfall of 99 inches/year	• Mean annual rainfall of 95 inches/year
• Waste generation rates classified as Middle income country (World Bank)	• Waste generation rates classified as Middle income country (World Bank)

The Philippine Model

Instructions

Please complete the information in the yellow highlighted cells. This information is the minimum input required for proper model operation.

General Information

Name/Title:	XYZ Landfill	**Edit title at left which feeds into the output table and graph.**
Location:	The Philippines	
Year Opened:	2001	**Input year landfill began receiving waste.**
Year Closed/Projected to Close:	2020	**Input closure year (i.e., the final year in which landfill will receive waste).**
Expected Methane Content of LFG:	50%	Please enter the expected methane content of the landfill gas. A value of 50% is recommended unless specific information is available from the site that warrants a different value. This value will be used to calculate the net flow of recovered gas.

Landfill Characteristics:

Are there signs of current or past subsurface fires at the landfill?	No

Criteria Determining Collection Efficiency:

1.	Is the waste placed in the landfill properly compacted on an ongoing basis?	Yes
2.	Does the landfill have a focused tipping area?	Yes
3.	Are there leachate seeps appearing along the landfill sideslopes? Or is there ponding of water/leachate on the landfill surface?	No
4.	Is the average depth of waste 10m or greater?	Yes
5.	Is any daily or weekly cover material applied to newly deposited waste?	Yes
6.	Is any intermediate/final cover applied to areas of the landfill that have reached interim or final grade?	Yes
7.	Does the landfill have a geosynthetic or clay liner?	Yes
8.	In which bracket (I to V) does the LFG System Area Coverage Percentage fall?	I (80 - 100%)

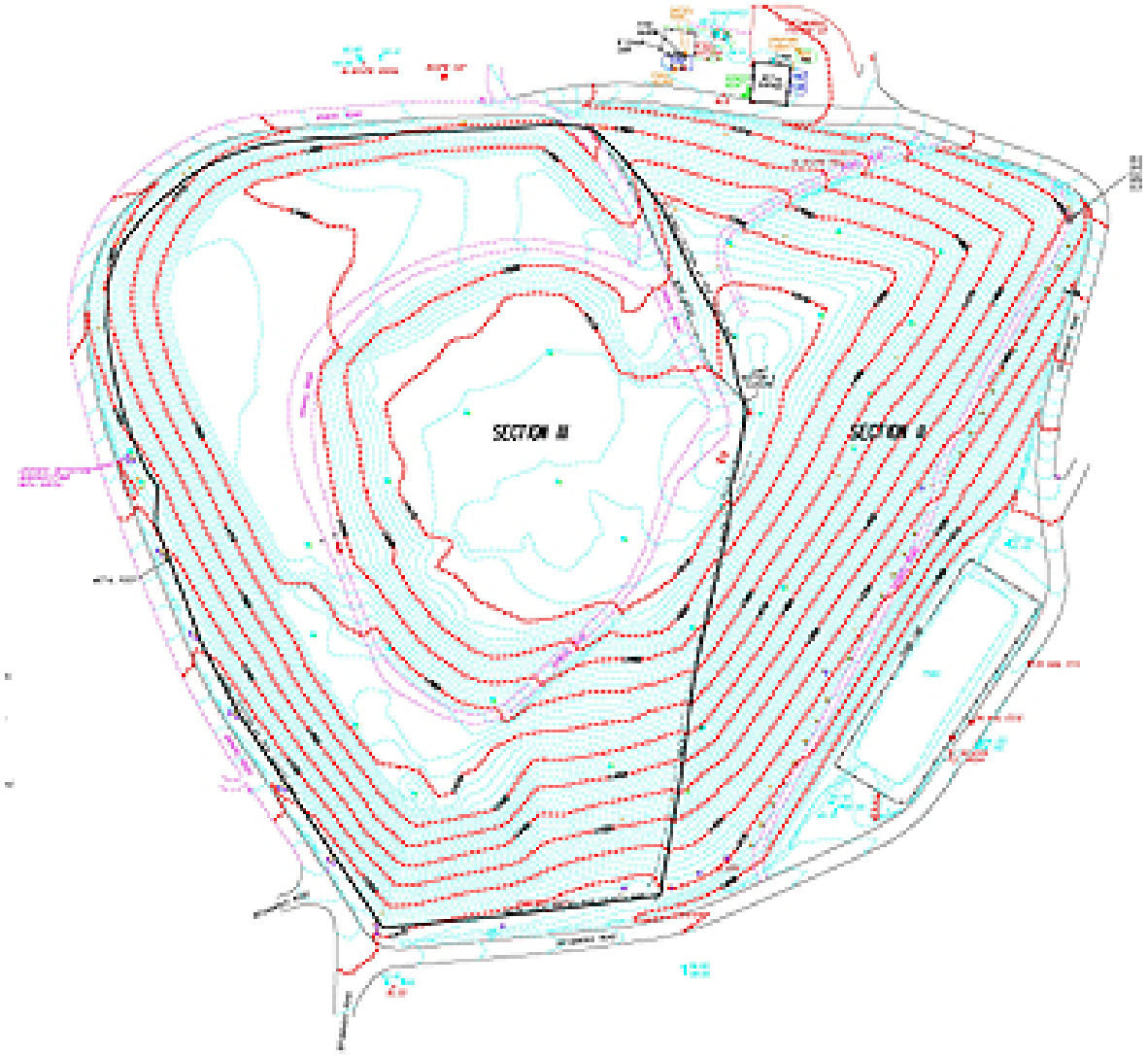
See user's manual for assistance in answering the above questions or for instructions on how to enter a user-specified or default collection efficiency below.

Geotechnical Investigation

In support of design for final closure

- 14 soil borings
- 11 soil borings performed on the site
- 43 samples were evaluated for In-situ moisture density
- Results of the moisture content of the soils ranged from 25.4% to 119.6%
- Permeability 10^{-5} – 10^{-9} cm/s

Leachate Seeps



Site Topography

Criteria for determining Collection Efficiency

No	Question	Response	Collection Efficiency Discount (below 85%) for Response
1	Is the waste placed in the Dump properly compacted on an ongoing basis?	No	3%
2	Does the Dump have a focused tipping area?	Yes	0%
3	Are there leachate seeps appearing along the Dump side slopes? Or is there ponding of water/leachate on the Dump surface?	Yes	10%
4	Is the average depth of waste 10 meters or greater?	Yes	0%
5	Is any daily or weekly cover material applied to newly deposited waste?	Yes	0%
6	Is any intermediate/final cover applied to newly deposited waste?	Yes	0%
7	Does the Dump have a geosynthetic or clay liner?	No	5%
8	In which bracket (I to V) does LFG System Area Coverage Percentage fall?	I (80-100%)	0%

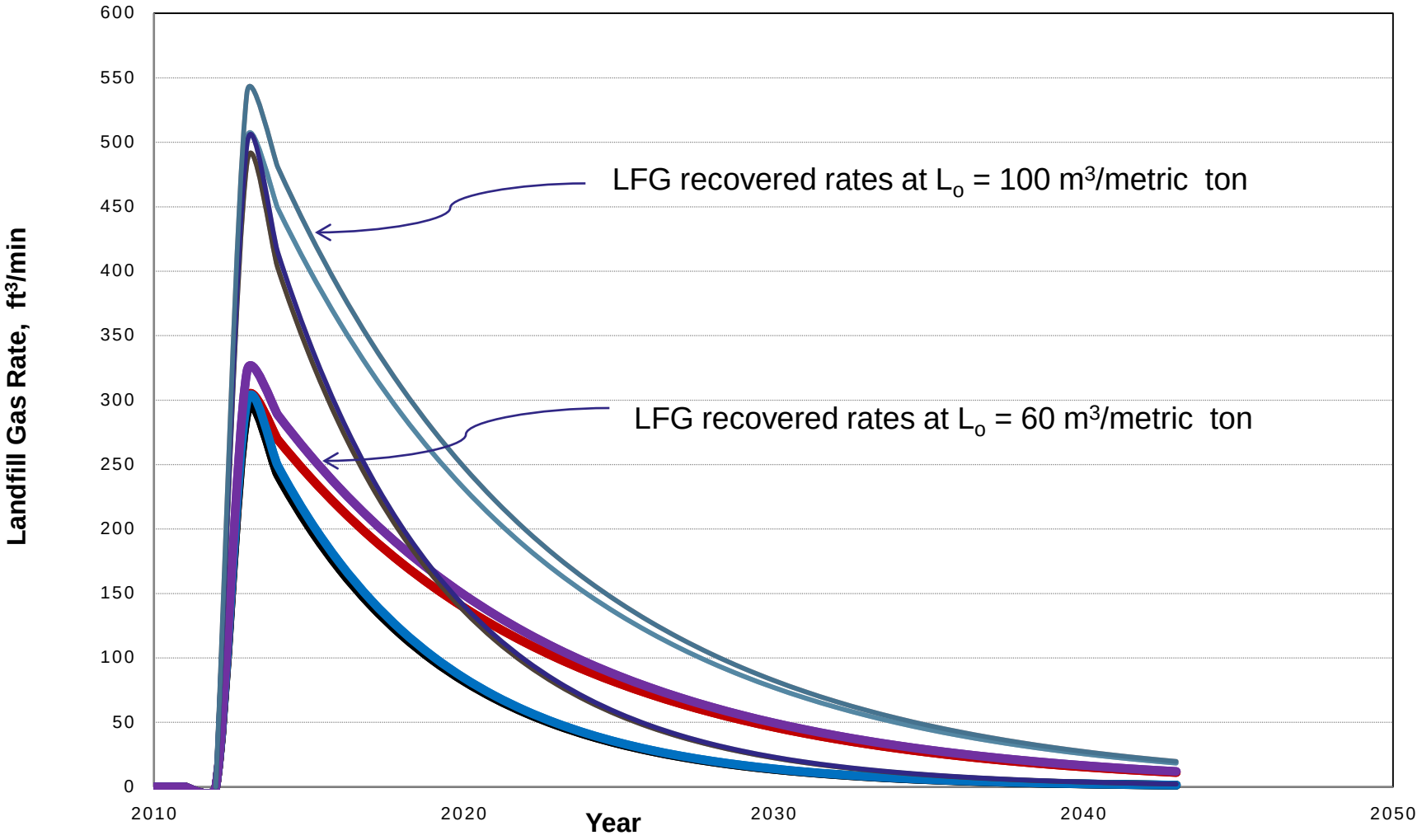
Estimated Waste Generation Rates

Year	Population	1.68 lbs/person/day	3.7 lbs/person/day
		Waste Generation Rate, tons/year	
2005	157,082	110,074	109,940
2006	157,537	113,726	111,361
2007	157,992	117,500	
2008	158,447	117,500	
2009	158,903	82,444	
2010	159,358	82,444	
2011	159,813	59,935	
Volume of Waste, yd3		4,500,000	
In place waste density, lbs/yd3		1,600	2,300

Philippines Model Scenarios Considered

Waste Density lbs/ yd^3	Methane Generation Rate Constant, k (per year)	Ultimate Methane Generation Potential L_o (m^3/Mg of Waste)[1]	Collection System Efficiency (%)
1,600	0.11	60	67
1,600	0.18	60	67
2,300	0.11	60	67
2,300	0.18	60	67
1,600	0.11	100	67
1,600	0.18	100	67
2,300	0.11	100	67
2,300	0.18	100	67

LFG Recovery at 67% Collection Efficiency



Philippine Model Results

Table 1. Landfill Gas Generation Rates Summary at 67% collection system efficiency			
Waste Density lbs/yd^3	Methane Generation Rate Constant, k (per year)	Ultimate Methane Generation Potential L_o (m^3/Mg of Waste)	LFG recovery rates from 2013 to 2023 , (ft^3/min)
Philippine Model			
1,600	0.11	60	301 - 90
1,600	0.18	60	289 - 40
2,300	0.11	60	322 - 96
2,300	0.18	60	298 - 41
1,600	0.11	100	501 - 167
1,600	0.18	100	482 - 80
2,300	0.11	100	537 - 179
2,300	0.18	100	497 - 82

Brown and Caldwell Table Source: USGS

LandGEM & Philippine Model Comparison

LandGEM

Year	2,300 lbs/yd^3 K=0.11 yr^{-1} Lo=100 m^3/Mg of Waste	67% collection efficiency
	LFG Potential (ft^3/min)	LFG recovered (ft^3/min)
2013	1,142	765
2023	381	255

Philippine Model

Year	2,300 lbs/yd^3 K=0.11 yr^{-1} Lo=100 m^3/Mg of Waste	67% collection efficiency
	LFG Potential (ft^3/min)	LFG recovered (ft^3/min)
2013	801	537
2023	267	179

Energy Output

Table 4-2 Energy Output for Each Scenario Considered				
Waste Density lbs/cu yd^3	Methane Generation Rate Constant, k (per year)	Ultimate Methane Generation Potential L_o (m^3/Mg of Waste)	Energy Output from direct use projects[a] 2013, (MW)	Energy Output from direct use projects[a] 2023, (MW)
1,600	0.11	60	0.8	0.3
1,600	0.18	60	0.8[b]	0.1[b]
2,300	0.11	60	0.9	0.3
2,300	0.18	60	0.8	0.1
1,600	0.11	100	1.4	0.5
1,600	0.18	100	1.3	0.2
2,300	0.11	100	1.5[c]	0.5[c]
2,300	0.18	100	1.4	0.2

[a] *assumes gas is combusted in a boiler with 85% efficiency to produce steam*

[b] *presents worst case scenario*

[c] *presents best case scenario*

Overview of Landfill Gas End Uses

- Generate electric power on-site from LFG and sell the power to the electric utility.
- Purify the LFG on site to make pipeline quality methane. Sell it to the natural gas utility.
- Sell the medium-Btu LFG directly to a nearby industrial natural gas user.
- Sell the medium-Btu LFG directly to a nearby offsite electric power plant.
- Purify the LFG on site to 90 percent methane quality and compress it to high pressure for fleet vehicle use as a compressed natural gas (CNG) substitute for diesel fuel.
- Use the LFG onsite for evaporation of leachate.

LFG Project Economic Feasibility Estimates

LFG Scenario	Installed Capital Cost ($)	First Year Operation and Maintenance Cost ($)	Internal Rate of Return ($)
Leachate Evaporation	High	High	Negative
Direct Use	High	Low	Negative
Small Engine-Generator Set	Low	Low	Positive @ 1%

Questions