BIOREACTOR BASICS

NY SWANA BIOREACTOR SEMINAR

Albany, New York

Wednesday, November 8, 2006

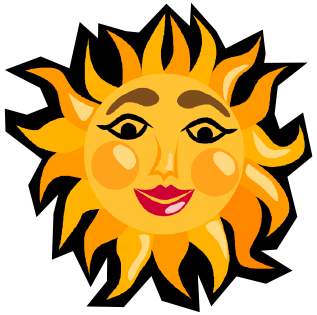
By Peter Kuniholm, PE
SCS Engineers
Valley Cottage, NY

TOPICS FOR DISCUSSION

- Landfill History 101
- Past & Future Concepts
- Bioreactor - Treatment
- Decomposition Process
- Landfill Gas Issues
- Waste Density & Optimum Consolidation
- Leachate Recirculation Design
- Aerobic and Hybrid systems
- Basic Economics

HISTORIC WASTE DISPOSAL

Village



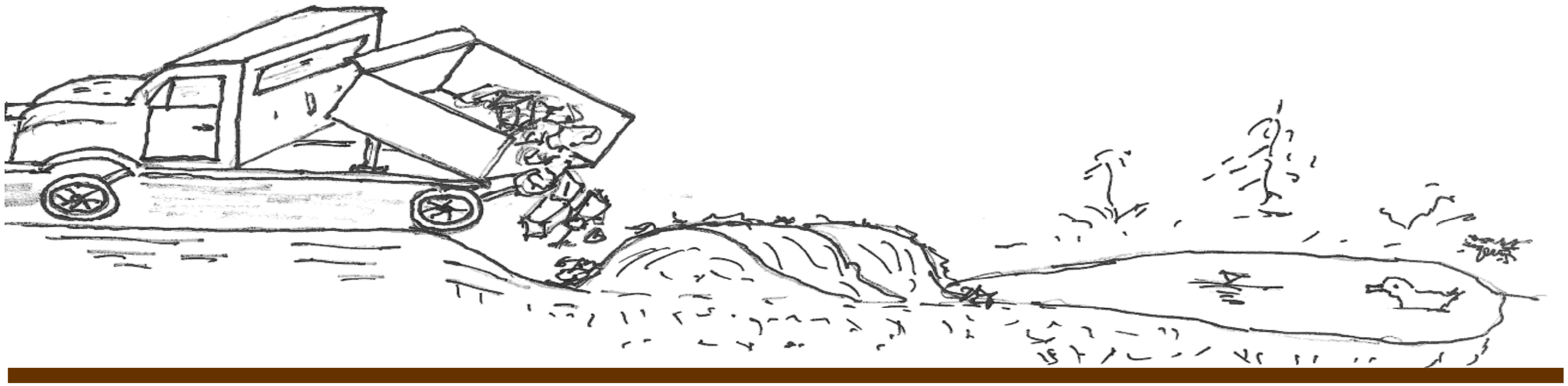
“Natural, Organic”

Decomposition

IN THE "OLD DAYS"

- ***A dump, is a dump, is a dump!***

- "Just put it near the Town line on some cheap land; fill in the swamp."



NOT TOO LONG AGO

- *Problem*
- Ground water pollution from leaking or unlined landfills.
- *Solutions*
- Close all unlined landfills
- Line all new landfills
- Prevent formation of leachable pollutants with water-tight caps (DRY TOMB!)

PROBLEM WITH TRYING TO PREVENT LEACHATE POLLUTANTS

PROBLEMS:

1. Incoming waste contains moisture
2. DECOMPOSITION OCCURS SLOWLY
3. Leachable contaminants remain in the landfill

SOLUTIONS:

4. Accelerated decomposition is beneficial.
5. Move toward organics waste treatment!
6. Reduce mobile contaminants faster.

PAST AND FUTURE CONCEPTS

Dump

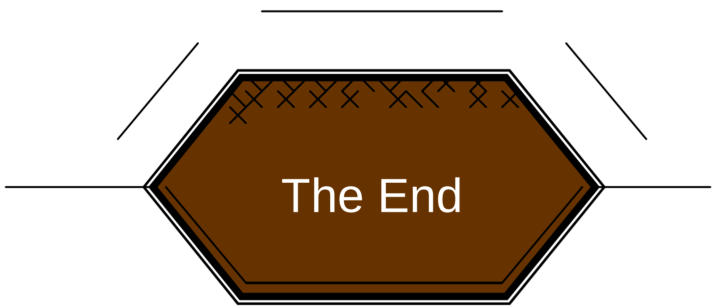
and

Fill

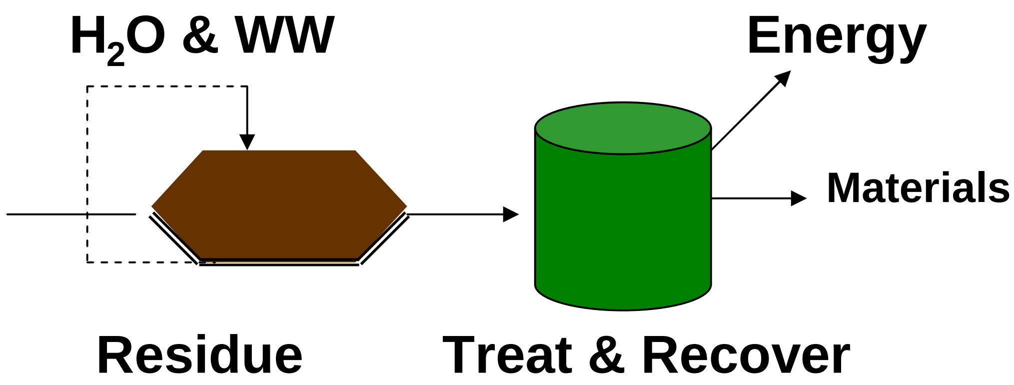
Treat

and

Re-Use



Landfill



Eco-Complex

LANDFILL AS TREATMENT
BIO- REACTOR

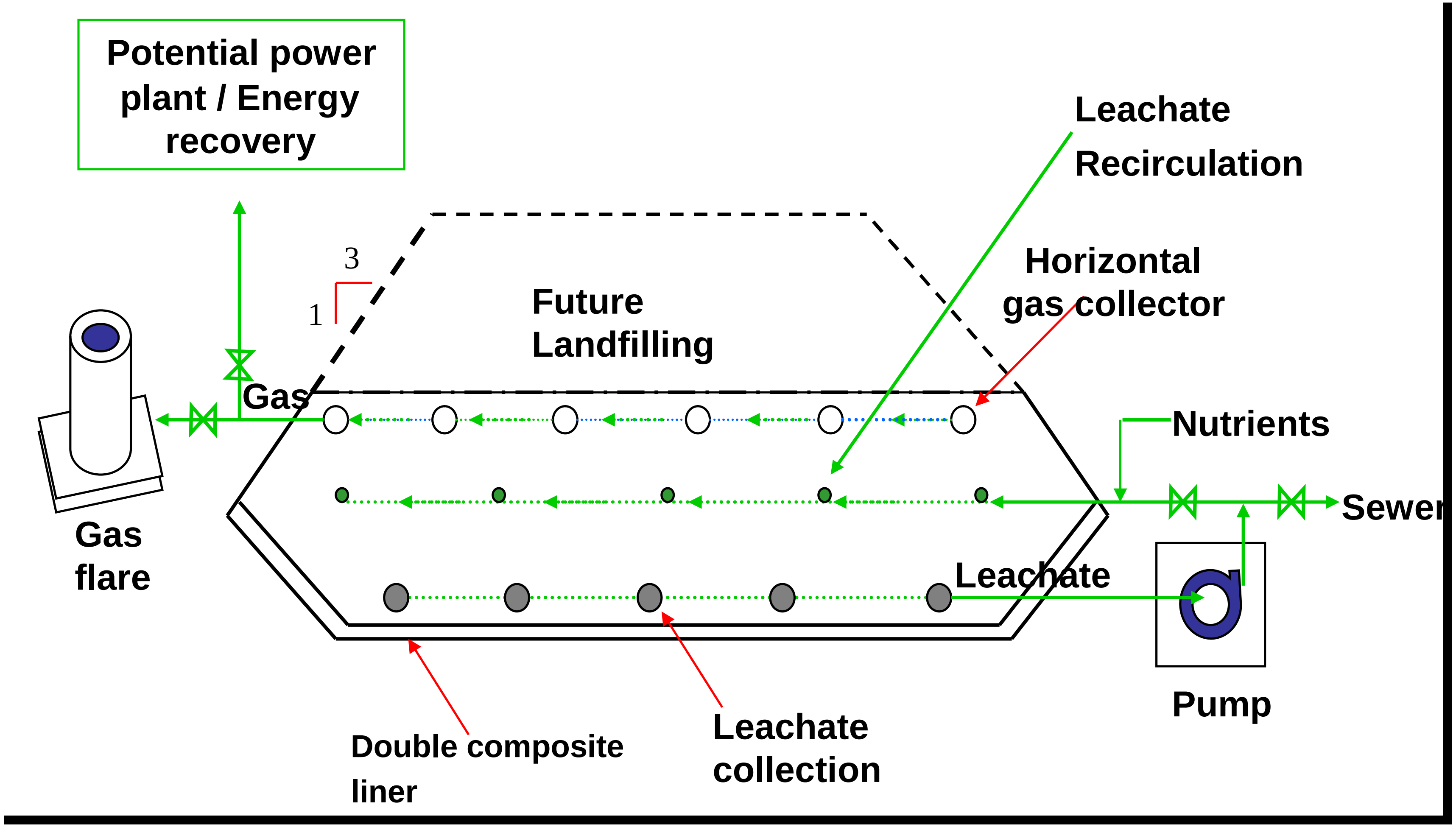
Types

- Aerobic
- Anaerobic
- Hybrid

Common Key Features

- Microbiologic Process
- Organic Fraction Treatment
- Optimal Controlled Moisture Content
- Accelerated Decomposition
- Reduce Contaminants in Leachate
- Reduce Volume of Waste

BASIC ANAEROBIC BIOREACTOR LANDFILL



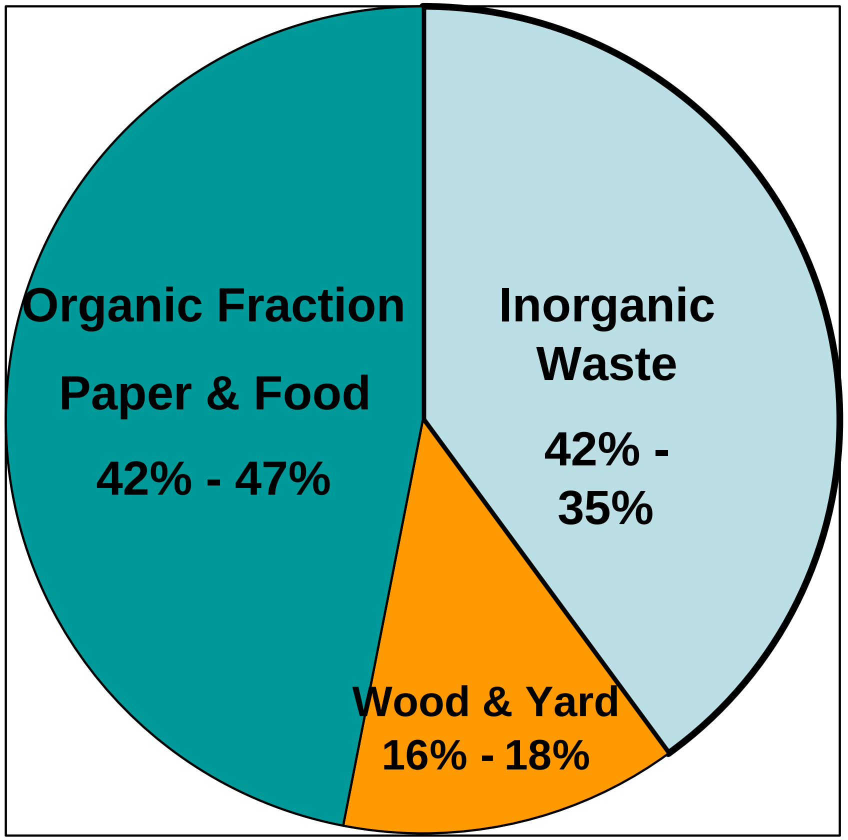
ADVANTAGES

- Bio-Stabilization – years vs. decades
- Lower waste toxicity & mobility
- Reduce Leachate disposal cost
- Gain 15-30 % air space volume
- Generate more LFG
- Reduce post closure care

CONSIDERATIONS AND CAUTIONS!

- Need more LFG collection /control
- Odor Potential
- Stability Issues
- Surface Seeps
- Fires – aerobic
- Additional Initial Cost
- Additional Monitoring & Operations

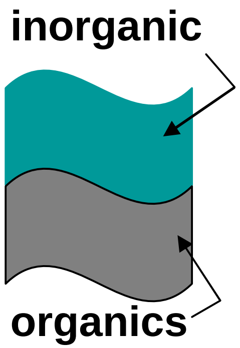
READILY DECOMPOSABLE FRACTION



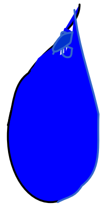
	Total	Net of Recycling
Paper	35%	26%
Yard	12%	8%
Food	12%	16%
Plastics	11%	16%
Metal	8%	7%
Glass	5%	6%
Wood	6%	8%
R, L, T	7%	9%
Other	4%	4%
	100%	100%

ANAEROBIC PROCESSES

Organic Waste fraction



+ Water



ANAEROBIC MICRO-ORGANISMS

Methane + Carbon Dioxide

(or Landfill Gas)

BIO-CHEMICAL REACTIONS

$$C_6H_{10}O_5 + H_2O = 3\,CO_2 + 3\,CH_4$$

Simplified to:

$$C + H_2O = 1/2\,CO_2 + 1/2\,CH_4$$

LANDFILL GAS REQUIREMENTS FOR BIOREACTORS

1. Prepare LFG system for additional gas
2. Use horizontal collectors above/offset from LRS
3. LFG well pumps may be needed
4. Monitor H_2S (Avoid C&D Fines)
5. Avoid impermeable (clayey) daily cover soil
6. Provide perimeter leachate & gas movement

Odor Potential = Key Issue

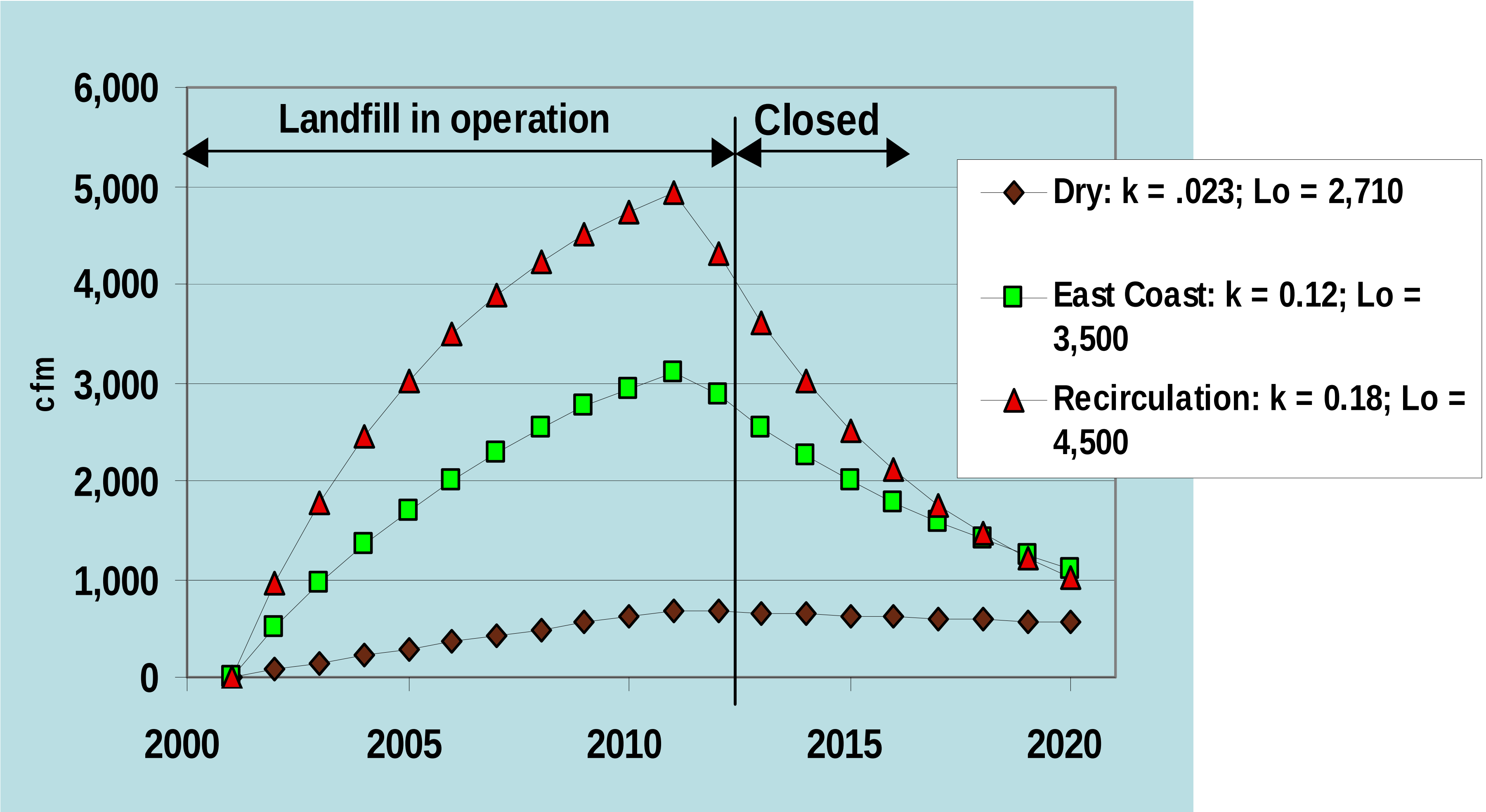
OPTIMIZATION FACTORS

- **Maximum LFG Production**
- **Sufficient *Excess Moisture***
- **Waste *Contact* with Moisture**
- **Active Bio-logic Population**
- ***Movement* of Water / Gas / Organisms**

OPTIMUM LANDFILL GAS YIELD

Stoichiometric Max. Yield		**=**	**200-230 L-CH_4/Kg**
EPA LandGEM	**L_o**	**=**	**6,600 CF/Ton Refuse**
For 70% Biodegradable	**L_o**	**=**	**4,620 CF/Ton Refuse**
Optimum Bioreactor	**L_o**	**=**	**4,500 CF/Ton Refuse**

TYPICAL GAS GENERATION CURVES



LANDFILL GAS REMOVED & WASTE DENSITY INCREASE

10 year	MSW wet tons	Total LFG generation (ft3)	Tons LFG		LFG Removed (tons)	% Removed	In-place waste density
			CH4	CO2			
Dry	3,575,000	2,243,227,159.0	23,203	63,808	87,011	2.4%	1,332
East Coast	3,575,000	11,749,216,528.0	121,529	334,204	455,733	12.7%	1,466
Recirculation	3,575,000	19,852,110,469.0	205,342	564,689	770,031	21.5%	1,580

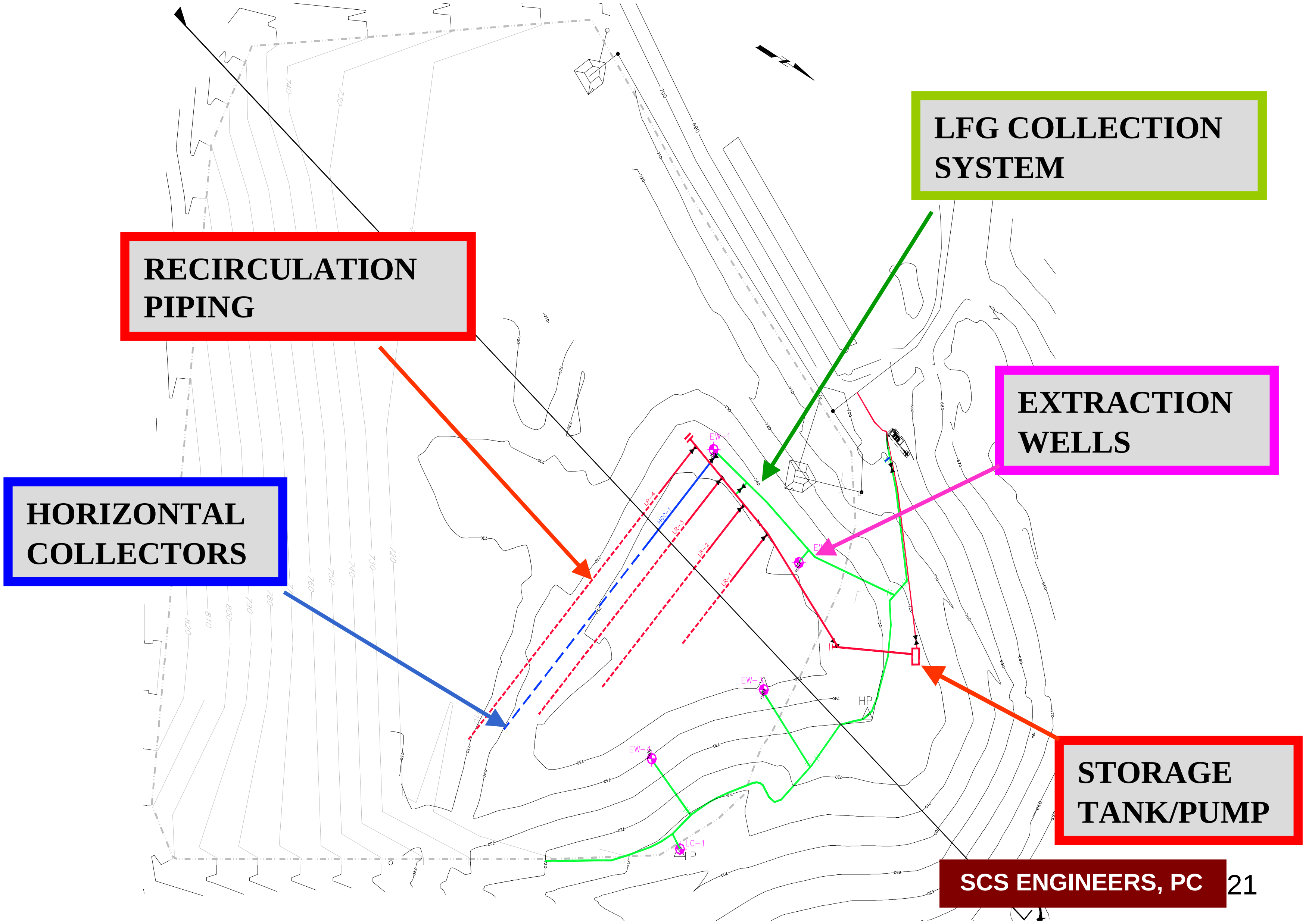
20 year	MSW wet tons	Total LFG generation (ft3)	Tons LFG		LFG Removed (tons)	% Removed	In-place waste density
			CH4	CO2			
Dry	3,575,000	5,488,637,011	56,772	156,123	212,895	6.0%	1,377
East Coast	3,575,000	21,528,027,840	222,677	612,360	835,037	23.4%	1,604
Recirculation	3,575,000	32,477,361,724	335,932	923,812	1,259,744	35.2%	1,758

Initial Density 1300 #/cy

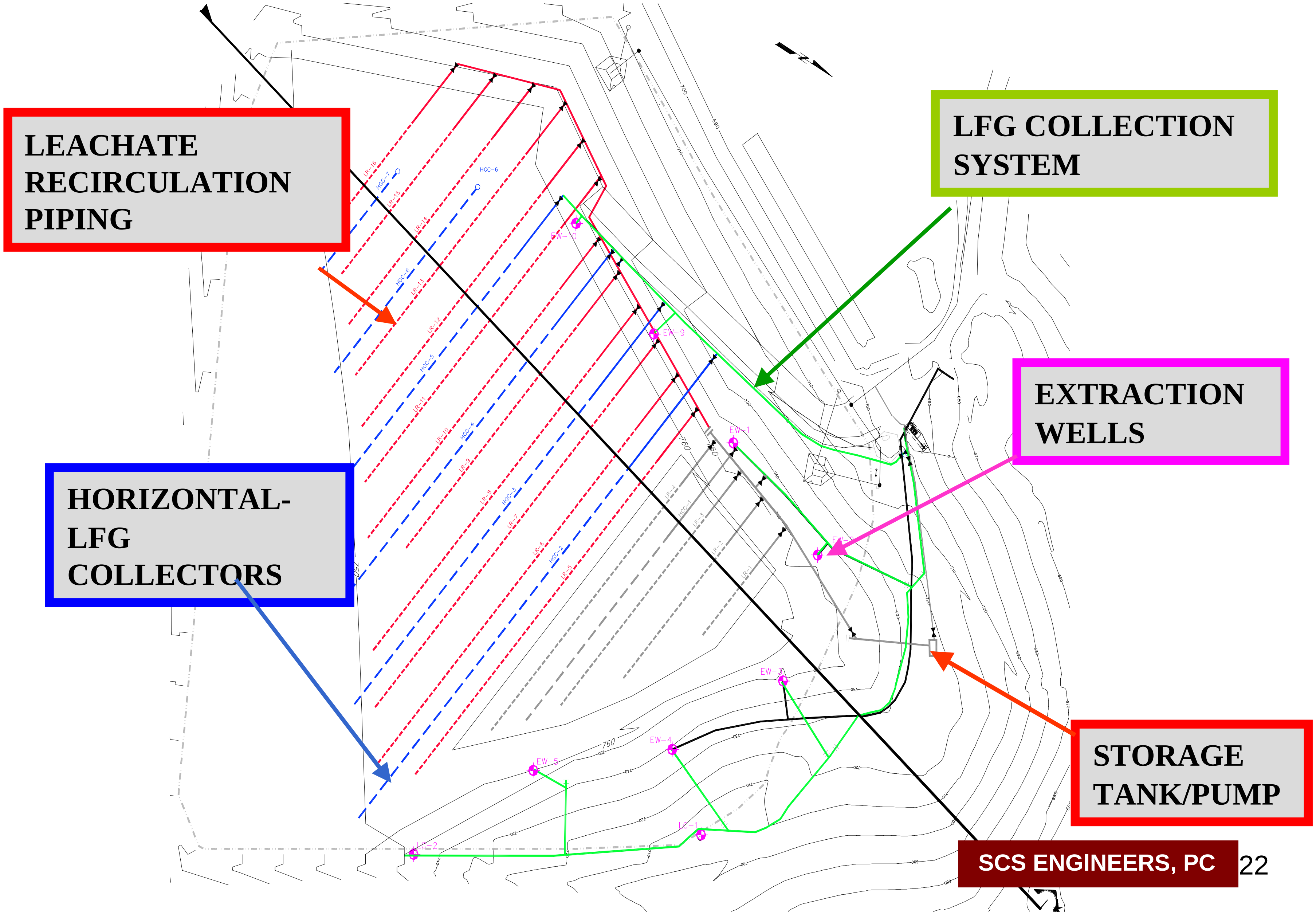
OPTIMUM DECOMPOSITION & CONSOLIDATION

- **Maximum - 35% (by weight)**
- **Maximum Density / Air Space, Depends on:**
  - **LFG Removal**
  - **Waste Matrix**
  - **Moisture Distribution**
  - **Landfill Height / Weight**
- **Actual Airspace Increase less than maximum**

Leachate Recirculation System - Phase 1

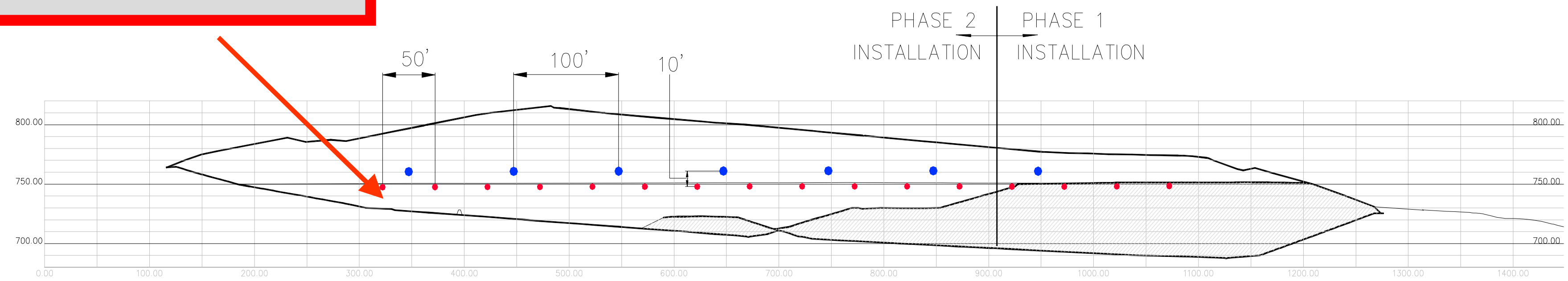


Leachate Recirculation System Phase II



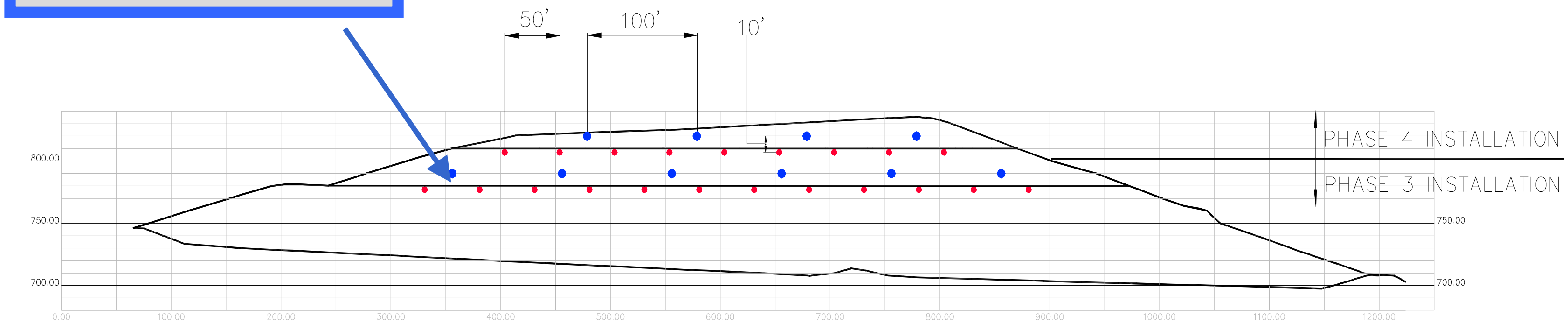
Landfill Sections

RECIRCULATION PIPING

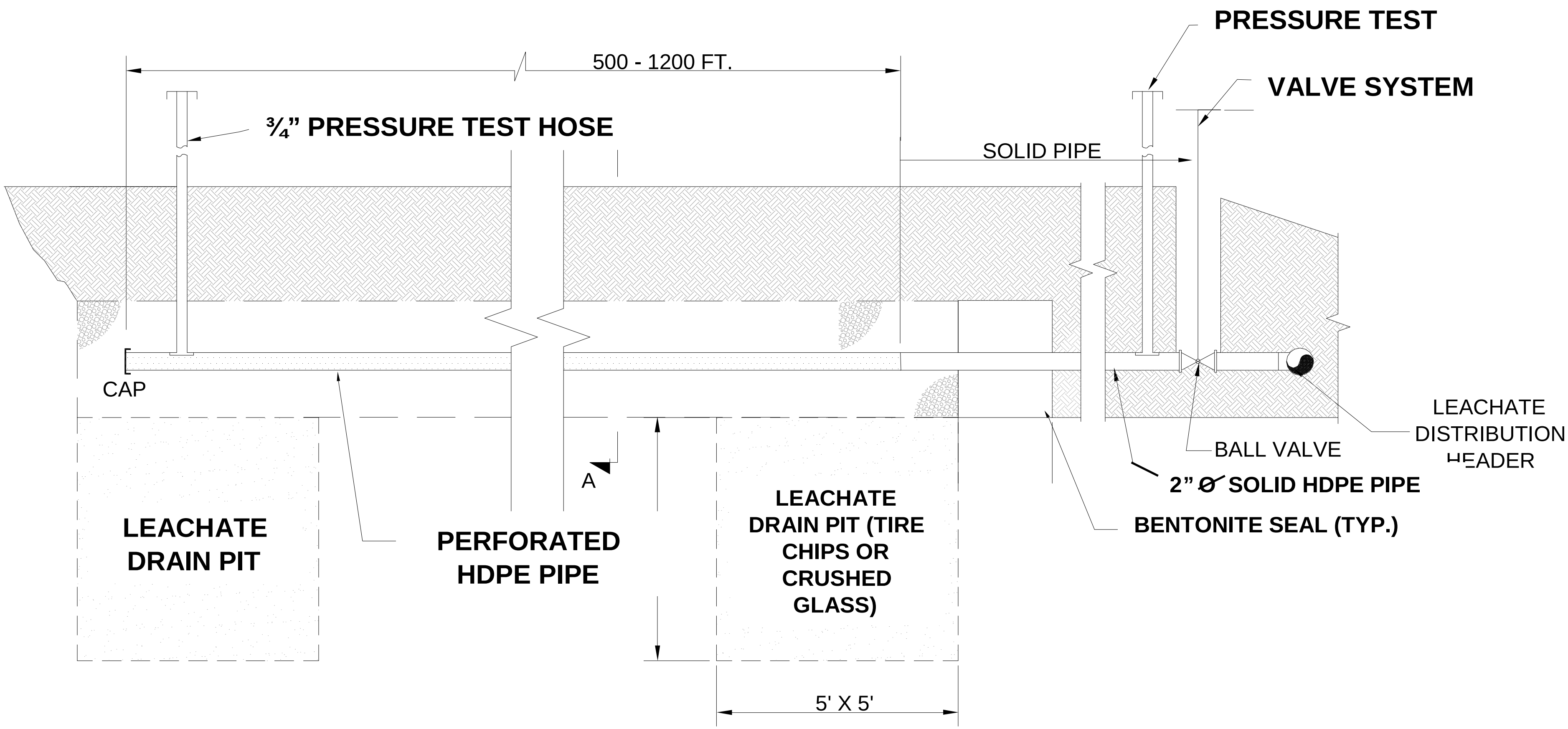


Phase 1 and 2 Installation

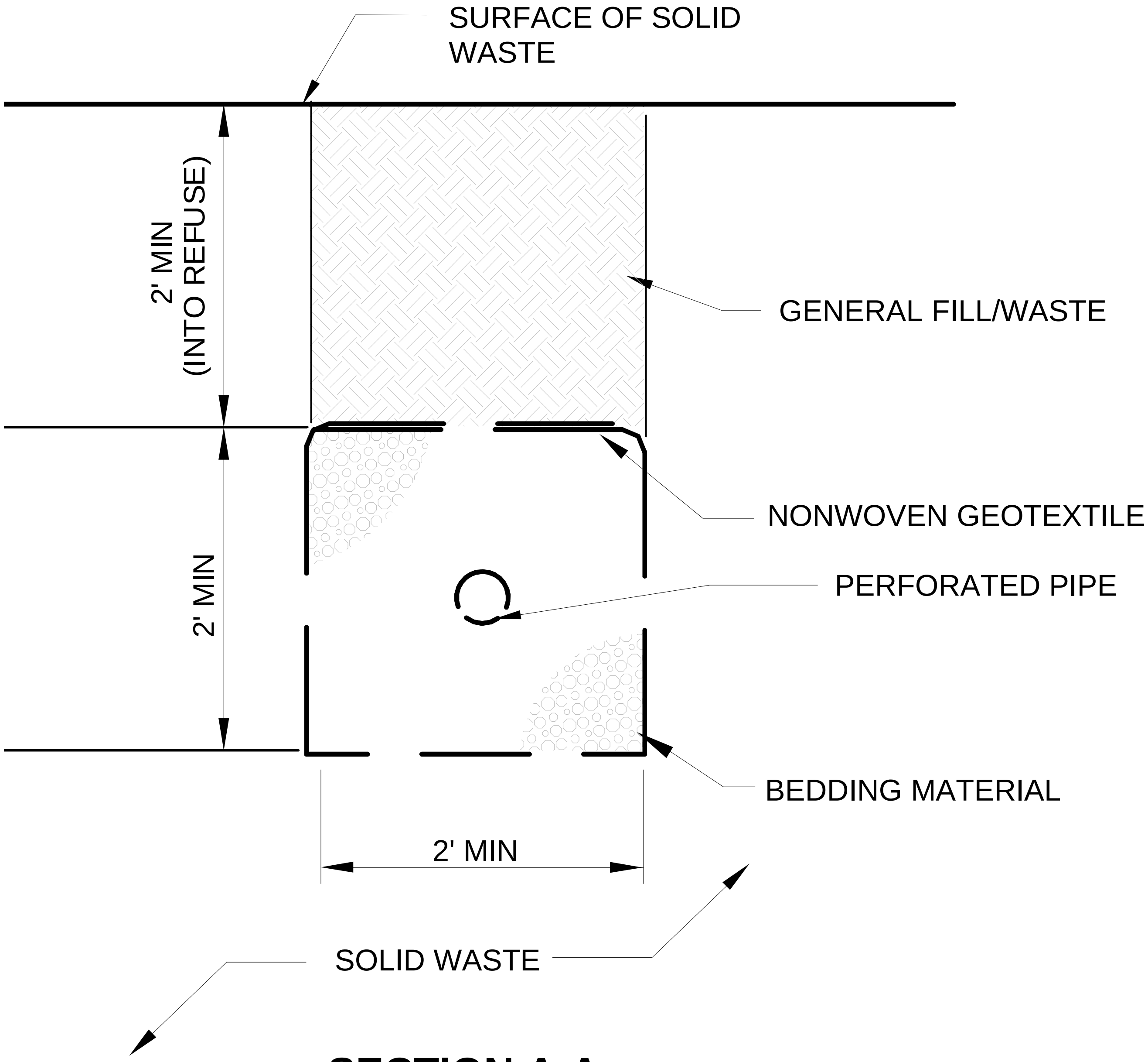
HORIZONTAL COLLECTORS



Phase 3 and 4 Installation

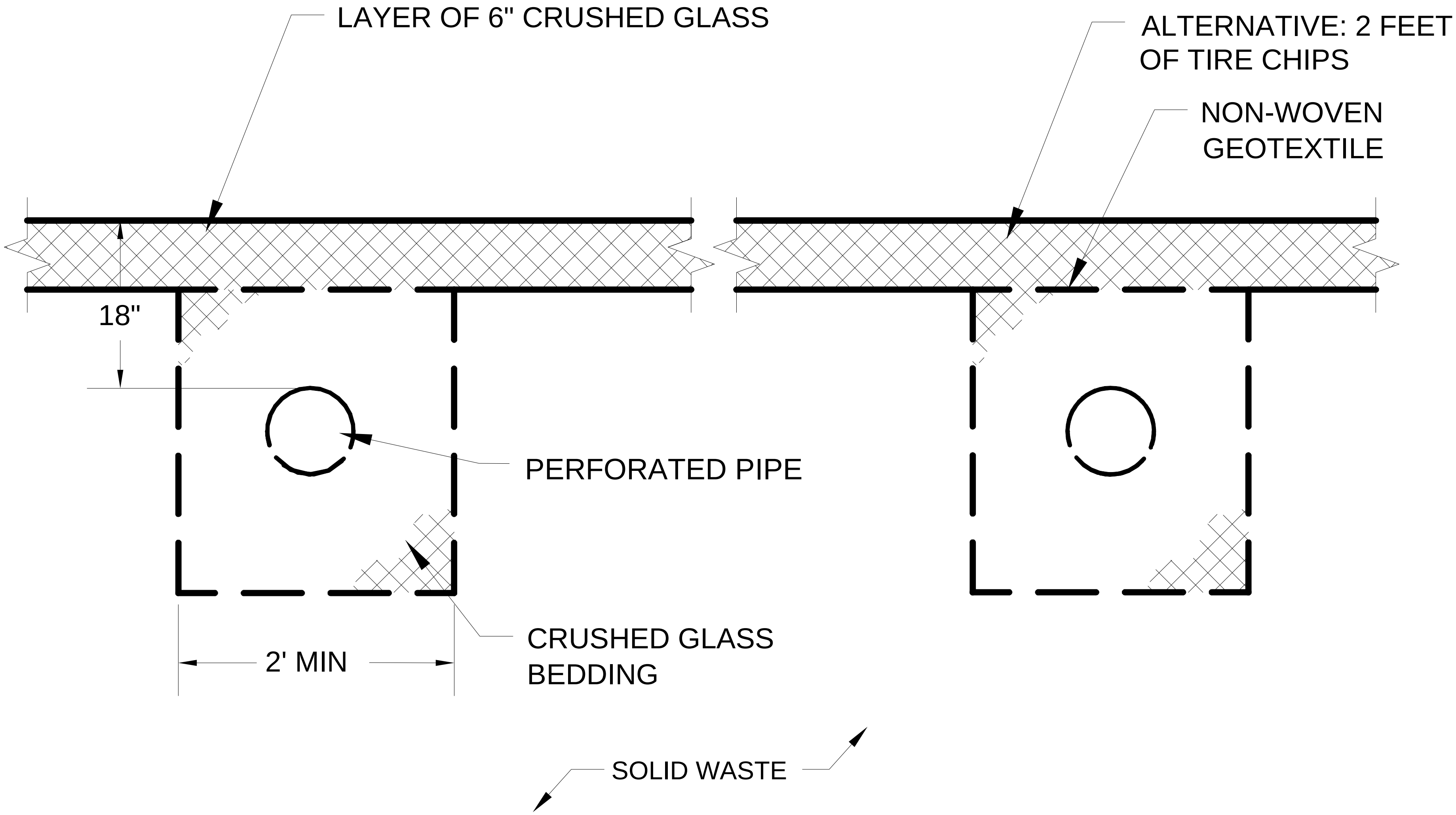


LEACHATE DISTRIBUTOR - SECTION



SECTION A-A

SCS ENGINEERS, PC



OPTIONAL SECTION A-A

PUMP HOUSE

LEACHATE STORAGE

PUMP

The Aerobic Landfill

- An in-place method for rapid waste degradation. 30 times faster than under anaerobic conditions. Generally considered a remediation technology but can be used in operating landfills as well.

- Controlled Injection of Air and Leachate into Waste Mass. Collect leachate,water from on-site sources- Similar to Composting. Utilizes the Landfill Infrastructure as a Closed vessel

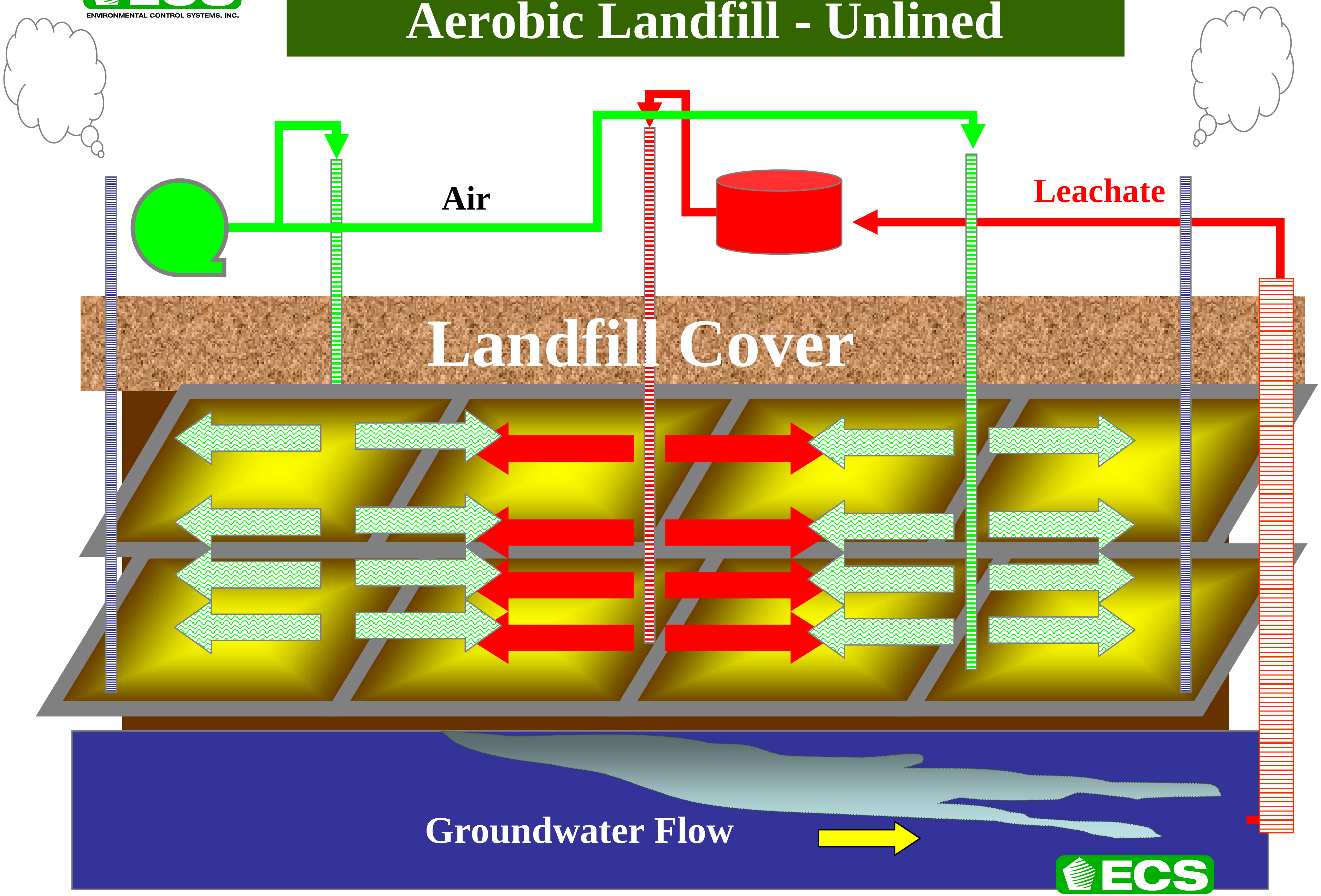
- Indigenous, Respiring Bacteria begin rapid *in-situ* consumption of Organics, VOCs, etc. in a moist environment

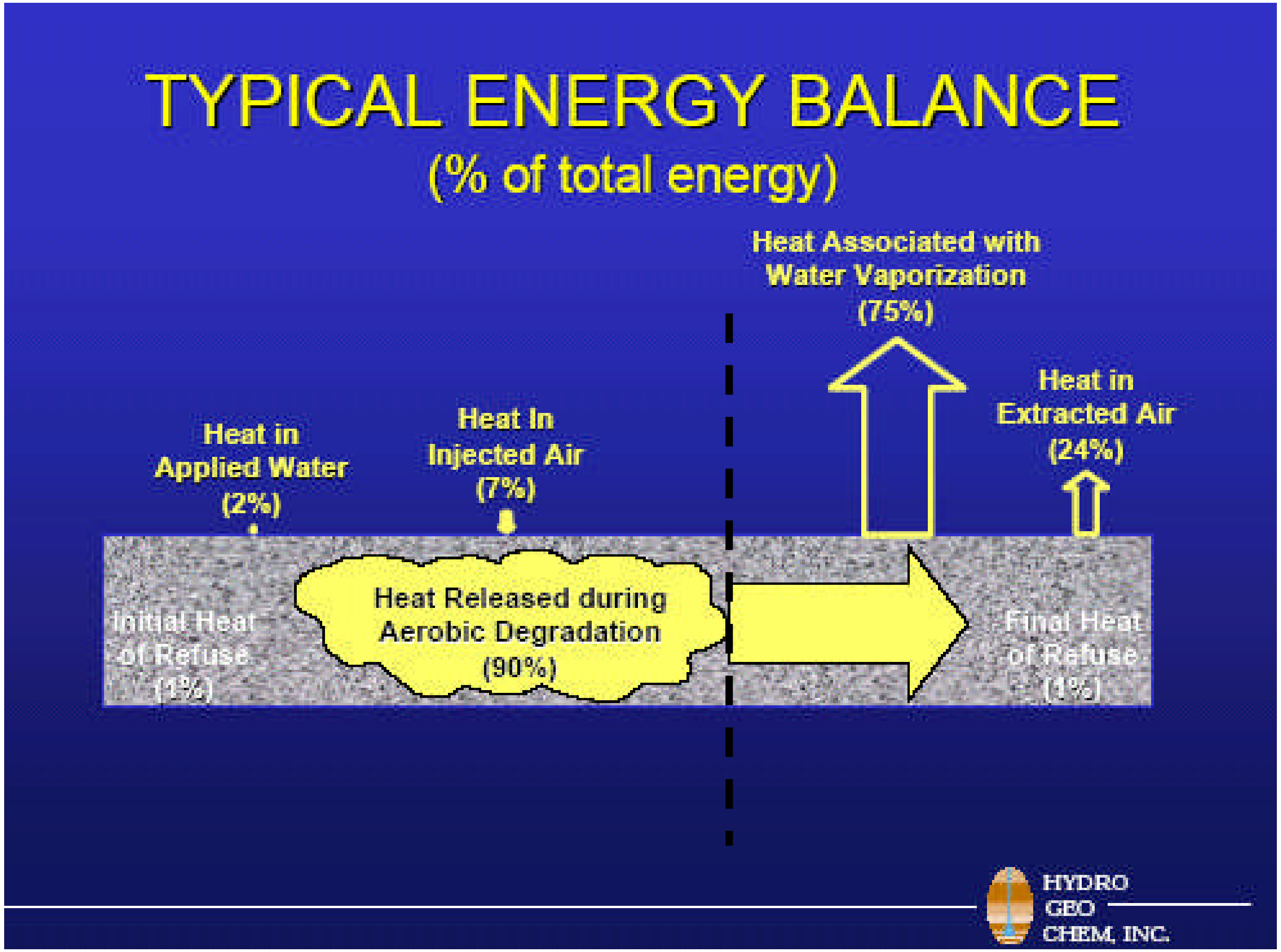
- Instead of CH_4- CO_2, Water and Heat are given off. Moisture and air regulates waste mass temperature (<55^{o}C), while CH_4 production is generally less than 5% (v/v)

- Leachate preferred but can also use other water sources- stormwater, wastewater, etc. No chemicals added. Natural process.

ECS
ENVIRONMENTAL CONTROL SYSTEMS, INC.

Aerobic Landfill - Unlined





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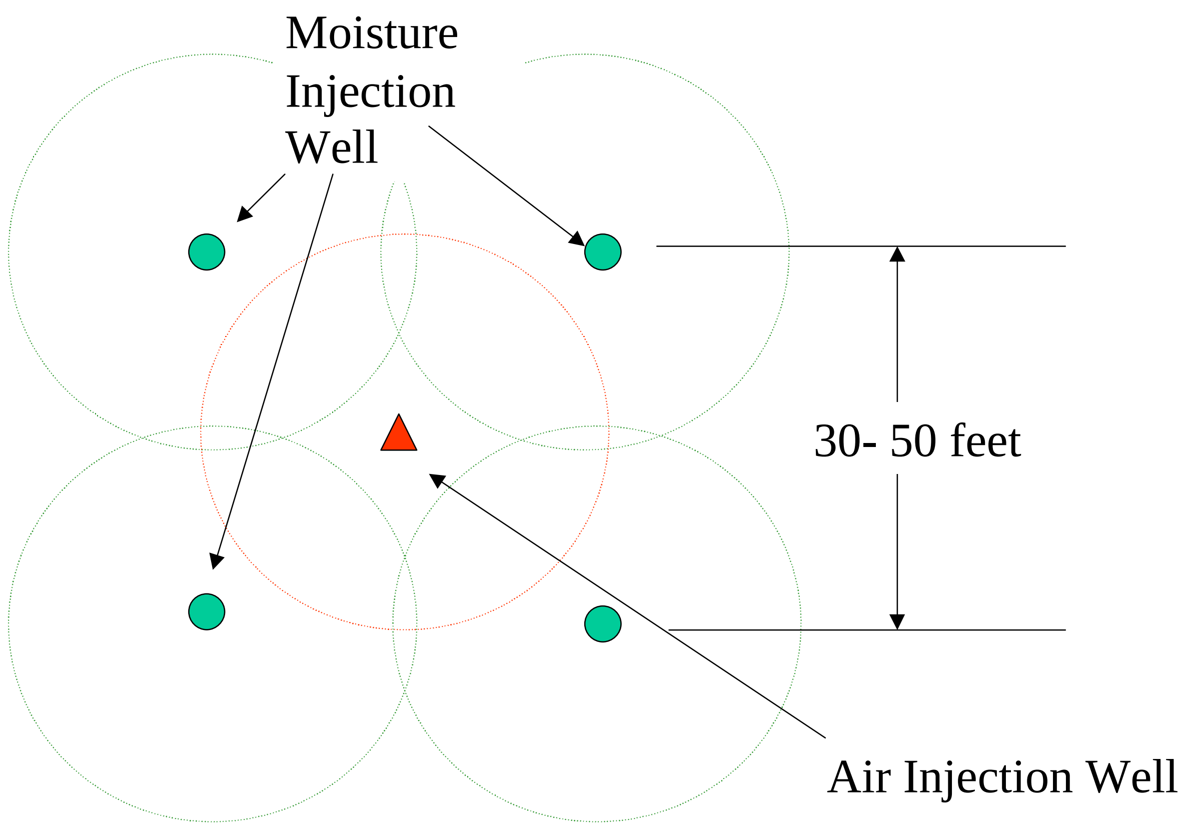
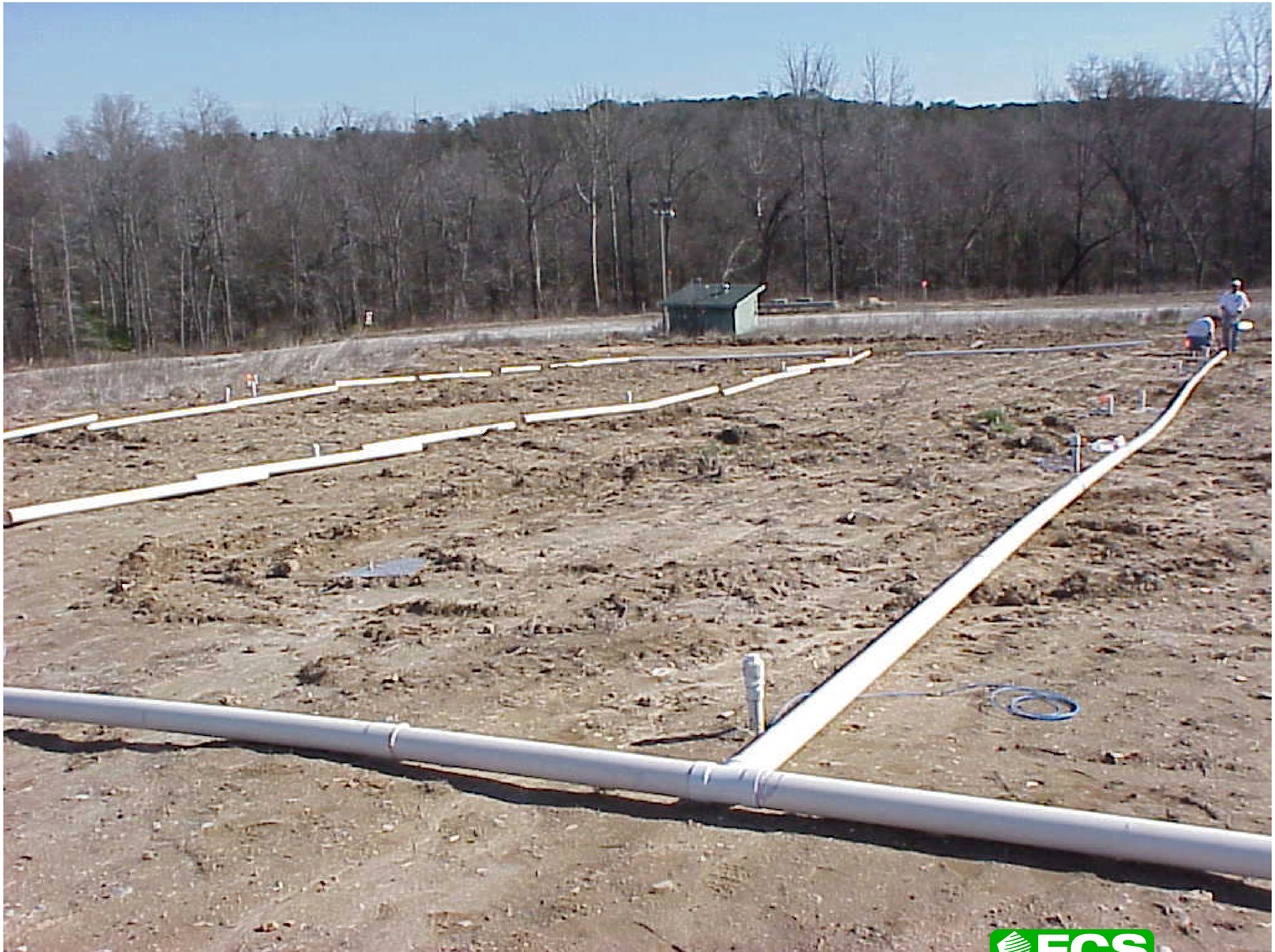
Leachate/Air Injection Well Head

Injection Well Spacing





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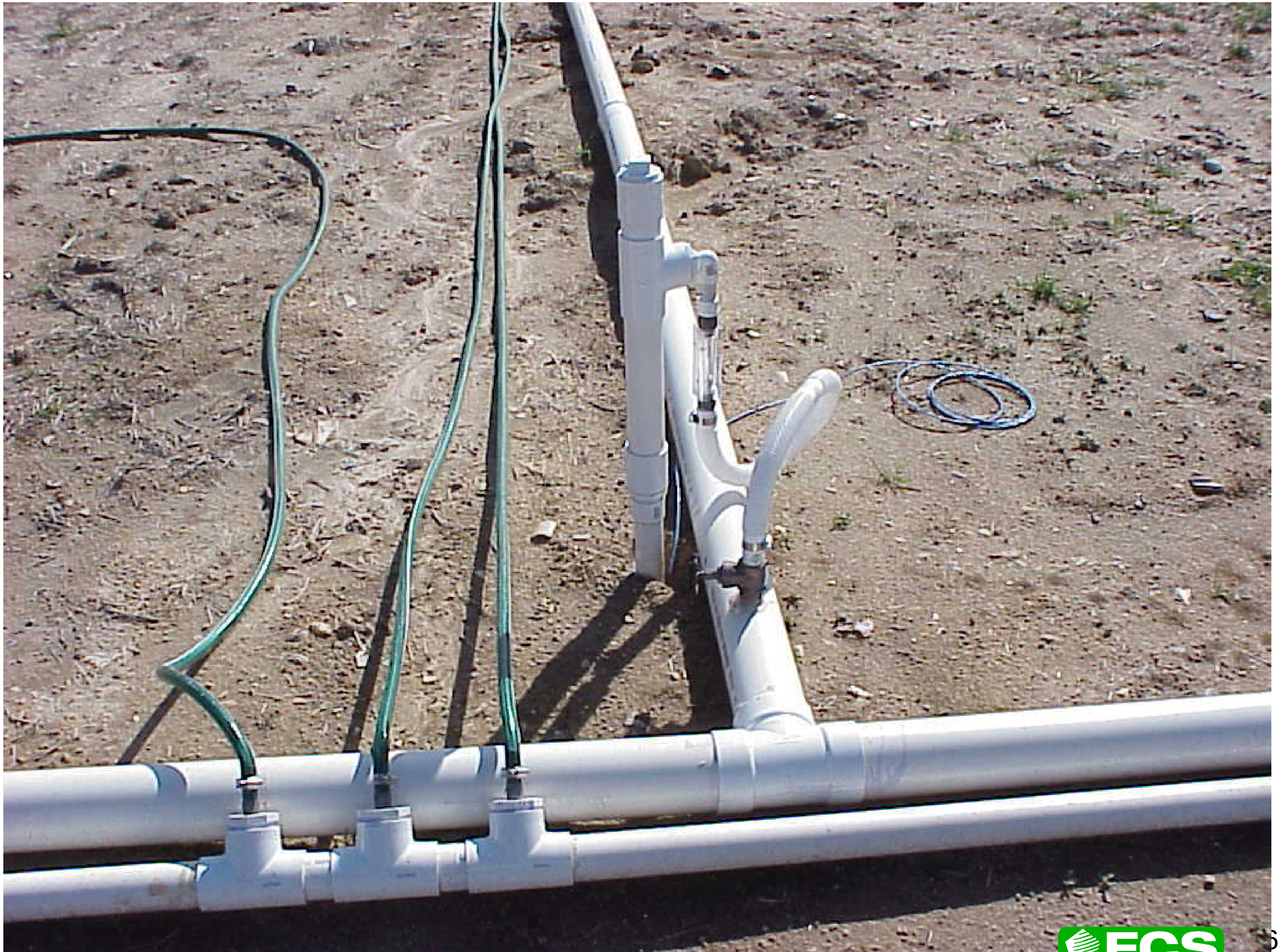
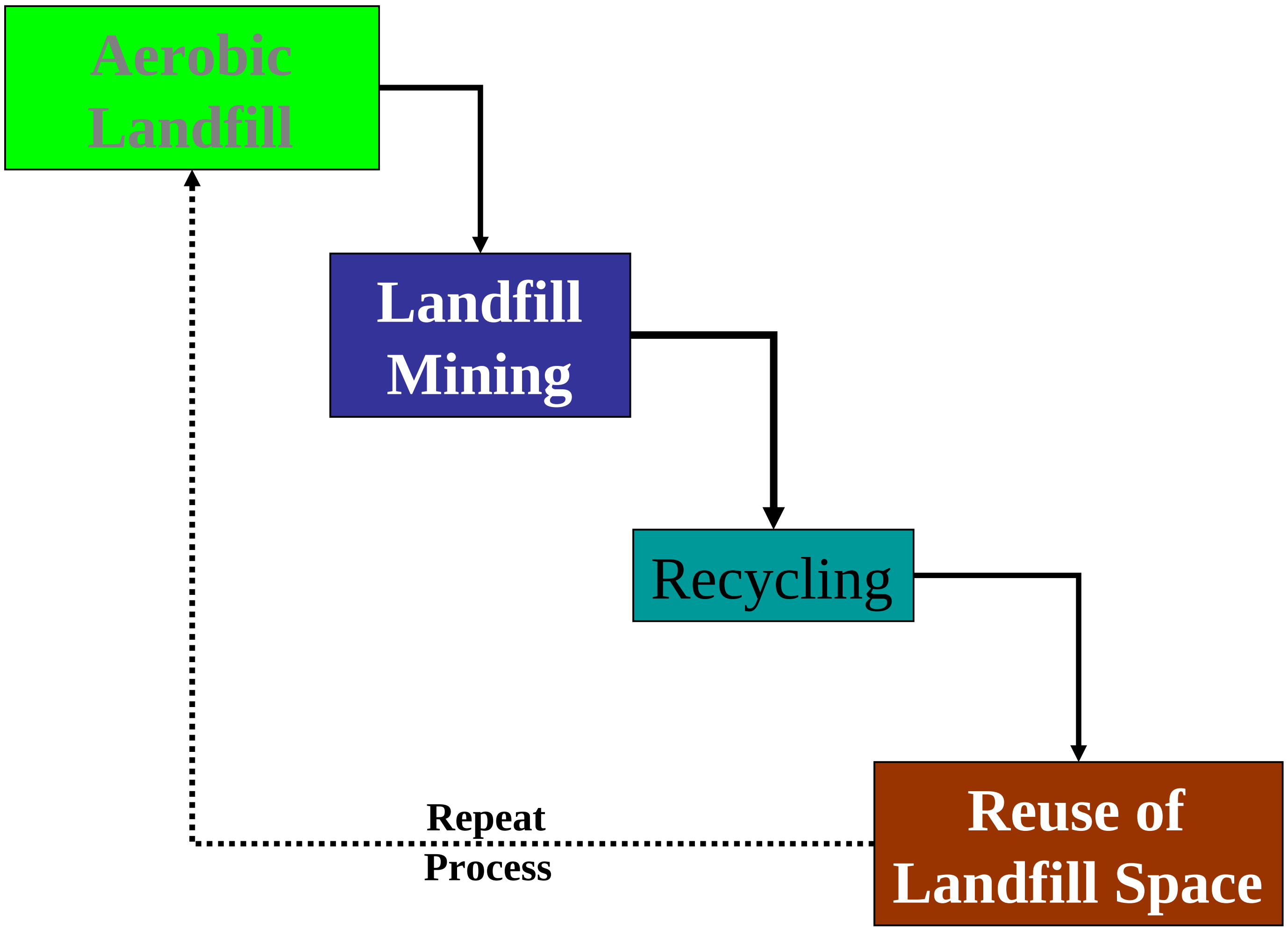


Air Injection

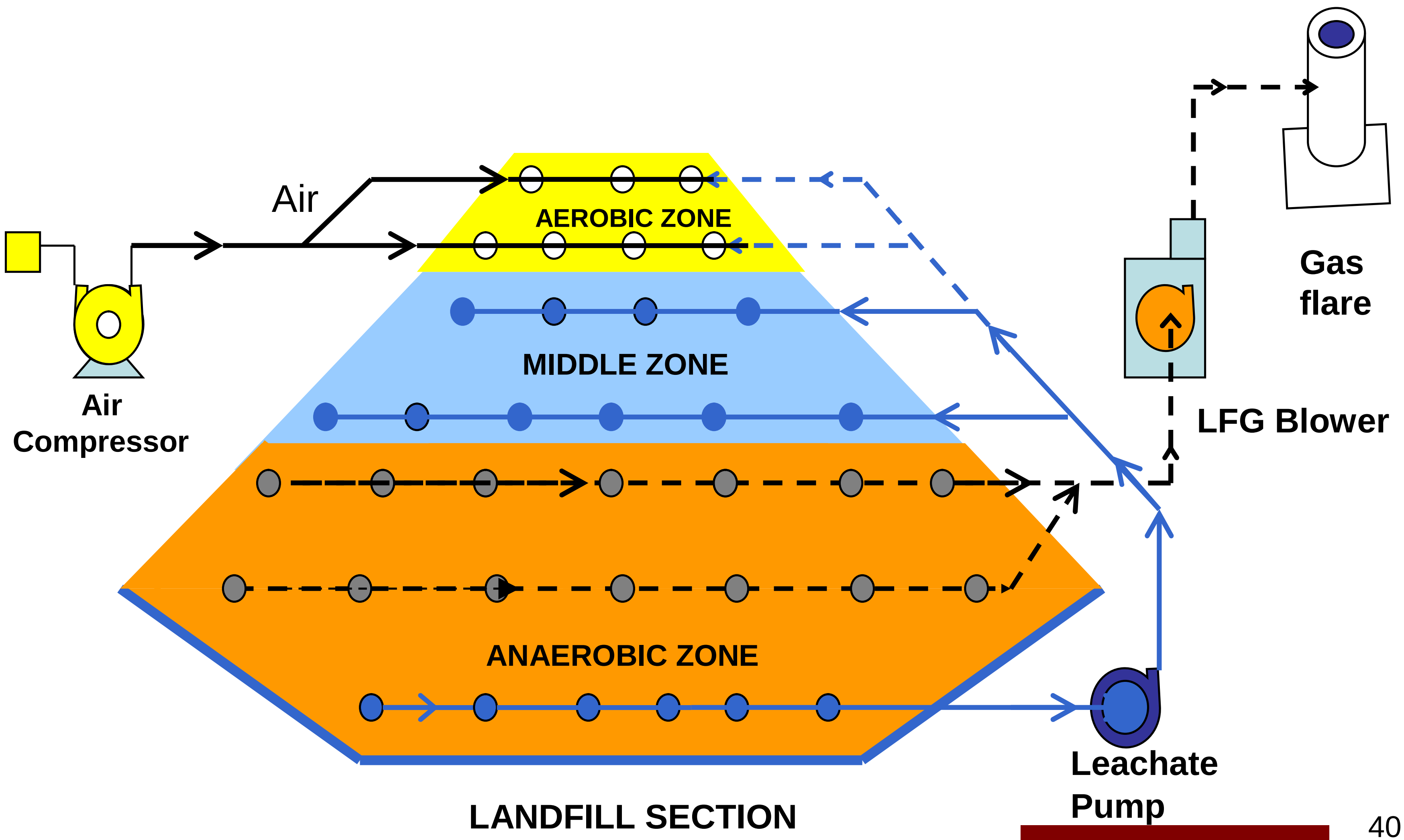
The Sustainable Landfill



TWO STAGE – HYBRID SYSTEM

- **TOP** – Air injection or vacuum, add some leachate
  - 30 - 90 days
  - 10 - 30 feet
- **MIDDLE** – Leachate addition, turn Anaerobic
  - Start LFG Collection
  - Primary leachate recirculation
- **LOWER** – Anaerobic System
  - LFG Collection - HC

TWO STAGE AEROBIC/ANAEROBIC HYBRID SYSTEM



DENSITY RANGES FOR LF ALTERNATIVES

	#/cy – In Place
1. Conventional Compaction	1200 – 1400
2. Balefill	1500 – 1800
3. Leachate Recirculation	1500 – 1700
4. Aerobic – Anaerobic (Hybrid)	1600 - 2000

ECONOMIC FACTORS

INITIAL INVESTMENTS

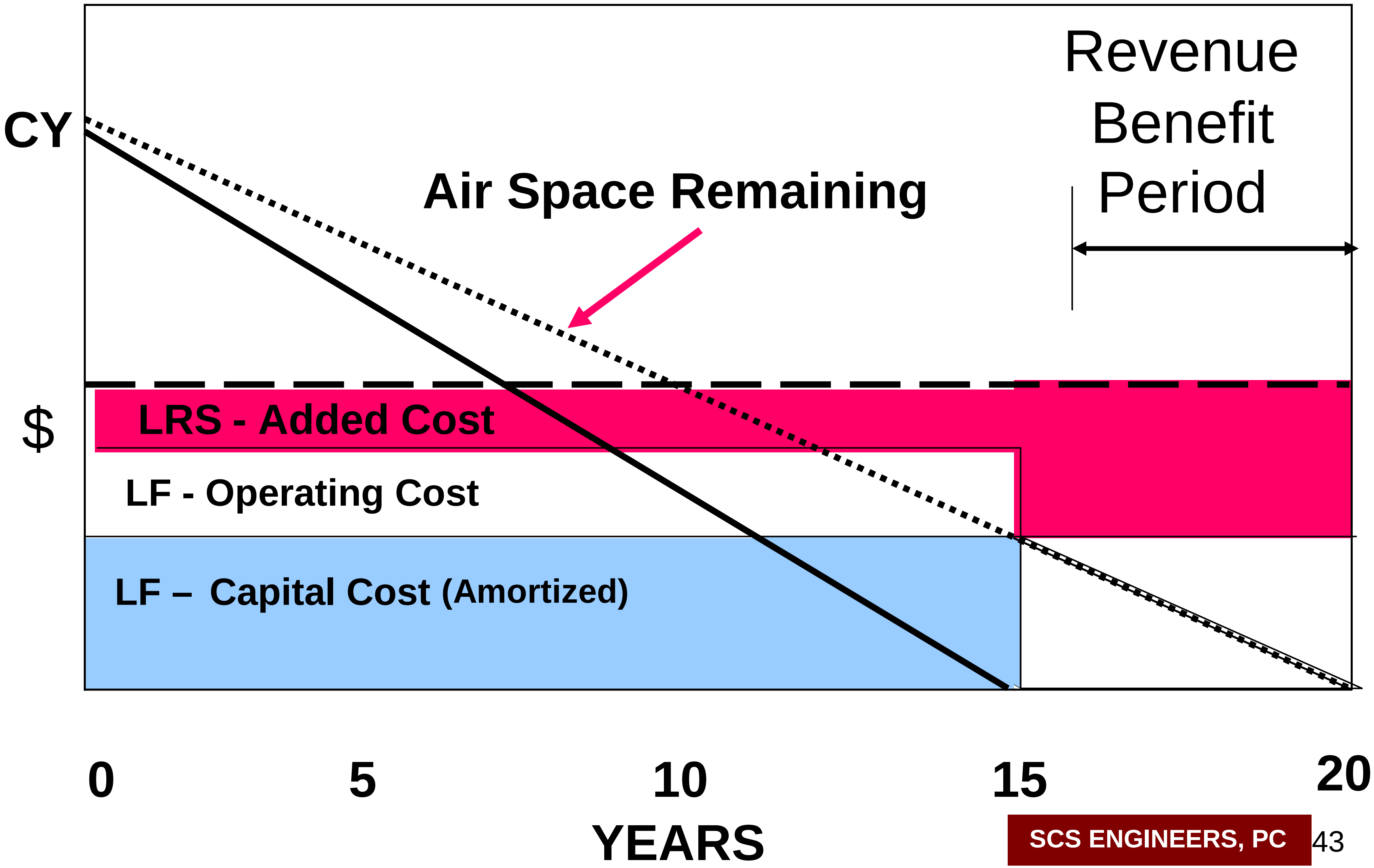
	Cost Range
• Pumps Station	$ 50,000 - $100,000
• Forcemain, headers	$100,000 - $150,000
• Structures and Controls	$ 50,000 - $150,000
• Engineering, Permits & Contingency	$ 80,000 - $150,000
	$280,000 - $550,000

ANNUAL O & M

• LRS Piping	$100,000 - $330,000
• O & M	$ 30,000 - $ 60,000
• Monitor and Reporting	$ 10,000 - $ 30,000
• Engineering and Admin	$ 10,000 - $ 30,000
	$150,000 - $450,000

COST PER WASTE TON $1.00 - $2.50/ton

ECONOMIC COST vs. BENEFITS



REDUCE POST CLOSURE CARE

"Bioreactor is a Proactive Strategy to Reduce Environmental Threats"

See September 2006, Interstate Technology & Regulatory Council (ITRC) Report www.itrcweb.org

"Liners Don't Last Forever"