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Settlement of landfills related to post-closure construction

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Outline

- Background
- Objectives
- Settlement Prediction Methods
- Stabilization Methods
- Construction on a Closed Landfill
- AGREMAX
- Experimental Procedure
- Ongoing work
- Thanks & Acknowledgements
- Sources

Background

Landfills: Operation & Design

- Cells – working face
  - .4 - .6 m depth
- Compaction
- Daily/intermediate cover
- Lifts
- Final Cover

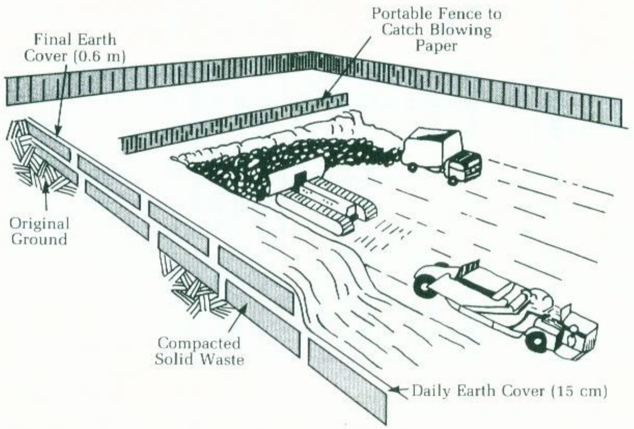


FIGURE 8-11
The area method.

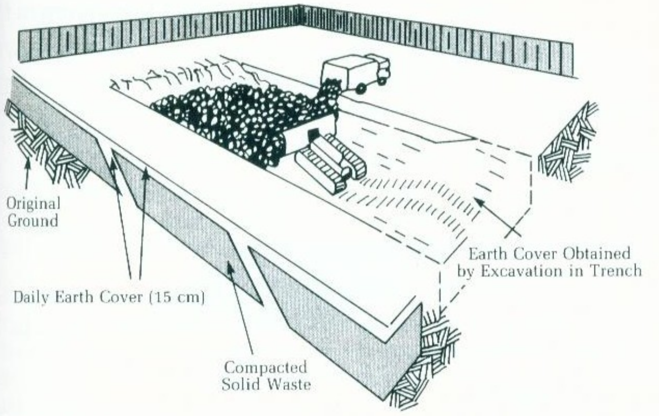


FIGURE 8-12
The trench method.

Landfills: Operation & Design

- Liner design
- Leachate collection and composition
- Gas collection and composition
  - Average production of 5 L/kg*yr

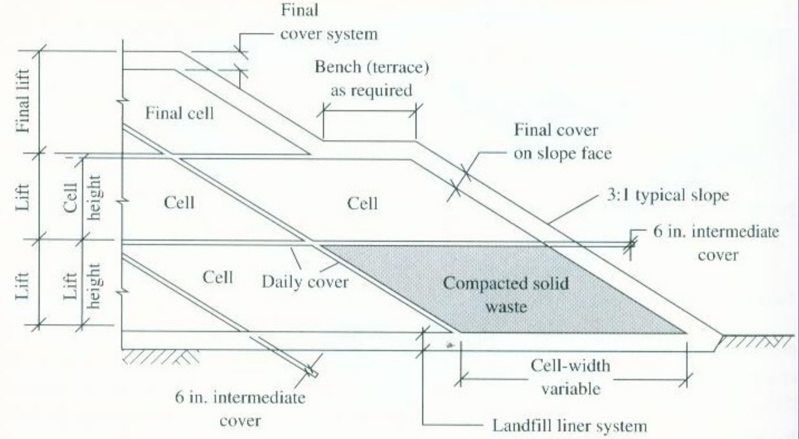


FIGURE 8-13
Sectional view through a sanitary landfill. (*Source:* G. Tchobanoglous, H. Theisen, and S. Vigil, *Integrated Solid Waste Management*, New York: McGraw-Hill, 1993. Reprinted by permission.)

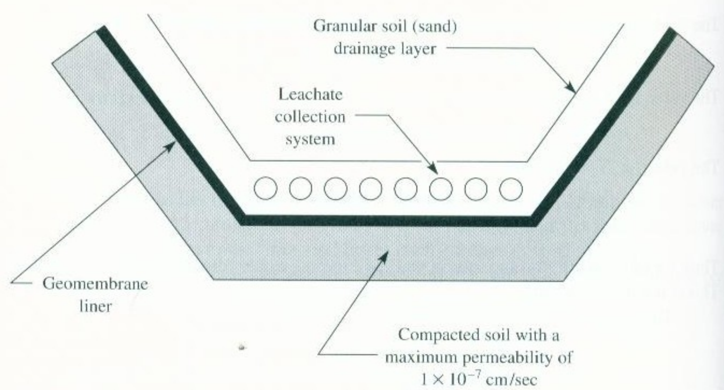


FIGURE 8-16
A composite liner and leachate collection system.

Daily Cover

- Reduces odor
- Discourages vectors (insects, birds, rodents, etc.)
- Maintain waste in place
- Material is generally natural soils
  - Trench method – on-site
  - Area method – off-site
- Material can also include textiles, chemical foam, shredded tires, bark and woodchips

Daily Cover (cont'd)

- Initially occupies ~20% of landfill volume
- Ultimately reduces to ~5%
  - Due to compression from overburden pressure
  - Migration into void spaces in waste

TABLE 8-5
Recommended depths of cover

Type of cover	Minimum depth (m)	Exposure time (d)
Daily	0.15	< 7
Intermediate	0.30	7 to 365
Final	0.60	> 365

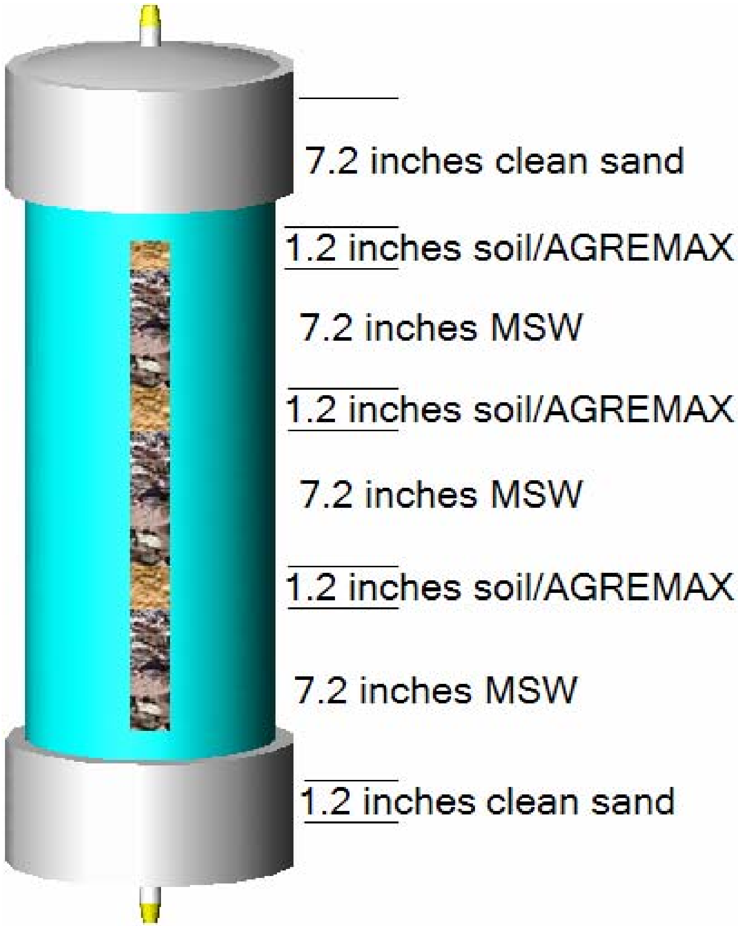
Objectives

Research Objectives

- Investigate:
- Previous projects in which motorways were constructed on top of closed MSW landfills
- Methods of stabilizing landfills to facilitate such construction
- Methods of predicting the magnitude and timeline of settlement within MSW landfills

Experimental Objectives

- Assess the viability of using manufactured aggregate (brand name AGREMAX) as an alternative daily cover in MSW landfills
- Measure the effects of MA on the settlement of the landfill as compared with natural soils
- Measure the effects of MA on the chemical properties and production of effluent (gas and leachate)



Settlement Prediction Methods

Settlement Mechanisms

- Total settlement can be as high as 30-40% of initial landfill height
- Can take place over a period of 20-30 years
- 3 stage process:
  - Initial – due to application of load, immediate
  - Primary – due to expulsion of pore water and gas, 30 days after load application
  - Secondary – due to creep of MSW material as well as biological/chemical breakdown, over several years

Settlement Prediction

- Site specific
- Primary and secondary settlement modeled separately
- Two approaches:
  - Model as organic soil similar to peat
  - Empirical data:
    - Sowers – primary and secondary settlement based on observation
      - Model based on Buisman's theory for secondary comression of soils
      - Validity confirmed by a number recent studies

Stabilization Methods

Primary Settlement Reduction

- Mechanical Compaction
  - Application of surcharge
  - Heavy roller compactor (30-ton, 50-ton, etc.)
  - Deep dynamic compaction (DDC)

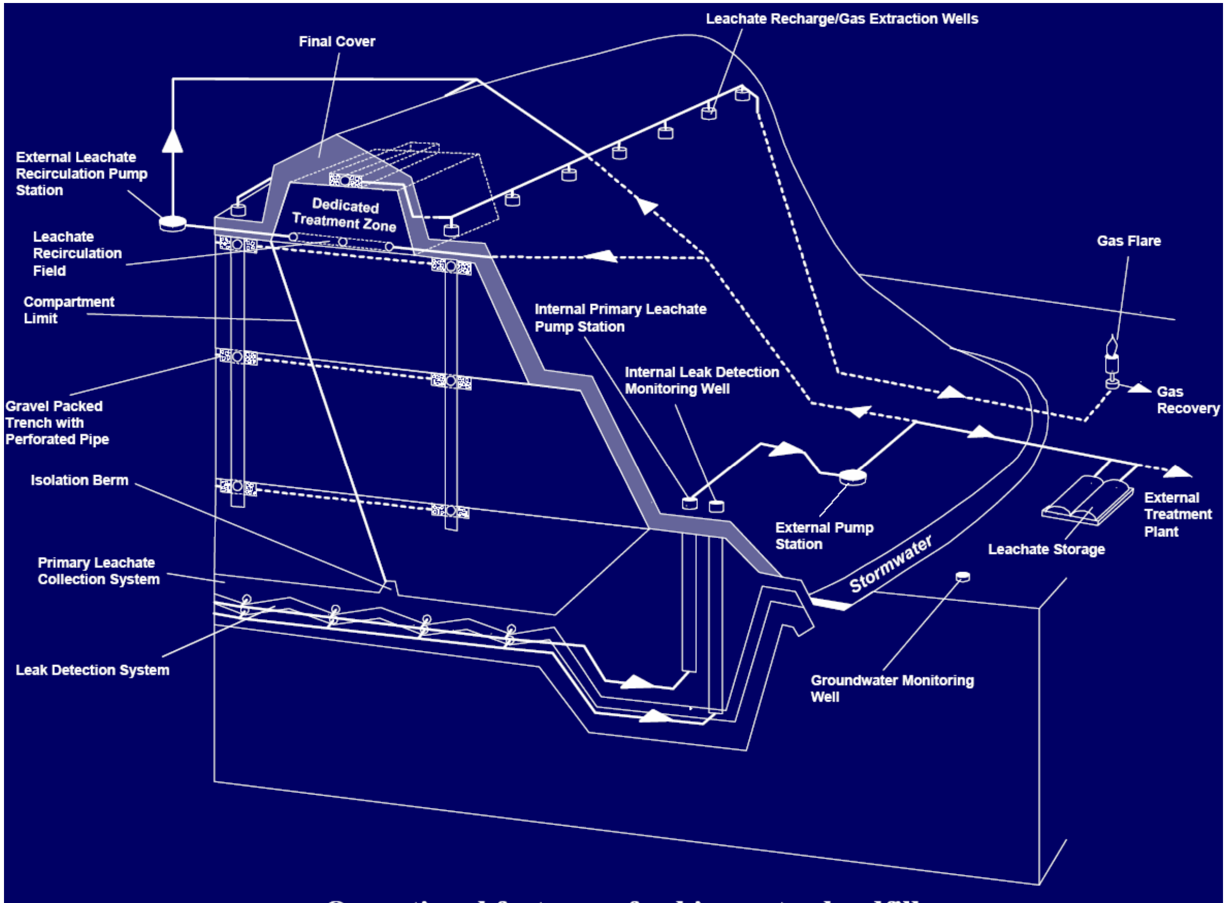
Secondary Settlement Reduction

- Bioreactor Landfills
  - Recirculation of leachate, introduction of liquid, microbes, nutrients, etc.
  - Accelerated secondary settlement due to increased biological activity
  - Effluent production occurs when liner is new and therefore unlikely to fail
  - Arrive at final maturation phase of stabilization possible in approximately 2 years
  - F. Pohland, 2003

Leachate Recirculation

- Moisture for biological activity
  - Accelerates stabilization through microbial decay
- Aids methane production
- Treatment of biodegradable components
  - Likely to reduce later treatment cost

Bioreactor Landfill Design



Operational features of a bioreactor landfill

Construction on a Closed Landfill

Why landfill sites?

- Can occupy large tracts of land from several to hundreds of acres
- Inexpensive real-estate
- Closeness to major roadways by design
- Limited land resources

Potential Uses

- ASCE recommends parks and other such recreational facilities
- Also parking lots, golf courses, highways, or green belts

Previous Roadway Construction Projects

- SR-52, San Diego, CA
- Sea World Drive, San Diego, CA
- RT-71 Arkansas

- I-85, Kearny, New Jersey
- I-76, Colorado

FIGURE 8 Interstate 85 westbound, 3 years after construction.

Summary

TABLE 1 Literature Survey: Construction on Sanitary Landfills (*1-6*)

Reference	Sanitary Landfill Thickness	Landfill Age	Landfill Loading	Method of Stabilization	Total Settlements After Stabilization
G. Sowers	25 ft	Old?	1-story wall-bearing building on 10-ft thick embankment	None	0.5 ft in 7 yr; one-half to two-thirds of this occurred in the first year.
L. Moore and M. McGrath	5-25 ft (dump fill)	4-18 yr	0.9 mi of flexible roadway on 2-3-ft -ft thick embankment	8 passes with 30-ton roller and 38 passes with 50-ton roller	0.3-0.9 ft (on roadway surface) after 5 years; resurfaced due to large differential settlements 12 yr after construction.
	40 ft	20 yr	1.0 mi of flexible roadway pavement	8 passes with 30-ton roller and 20 passes with 50-ton roller; before rolling, the fill was undercut 4.5 ft and backfilled with granular soil.	Field inspection showed pavement still has very good serviceability 14 yr after construction.
J. Chang and J. Hannon	18-20 ft	7-10 yr	10-ft thick embankment	105 passes with 50-ton roller and numerous passes with loaded mechanical scraper before attaining full embankment height.	0.7 ft (average) after 400 days.
			10-ft thick embankment	Two layers of rebar steel placed near landfill surface. 30 passes with 50-ton roller and loaded mechanical scraper.	0.9 ft (average) after 400 days.
J. P. Welsh	20-38 ft	3-4 yr	18-ft thick, 40-ft diameter embankment	20-ton weight dropped from 88 ft, up to 20 times per location in grid pattern and 5-ft thick layer of coarse granular material spread over site.	0.05 ft after 6 days vs. 0.96 ft without stabilization.
R.G. Lukas	60 ft (dump fill of burned refuse and miscellaneous materials)	3 yr +	2, 2-story buildings	6-ton weight dropped from 35 ft, 9 times per location in grid pattern.	Up to 0.42 ft after 6 months. Buildings performed satisfactorily 2-3 yr after construction.

AGREMAX

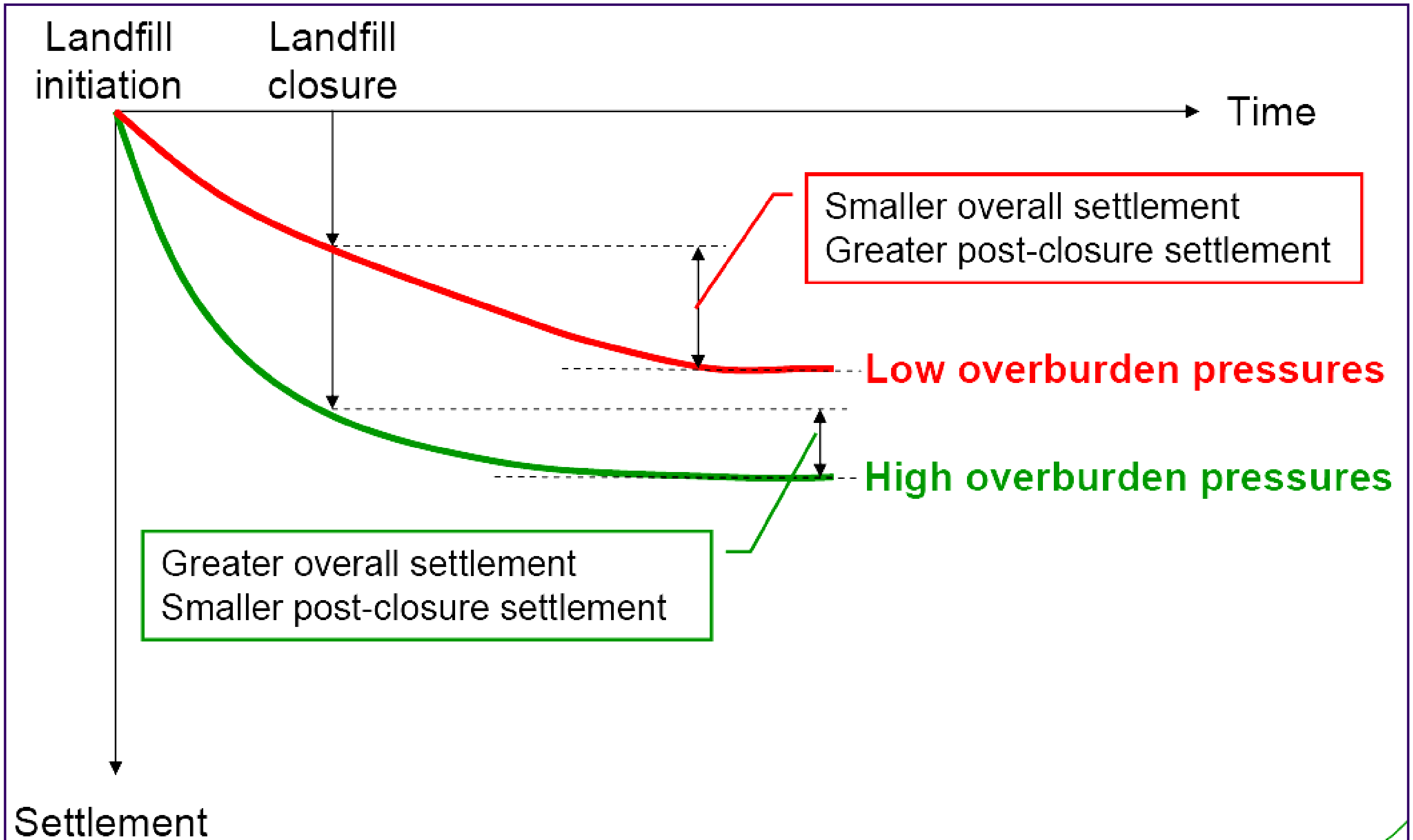
What are CCPs?

- Coal combustion by-products
- Fly ash – finely divided, silt-sized particles
  - Silica, aluminum, iron, calcium oxides
- Bottom ash – coarse grained particles (gravel to fine sand)
  - Silica, alumina, iron, calcium, magnesium, sulfates
- Manufactured aggregate – Coarse grained (gravel to fine sand)
  - Mixture of fly ash and bottom ash with water

Properties of AGREMAX (MA)

- Specific gravity
  - Fine particles (<2.36mm) – SG 2.69
  - Coarse particles (>2.36mm) – SG 1.16
- pH – 1:5 ratio MA to water = 10.5 average
- Shear strength higher than that of natural soils means resistance to deformation due to traffic
- Relatively easy to compact
- Low potential for expansion due to water absorption

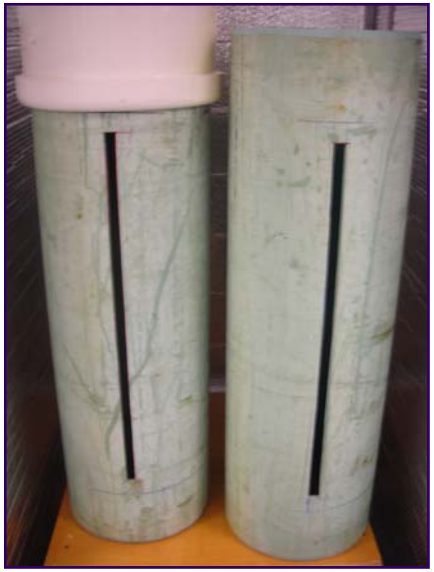
Graphical Representation of Expected Results



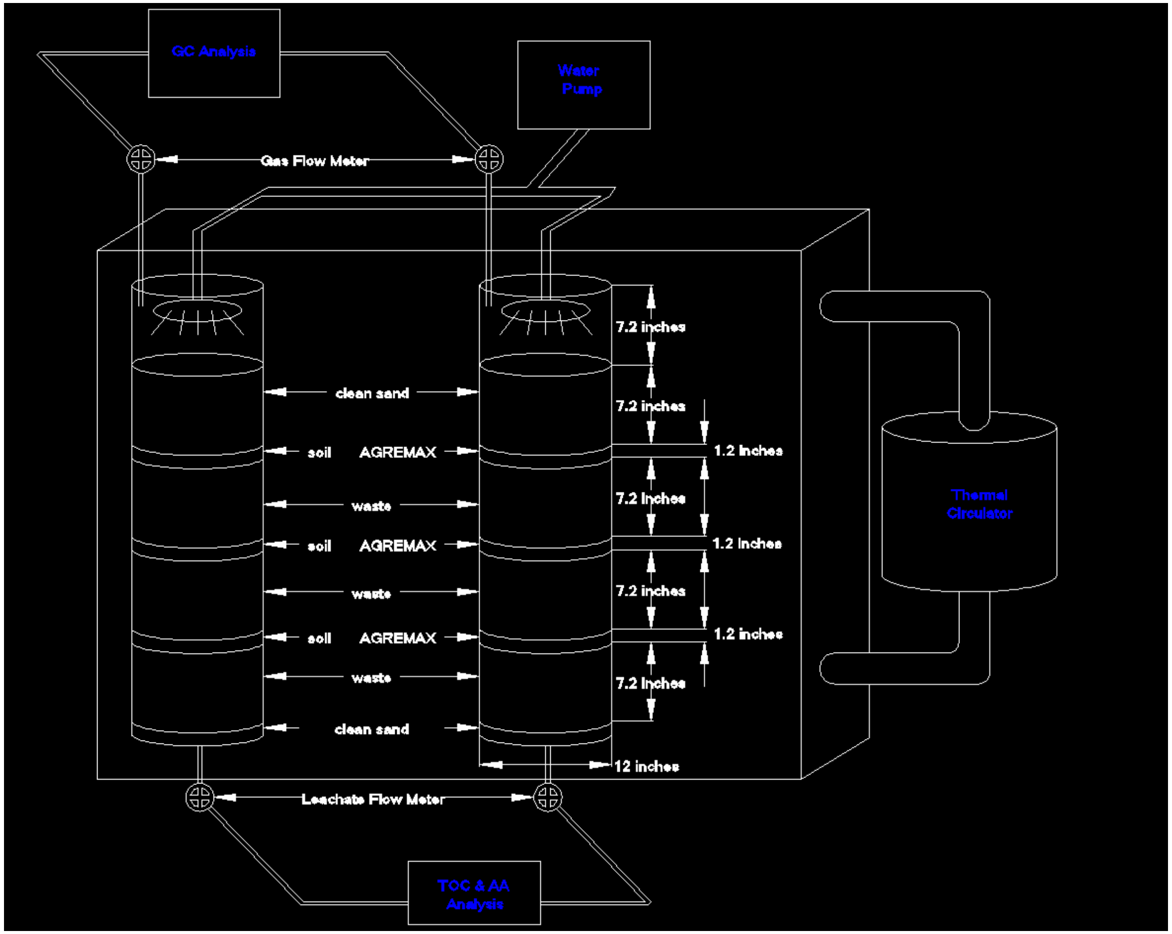
Experimental Procedure

Laboratory Procedure

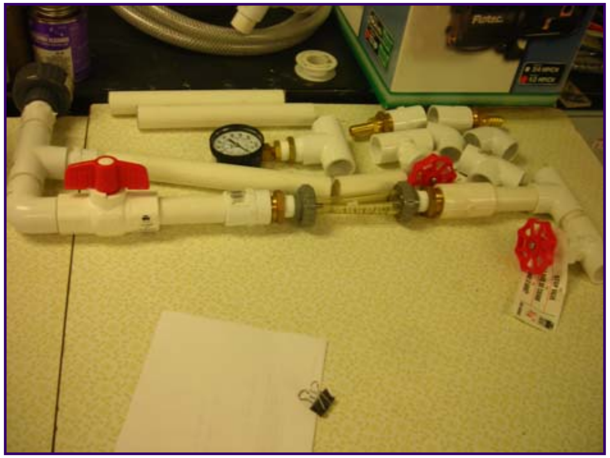
- Environmental chamber
- Laboratory landfill cells
- Precipitation simulation
- Settlement observation
- Leachate Extraction
  - Monitoring pH
  - Total Organic Carbon
  - Oxidation-Reduction Potential
  - Production rate/total
- Gas Extraction
  - Composition (gas chromatograph)
  - Production rate/total



Chamber Design Parameters



My Part



Ongoing Work

Thanks & Acknowledgements

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- Dr. Benjamin Colucci
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(And everyone else who was lucky enough to escape my camera!)

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