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# **Landfill Functional Stability – Technical Basis to Optimizing PCC Systems Over Time and Determining the End of PCC per Part 115**

## **Presentation to the Michigan Upper Peninsula Materials Management Forum**

April 26, 2023

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Louis Bull PG, PHG, CHG

Director, Groundwater and Technical Programs

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# Agenda

- I. Part 115 Amended Michigan Statute Summary (PCC)
- II. History - Evaluation of Post Closure Care (EPCC)
- III. Goal of Post Closure Care (Time-Based vs. Performance-Based)
  - Partnership
  - Importance of Beneficial End Use Strategy
  - Follow the Science/Data
  - Confirmation Monitoring
- IV. What is Functional Stability and How Does it Work?
  - Performance Metrics - Transitioning from Functional Stability to Custodial Care
- V. Q&A

# Primary Presentation Objectives

- Understanding Functional Stability Process
- Importance of Confirmation Monitoring
- Driver for Decision-Making is Data (Performance-Based)

# PART 115

## SOLID WASTE MANAGEMENT

### 324.11503.amended Definitions; D to G.

(27) "Functional stability" means the stage at which a landfill does not pose a significant risk to the environment, natural resources, or the public health, safety, or welfare at a point of exposure, in the absence of active control systems



**Department of Environment, Great Lakes, and Energy**

# PART 115 SOLID WASTE MANAGEMENT

324.11517.amended

## *Time-Based vs. Performance-Based*

Sec. 11517. (1) The postclosure plan may include monitoring and maintenance provisions not otherwise required by part 115 if designed to achieve **and demonstrate functional stability**,...



**Department of Environment, Great Lakes, and Energy**

# PART 115 SOLID WASTE MANAGEMENT

## 324.11517.amended

324.11517.amended Approval of closure certification and **postclosure plan**; modification of postclosure care period; release from postclosure care; **duties of owner or operator**.



**Department of Environment, Great Lakes, and Energy**

## Where Are We?

- EPA Slow to Change
- States taking the lead
- Subtitle C PCC Guidance Published 12/15/16



### MEMORANDUM

**SUBJECT:** Guidelines for Evaluating the Post-Closure Care Period for Hazardous Waste Disposal Facilities under Subtitle C of RCRA

**FROM:** Barnes Johnson, Director  
Office of Resource Conservation and Recovery

**TO:** RCRA Division Directors, Regions 1-10  
RCRA Enforcement Managers, Regions 1-10  
Regional Counsels, Regions 1-10



Prepared for:  
**WASTE MANAGEMENT OF MICHIGAN, INC.**  
5900 Hannan Road  
Wayne, Michigan 48184

## Evaluation of Post-Closure Care (EPCC) Plan Woodland Meadows North Landfill Wayne, Michigan

### PART VI

#### SCHEDULE OF COMPLIANCE

Within 180 days of license issuance the licensee shall submit a plan to the Division Director, for review and approval, that outlines an approach to performing an Evaluation of Postclosure Care (EPCC), including the components and duration. Specifically, the submitted EPCC plan will provide the foundation to evaluate the monitoring and maintenance data collected during the extended postclosure care period, and determine if the conclusions support modification or termination of postclosure activities during periodic review of the license requirements. The EPCC plan will be consistent with the U.S. EPA Memorandum dated December 15, 2016, and titled, *Guidelines for Evaluating the Post-Closure Care Period for Hazardous Waste Disposal Facilities under Subtitle C of RCRA*, issued by the Office of Resource Conservation and Recovery.

Prepared by:

**Geosyntec**   
consultants

Geosyntec Consultants of Michigan  
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Ann Arbor, Michigan 48015

Project Number: ME1733

24 May 2019



## Why Increased Focus Today?

- Landfill PCC permits expiring
- EPA – No Guidance on “protection of human health and the environment”
- Certainty – No “Kicking the Can”
  - All stakeholders are seeking “certainty” - need an objective process for planning purposes



# Post-Closure Care and Protection of HH&E (Subtitle D)

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## What is the Federal Framework?

(1) The length of the post-closure care period may be:

- (A) decreased by the Director of an approved state if the owner or operator demonstrates that the reduced period is sufficient to protect human health and the environment; or
- (B) increased by the Director if it is determined that the lengthened period is necessary to protect human health and the environment.

### EPA on evaluating threat of MSW Leachate:

- *“Concentrations at the point of exposure, rather than concentrations in the leachate in the collection system, may be used when assessing threats.”*

*- EPA 1998, Section 6.6.3*

## Guiding Principle

RCRA was not established with the goal of permanently marginalizing land; the intent for completion of PCC followed by suitable reuse of former landfill properties is the intent of the regulation

# Consistency with Sustainability Concepts

- Landfill managed so that outputs are controlled in an acceptable way
- Residues should not pose an unacceptable environmental risk
- Future uses of groundwater other resources not compromised

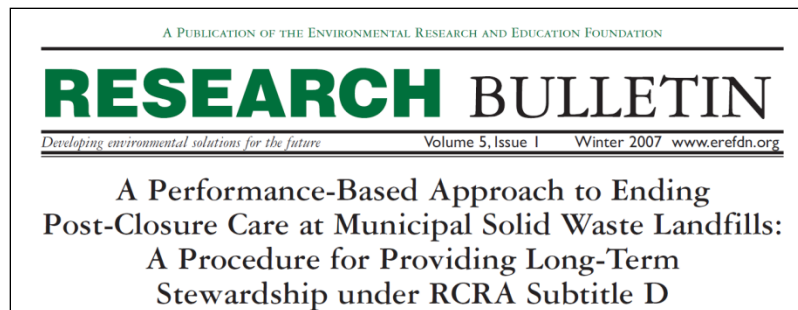
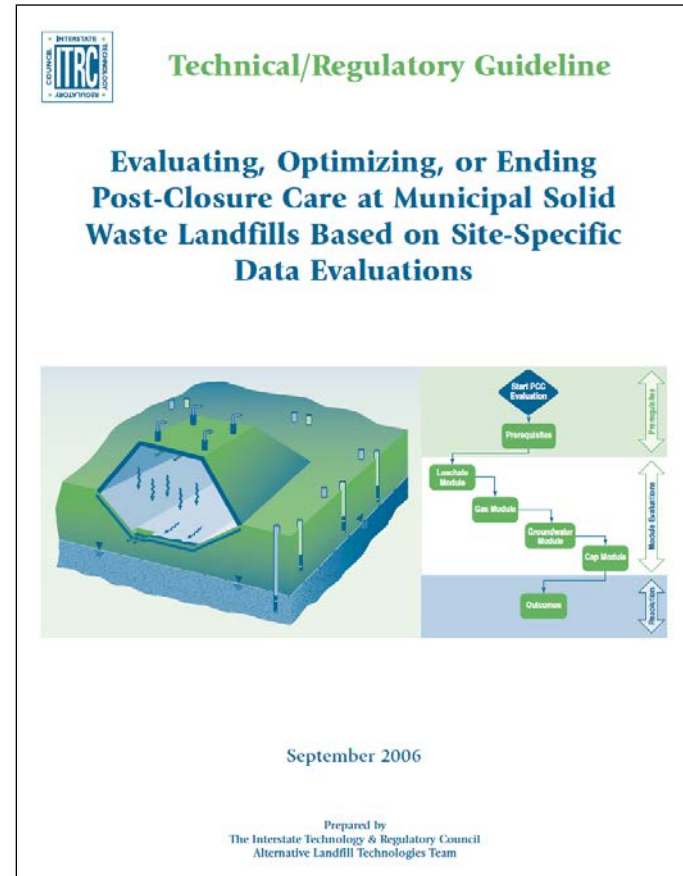
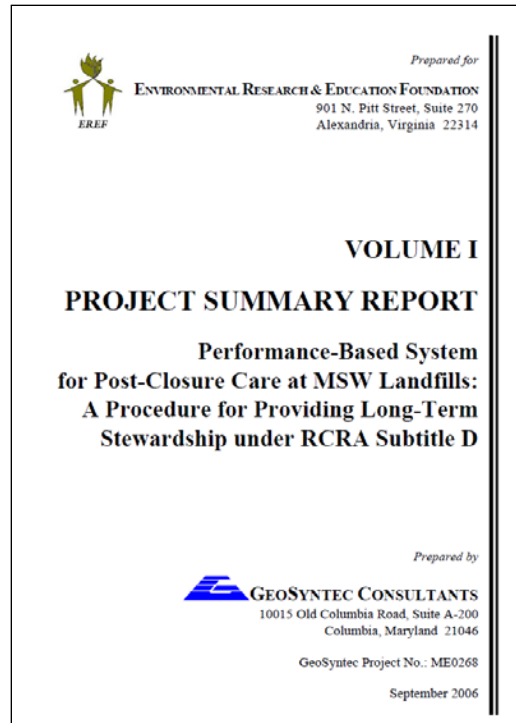
Beneficial Reuse - Reintegrating property into community critical component to long-term landfill sustainability



“Safe transfer of waste from society to nature”



# Technical Foundation - Initial Peer-Reviewed Performance-Based Methods



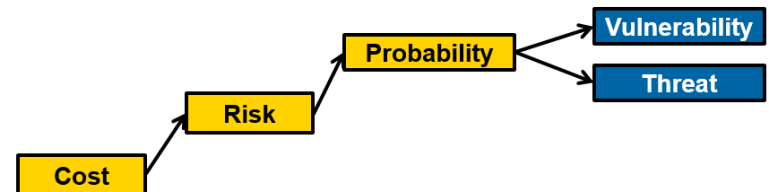
# SWANA's Technical Policy T-9.3

- "T-9.3 Termination of MSW Landfill Post Closure Care Requirements"

- Developed in Collaboration with NWRA
- Reviewed and Approved by Technical Divisions and 70 Member International Board

- Policy Statement:

- PCC Term is finite
- Term should be defined using site-specific data and a performance-based approach
- Technical evaluation methodology and performance-based criteria should be agreed upon in advance





# Elements of PCC



# Technical Basis for EPCC Process

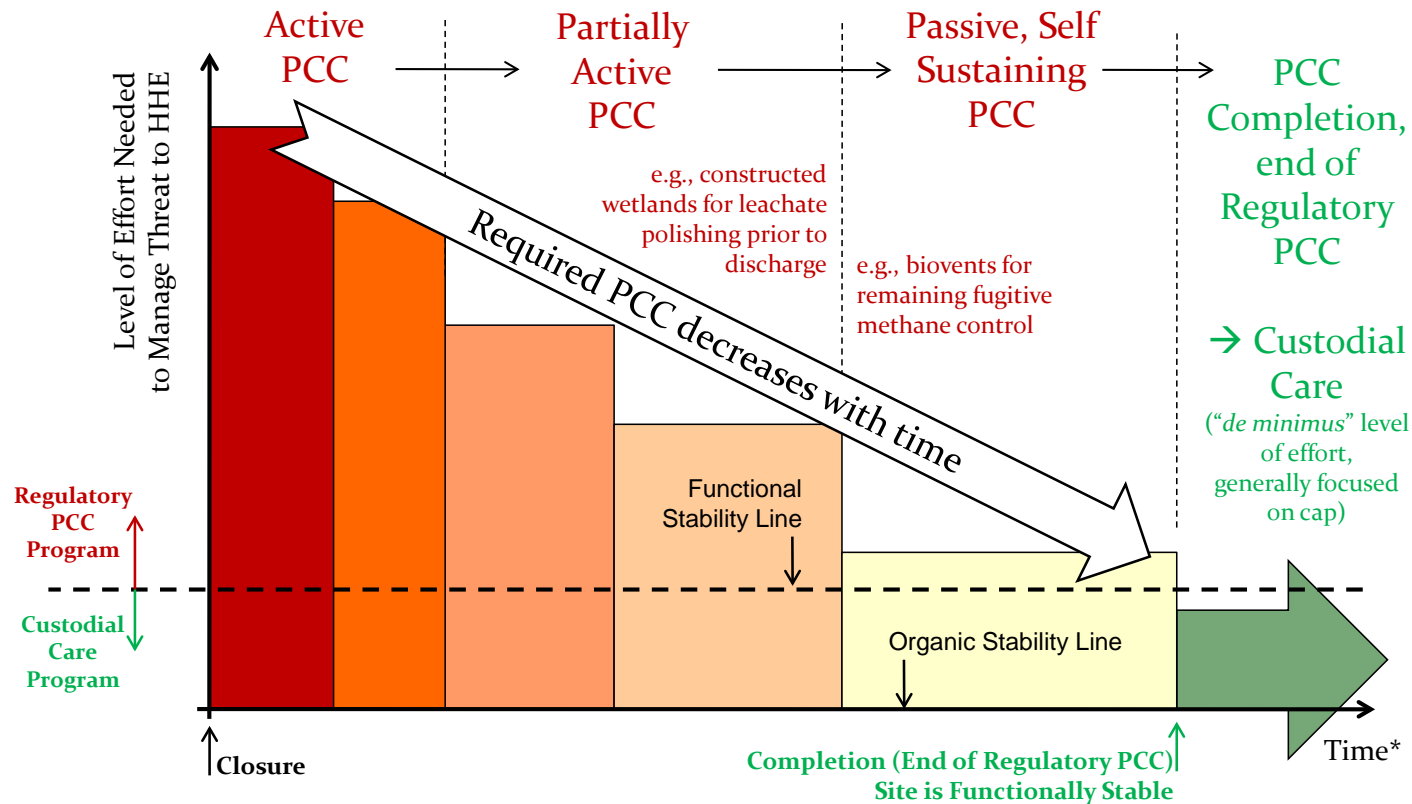
Define activities and duration of care in terms of Functional Stability

- Monitor to confirm predictions (**Confirmation Monitoring**)
- Performance-based, site-specific
- Focused on emissions, which defines relationship with environment
  - Leachate and landfill gas
  - The release of constituents can be evaluated for potential impacts at the POC/POE
- Step-down reductions in PCC, and eventual termination, can be justified based on the outcome of these evaluations



# Functional Stability Model

## Performance-Based Post-Closure Care and Functional Stability



\*(No presumptive scale; time needed to move from Closure to Completion is site specific)

# Elements of Functional Stability Postclosure Plan

Iterative Process for making incremental improvements to landfill control elements

## Major Components

1. Confirm target goals for each PCC element
2. Assemble and evaluate existing data
3. Identify data gaps (e.g., parameters)
4. Develop sampling approach to address data gaps
5. Continue PCC operations and monitoring approach until such time as re-evaluation is possible (based on data)

**Look for system and monitoring optimization opportunities based on data**

# Demonstrating Functional Stability

- Confirm the end goals for PCC in terms of Functional Stability



- Confirm reliable indicators of Function Stability on a site-specific basis



- DATA



- Perform evaluations to demonstrate Functional Stability

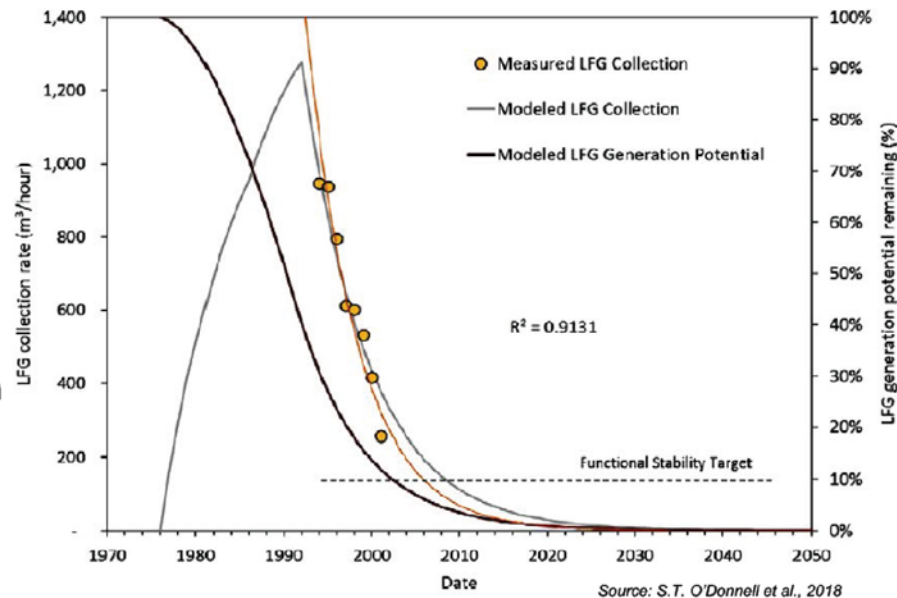


- Custodial Care

# EPCC Summary

## Demonstrating Functional Stability

- LFG production is stable or decreasing
  - < 10% of peak LFG generation
- Settlement is essentially complete
  - <5% annually relative to cumul. total post-closure volume reduction
- Leachate quality is stable or improving
  - satisfy criteria for 'gateway indicators' (e.g. BOD/COD < 0.1) then meet WQS (preferably at source or, failing that, at POC)
- Emissions of leachate/LFG will not unacceptably impact HHE via potential pathways to air, groundwater, surface water or vadose zone
- Critical aspect of the approach is a confirmation monitoring program, which is designed to track when active controls can be stopped and a full transition from PCC to custodial care can occur



### Analysis of LFG Collection Using Functional Stability Approach

- Plot measured data
- Run LANDGEM model for LFG generation
- Run LANDGEM model for collected LFG
- Align with data so model results match observations, which provides a projection of future LFG collected
- Determine when stability target for LFG is achieved

# LFG - Measured vs. Modeled

S.T. O'Donnell et al./Waste Management 75 (2018) 415–426

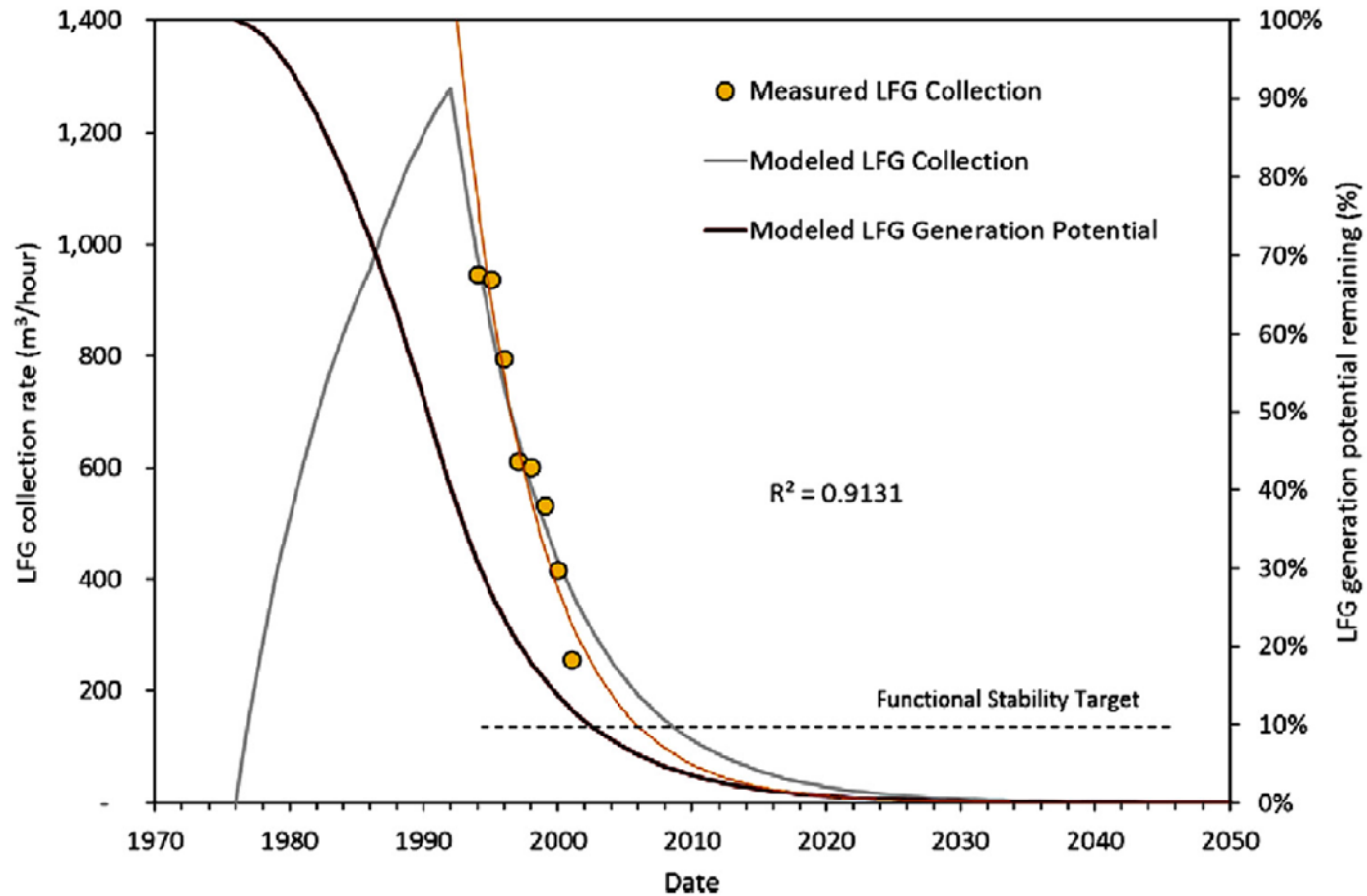
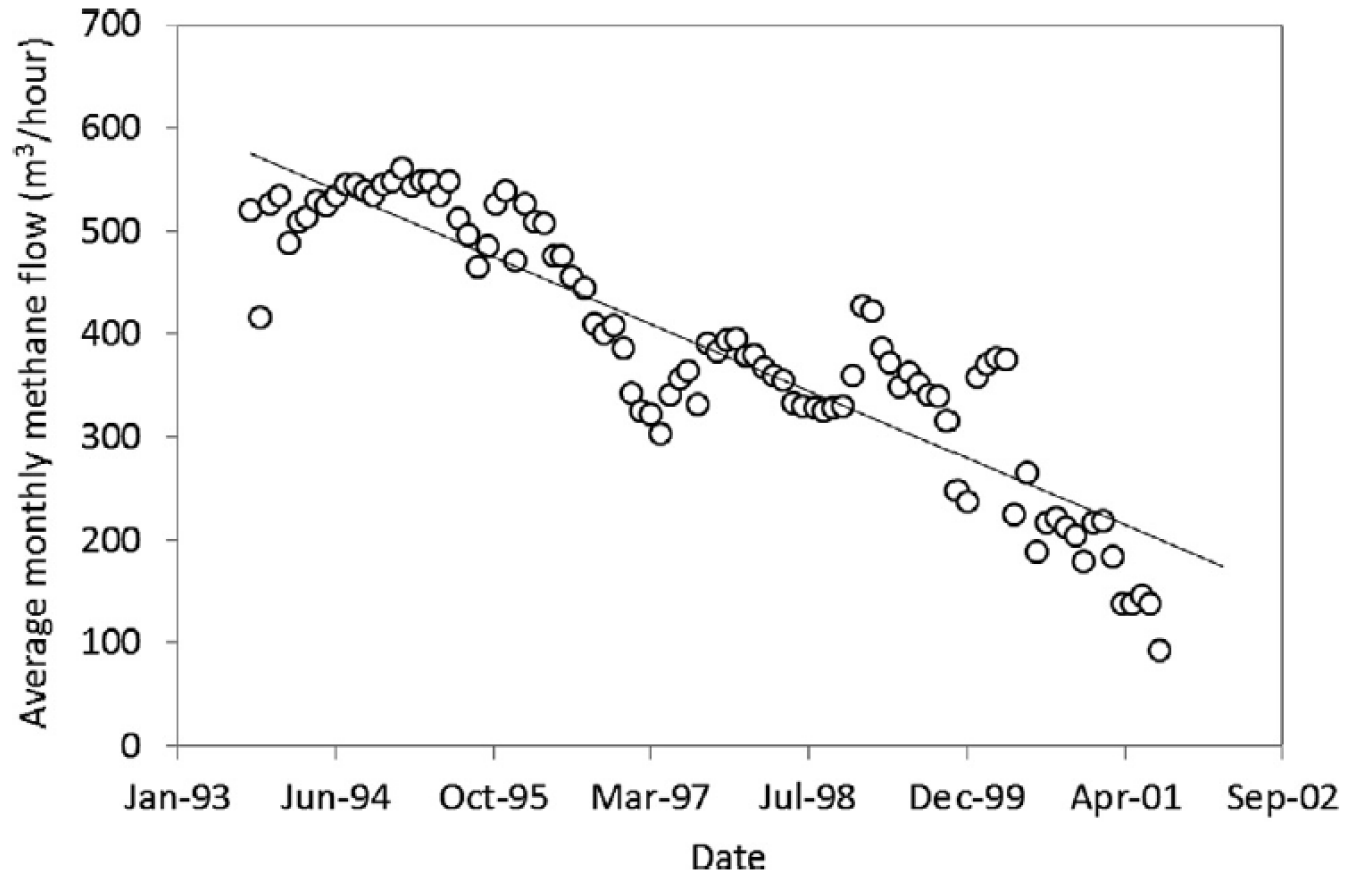


Fig. 2. Analysis of LFG collection data using to EPCC methodology.

# Methane Flow



**Fig. 1.** Monthly average methane flow.

# BOD and COD - Leachate Surrogate Parameters

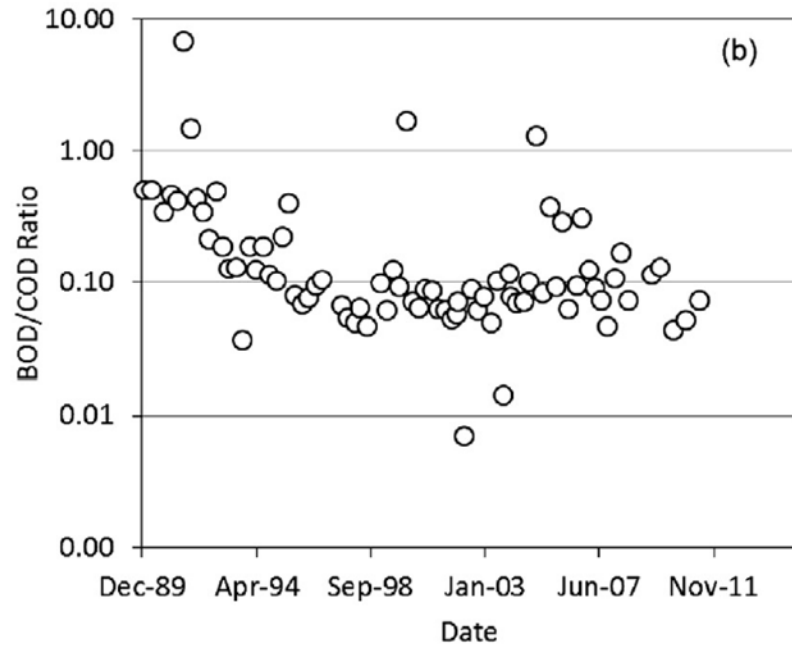
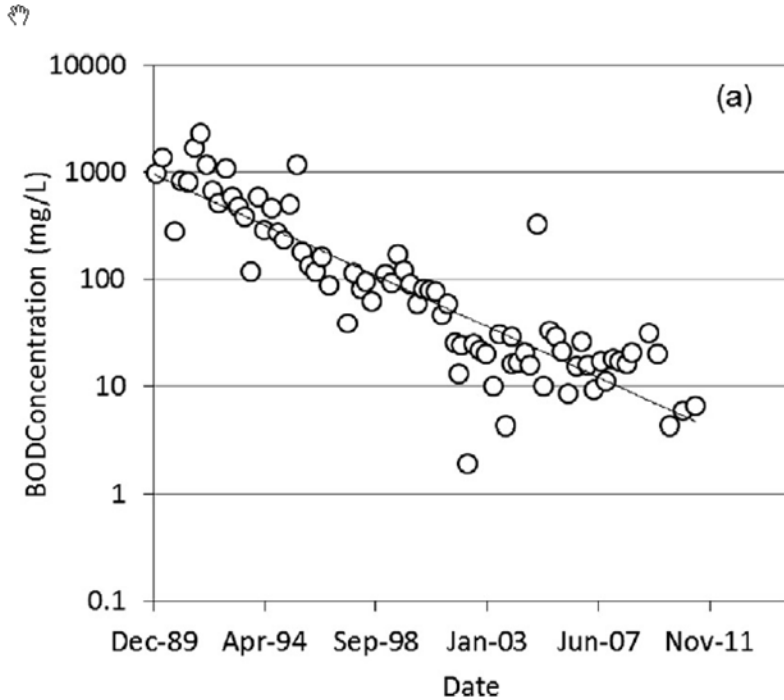


Fig. 5. Leachate trends in (a) BOD concentration, and (b) BOD/COD ratio.

# Groundwater/Leachate Evaluation

$$DF = \frac{K * i * w * d}{I * A_{landfill}}$$

Where:

$DF$  = dilution factor (dimensionless);

$K$  = aquifer hydraulic conductivity (ft/day);

$i$  = hydraulic gradient (ft/ft);

$w$  = width of the landfill perpendicular to the direction of groundwater flow (ft);

$d$  = thickness of the mixing zone (ft);

$I$  = infiltration rate (ft/day); and

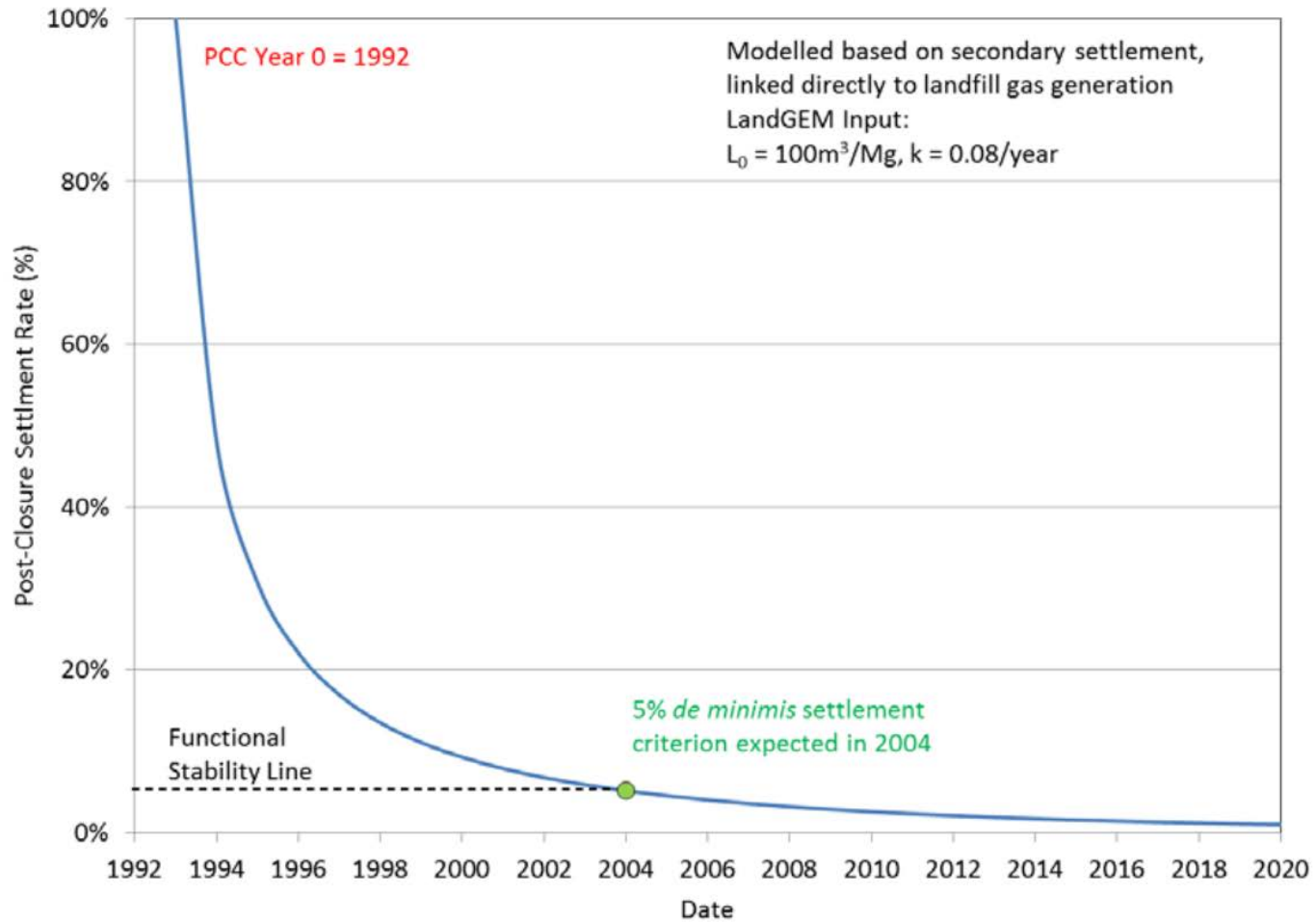
$A_{landfill}$  = landfill area over which infiltration occurs (ft<sup>2</sup>).

The U.S. EPA's HELP model was used to estimate the potential leakage rate from the base of the landfill (through minor imperfections in the liner system) after closure using the approved ET cap design and assuming that operation of the LCS was discontinued. To calibrate the model,

Analyte	Standard	Units	DF-Adjusted Allowable Concentration in Leachate	Current Leachate Concentration	Pass at POC?
	Note 1		Note 2	Note 3	
1,1-Dichloroethane	1 <sup>a</sup>	µg/L	8,581	1	TRUE
cis-1,2-Dichloroethene	70 <sup>a</sup>	µg/L	600,670	2	TRUE
Ammonia	2.8 <sup>b</sup>	mg/L	24,027	930	TRUE
Arsenic	0.05 <sup>a</sup>	µg/L	429	580	FALSE
Benzene	1 <sup>a</sup>	µg/L	8,581	2	TRUE
Chloride	54 <sup>b</sup>	mg/L	463,374	2,700	TRUE
Ethylbenzene	700 <sup>a</sup>	µg/L	6,006,700	37	TRUE
Iron	0.3 <sup>a</sup>	mg/L	2,574	3.9	TRUE
Nickel	10 <sup>b</sup>	µg/L	85,810	220	TRUE
Toluene	1 <sup>a</sup>	mg/L	8,581	0.03	TRUE
Vinyl chloride	0.02 <sup>a</sup>	µg/L	172	1	TRUE
Xylene	10 <sup>a</sup>	mg/L	85,810	0.088	TRUE



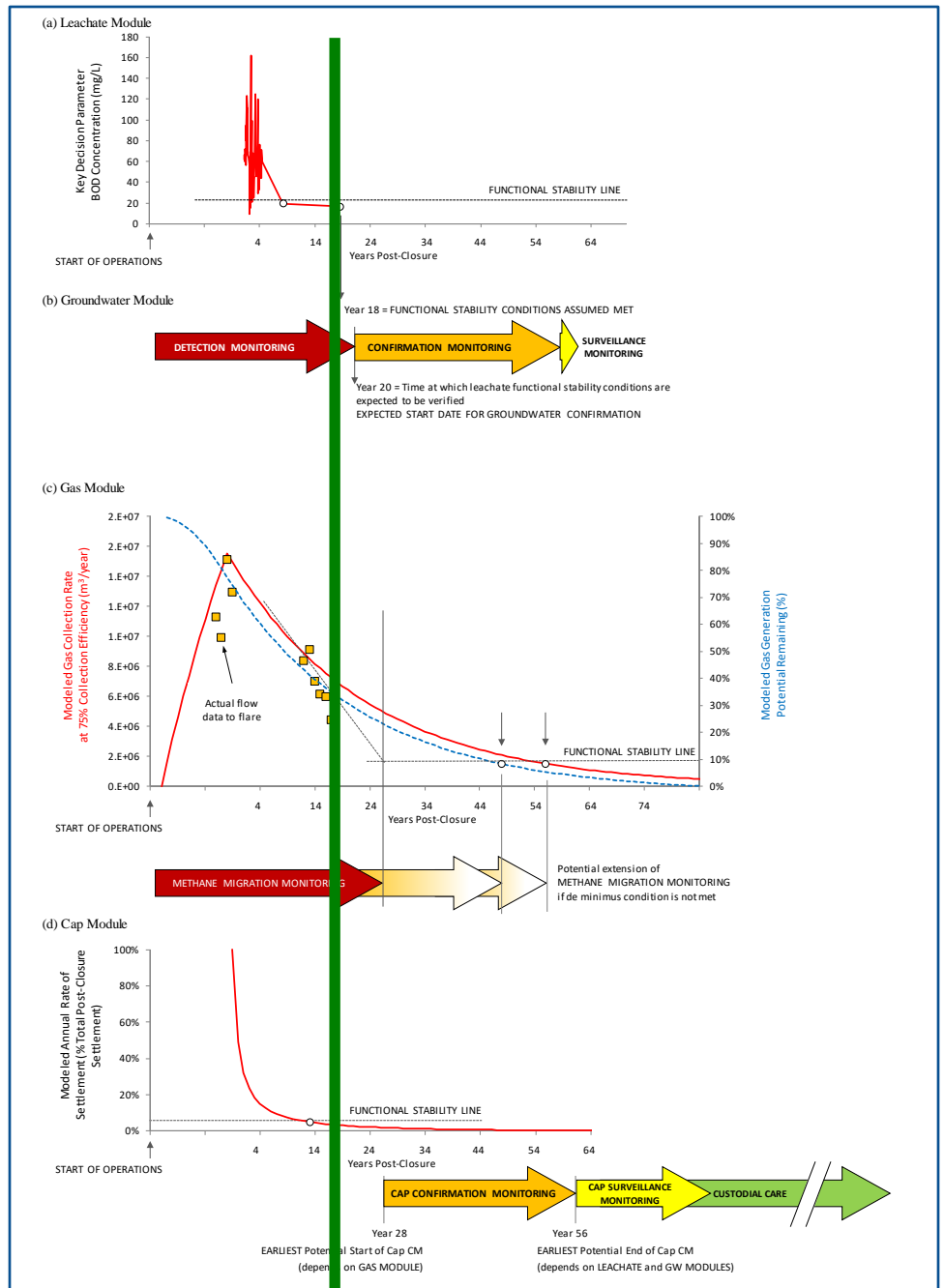
# Cover Settlement



"That's where we are on the curve!"



Reference: Morris, Caldwell, Bull (2012) Application of a performance-based methodology to evaluate optimization and completion of post-closure care at a municipal landfill. Proc. Global Waste Management Symposium, 30 September - 3 October 2012, Phoenix, Arizona



# What is Custodial Care?

- Routine level of passive care needed after active PCC obligations are completed (defined by demonstrating **Functional Stability**)
- Land ownership care obligations:
  - Maintenance of site features and access controls
  - Control of nuisances
- Mandated through land use controls
  - Deed restrictions, covenants, other legal instruments
  - Uniform Environmental Covenants Act (UECA) - if applicable

**No walk away**

# Beneficial Reuse of Landfills: Put your Closed Site to Work!



# Example



## **Partnership in Land Development – Beneficial Re-Use of a Closed Landfill**

**Functional Stability and Land Development –  
Case Study of a cooperative effort between Waste  
Management, the City of Ft. Worth and TCEQ**



**TEXAS COMMISSION  
ON ENVIRONMENTAL QUALITY**



# Trinity River Re-Development Project – Gateway Park

Discover *the Future of*  
**GATEWAY PARK**

FIND DETAILS ABOUT THE ENTIRE TRINITY RIVER VISION PROJECT AT [TRINITYRIVERVISION.ORG](http://TRINITYRIVERVISION.ORG)

Gateway Park's realization is a major component of the Trinity River Vision. Restoring the park to its natural beauty is a key initiative, including the planting of over 80,000 native oak and pecan trees. New, community-requested recreational amenities being added across its 1,000 acres will make Gateway one of the largest urban programmed parks in the nation. The resulting economic development will help connect Fort Worth's east & southeast neighborhoods to the Trinity River Corridor.

### KEY TO GATEWAY PARK IMPROVEMENTS

<ul style="list-style-type: none"> <li> EXISTING PARKING</li> <li> NEW PARKING</li> <li> NEW ENTRY TOWERS</li> <li> NEW PEDESTRIAN BRIDGE</li> <li> NEW SPLASH PARK</li> <li> NEW BOAT LAUNCH</li> <li> EXISTING BOAT LAUNCH</li> <li> NEW ROCK WEIR</li> <li> NEW PLAYGROUND</li> <li> NEW ECOSYSTEM RESTORATION</li> <li> NEW MAINTENANCE FACILITY</li> <li> NEW EQUESTRIAN TRAILS</li> <li> NEW PRIMITIVE HORING TRAILS</li> <li> NEW SOFT-PAVED TRAILS</li> <li> EXISTING TRAILS</li> <li> EXISTING DISC GOLF COURSE</li> <li> NEW SCENIC RIVER OVERLOOKS</li> <li> NEW CONCESSION AREA</li> </ul>	<ul style="list-style-type: none"> <li> NEW BASEBALL/SOFTBALL FIELDS</li> <li> NEW SOCCER FIELDS</li> <li> EXISTING BASEBALL/SOFTBALL FIELDS</li> <li> EXISTING SOCCER FIELDS</li> <li> NEW MOUNTAIN BIKE COURSE</li> <li> EXISTING MOUNTAIN BIKE TRAILS</li> <li> EXISTING DOG PARK</li> <li> NEW LAKE &amp; WETLANDS</li> <li> NEW TRAILHEADS</li> <li> NEW SKATE PARK</li> <li> NEW RESTROOMS</li> <li> NEW PICNIC AREA</li> </ul>	<ul style="list-style-type: none"> <li> EXISTING TRAILS</li> <li> EXISTING TRAILS TO BE REVERT</li> <li> EXISTING SOFT-PAVED TRAILS</li> <li> NEW CONCRETE TRAILS</li> <li> NEW EQUESTRIAN TRAILS</li> <li> EXISTING INTERIOR PARK ROADS</li> <li> NEW INTERIOR PARK ROADS</li> <li> EXISTING MOUNTAIN BIKE TRAILS</li> </ul>
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**PROJECT PARTNERS**

MAP IS FOR ILLUSTRATIVE PURPOSES ONLY.

Bryan W. Shaw, Ph.D., P.E., *Chairman*  
Toby Baker, *Commissioner*  
Richard A. Hyde, P.E., *Executive Director*



## TEXAS COMMISSION ON ENVIRONMENTAL QUALITY

*Protecting Texas by Reducing and Preventing Pollution*

August 13, 2015

Mr. Andrew Shafer  
District Manager  
Waste Management of Texas, Inc.  
9590 Clay Road  
Houston, Texas 77080

Re: Eastside Landfill – Tarrant County  
Municipal Solid Waste (MSW) – Permit No. 1004C  
Completion of Post-Closure Care Period and Permit Revocation  
Tracking No. 19525583; RN100218437/CN602613069

Dear Mr. Shafer:

On July 22, 2015, Ms. Jennifer Wells of the Texas Commission on Environmental Quality (TCEQ), Region 4, Office in Fort Worth, inspected the referenced MSW facility. The purpose of the inspection was to verify that all on-site activities necessary for the site to exit the post-closure care maintenance period had been completed. In a follow up report, our representative determined that all post-closure care maintenance requirements stated in Title 30 of the Texas Administrative Code (TAC), Section (§)330.463 (relating to Post-Closure Care Maintenance Requirements) had been satisfied and the site has completed the post-closure care maintenance period. This office is also in receipt of the Request for Voluntary Revocation form signed by you. A certified copy of an "Affidavit to the Public" for this site was received on July 17, 2015.

# New York Landfill - Case Study (~1970-1993)

Waste Management 75 (2018) 415–426



Contents lists available at [ScienceDirect](#)

Waste Management

journal homepage: [www.elsevier.com/locate/wasman](http://www.elsevier.com/locate/wasman)



## Case study comparison of functional vs. organic stability approaches for assessing threat potential at closed landfills in the USA



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EPCC methodology

### ABSTRACT

Municipal solid waste (MSW) landfills in the USA are regulated under Subtitle D of the Resource Conservation and Recovery Act (RCRA), which includes the requirement to protect human health and the environment (HHE) during the post-closure care (PCC) period. Several approaches have been published for assessment of potential threats to HHE. These approaches can be broadly divided into organic stabilization, which establishes an inert waste mass as the ultimate objective, and functional stability, which considers long-term emissions in the context of minimizing threats to HHE in the absence of active controls. The objective of this research was to conduct a case study evaluation of a closed MSW landfill using long-term data on landfill gas (LFG) production, leachate quality, site geology, and solids decomposition. Evaluations based on both functional and organic stability criteria were compared. The results showed that longer periods of LFG and leachate management would be required using organic stability criteria relative to an approach based on functional stability. These findings highlight the somewhat arbitrary and overly stringent nature of assigning universal stability criteria without due consideration of the landfill's hydrogeologic setting and potential environmental receptors. This supports previous studies that advocated for transition to a passive or inactive control stage based on a performance-based functional stability framework as a defensible mechanism for optimizing and ending regulatory PCC.

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# WAC 173-351-500: Closure and Post-Closure Care

## WAC 173-351-500(2)(a)

- A closed landfill is **functionally stable** when it does not present a threat to HHE at the POE for humans or environmental receptors

## WAC 173-351-500(2)(b)(iii) – Consider at least the following factors:

- (A) Leachate production and quality must be such that maintenance and operation of the LCS can be ceased...
- (B) LFG production and composition must be such that maintenance and operation of the GCS can be ceased...
- (C) The cover system must attain geotechnical stability for slope and settlement...
- (D) Groundwater quality must remain in compliance with the protection standards established in WAC 173-351-440(8) at the relevant POC



## **COLORADO**

**Hazardous Materials  
& Waste Management Division**

Department of Public Health & Environment

<b>Policy Title:</b> ☞	<b>End of Post-Closure Care for Solid Waste Sites and Facilities</b>
<b>Program(s) Initiating the Policy:</b>	<b>Solid Waste and Materials Management Program</b>
<b>Program(s) Subject to the Policy:</b>	<b>Solid Waste and Materials Management Program</b>
<b>Regulatory Citations:</b>	<b>6 CCR 1007-2, §§2.6, 3.6 and 17.6</b>

### **Policy Purpose:**

The Colorado Regulations Pertaining to Solid Waste Sites and Facilities (the Regulations) require facility owners and/or operators to perform long-term post-closure care and maintenance when landfills or other solid waste units that leave waste and/or contamination behind close. The purpose of this policy is to define the criteria by which the Department will determine that post-closure care and maintenance may end at landfills and other solid waste units where wastes and/or contamination remain after closure.

### **Policy:**

The Regulations, in sections 2.6, 3.6, and 17.6, establish requirements for post-closure care and maintenance for landfills and other units where solid wastes and/or contamination will remain after closure. These requirements ensure ongoing protection of human health and the environment until such



# Florida Department of Environmental Protection

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2600 Blair Stone Road  
Tallahassee, Florida 32399-2400

Rick Scott  
Governor

Carlos Lopez-Cantera  
Lt. Governor

Jonathan P. Steverson  
Secretary

## Guidance Document SWM-04.45 LTC AT SOLID WASTE DISPOSAL FACILITIES February 20, 2016

The performance-based approach focuses on helping regulators and owner/operators decide when a disposal facility has reached "functional stability" rather than, for example, becoming completely stabilized. For the purposes of this guidance, functional stability for a disposal facility means the facility no longer poses an unacceptable threat to human health or the environment (HHE) at the point of exposure in the absence of active controls. Once a disposal unit has reached functional stability, then the regulatory LTC period for that facility is complete and it can be moved into non-regulatory, custodial care. Custodial care could include activities

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<sup>7</sup> Florida's concept of LTC is identified as post-closure care (i.e., PCC) in EPA's Subtitle D regulations and essentially means the same thing for the purposes of this guidance.

<sup>8</sup> For example, case studies using this methodology are presented in EREF (2011), and Morris, et al. (2013).

# Functional Stability Q&A

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- ➔ Is it really as simple as “where are you on the curve?”
  - ➔ Qualified Yes.....this requires data.
- ➔ Can this concept be used on a modular basis to optimize OPEX prior to ending PCC for the landfill?
  - ➔ Yes - optimizing PCC costs is a critical element of the functional stability objective
- ➔ What is the next step after determining a landfill is functionally stable?
  - ➔ Confirmation monitoring. Monitor to confirm shutting off active controls is protective
- ➔ After that?
  - ➔ Custodial Care. Non-regulatory (non-FA) property management (perhaps with Institutional controls/deed restriction).

## Take Away Messages

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- Performance-based EPCC Methodology is a technical framework that can be a bridge between a closed landfill & beneficial property re-use
- A functional stability-derived outcome provides:
  - Risk and cost “certainty” for all stakeholders
    - Alternative to perpetual care or source removal alternatives
    - Places burden on the O/O to show “no threat at a POE”
  - Reasonable allocation of financial resources aimed at a shared objective of beneficial re-use of the property

Process provides a more objective outcome with the goals understood by all parties in advance

Thank You!