NACT 285
Landfill Gas Control

Introductions

- Your Name ?
- Where You Work?
- How Long?
- What do you Do All Day?
- How much experience do you have with landfills?

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Course Objectives

- Landfill Basics 101
- Air Pollutants
- Rules and Regulations
- Landfill Gas Collection
- Surface Monitoring
- Landfill Gas Controls
- Methane Monitoring Equipment
- Inspection and Safety Tips

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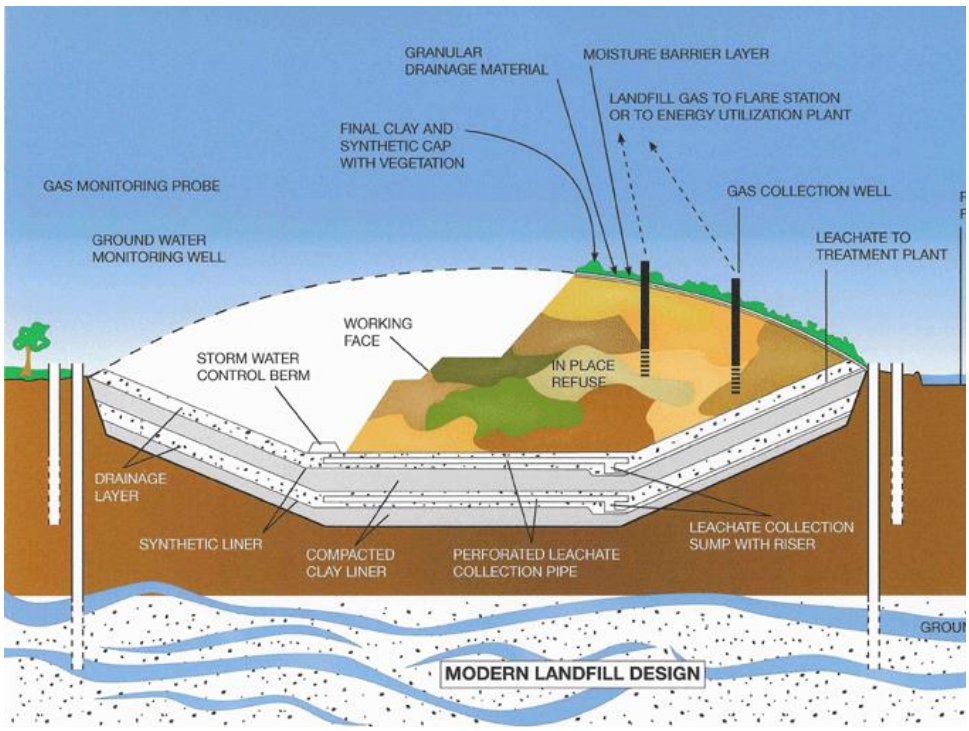
Not So Long Ago



Topsoil/Barrier

Geomembrane (Plastic)

Clay

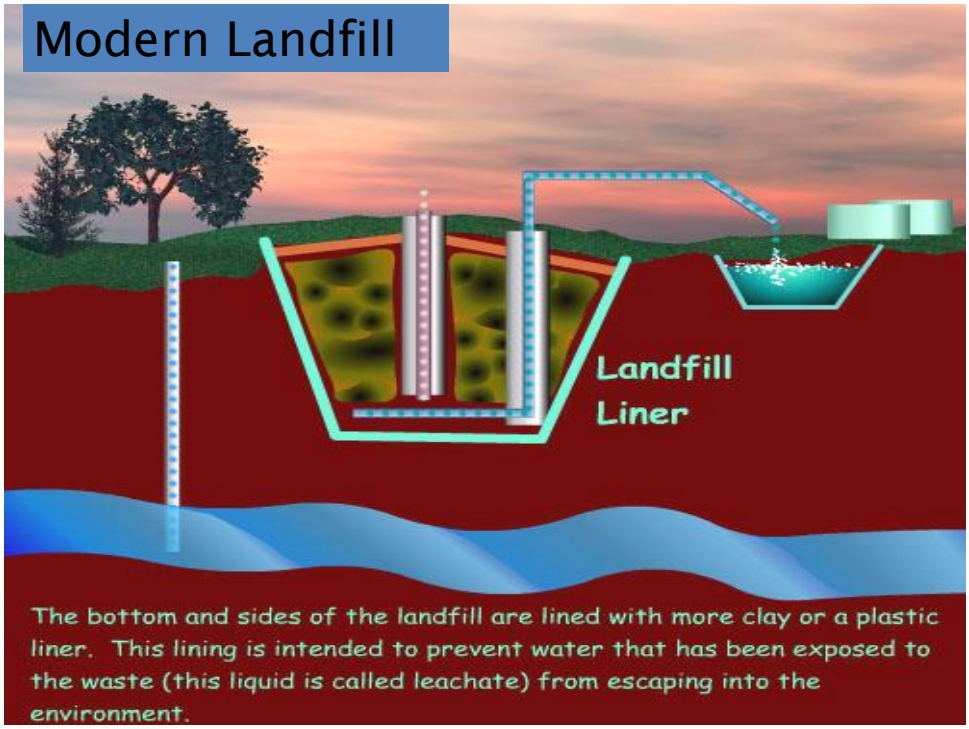
Gas Venting Layer

Garbage

Primary Leachate Collection and Removal

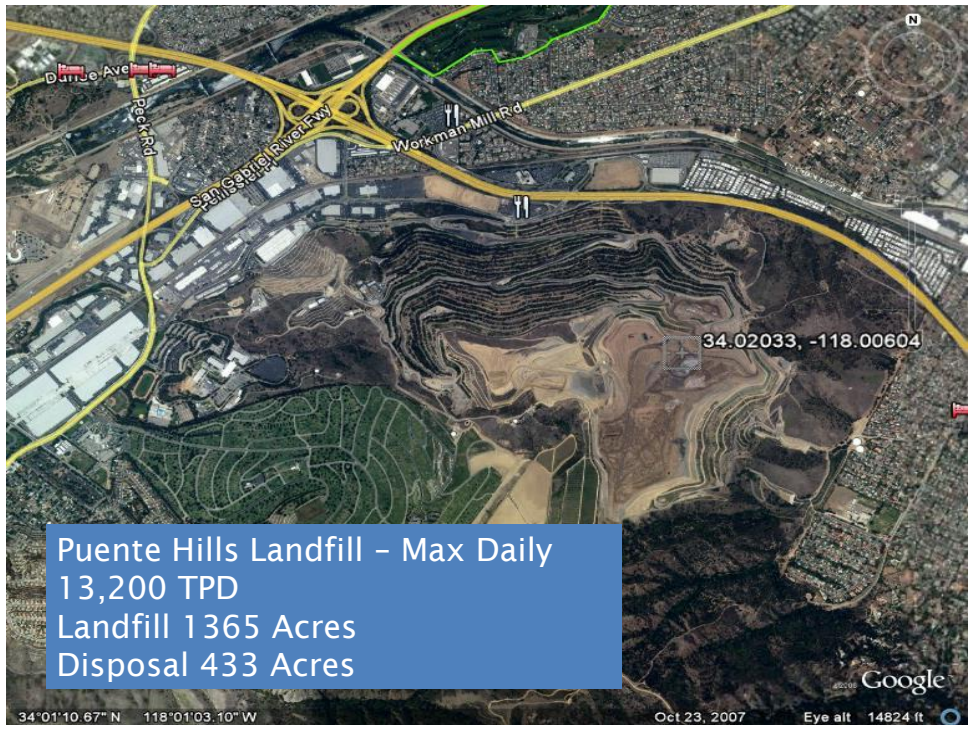
Structural Fill

Anatomy of A Modern Landfill

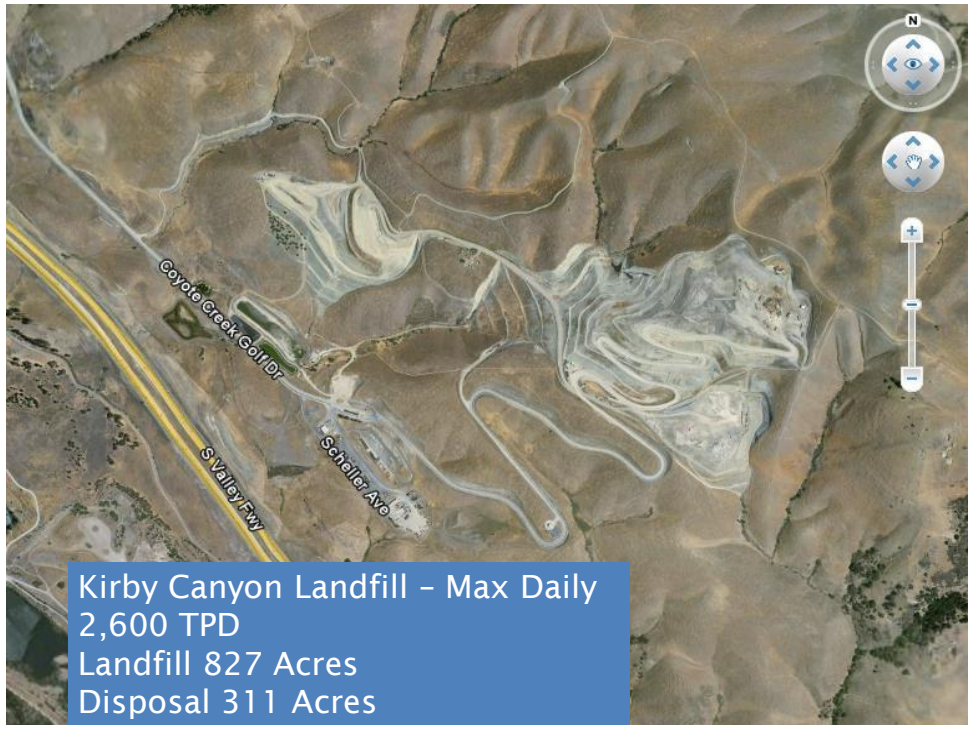


- New York City's garbage for over 50 years
- **Fresh Kills Landfill is the largest landfill in the world.**
- 2,200 acres, (over 50 football stadiums) received 14,000 tons per day.
- Shut down in 2001.

- It became the disposal site for the remains of the World Trade Center after the terrorist attack of September 11, 2001.



Puente Hills Landfill – Max Daily
13,200 TPD
Landfill 1365 Acres
Disposal 433 Acres


Coyote Creek Golf Dr
S Valley Fwy
Scheller Ave
Kirby Canyon Landfill – Max Daily
2,600 TPD
Landfill 827 Acres
Disposal 311 Acres


37.87417, -121.18828
S Austin Rd
Forward Landfill – Max Daily
8,668 TPD
Landfill 567 Acres
Disposal 354 Acres
Google
37°52'25.86" N 121°11'16.73" W
May 2002
Eye alt 3386 ft

Daily and Alternative Daily Cover

- Dirt
- Tarps
- Construction and Demolition (C&D)
- Greenwaste
- Sludge
- Tire Shreds
- Foam/Cellophane

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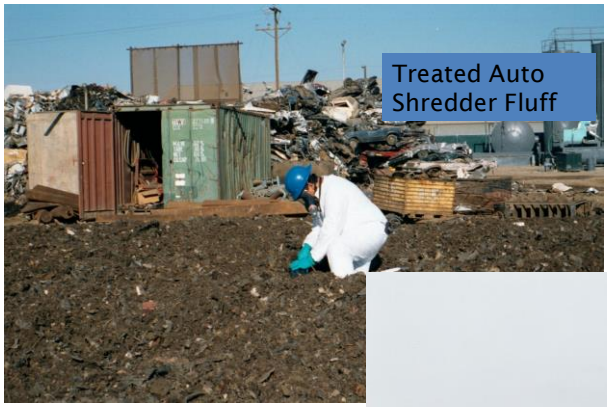
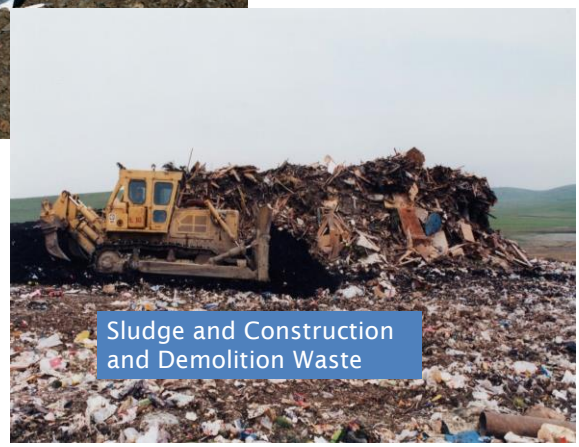
Active or Working Face

Most Landfills Operate 7 Days a Week, 365 Days a Year!!!!

Walking Floor Trucks


Treated Auto
Shredder Fluff

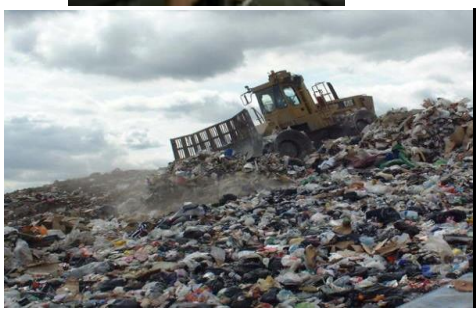

Sludge and Construction
and Demolition Waste

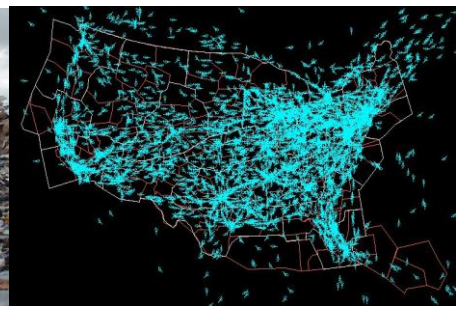

Greenwaste Cover


Foam Cover

How Do Landfills Make $$

- Compaction
- Airspace

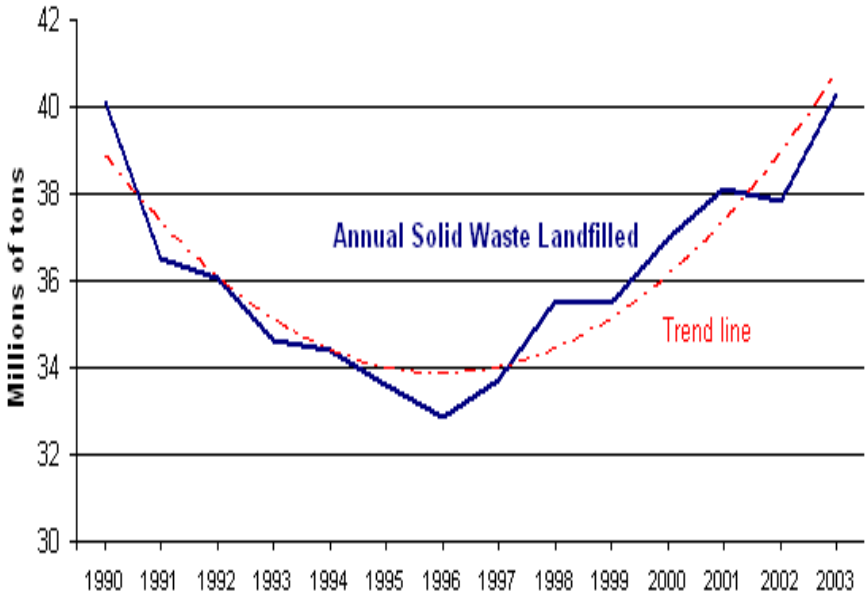




Waste Generated, Diverted and Disposed

- 88.2 million tons generated
  - 42.0 tons disposed
  - 46.2 tons diverted
- 52% generated was diverted

Path of Solid Waste



http://ciwmb.ca.gov/landfills/lfdata.htm

Waste Disposal By Sector Household

Household

- 17,309226 tons/yr
- 2.1lbs/person/day
- Leaves and Grass 10% of total

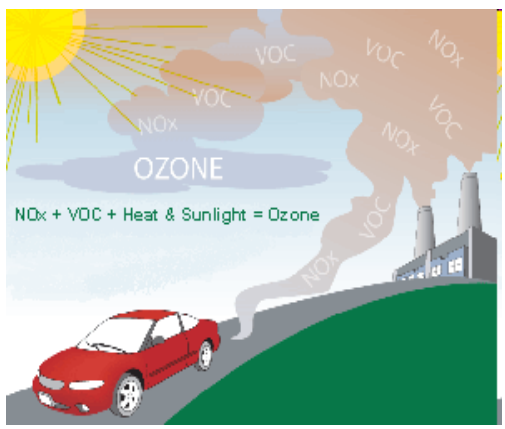
Waste Disposal
By Sector Business

Business

- 25,963,839 tons/yr
- 8.5 lbs/employee/day
- Paper 11% of total
- Retail Trade- Restaurants highest category

National Criteria Pollutants for Ambient Air

- Ozone
- Carbon Monoxide
- Nitrogen Dioxide
- Sulfur Dioxide
- Particulate Matter
- Lead



Primary Air Pollutants @ Landfills

- Methane (CH4)
- Non Methane Organic Compounds NMOC's
- Volatile Organics (VOCs)
- Toxics (HAPs & TACs)
- Odors (PUs)
- Particulate Matter (PM)
- CO2

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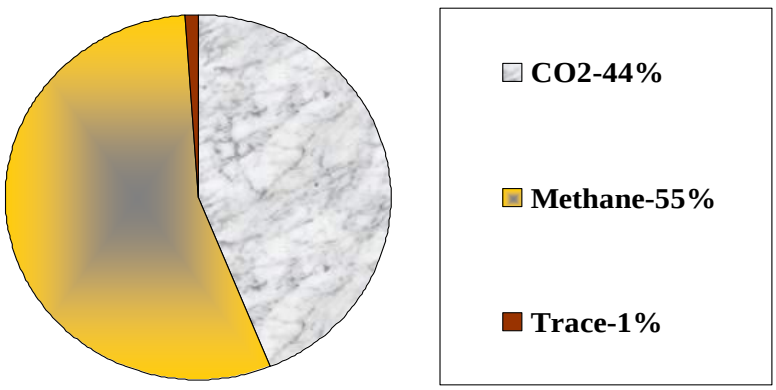
How Do We Capture Those Pollutants?

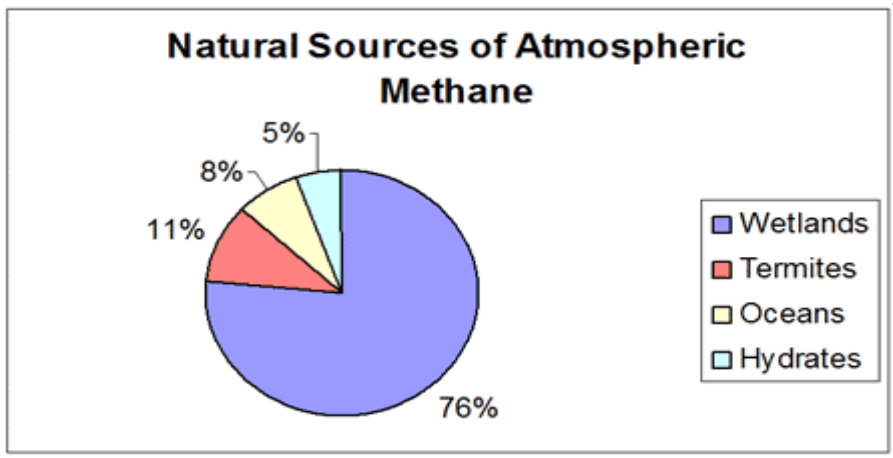
We Capture the Landfill Gas!!!

Breakdown of Landfill Gas

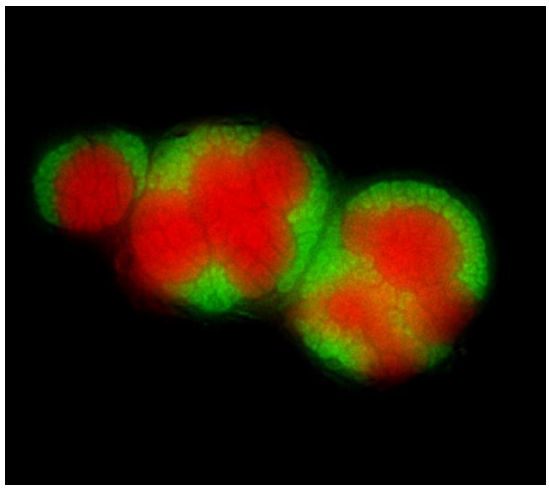


Methane Sources Other Than Landfills

Natural Methane Sources



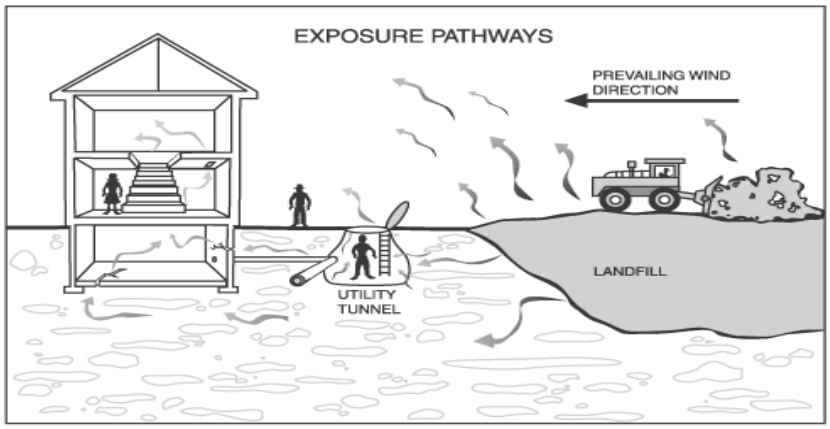
How is Methane Produced @ Landfills?



Methane Properties

- Colorless
- Odorless and tasteless
- Lighter than air
- Relatively insoluble in water
- Highly Explosive

Exposure Pathways

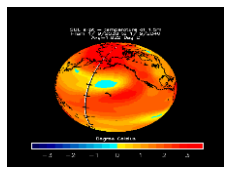


Methane (CH_4)

Explosive Hazard

Economic

Vegetation/Crop Damage



Global Warming

Effects of Methane/ Landfill Gas

Well Drilling In Neighborhood

Dying Vegetation

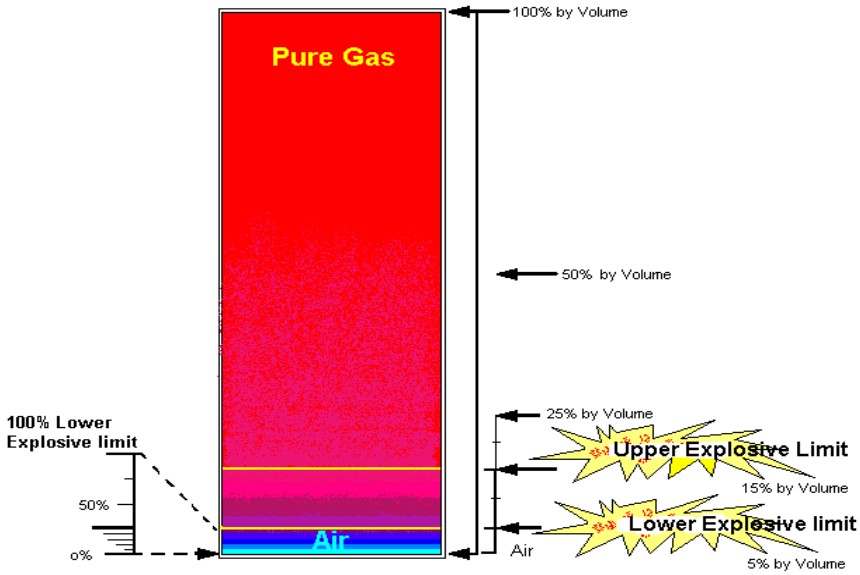
What Else is in Landfill Gas?

- Methane - 45 to 60 %
- CO_2 - 40 to 60 %
- N_2 - 2 to 5 %

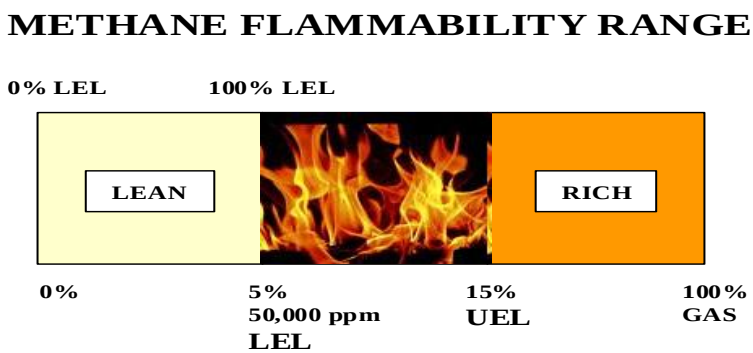
Trace amounts:

- O_2,
- ammonia,
- H_2,
- sulfur compounds,
- solvents,
- alcohols
- hydrocarbons

Upper and Lower Explosive Limits of Landfill Gas



Methane Explosive Limits



Methane
General Statistics

- ✓Landfill methane:
  - ✓40% of man-made emissions
  - ✓21 times the global warming impact of CO_2
  - ✓50 - 90% Recovery possible


Olinda Alpha Orange County

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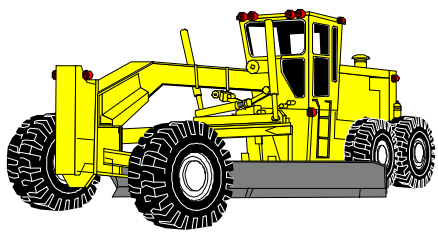
Landfill Gas Production
Timeline

- ✓Aerobic -- Days or months
- ✓Anaerobic -- After all the O_2 is gone
- ✓Methanogenic -- 6 to 18 months
- ✓Steady State -- 50 Years post-closure



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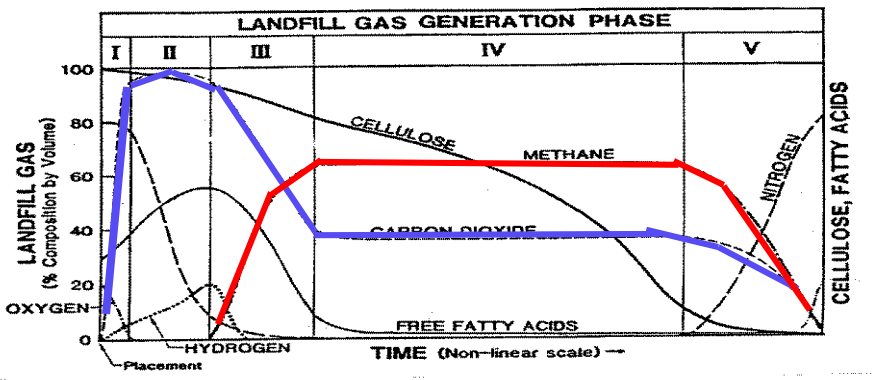
Overall Landfill Gas Timeline



SOURCE: Farquar and Rovers, 1973, as modified by Rees, 1980, and Augenstein & Pacey, 1991

Figure 2. Typical landfill gas generation pattern

Volatile Organic Compounds Key Notes

- **High Vapor Pressure**
- **Low Water Solubility**
- **Aids in Formation of Ozone**

Volatile Organic Compounds & Ozone

VOCs + NOx + Sunshine

=

Ozone

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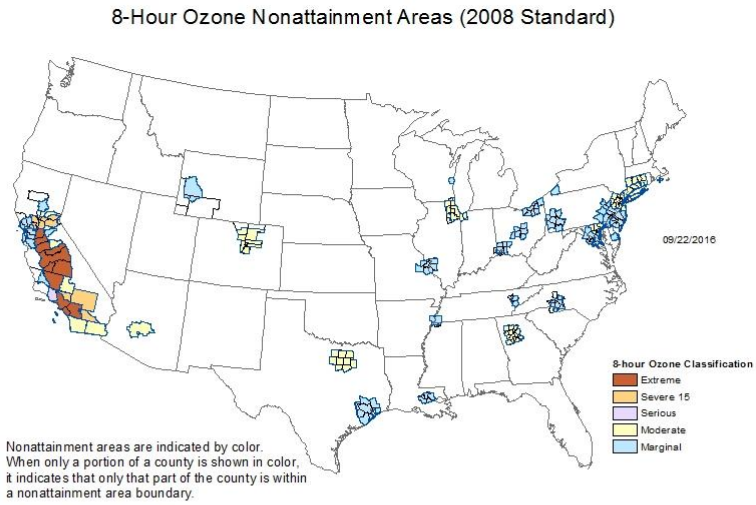
Do You Work in One of these Counties??



VOC's in Landfill Gas

- ✓13.6 to 35.8 Tons of VOCs per million tons of refuse
- ✓Vegetation damage


Sunshine Canyon, LA County

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Toxic Compounds

- ✓Thousands of chemicals
- ✓Hazardous Air Pollutants (Federal)
- ✓Toxic Air Contaminants (California)
- ✓HAPs are TACs

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LFG Concentration Statistics

Concentration - PPBV

Compound	Contamination Detected *	Median	Ave **	Max **
Perchloroethylene	241	38	1,100	45,000
Trichloroethylene	228	30	840	11,000
Methylene Chloride	197	37	4,800	160,000
1,1,1-Trichloroethane	180	2 U ***	650	96,000
Benzene	180	132 U	2,500	480,000
Vinyl Chloride	160	106 U	2,200	72,000
Ethylene Dichloride	65	5.1 U	600	98,000
Chloroform	58	0.8 U	360	11,000
Carbon Tetrachloride	31	1.2 U	11	2,100
Ethylene Dibromide	24	0.3 U	4	660

* = Landfill Gas Sampling was Conducted on 340 Landfills.

** = Medians and Maximums of the Average Sampling from Sites.

*** = U - Means Non-Detected; The number shown is detection limit.

Odors (PU's)

- ✓Character
- ✓Intensity
- ✓Frequency
- ✓Duration
- ✓Individual Sensitivity

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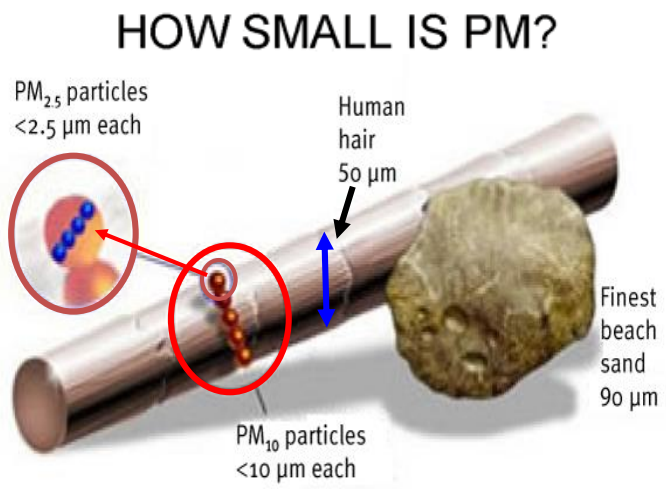
Odor Issues

Particulate Matter (PM)

- ✓Dust
  - ✓Soil
  - ✓Waste



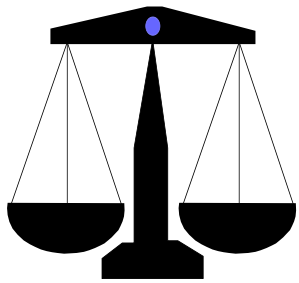
Violation?

Sources of Particulate Matter

Sources of Particulate Matter

Legal Requirements

- ✓Federal
- ✓State
- ✓Local
  - ✓Agency Rules



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Regulation & Standards

Oversight for air quality issues is mostly at the Air Agency level, however there are Federal standards as well:

- ✓**Title V of the CAA (40 CFR 70 and 71)**
- ✓**NSPS (40 CFR 60 Subpart WWW and Cc)**
- ✓**NSPS (40 CFR 60 Subpart XXX and Cf)**
- ✓**NESHAPS (40 CFR 63 Subpart AAAA)**

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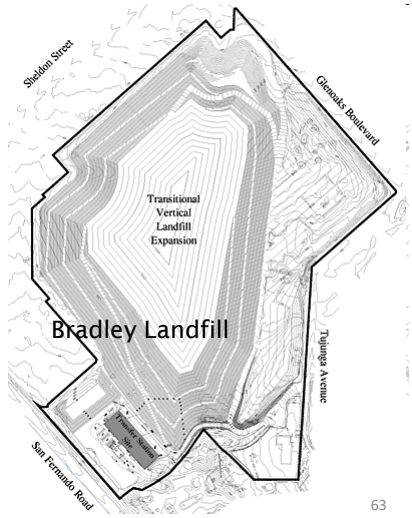
Clean Air Act - Title V

A landfill is subject to Title V if:

- **Design capacity is equal to or greater than 2.5 million Mg <u>and</u> 2.5 million m³**
- **Its uncontrolled emissions are greater than the Major Source thresholds**



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40CFR Part 60 Subpart WWW

Applies to MSW landfills constructed, modified or reconstructed <u>after</u> 05/30/1991

Landfills larger than 2.5 million Mg AND 2.5 million m³ AND NMOC emissions greater than 50 Mg/yr must install landfill gas collection and control system

Regulation includes requirements for NMOC emission determination (3 tiers), collection system placement, lfg control systems, lfg treatment, wellhead operating standards, surface monitoring, removal of GCCS, corrective actions, design plans, and reporting.

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40CFR Part 60 Subpart Cc

Requires States to enact regulations similar to WWW for MSW landfills constructed, modified or reconstructed on or before 05/30/1991 and accepted waste anytime on or after 11/08/87 or has additional capacity available for additional waste placement.

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40CFR Part 63 Subpart AAAA

Developed as part of the federal urban air toxics strategy.

Applies to MSW landfills that accepted waste since 11/08/87 or have additional capacity and that are or at a major source of HAPS or is an area source but has a design capacity greater than 2.5 million megagrams and 2.5 m^3 and NMOC emissions equal to or greater than 50 megagrams per year.

Requires compliance with WWW or Cc plus semi annual reports and a SSM plan.

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40CFR Part 60 Subpart XXX

Published in FR 08/29/16
Effective 10/28/16

Applies to MSW landfills constructed, modified or reconstructed after 7/17/14

Landfills larger than 2.5 million Mg AND 2.5 million m^3 AND NMOC emissions greater than 34 Mg/yr must install landfill gas collection and control system

Regulation includes requirements for NMOC emission determination (added Tier 4), exclusion of low lfg production areas, lfg treatment, wellhead operating standards, surface monitoring, removal of GCCS, corrective actions, design plans, SSM, and electronic reporting

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40CFR Part 60 Subpart Cf

Published in FR 08/29/16
Effective 10/28/16

Applies to MSW landfills constructed, modified or reconstructed on or before 7/17/14 (think WWW)

States must submit plan by May 30, 2017

Landfills larger than 2.5 million Mg AND 2.5 million m^3 AND NMOC emissions greater than 34 Mg/yr AND accepted waste after 11/8/87 must install landfill gas collection and control system

Regulation requires states to include all of the requirements of XXX but adds in allowances for closed or closing landfills.

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EPA RECONSIDERATION.

EPA Administrator issued letter on 5/5/17 announcing stay of Subparts XXX and Cf for 90 days. Published in FR on 5/31/17. Stay effective 5/31/17 to 8/29/17.

Stay extended for Subpart XXX on 8/29/18.

Stay was lifted by EPA at some point

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EPA RECONSIDERATION.

On 8/26/2019, EPA finalized modifications to Subpart Cf to extend state plan submittal date to 8/29/19 and lengthen EPA review timelines.

On 3/9/20, EPA issued a notice of failure to submit state plans.

Federal plan proposed on 8/22/19

States must either submit plans or accept federal plan.

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New Source Review (NSR) Considerations

Potentially applicable to any *new* or *modified* source

- **BACT - Best Available Control Technology, may be required on new or modified sources**
  - **Secondary Pollutants**
  - **Toxics (TBACT)**
- **LAER for nonattainment NSR**

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New Source Review (NSR) Considerations Cont.

- **May result in more stringent requirements than those in NSPS or Agency Rules**
  - **Permitting authority will study feasibility (Achieved-in-Practice, Technologically Available, Alternate Basic Equipment)**
  - **Cost effectiveness**

New Source Review (NSR) Considerations Cont.

- Public Noticing – Projects with significant environmental impacts
  - Annual and daily emissions thresholds
  - Triggering offsets
  - Triggering Major Modification
  - CEQA Concerns
  - Environmental Justice

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New Source Review (NSR) Considerations Cont.

- Offsets – Availability and Cost concerns
- Monitoring, Recordkeeping, Reporting (MRR)
- Source Testing

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How are Emissions Assessed?

VOC Emissions:

- ✓Samples from well sites Mass-balance calculations (SOx and HCl)
- ✓ LandGEM - AP-42 based methodology (Section2.4.4.1)

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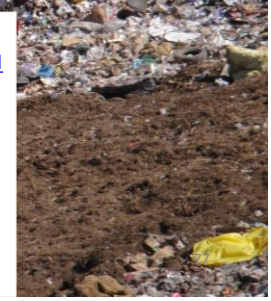
Emissions Assessment Cont.

PM10 Emissions:
AP-42 Drop Equation (Section 13.2.4.3)
Maximum limits on earth moved for daily cover
AP-42 on road and off road vehicle emissions

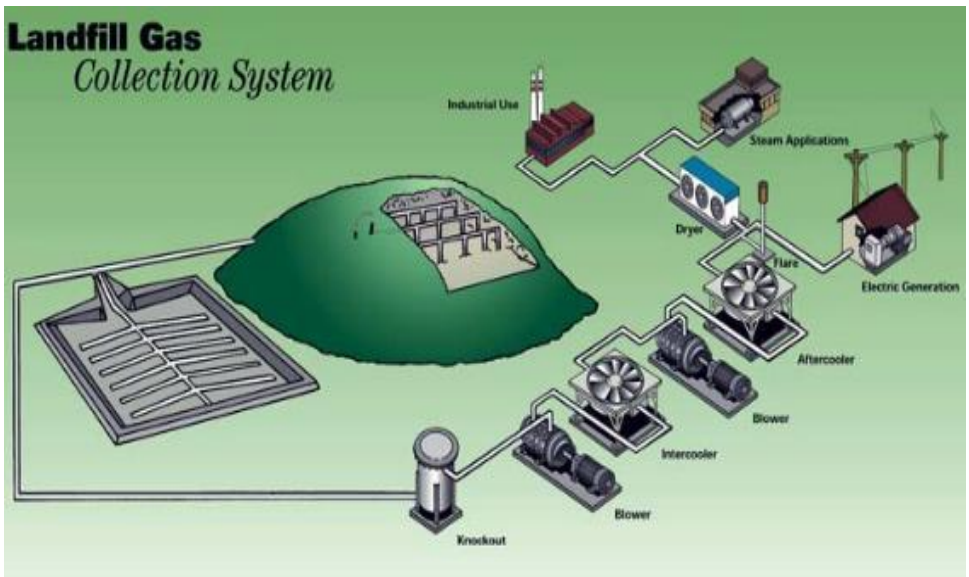
LANDGEM Tool for Calculating Annual Emissions Version 3.02



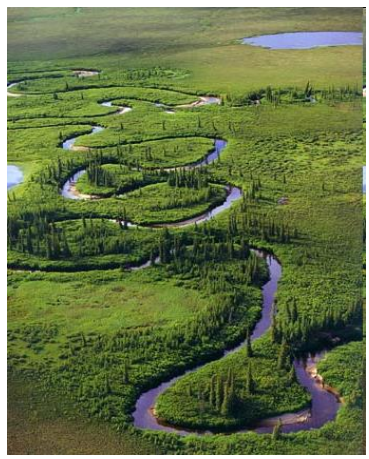
http://www.epa.gov/ttn/catc/products.html#/software

National Technical Information Services
5285 Port Royal Road
Springfield, VA 22161
(703) 487-4650

Gas Collection



LFG - Movement



Monitoring and Movement

- ✓Gas follows the path of least resistance
- ✓Moves over, under, and around obstacles in its path
- ✓Dilutes as it travels away from source
- ✓Pressure gradients

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LFG – Monitoring Systems

- ✓Subsurface perimeter
- ✓Surface emissions

- ✓Enclosed space (Buildings)

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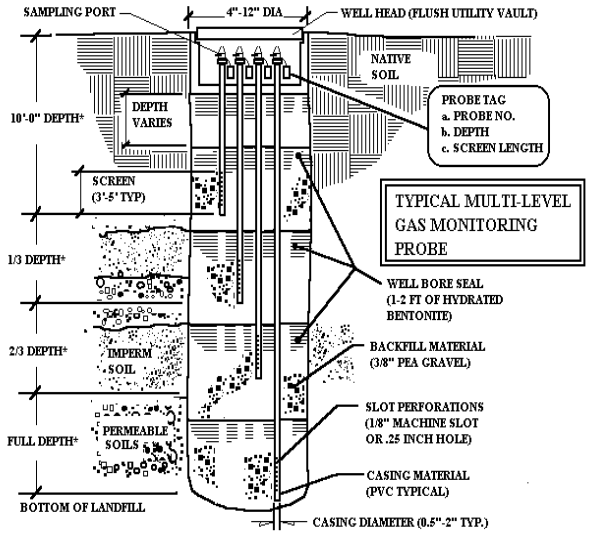
Typical Monitoring Well Diagram



Typical Monitoring Wells

Installation of a Three Tier Probe

Monitoring Probe with Cap

Well Installation

Gas Collection & Control System Design Criteria

- ✓Expected ambient and gas temperature
- ✓Above/below ground header system
- ✓Future requirements to bury system
- ✓Seasonal conditions to bury system
- ✓Existing odor problems

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Gas Collection & Control System Design Criteria

- ✓Landfill location and type
- ✓Geometry, geography, topography, hydrology, geology
- ✓Existing landfill design and history
- ✓ Refuse depth to surroundings
- ✓ Existing permit conditions

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Gas Collection & Control System Design Criteria

- ✓Tonnage chronology
- ✓Landfill surface cover material (past and present)
- ✓Placement and compaction of refuse
- ✓Leachate presence and control
- ✓Groundwater monitoring network

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Gas Collection & Control System Design Criteria

- ✓Utility access
- ✓Sewer, electrical, water, cable, etc
- ✓Condensate drainage
- ✓Slopes, piping, and grade

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Gas Collection & Control System Design Criteria

Other Considerations?

Various Collection Systems

- ✓Horizontal trench
- ✓Passive collection
- ✓Active vertical well

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Active Control System

- ✓Perimeter air injection trenches
- ✓Perimiter extraction trenches
- ✓Perimeter extraction wells
- ✓Perimeter air injection wells

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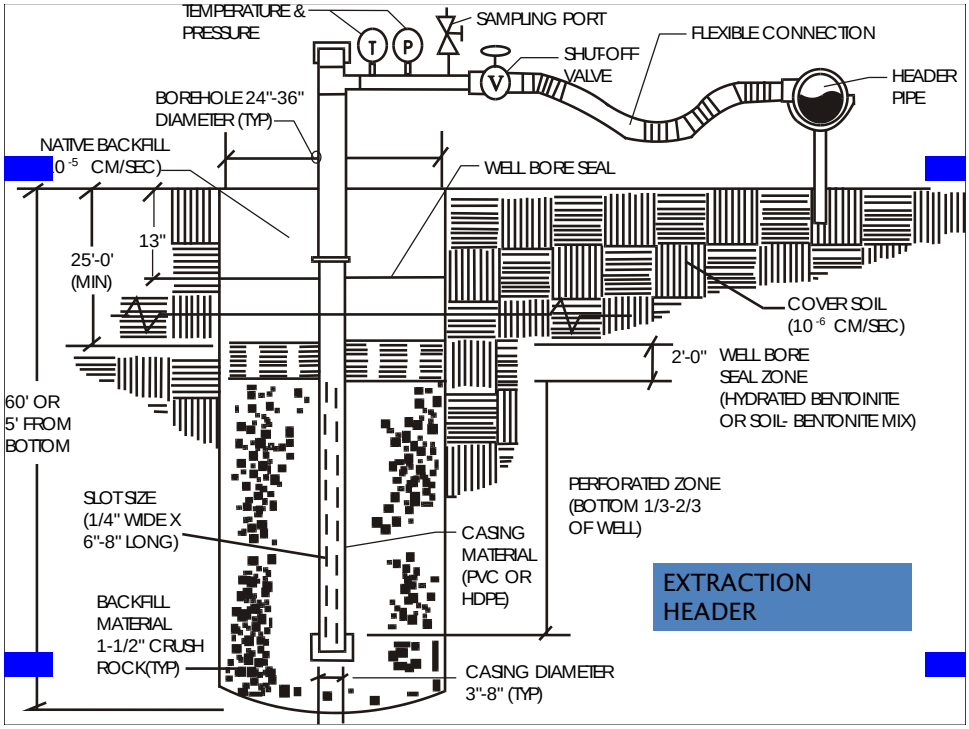
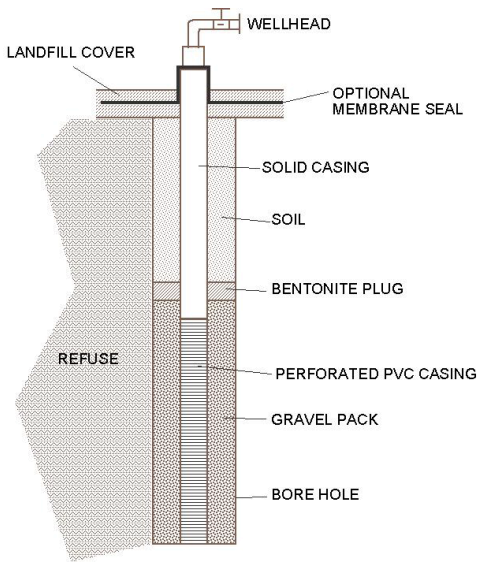
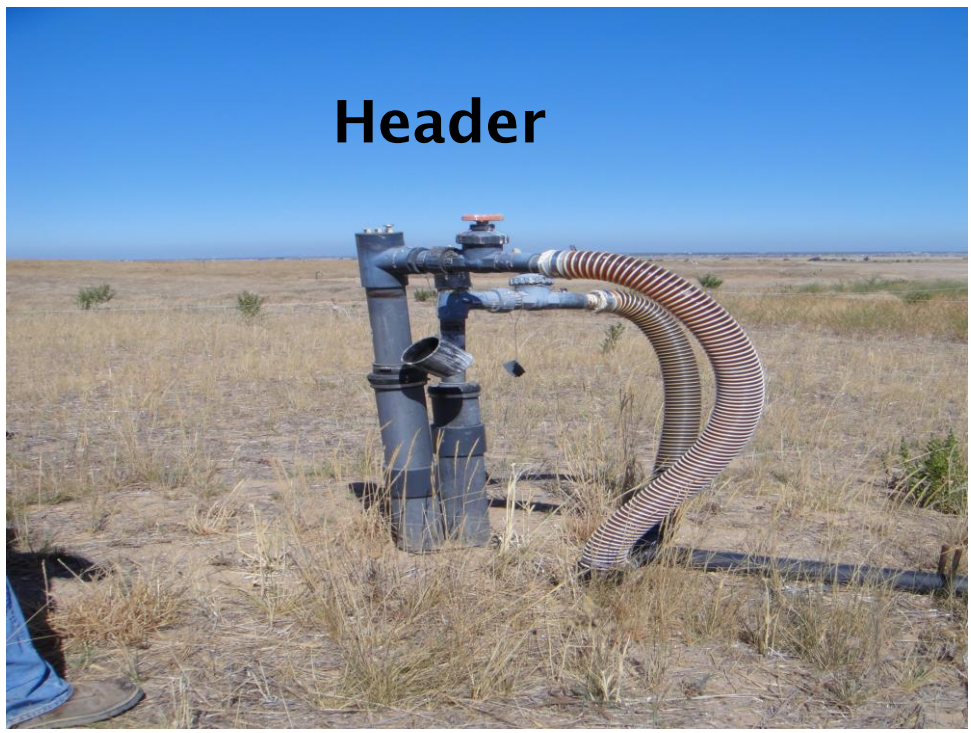


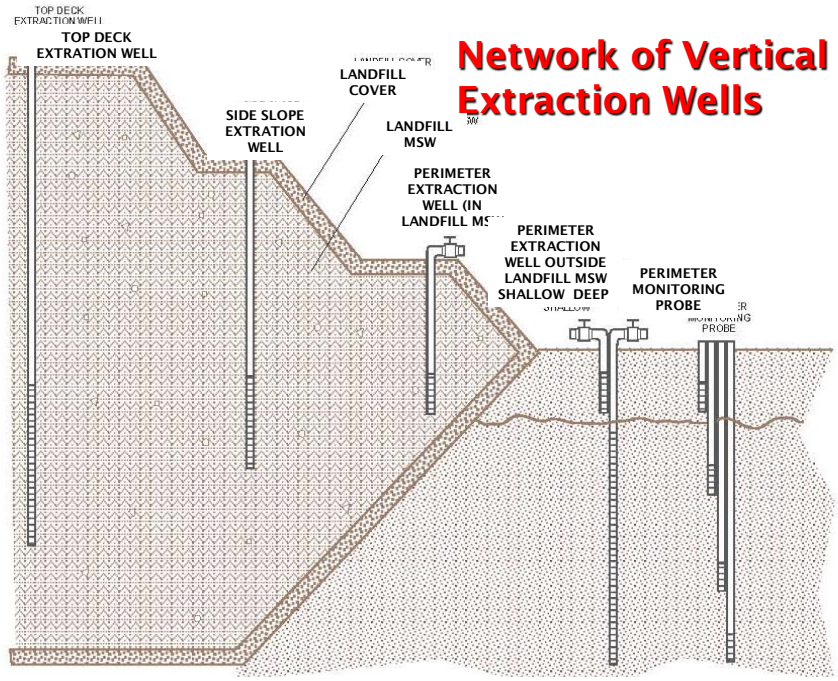
Extraction Well



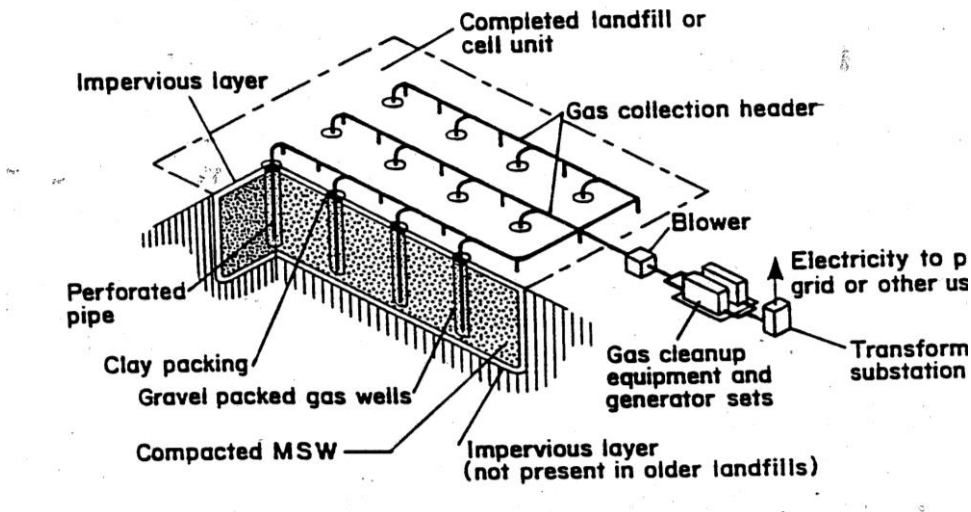

Gas Collection Header


E.W.38
Sampling Ports on some Headers

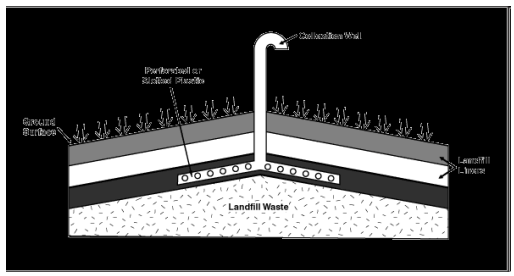

Header



Active Vertical Well System

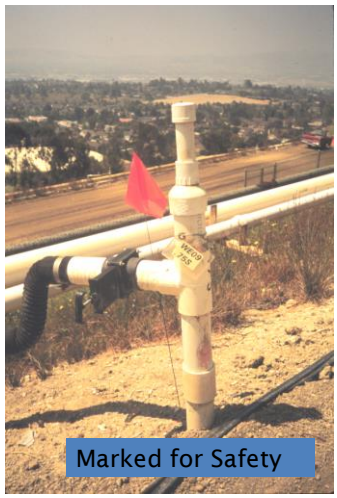


Passive Control System



✓Relief vents

✓Perimeter barrier trenches



Erosion Issues at
Landfills

Landfill Gas Manifolds Everywhere

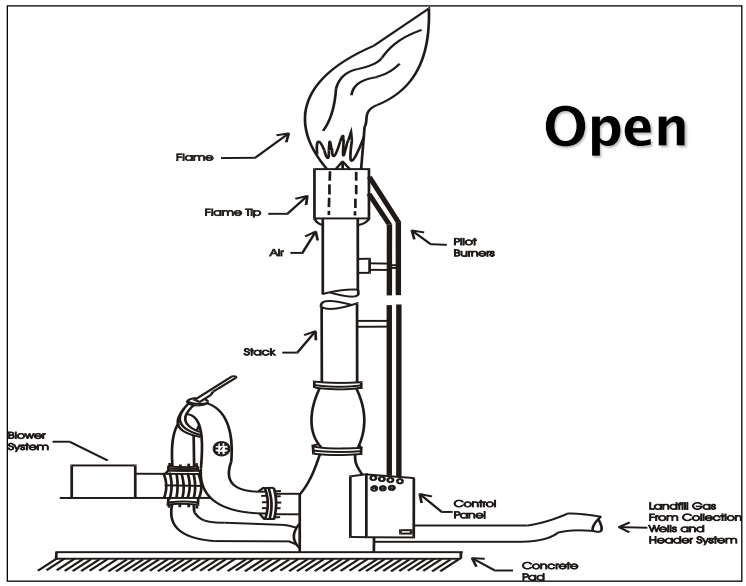
Gas Sample with Summa Canisters

Control Measures

Flares

Energy production

Flare Types



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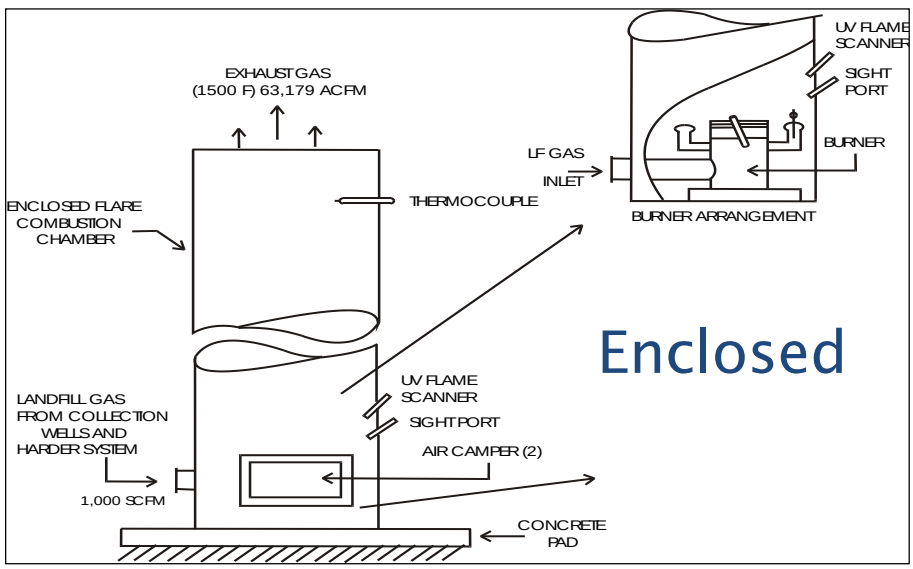
Flare Types



Flare Types Continued

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Blowers

Energy Production

- ✓ Internal combustion engine
- ✓ Turbines
- ✓ Boilers
- ✓ Pipeline
- ✓ Fuel Cell

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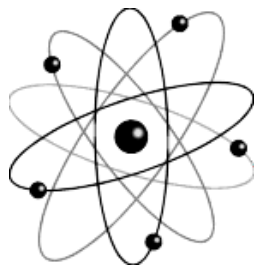
Methane - Energy Content

	BTU / ft^3
· CH4 maximum –	1,013
· Pipeline -	900
· LFG Avg. –	300-500



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Electricity Generation Technology

	IC Engines	Turbines	Boilers
Advantages	* Low cost * High efficiency * Common technology	* Corrosion resistant * Low O&M costs * Small physical size * Low Nox emissions	* Corrosion resistant * Can handle gas Composition variations * Low NOx emissions
Disadvantages	* Problems due to PM buildup * Corrosion of engine Parts and catalysts * High Nox emissions	* Inefficient at partial load * High parasitic loads Due to high compression req. * High capital costs	* Innefficient at smaller sizes * Requires large amounts of clean water


Leachate Condensate Tank


Leachate Collection Using Vault Access

Secondary Air Pollutants

NOx

Toxics

SOx

PM

CO

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Methane Monitoring Instruments

- ✓Infrared detector (GEM 2000)
- ✓Catalytic oxidation detector (%LEL)
- ✓Thermal conductivity meter (% Gas)
- ✓Flame Ionization Detector (FID)
- ✓Photo Ionization Detector (PID)

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Monitoring Equipment

Photoionization Detector

Foxboro
Flame Ionization Detector
(0-1000 PPM)
$4,000

GMI CGI Thermal Conductive (% Gas)
Combustible Gas Indicator (% LEL)
with CO and O2 Sensors

GEM 2000 Infrared and
CGI Detection

FID/PID

Photoionzation

- Advantages
  - Good with low level detection
  - Is not temperature dependent
- Disadvantages
  - Not good in a high methane concentration environment
  - Must have proper eV lamp (13.0)
  - Wears out faster
  - Sensitive to humidity/dust
  - Electromagnetic interference

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Combustible Gas Indicator

Advantages

- Small and portable
- Internal battery
- Thermal mode for high or low O_2
- Easy to use
- "Safe"

Disadvantages

- Temperature dependant
- Calibration gas impacts results
- Catalytic mode problem with O_2
- Leaded gas, halogens, sulfur, silicon can harm filament
- CO_2 fouls O_2 cell

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Flame Ionization Detectors

Advantages

- Fast response
- Sensitivity (1 - 100,000 ppm)
- Accuracy
- Variety of probes
- Reads LEL in low O_2 environment

Disadvantages

- Short battery life
- False positives
- Few portable models
- Calibration gas impacts
- EXPENSIVE!

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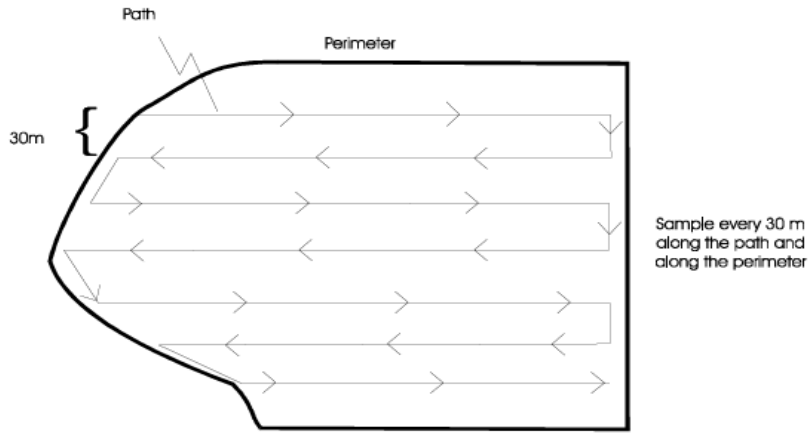
Total Vapor Analyzer Combo FID/PID

What Do We Do with These Instruments?

Monitoring A Perimeter Well

Traverse for Monitoring Methane Concentrations



Ideal Land Use for a Closed Landfill???

Inspections

- ✓Pre-inspection
  - ✓File review
  - ✓Rule review
  - ✓Inspection forms
  - ✓Equipment check
- ✓Inspection
  - ✓Pre-entry and entry
  - ✓Pre-inspection meeting
  - ✓Facility procedures
- ✓Post inspection

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Safety

- ✓Hard hat
- ✓Eye protection
- ✓Hearing protection
- ✓Safety boots
- ✓Monitoring device
- ✓Safety vest

Pre-Inspection General Guidelines

- ✓Regulation review
- ✓Equipment check
- ✓Pre-entry and entry
- ✓Pre-inspection meeting
- ✓Permit check

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Pre-Inspection Meeting

- ✓Facility name and ownership
- ✓Address w/ city and zip
- ✓Contact name and title
- ✓Phone number w/area code
- ✓Production rate
- ✓Operating schedule
- ✓Operation season
- ✓Date of last source test
- ✓Fuel usage & sulfur content

What's new?

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Inspection Report

- ✓Description of the facility and process(es)
- ✓Flowchart with equipment location and emission points
- ✓Process diagram (materials handled, flow rates, temperature, pressure)
- ✓Statement as to compliance/ non-compliance
- ✓Recommendations

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GUARD-IT


SYSTEM OVERVIEW SCREEN
IC ENGINE 4
IC ENGINE 5
Red Blinking Lights?

Control Device

- ✓Are there any visible leaks?

- ✓Is it functioning?
- ✓Can the device handle the job?

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Subsystem

- ✓What is the ultimate fate of captured or concentrated emissions?

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The End!!

Time for the Field Trip