Maximizing Greenhouse Gas Emissions Reductions at the Vancouver Landfill

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Presentation Outline

- City of Vancouver / Greenest City Action Plan
- Vancouver Landfill Background
- Landfill Gas Capital Improvements
- LFG Modeling
- Optimizations and Innovations
- Summary
- Discussion/Questions

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Vancouver's Context

- A city of 578,000 residents and 378,000 jobs, in a region of over 2.2 million people and 1.1 million jobs
- Compact community (59% apartments and 41% homes)
- Annual community GHG emissions of 2.7 million tonnes

The Challenge

GREENEST CITY IN THE WORLD BY 2020

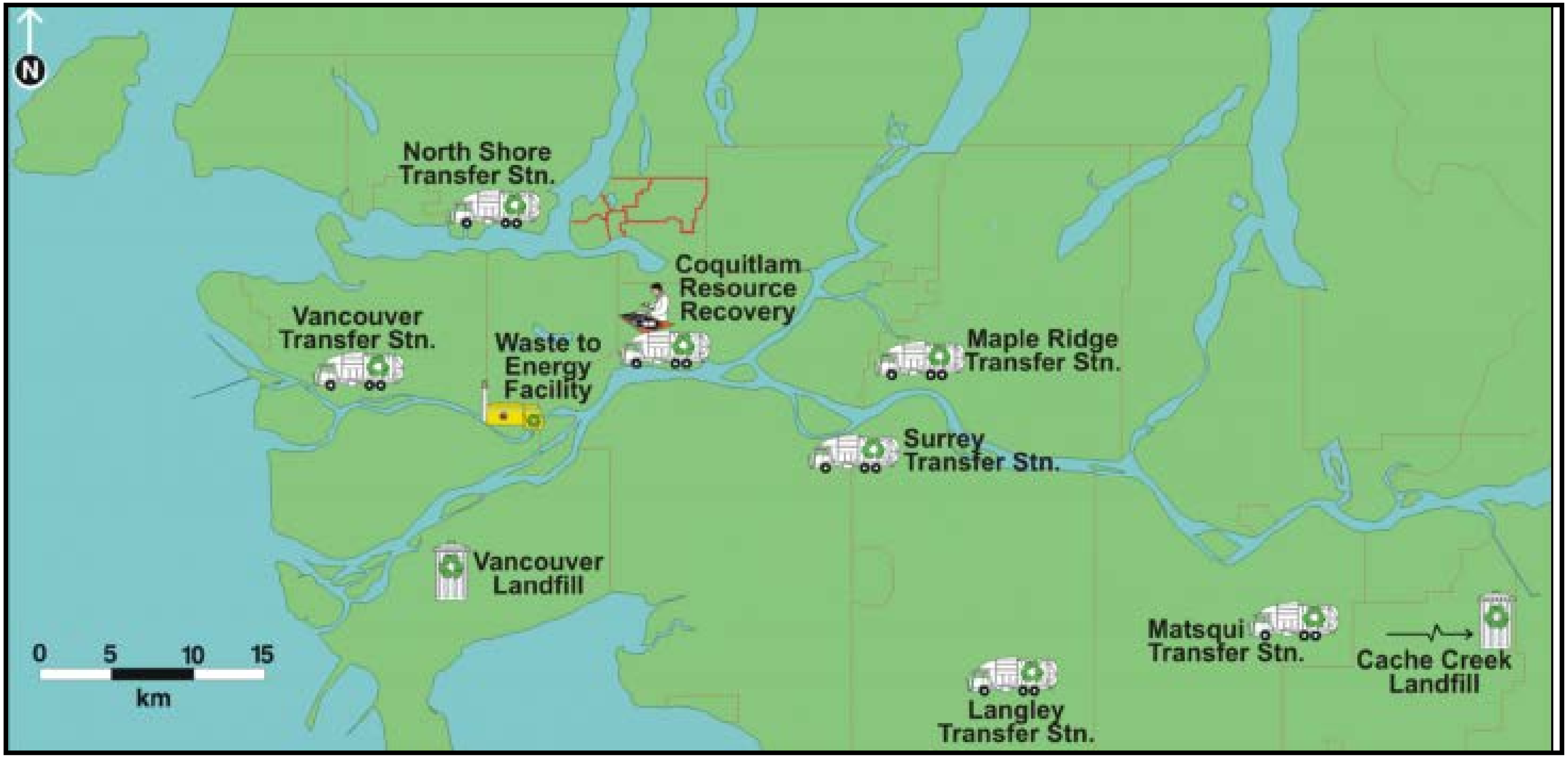
In early 2009, the City's Mayor formed the Greenest City Action Team (GCAT) with a mandate to make recommendations on how Vancouver can become the greenest city in the world by 2020.

GCAP Goals

There are **ten** Greenest City goals, each with their own 2020 target(s)

Two of the goals, ‘Climate Leadership’ and ‘Zero Waste’ helped drive our local efforts for methane abatement at the Vancouver landfill

Solid Waste Management Facilities in MV



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Vancouver Landfill Background Information

Opened: 1966

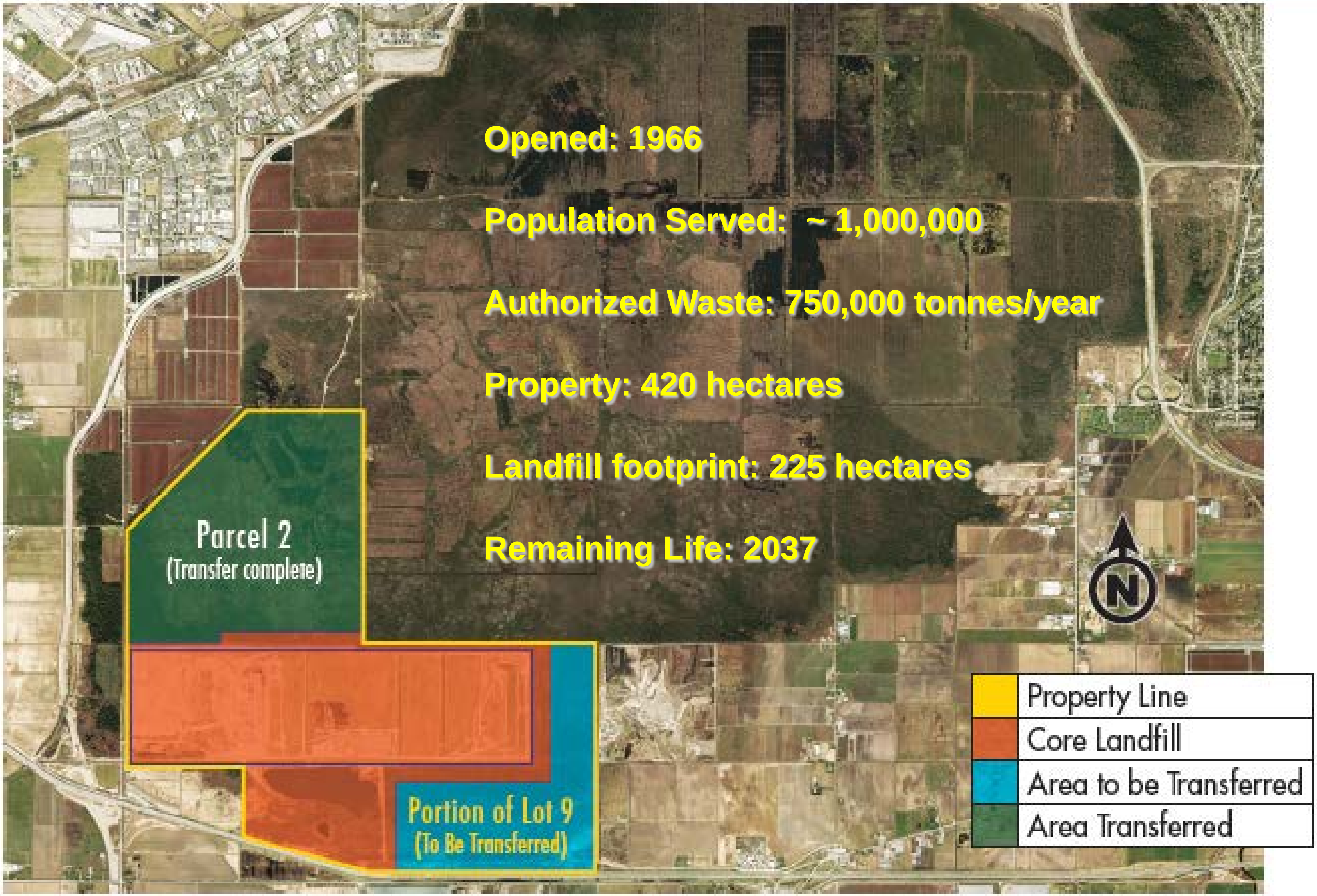
Population Served: ~ 1,000,000

Authorized Waste: 750,000 tonnes/year

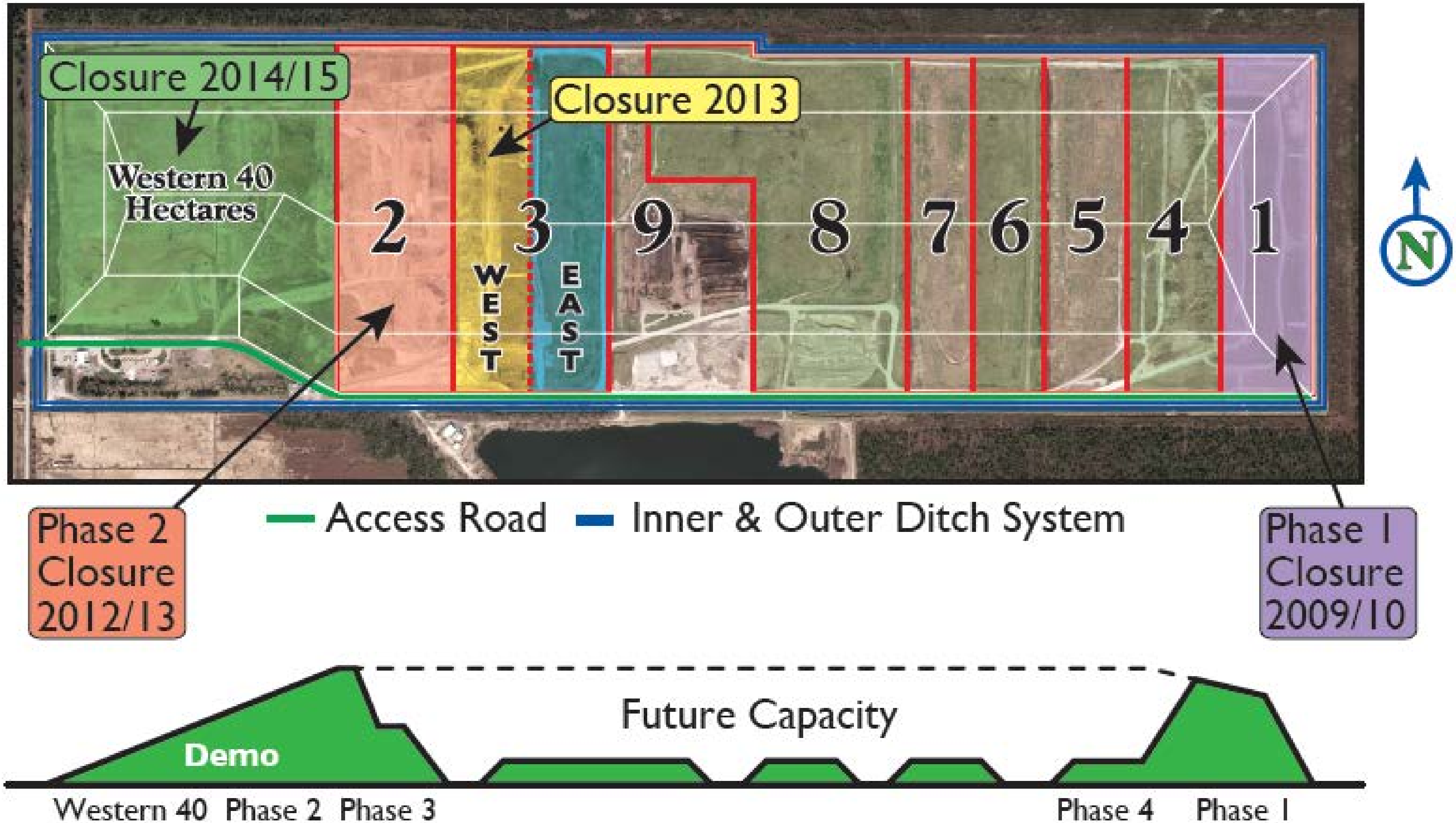
Property: 420 hectares

Landfill footprint: 225 hectares

Remaining Life: 2037



Vancouver Landfill Fill Plan



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Landfill Gas Control

- Collection since 1991; utilization since 2003
- Control of odours and GHG emissions
- Local source for power production & heat recovery

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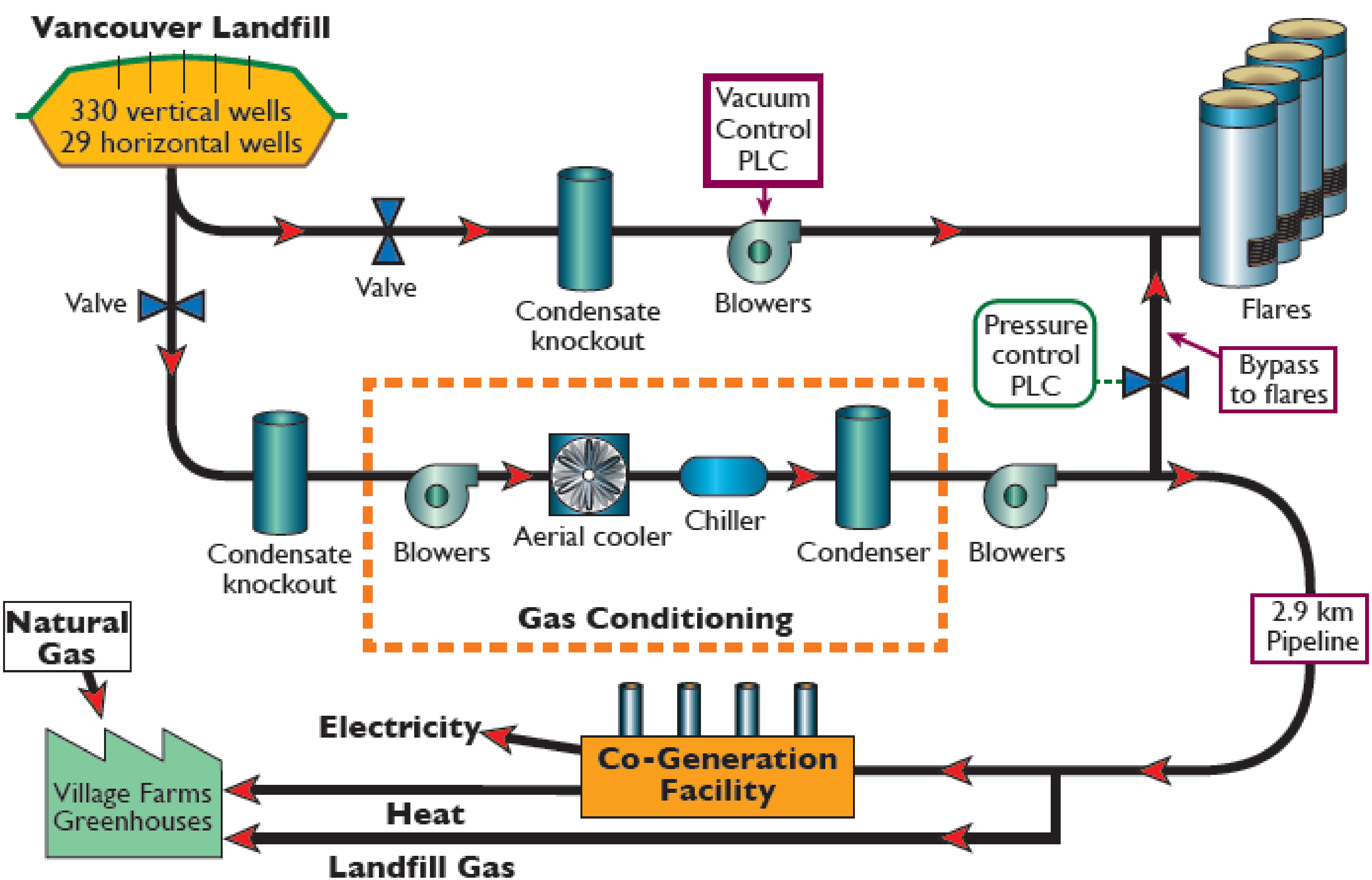
Landfill Gas Utilization

- 20 year Agreement with Maxim
- 4 CAT 3532 reciprocating engines produce 7.4 MW, electricity for 6000 homes
- LFG fired boilers & waste heat utilization for greenhouses

Vancouver Landfill
Gas Collection and Beneficial Use



Vancouver Landfill & Village Farms

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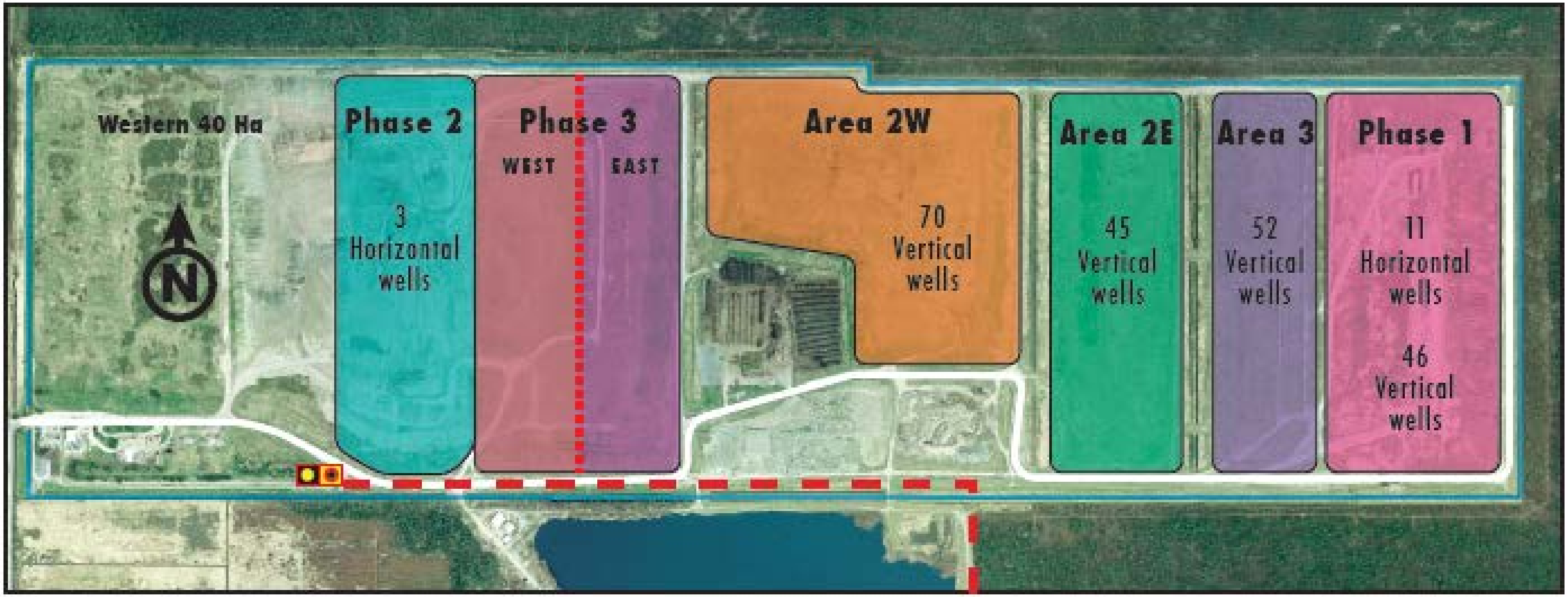
Vancouver Landfill
Gas Collection System 2011

Total Landfill Gas Wells 227 | **14 Horizontal Wells** | **213 Vertical Wells**



- Flare station
- Conditioning facility
- 2.9 km Pipline across HWY 99

Co-Generation facility
Electrical generators (engines) to supply power to BC Hydro and heat utilized in greenhouses

Capital Costs for LFG and Closure Works

Description	Capital Cost	Commissioning Date
New LFG Wells	$3M	2012
Phase 2 Closure/101 wells	$19M	2012/2013
Phase 3W Closure/34 wells	$13M	2013
W40 Ha Closure Design/Construction	$27M	2014/2015
Additional wells/improvements	$5M	2014/2015

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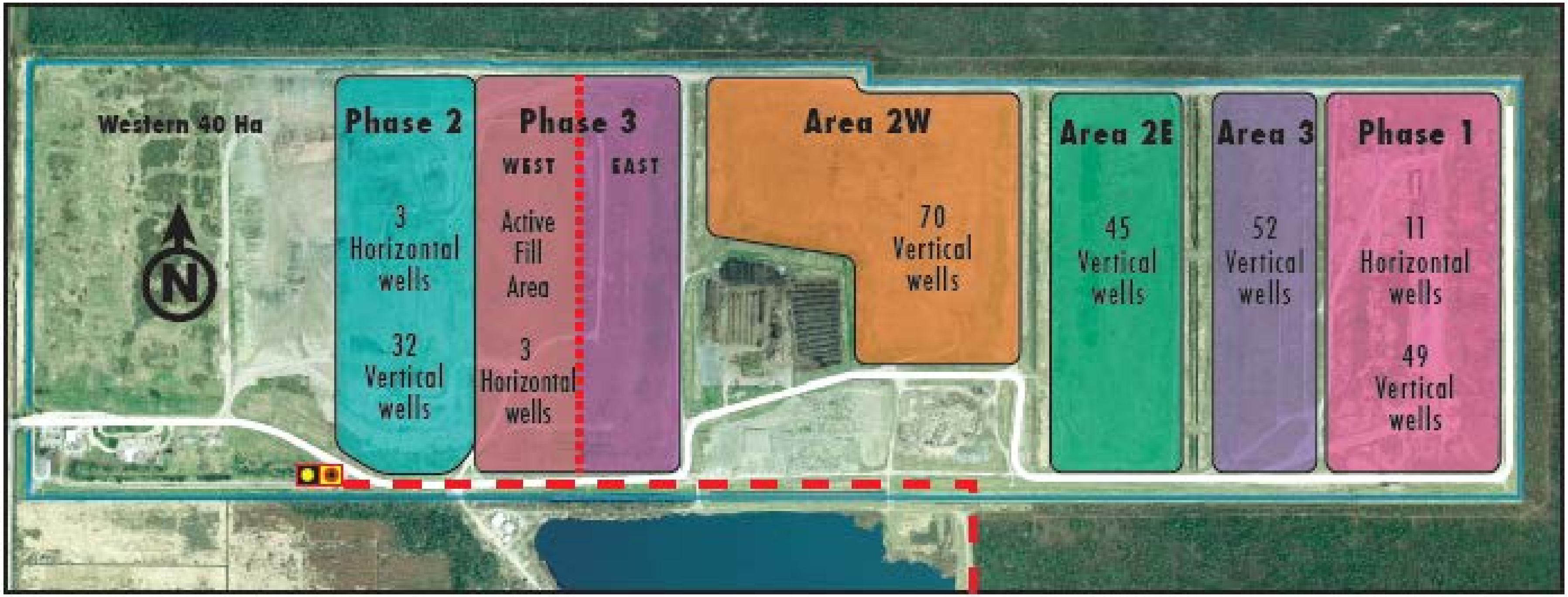
Vancouver Landfill Gas Collection System 2012

Total Landfill Gas Wells 263 | 17 Horizontal Wells | 246 Vertical Wells



- Flare station
- Conditioning facility
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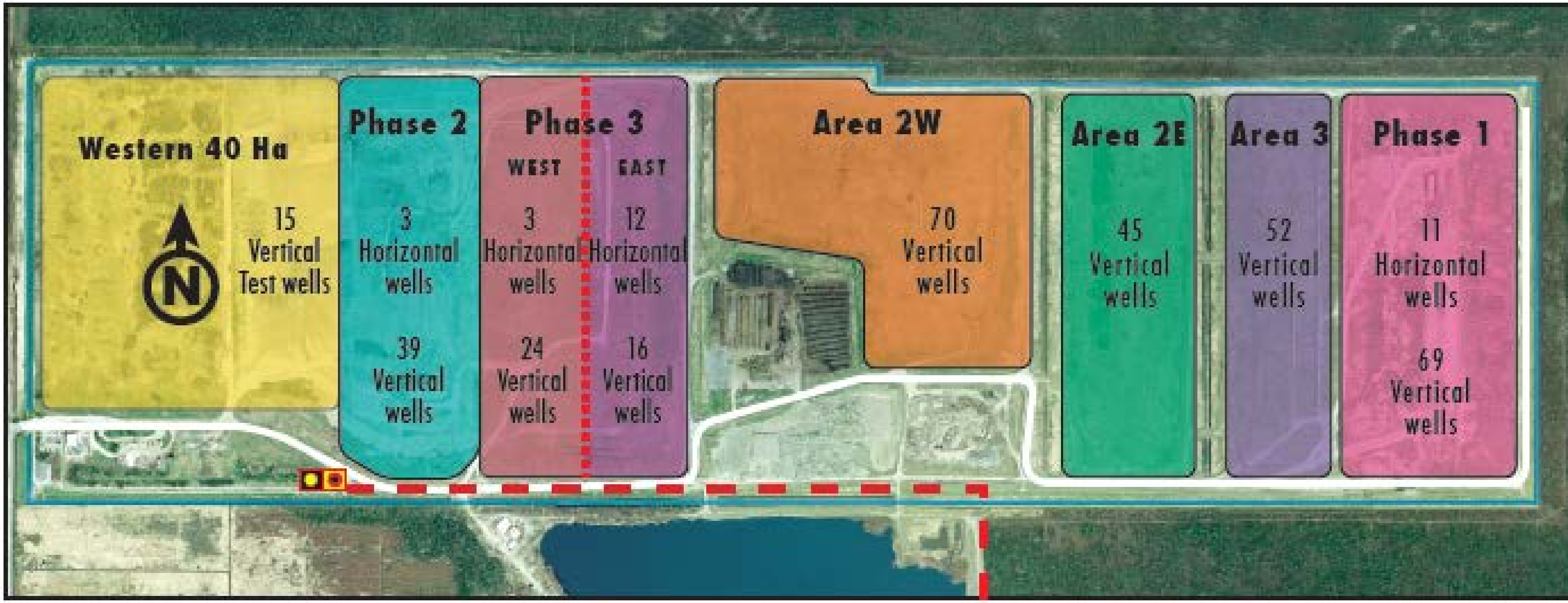
Co-Generation facility
Electrical generators (engines) to supply power to BC Hydro and heat utilized in greenhouses

Vancouver Landfill Gas Collection System 2013

Total Landfill Gas Wells 359 **29 Horizontal Wells** **330 Vertical Wells**



- Flare station
- Conditioning facility
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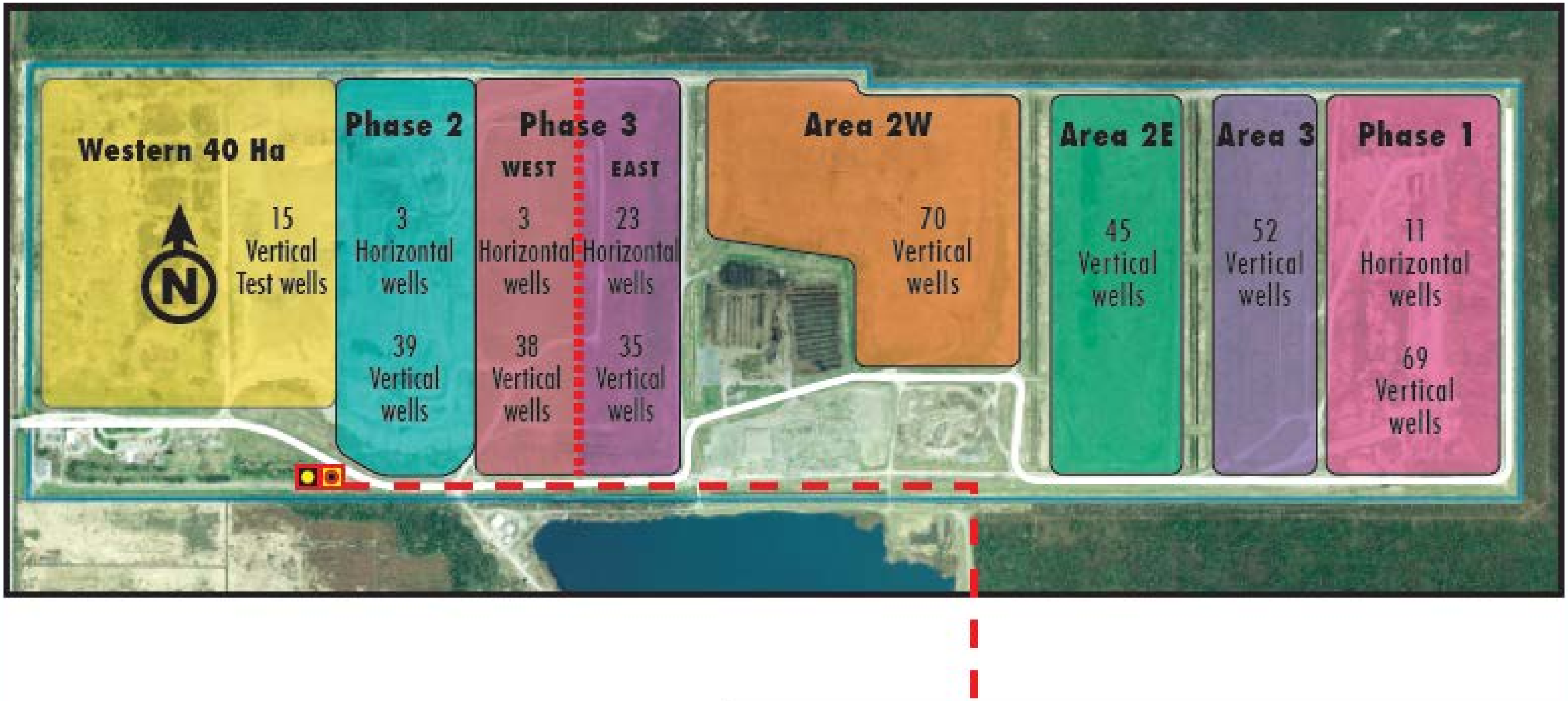
Co-Generation facility
Electrical generators (engines) to supply power to BC Hydro and heat utilized in greenhouses

Vancouver Landfill
Gas Collection System 2016

Total Landfill Gas Wells 403 | 40 Horizontal Wells | 363 Vertical Wells



- Flare station
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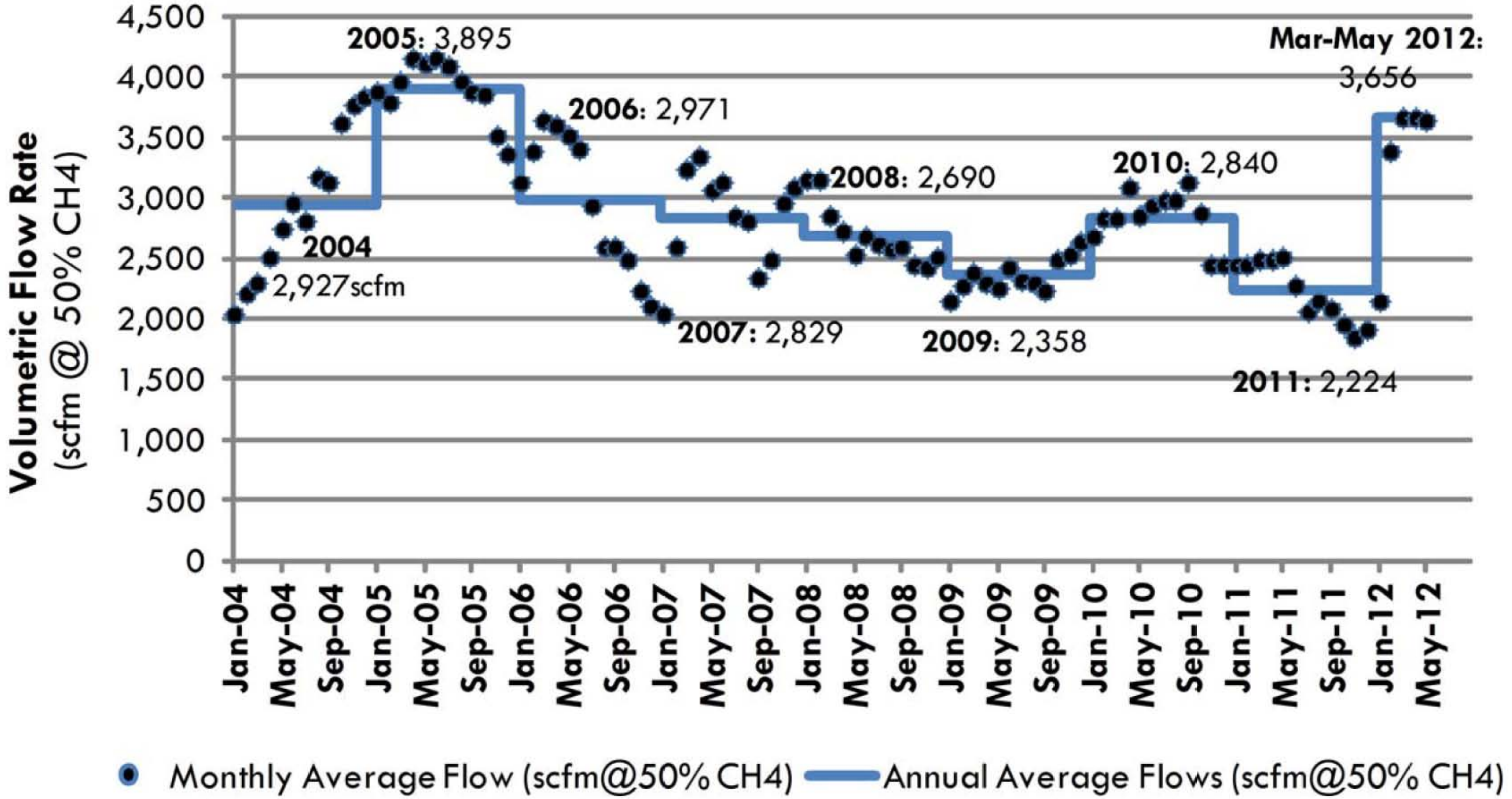
Co-Generation facility
Electrical generators (engines) to supply power to BC Hydro and heat utilized in greenhouses

LFG Modeling – Empirical Approach

- LFG generation and recovery forecasting tool – LFG model
- LFG model should explain historical data
  - Annual waste disposal by area and type
  - Actual LFG recovery and methane % (total)
  - Estimated collection efficiency – based on assessment of wellfield design/operations
- Challenges:
  - 7 landfill areas with different collection efficiencies
  - 3 waste categories (MSW, demo, demo-hog) with different LFG generating characteristics
- Solution:
  - Model with separate "modules" for each landfill area
  - Each module has separate "sub-modules" by waste category
  - Total of 7 modules x 5 sub-modules = 35 sets of calculations

Historical Data – Actual LFG Recovery



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Model Calibration by Landfill Area (2012)

	Western 40	Cell B&C	Cell D	Cell E	Phase 1	Phase 2	Phase 3	Total Site
LFG Generation (m^3/hr)	532	442	255	463	2,883	3,074	2,521	10,170
Percent of Total %	5.2	4.4	2.5	4.6	28.3	30.2	24.8	100.0
Collection Efficiency (%)	0%	64%	70%	55%	70%	75%	47%	61%
LFG Recovery (m^3/hr)	0	281	179	255	2,014	2,310	1,173	6,212

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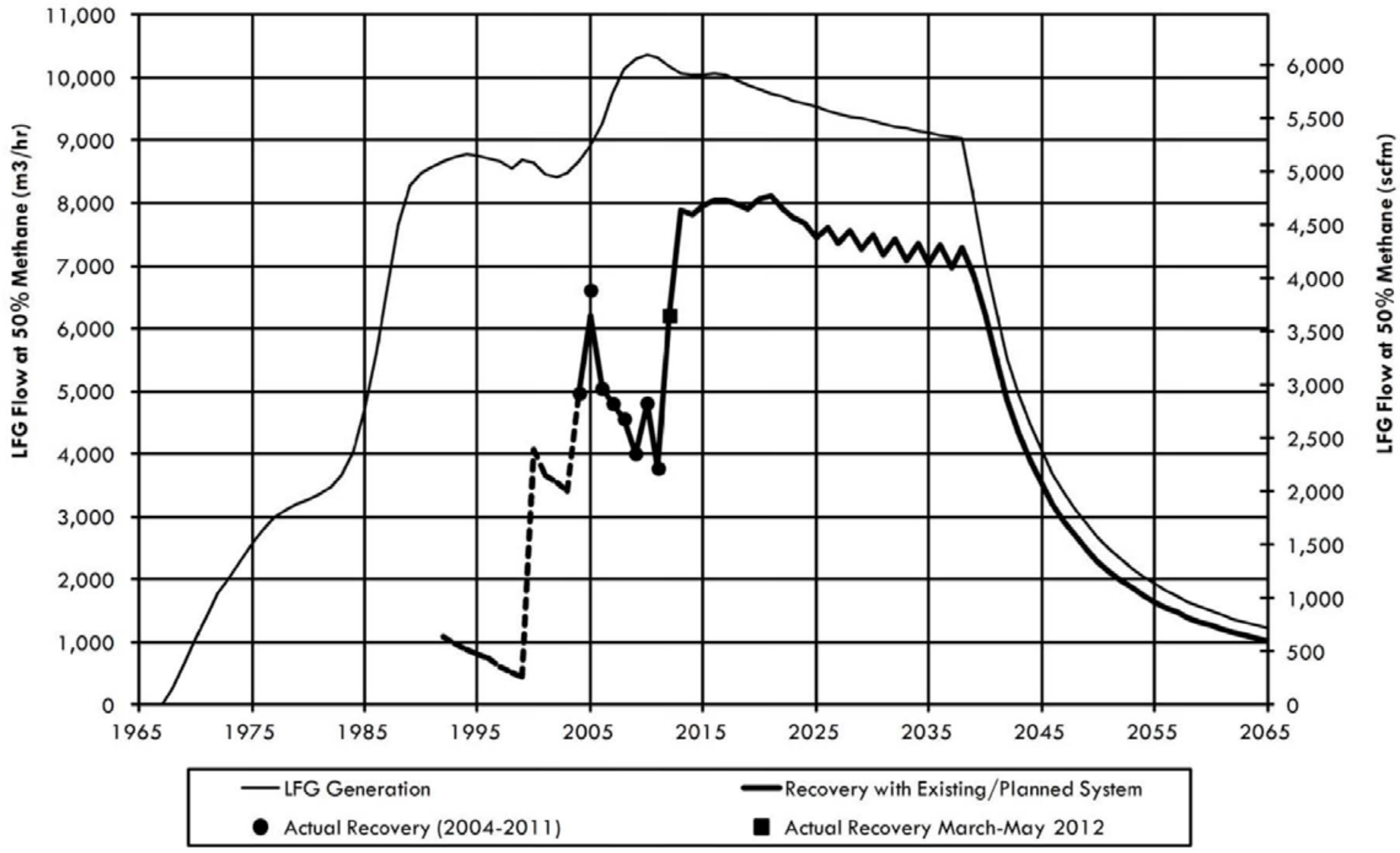
Total Site LFG Generation and Recovery



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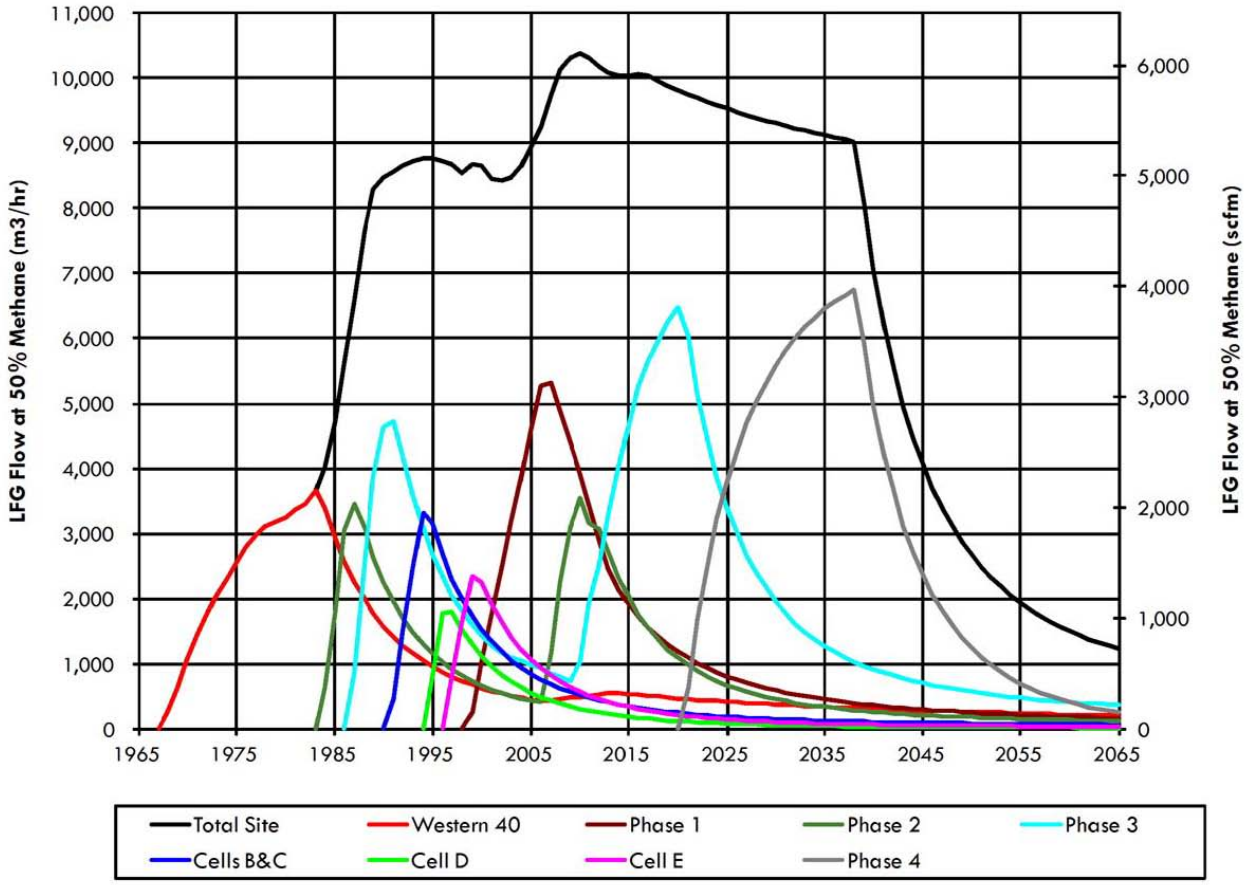
Projected LFG Generation by Area



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Comparison of Model Input Assumptions for MSW

	Fast-Decay Organics			**Medium-Decay Organics**			**Slow-Decay Organics**		
	Waste Types	k (1/yr)	L_0 (m^3/Mg)	Waste Types	k (1/yr)	L_0 (m^3/Mg)	Waste Types	k (1/yr)	L_0 (m^3/Mg)
SCS	Food, 50% of garden	0.3	69-70[1]	Paper, textiles, 50% of garden	0.12	156-162[1]	Wood, leather, rubber	0.03	106-134[1]
IPCC[2]	Food[3] Garden[3]	0.185 0.10	70 93	Paper textiles	0.06 0.06	186 112	Wood	0.03	200
BC MOE[4]	Food, yard, landscape, "other"	0.11	160	All other waste with organics	0.06	120	Inorganic waste	0.02	20

1. SCS assigned different Lo values for waste disposed before and after 1/1/2007 based on variations in the composition of wastes disposed.
2. IPCC (Intergovernmental Panel on Climate Change) values for wet, temperate climate.
3. IPCC model has 4 organic waste categories, including separate categories for food and garden waste shown under "fast-decay organics."
4. BC MOE uses categories "decomposable", "moderately decomposable", and "relatively inert" which are compared here to fast-decay, medium-decay, and slow decay organic wastes.

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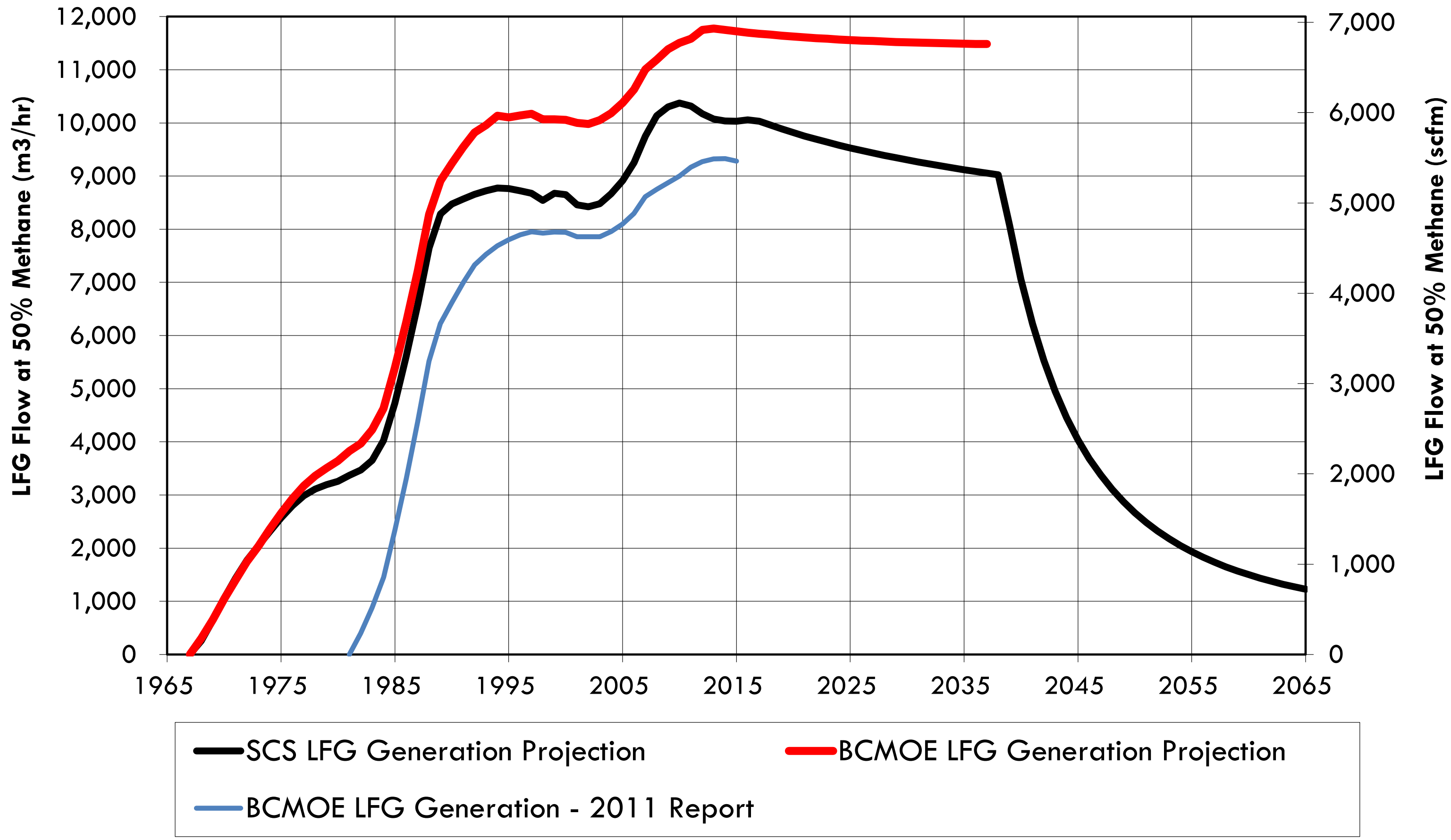
Comparison of LFG Generation Estimates



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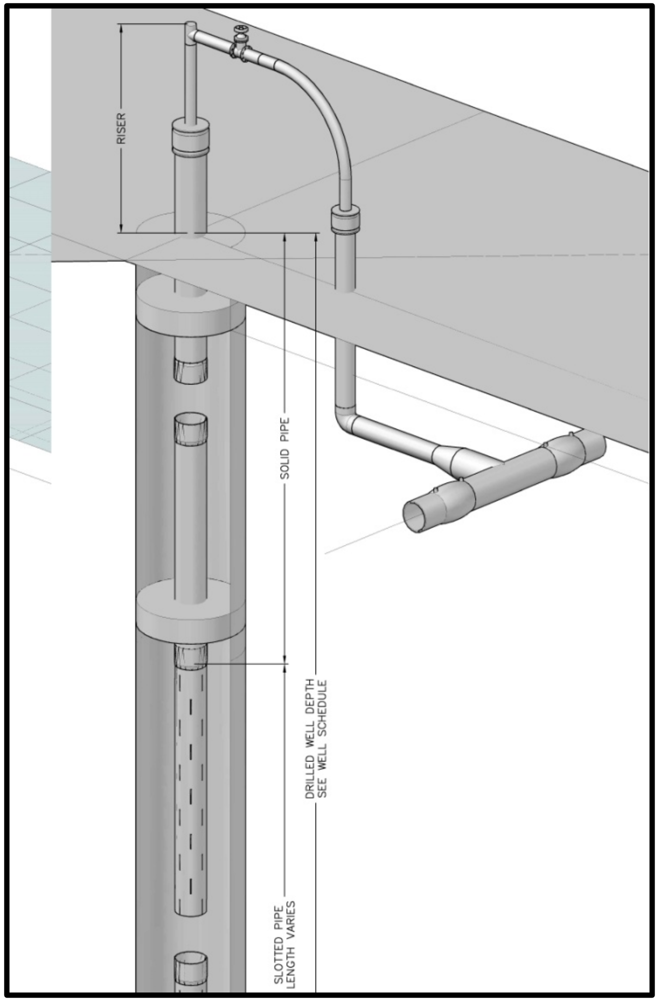
Landfill Gas Generation, Recovery and Collection Efficiency

Year	Collection System Efficiency (%)	Modeled LFG Generation		Modeled LFG Recovery from Existing & Planned System		Actual LFG Recovery	
		m^3/hr	scfm	m^3/hr	scfm	m^3/hr	scfm
2011	37%	10,317	6,072	3,777	2,223	3,777	2,223
2012	61%	10,170	5,986	6,212	3,656	6,212	4,159
2013	74%	10,075	5,930	7,471	4,397		
2014	74%	10,039	5,909	7,435	4,376		
2015	75%	10,033	5,905	7,510	4,420		
2016	76%	10,060	5,921	7,647	4,501		

Optimizing Gas Extraction - Vertical Gas Well Design



1. Boring Diameter, 900 mm
2. Pipe Material, PVC
3. Pipe Dia./Wall, 200 mm/13 mm (Sch 80)
4. Pipe Openings, Slotted
5. Pipe Joint, Bell End
6. Filter Pack, 19 to 50 mm Stone
7. Seal Thk. & Qty, 900 mm at 3 locations
8. Centralizer(s), every 9 m

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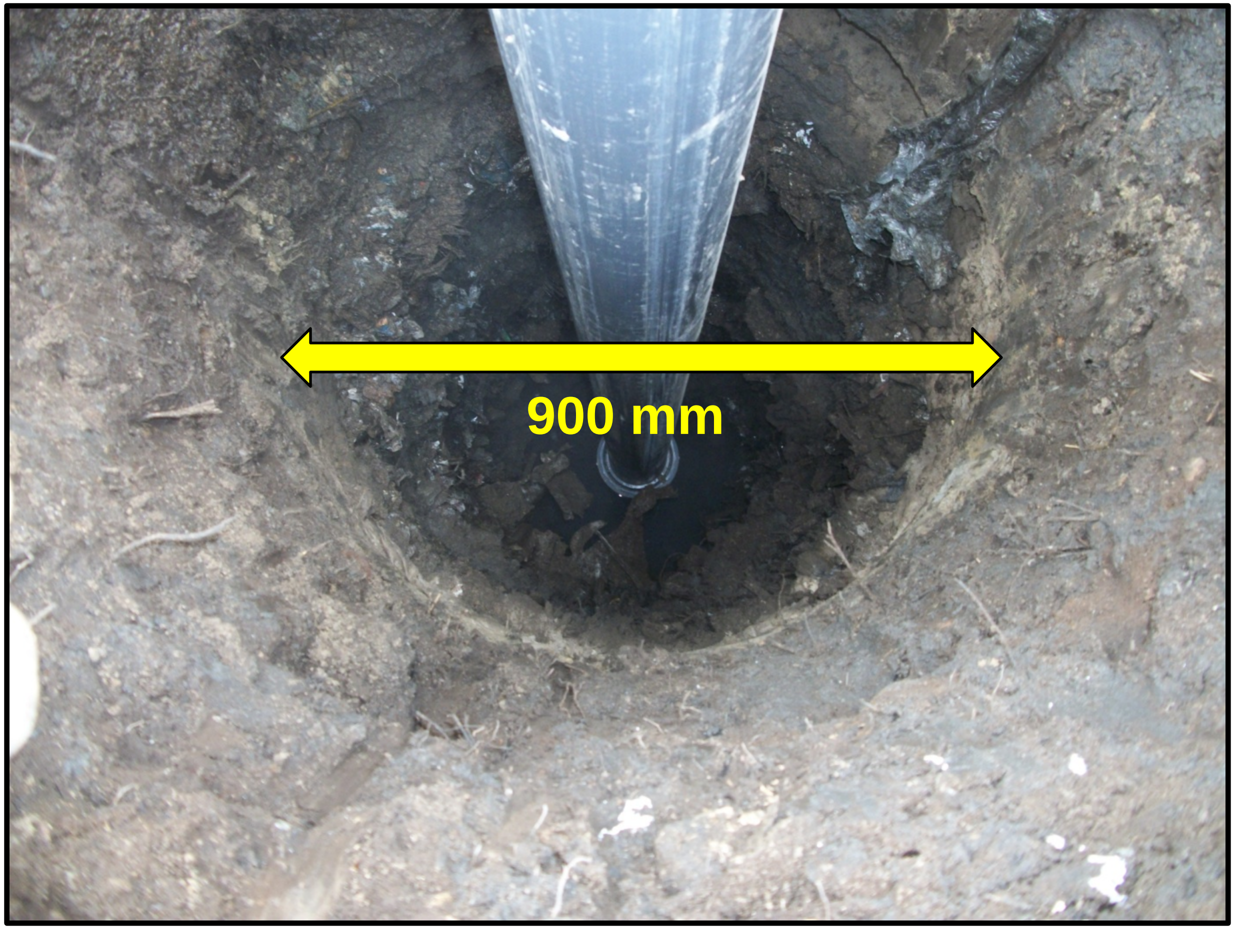
Optimizing Gas Extraction – Larger Boring Diameter



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Optimizing Gas Extraction – Larger Boring Diameter

Exposed Area of Waste for Various Boring Diameters

Boring Diameter (mm)	Exposed Area of Waste for Select Length of Slotted/Perforated Pipe: per 1 m (m2)	per 10 m (m2)	per 30 m (m2)	Increase from 300 mm Boring %
230 [A]	0.7	7.2	21.7	
300 [B]	0.9	9.4	28.3	
450	1.4	14.1	42.4	150
600	1.9	18.8	56.5	200
750	2.4	23.6	70.7	250
900 [C]	2.8	28.3	84.8	300

size for conventional water well drilling rig (yellow)

size for caison type drilling rig (green)

A size installed prior to 2006

B size installed prior to 2010

C size installed in 2011 and 2012

Optimizing Gas Extraction – Greater Open Area per Metre of Pipe

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Optimizing Gas Extraction - Centralizers

Optimizing Gas Extraction – Well Seals to Prevent Air Intrusion

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Optimizing Gas Extraction – Well Seals to Prevent Air Intrusion

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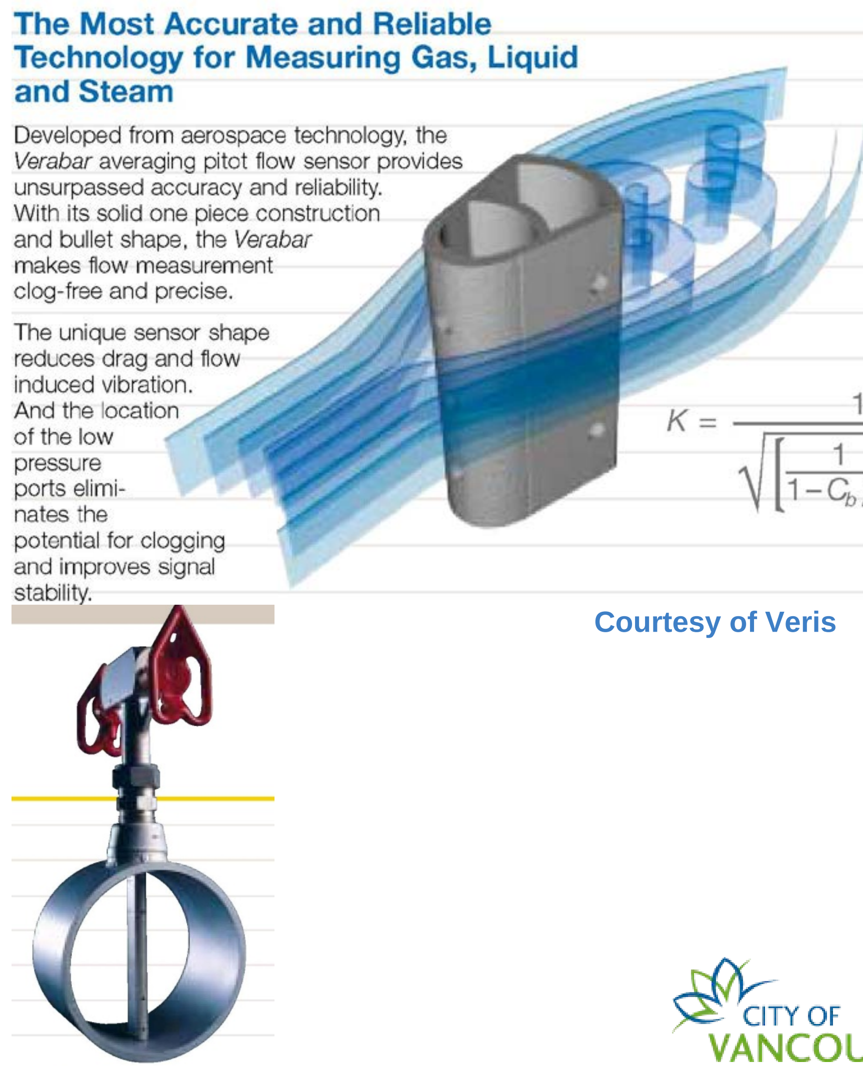
Optimizing Gas Extraction - CQA for Gas Wells

Optimizing Gas Extraction – Accurate Flow Meters for Each Landfill Subarea for Enhanced Metering and Model Calibration and Vacuum Control



Courtesy of Veris

Innovations – Infrastructure for Dewatering Gas Wells where Needed

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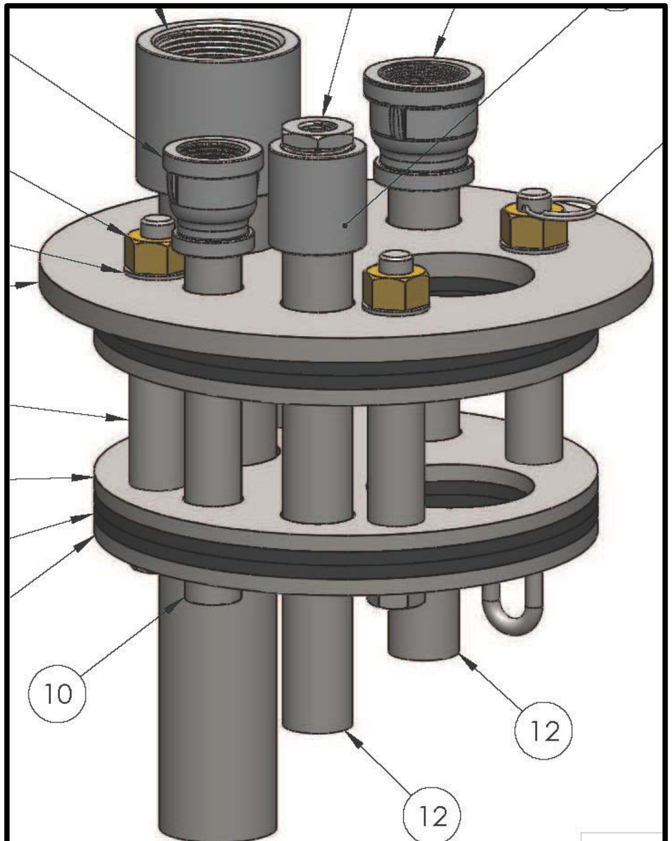
Innovations – Well Head Adapter for Mounting Pumps, Monitoring Devices and Bubblers



Courtesy of ATZ

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Innovations – Monitoring Devices for User Friendly Operations and Accurate Flow Measurement and Control

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Innovations – Non-Intrusive/Disruptive Water Level Measurements

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Innovations – Remote Monitoring for Separate Areas

Courtesy of ATZ

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Summary

- Vancouver is showing leadership in green initiatives through accelerated gas works construction
- Potential reduction of 800,000 tonnes CO_2 (2012 – 2016)
- Reduced odours in the community
- Implementing innovative technology
- Spent $16M to date, committed to an additional $63M to 2016

Discussion/Questions

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