2025 Report Card for America's Infrastructure

Hazardous Waste

October 27th, 2026

ASCE
AMERICAN SOCIETY OF CIVIL ENGINEERS



Agenda

- Overview of ASCE Report Card
- Panel Perspectives
- Q&A



ASCE
AMERICAN SOCIETY OF CIVIL ENGINEERS



Presentation FYI

- Webinar is being recorded
- Recording and slides will be made available
- Attendee input via typed questions
- Send any technical issues/questions through the chat function

ASCE
AMERICAN SOCIETY OF CIVIL ENGINEERS

ASCE *Making the Grade: Hazardous Waste*

Panelists



Adam Mehevec,
Vice President, Civil & Environmental Consultants, Inc



Sara Bixby,
Director of Regulatory and Environmental Affairs, NWRA



Dr. Bryan Staley,
President, EREF



Andy Hoffman,
Senior Manager Strategic Services, Republic Services



Ken Mika,
ASCE Committee on America's Infrastructure

Civil & Environmental Consultants, Inc.

Collect Recycle Innovate
National Waste & Recycling Association

EREF
Environmental Research & Education Foundation
Lighting the way towards a more circular economy

REPUBLIC SERVICES
Sustainability in Action

ASCE
AMERICAN SOCIETY OF CIVIL ENGINEERS

ASCE
AMERICAN SOCIETY OF CIVIL ENGINEERS



ASCE 2025 REPORT CARD FOR AMERICA'S INFRASTRUCTURE

2025 Report Card for America's Infrastructure

AVIATION		D+
BRIDGES		C
BROADBAND	NEW	C+
DAMS	↑	D+
DRINKING WATER		C-
ENERGY	↓	D+
HAZARDOUS WASTE	↑	C
INLAND WATERWAYS	↑	C-
LEVEES	↑	D+
PARKS AND RECREATION	↑	C-
PORTS	↑	B
RAIL	↓	B-
ROADS	↑	D+
SCHOOLS		D+
SOLID WASTE		C+
STORMWATER		D
TRANSIT	↑	D
WASTEWATER		D+

America's Cumulative Infrastructure Grade



A	EXCEPTIONAL
B	GOOD
C	MEDIOCRE
D	POOR
F	FAILING

What the Grades Mean



EXCEPTIONAL
Fit for the future



GOOD
Adequate for now



MEDIOCRE
Requires attention



POOR
At risk



FAILING/CRITICAL
Unfit for purpose

Methodology

- CAPACITY
- OPERATION AND MAINTENANCE
- CONDITION
- PUBLIC SAFETY
- FUNDING
- RESILIENCE
- FUTURE NEED
- INNOVATION

Investment Gap

Infrastructure System	TOTAL NEEDS	FUNDED	FUNDING GAP
AVIATION	$310	$197	$113
BRIDGES	$538	$165	$373
BROADBAND	$61	$61	$0
DAMS	$185	$20	$166
DRINKING WATER	$670	$361	$309
ENERGY	$1,886	$1,308	$578
HAZARDOUS & SOLID WASTE	$162	$146	$16
INLAND WATERWAYS & PORTS	$45	$32	$13
LEVEES	$97	$7	$91
PUBLIC PARKS	$106	$62	$44
RAIL	$145	$113	$32
ROADS	$2,233	$1,549	$684
SCHOOLS	$1,100	$671	$429
TRANSIT	$618	$466	$152
WASTEWATER + STORMWATER	$983	$293	$690
TOTALS	**$9,139**	**$5,450**	**$3,689**

$3.7 Trillion needed



CURRENT FUNDING | FUNDING GAP


Sustaining Investment
Prioritizing Resiliency
Advancing Policy & Innovation

Grading Public Hazardous Waste

2021 Grade = D+ 2025 Grade = C

Criteria	Change	Why?
Capacity		Generation of hazardous waste from industry has remained stable and existing infrastructure to manage hazardous waste generation is adequate.
Condition		IIJA funding has eliminated the backlog of Superfund sites where cleanup had not started. Of 1,789 current/past Superfund sites, 69% have constructed remedies in place.
Funding		The IIJA along with the reinstatement of the Chemical Feedstock Tax and Petroleum and Oil Tax provide for sustained funding at higher levels.

Grading Hazardous Waste

2021 Grade = D+ 2025 Grade = C

Criteria	Change	Why?
Future Need		Additional resources for transport of hazardous waste from locations of generation to treatment/disposal are needed.
Public Safety		Greater protection of public health has resulted from accelerated clean up activities and increased regulations
Resilience		To better support resilient outcomes, potential impacts from storm surge, wildfires, etc. are evaluated when selecting treatment locations.
Innovation		Remediation technologies continue to improve, major R&D investments focused on understanding PFAS toxicity, sampling, analysis, and treatment.

Recommendations to Raise the Grade

- Establish a geologic repository for permanent storage of radioactive waste.
- Resolve long-standing technology and implementation problems for long-term stabilization of high-level radioactive wastes.
- Develop more reliable hazardous remediation cost estimating tools so the nation can effectively plan and budget for future hazardous waste management and infrastructure costs.
- Strengthen the nation's existing recycling systems.
- Accelerate and increase investment in PFAS research.
- Direct robust funding to the state RCRA programs.
- Maintain current funding levels for Superfund and Brownfield programs.

U.S. Hazardous Waste Infrastructure

State of Practice, Capacity and What Comes Next



Bryan Staley, PhD, PE
President & CEO, Environmental Research & Education Foundation
October 2026

Civil & Environmental Consultants, Inc.

Collect Recycle Innovate
National Waste & Recycling Association®

EREF
Environmental Research & Education Foundation™
Lighting the way towards a more circular economy

REPUBLIC SERVICES
Sustainability in Action

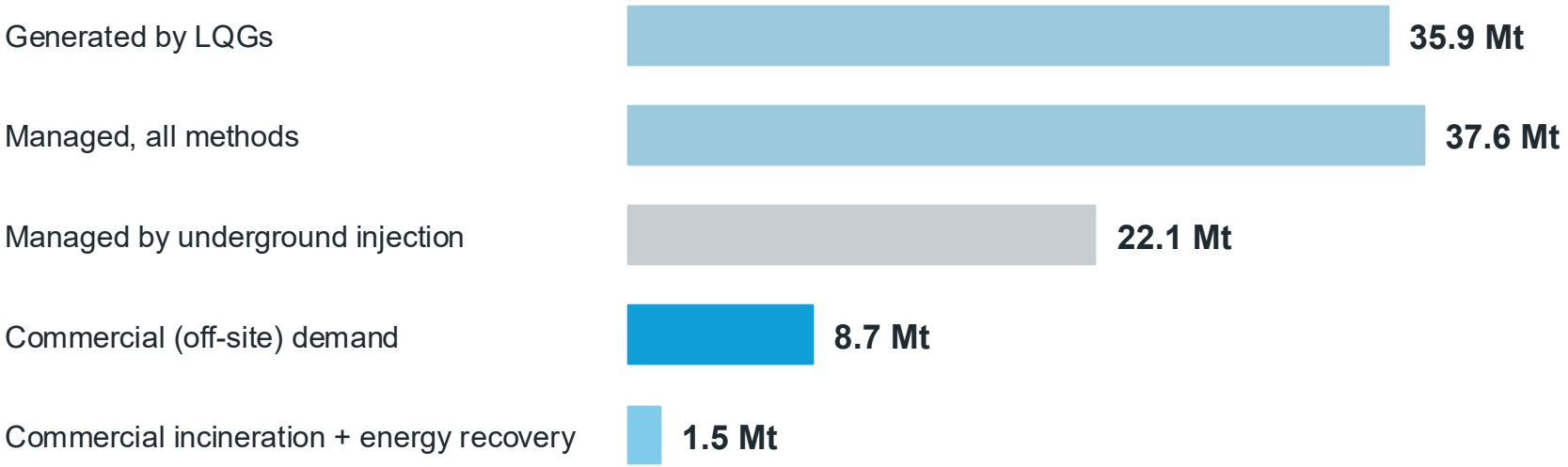
ASCE
AMERICAN SOCIETY OF CIVIL ENGINEERS

Four Quantities That Are Routinely Conflated

Generation, management, commercial demand and thermal demand differ by more than an order of magnitude



U.S. hazardous waste, 2021 (million short tons)



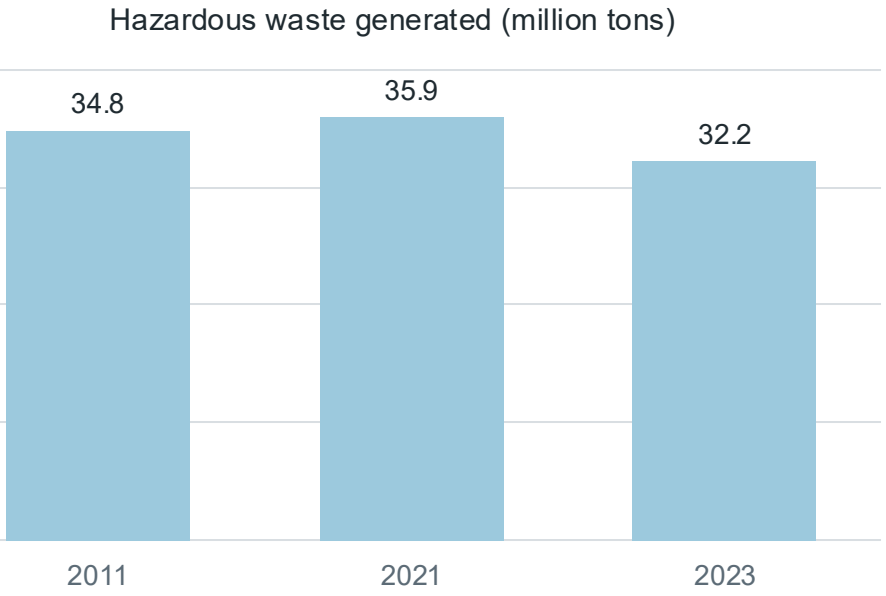
Managed exceeds generated because cleanup wastes and multi-step management are counted. Commercial demand ≈ 24% of generation.

SOURCE: ASCE 2025 Report Card, Hazardous Waste; U.S. EPA RCRA Biennial Report (2021); U.S. EPA National Capacity Assessment (Jan. 2025), Table III

CEC Civil & Environmental Consultants, Inc.
Collect Recycle Innovate National Waste & Recycling Association®
EREF Environmental Research & Education Foundation™ Lighting the way towards a more circular economy
REPUBLIC SERVICES Sustainability in Action
ASCE AMERICAN SOCIETY OF CIVIL ENGINEERS

Generation Is Flat in Aggregate and Highly Concentrated

National tonnage reflects a small number of very large industrial generators



~50%

of national generation reported in Texas

~80%

from three sectors: chemicals, petroleum & coal products, waste treatment

8

facilities each generated more than 1 million tons (2021)

19,310

reporting generator sites (2021)

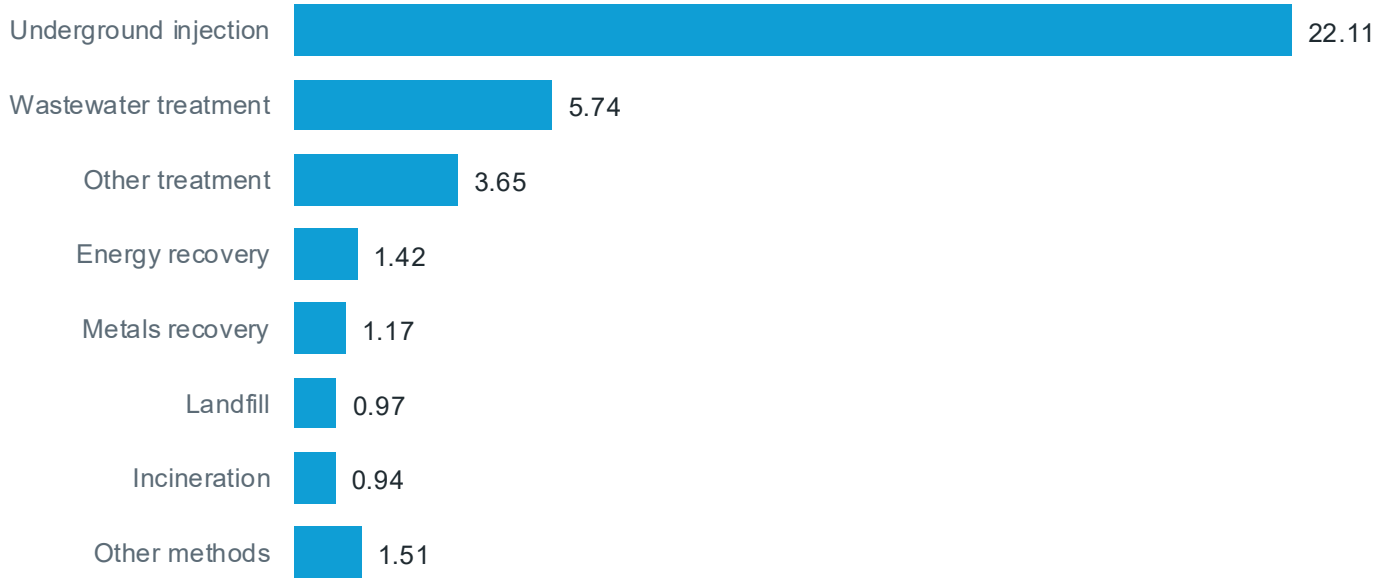
Concentration indicates a few large Gulf Coast sites, managing aqueous wastes on-site, set the national total.

SOURCE: U.S. EPA RCRA Biennial Reports (2011, 2021, 2023); ASCE 2025 Report Card, Hazardous Waste

CEC Civil & Environmental Consultants, Inc.
Collect Recycle Innovate National Waste & Recycling Association®
EREF Environmental Research & Education Foundation™ Lighting the way towards a more circular economy
REPUBLIC SERVICES Sustainability in Action
ASCE AMERICAN SOCIETY OF CIVIL ENGINEERS

Most Tonnage Never Enters the Thermal or Landfill Network

Hazardous waste managed by method, 2021 (37.6 million tons)



59% underground injection

Largely on-site Class I wells at the generating facility

6% thermal

Incineration (0.94 Mt) plus energy recovery (1.42 Mt)

2.6% landfill

0.97 Mt to Subtitle C landfill after treatment to LDR standards

SOURCE: U.S. EPA RCRA Biennial Report (2021) as reported in ASCE 2025 Report Card, Hazardous Waste

CEC Civil & Environmental Consultants, Inc.
Collect Recycle Innovate National Waste & Recycling Association®
EREF Environmental Research & Education Foundation™ Lighting the way towards a more circular economy
REPUBLIC SERVICES Sustainability in Action
ASCE AMERICAN SOCIETY OF CIVIL ENGINEERS

Fewer Facilities Manage the Same Tonnage

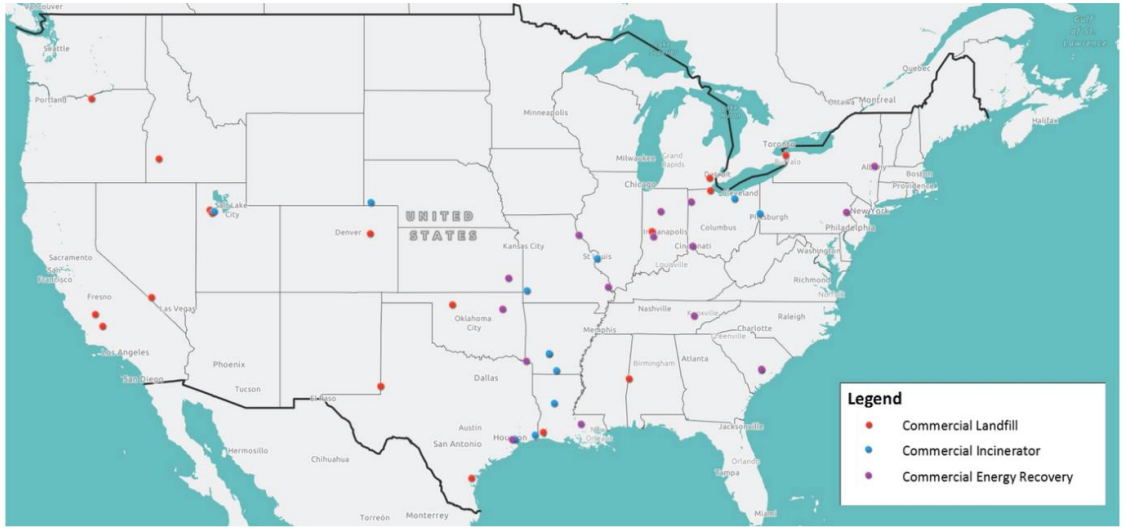
The regulated management network has consolidated while generation stayed flat

1,395 → 882

RCRA management facilities, 2011 to 2021 (−37%), while generation rose 3%

Commercial pathway	Facilities	2021 demand*	Capacity
Incineration	10 + 1 specialty	0.50 Mt	0.89 Mt/yr
Energy recovery	13	0.98 Mt	1.90 Mt/yr
Subtitle C landfill	17	0.84 Mt	75.6 Mt remaining

**Demand = EPA commercial process + cleanup waste. Landfill capacity is remaining permitted tons (stock); others are annual maximum operational capacity.*



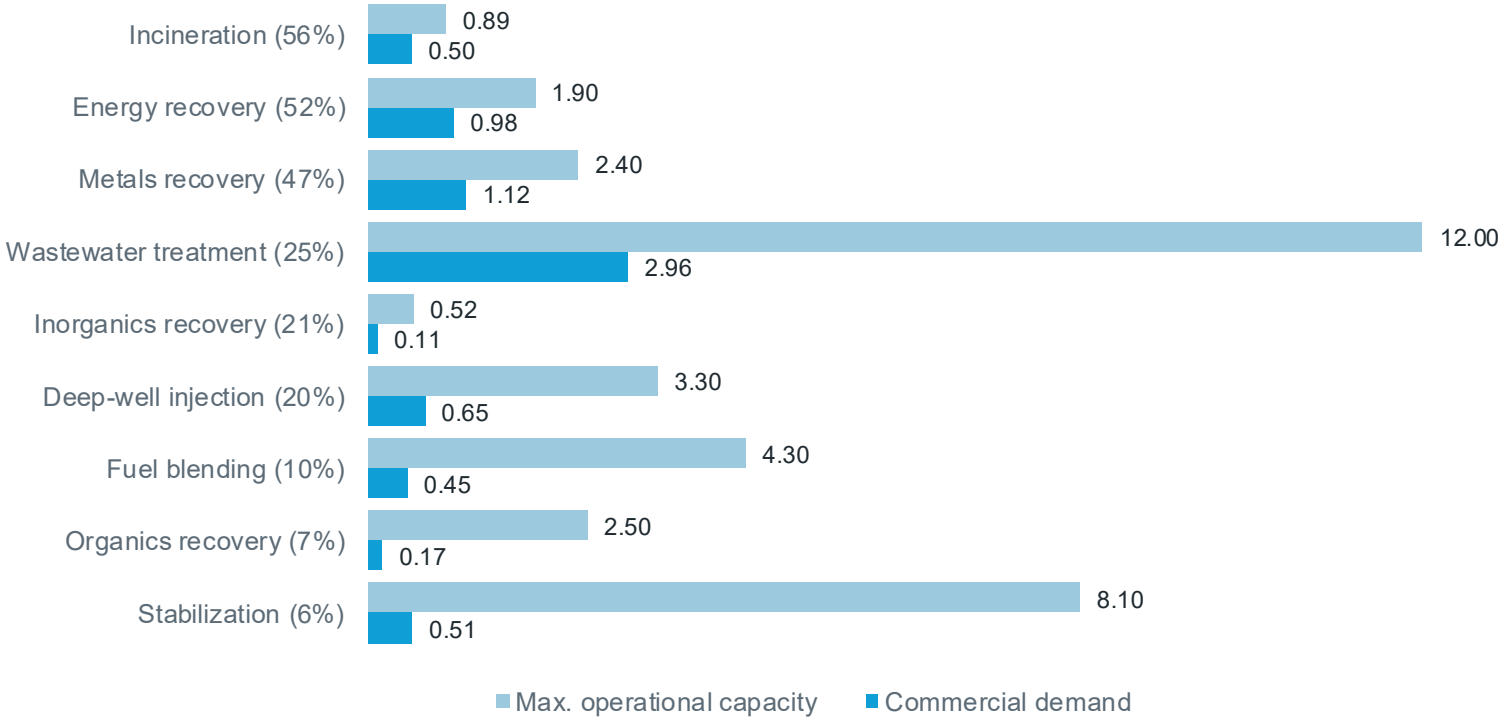
Commercial landfills, incinerators and energy-recovery facilities. Excludes recovery, wastewater treatment and injection facilities.

SOURCE: ASCE 2025 Report Card, Hazardous Waste (map sourced to U.S. DOE); U.S. EPA National Capacity Assessment (Jan. 2025), Table III and Appendix A

CEC Civil & Environmental Consultants, Inc.
Collect Recycle Innovate National Waste & Recycling Association®
EREF Environmental Research & Education Foundation™ Lighting the way towards a more circular economy
REPUBLIC SERVICES Sustainability in Action
ASCE AMERICAN SOCIETY OF CIVIL ENGINEERS

Most Commercial Pathways Run Well Below Operational Capacity

2021 commercial demand vs. maximum operational capacity (million tons/yr); utilization in parentheses



Thermal is the tight segment

Incineration and energy recovery are the only pathways above 50%

Three distinct capacities

- Permitted: what a unit is authorized to receive
- Operational: what it can process given downtime and feed limits
- Accessible: what a given generator can use after acceptance criteria, distance and cost

SOURCE: U.S. EPA National Capacity Assessment Report (Jan. 24, 2025), Table III; demand base year 2021, capacity base year 2023

Civil & Environmental Consultants, Inc.

Collect Recycle Innovate
National Waste & Recycling Association®

EREF
Environmental Research & Education Foundation™
Lighting the way towards a more circular economy

REPUBLIC SERVICES
Sustainability in Action

ASCE
AMERICAN SOCIETY OF CIVIL ENGINEERS

Incineration Is the Binding Constraint, and Tons Understate It

A unit at 56% of tonnage capacity can be fully booked for specific waste forms



11
commercial incinerators in the EPA inventory

0.89 Mt/yr
maximum operational capacity (2023 base)

+0.17 Mt/yr
announced additions, ≈19% of current capacity

Why tonnage misleads

Throughput is set by heat release, feed form and halogen/metals feed-rate limits, plus refractory downtime. EPA reports the shortfall falls mainly on containerized wastes.

Capacity response

Clean Harbors, Kimball, NE: 70,000 tons/yr, opened late 2024 and ramping.

Veolia, Arkansas: ~100,000 tons/yr in development.

Demand pressure

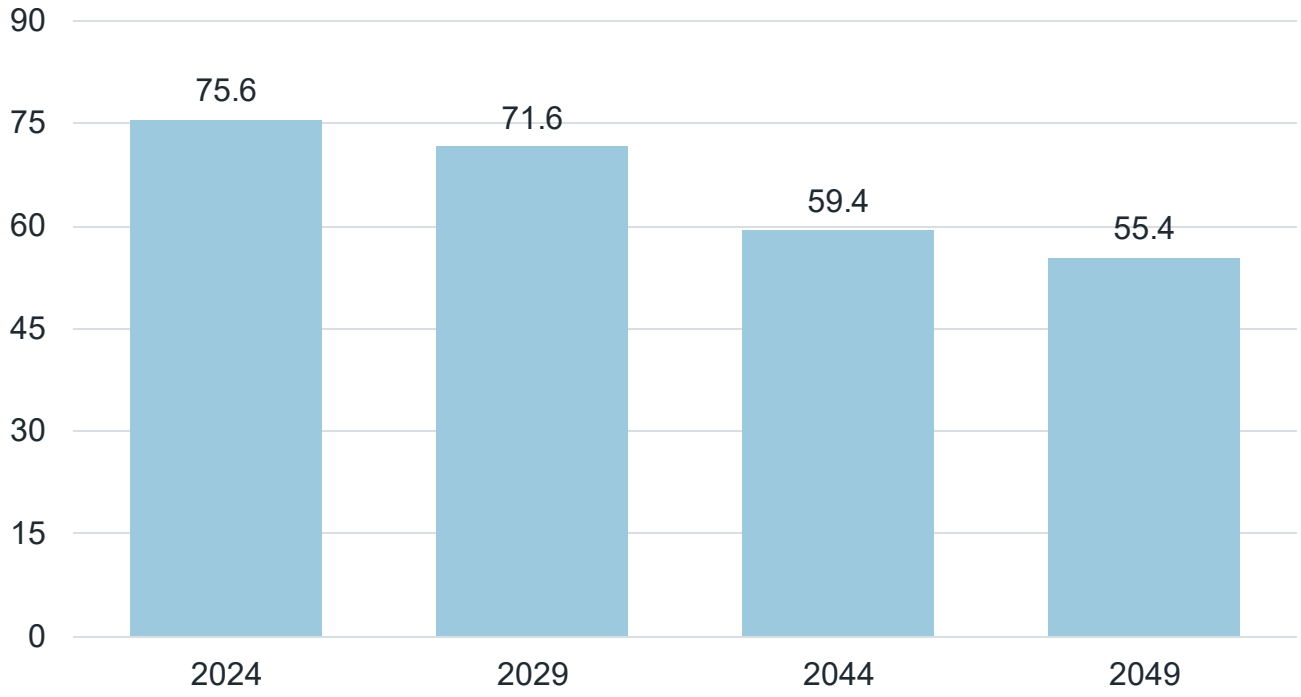
PFAS wastes, pharmaceutical and semiconductor manufacturing, and containerized lab-pack streams all compete for the same units.

SOURCE: U.S. EPA National Capacity Assessment (Jan. 2025); Waste Dive (Oct. 2024; 2025) reporting on Clean Harbors and Veolia capacity additions

CEC Civil & Environmental Consultants, Inc.
Collect Recycle Innovate National Waste & Recycling Association®
EREF Environmental Research & Education Foundation™ Lighting the way towards a more circular economy
REPUBLIC SERVICES Sustainability in Action
ASCE AMERICAN SOCIETY OF CIVIL ENGINEERS

Subtitle C Landfill Space Is a Stock That Is Drawing Down

EPA projected remaining permitted commercial Subtitle C capacity (million tons)



0.84 Mt
annual commercial landfill demand (2021)

−27%
drawdown of remaining capacity by 2049

~90 yr
static life (75.6 ÷ 0.84), a misleading average

17
commercial Subtitle C landfills

Projection assumes no new permitted space; episodic cleanup volumes are not in the baseline.

SOURCE: U.S. EPA National Capacity Assessment (Jan. 2025), Tables III and VI; capacity base year 2023, demand base year 2021

Civil & Environmental Consultants, Inc.

Collect Recycle Innovate
National Waste & Recycling Association®

EREF
Environmental Research & Education Foundation™
Lighting the way towards a more circular economy

REPUBLIC SERVICES
Sustainability in Action

ASCE
AMERICAN SOCIETY OF CIVIL ENGINEERS

PFAS Mainly Changes Where Waste Goes

Federal direction now steers PFAS residuals toward the three most capacity-limited pathways



REGULATORY STATUS

- **Apr 2024** — PFOA and PFOS designated CERCLA hazardous substances
- **Apr 2026** — EPA interim destruction & disposal guidance, third version
- **May 2026** — Proposal to list 9 PFAS as RCRA hazardous constituents withdrawn
- **Aug 2026** — D.C. Circuit upholds CERCLA designation

GUIDANCE PATHWAY → INFRASTRUCTURE STATUS

Guidance pathway	Commercial infrastructure
Thermal treatment (>1,100 °C, long residence time)	11 incinerators at 56% utilization; tightest segment
Subtitle C landfill	17 facilities; 2026 data suggest higher release rates than assumed in 2024
Class I injection (liquids)	20% utilized nationally; geology limits locations

CERCLA hazardous substance ≠ RCRA hazardous waste: routing is driven by liability exposure.

SOURCE: 89 FR 39124 (May 2024); D.C. Cir., Chamber of Commerce v. EPA, No. 24-1193 (Aug. 18, 2026); EPA Interim PFAS Destruction & Disposal Guidance (Apr. 2026); EPA withdrawal notice (May 8, 2026)

CEC Civil & Environmental Consultants, Inc.
Collect Recycle Innovate National Waste & Recycling Association®
EREF Environmental Research & Education Foundation™ Lighting the way towards a more circular economy
REPUBLIC SERVICES Sustainability in Action
ASCE AMERICAN SOCIETY OF CIVIL ENGINEERS

Recent full-scale incinerator U.S. EPA stack test



	Haz Waste Incinerator (Clean Harbors, Aragonite, Utah)
Unit	Hazardous waste incinerator: rotary kiln + afterburner
Temperature	Kiln 950–1196 °C; afterburner >1100 °C
Feed	AFFF concentrate plus nine spiked PFAS
PFAS Reduction	99.95–99.9999% (nine spiked PFAS)
C2F6 indicator Reduction	99.99–99.9999%
Stack results	Volatile fluorinated compounds <1 ppbv; most PFAS non-detect

SITE-SPECIFIC OBSERVATIONS

- Clean Harbors: whole-system mass balance gave destruction efficiency of 99.97–99.9999%; third test at this unit
- C2F6 is harder to destroy than most PFAS, so both studies point to it as a simpler indicator for future testing

Source: U.S. EPA (2025) EPA 600/R-25/172

Civil & Environmental Consultants, Inc.

Collect Recycle Innovate
National Waste & Recycling Association®

EREF
Environmental Research & Education Foundation™
Lighting the way towards a more circular economy

REPUBLIC SERVICES
Sustainability in Action

ASCE
AMERICAN SOCIETY OF CIVIL ENGINEERS

Future Drivers Change the Mix and Location of Demand

Separating quantified signals from directional ones



Driver	Quantitative signal	Infrastructure affected	Confidence
Manufacturing growth (semiconductors, pharma, autos)	37.4 Mt by 2033, +5 Mt vs. 2023; 4 Mt from manufacturing	Commercial treatment and thermal	Moderate (industry-sponsored estimate)
PFAS	Federal guidance favors thermal, Subtitle C and Class I wells	Incineration, landfill, injection	High on direction, low on magnitude
Lithium batteries and PV panels	Universal waste rule: proposal targeted 2026, final 2027	Collection, storage, recycling, fire safety	High on direction
Climate and remediation	~60% of non-federal NPL sites in areas exposed to climate hazards	Landfill, transport, remedy resilience	Episodic and regional
Data and oversight	e-Manifest paper sunset targeted 2027; RCRA state grants flat since 1995	Tracking, permitting throughput	High

SOURCE: Charles River Associates for Veolia (2025), via Waste Dive; EPA Unified Agenda (2026); ASCE 2025 Report Card; GAO-20-73

CEC Civil & Environmental Consultants, Inc.
Collect Recycle Innovate National Waste & Recycling Association®
EREF Environmental Research & Education Foundation™ Lighting the way towards a more circular economy
REPUBLIC SERVICES Sustainability in Action
ASCE AMERICAN SOCIETY OF CIVIL ENGINEERS

TAKEAWAYS

Adequacy Is a Question of Fit, Location and Waste Form

National capacity totals can mask shortages for specific waste streams and regions



01

Tonnage is the wrong headline

About 24% of generation reaches the commercial market and about 4% reaches commercial thermal units. Capacity questions live in those slices.

02

Thermal is the constraint

Incineration runs at 56% of tonnage capacity yet is short for containerized wastes; announced additions equal ≈19% of current capacity.

03

Demand is shifting toward constrained pathways

PFAS guidance, manufacturing growth and liability-driven routing all point to the same 11 incinerators and 17 landfills.

Will the right capability exist, in the right place, for the right waste?

SOURCE: U.S. EPA National Capacity Assessment (Jan. 2025); ASCE 2025 Report Card, Hazardous Waste

CEC Civil & Environmental Consultants, Inc.

Collect Recycle Innovate National Waste & Recycling Association®

EREF Environmental Research & Education Foundation™ Lighting the way towards a more circular economy

REPUBLIC SERVICES Sustainability in Action

ASCE AMERICAN SOCIETY OF CIVIL ENGINEERS



Synthetic Final Cover Over a Hazardous Waste Landfill

Adam Mehevec, P.E.

Civil & Environmental Consultants, Inc.

Collect Recycle Innovate
National Waste & Recycling Association®

EREF
Environmental Research & Education Foundation™
Lighting the way towards a more circular economy

REPUBLIC SERVICES
Sustainability in Action

ASCE
AMERICAN SOCIETY OF CIVIL ENGINEERS

Beyond Disposal

Circularity Enhancements in Hazardous Waste



Civil & Environmental Consultants, Inc.

Collect Recycle Innovate
National Waste & Recycling Association®

EREF
Environmental Research & Education Foundation™
Lighting the way towards a more circular economy

REPUBLIC SERVICES
Sustainability in Action

ASCE
AMERICAN SOCIETY OF CIVIL ENGINEERS

Presenter



Andy Hoffman

Senior Manager, Strategic Services – ES

Republic Services

Phoenix, Arizona

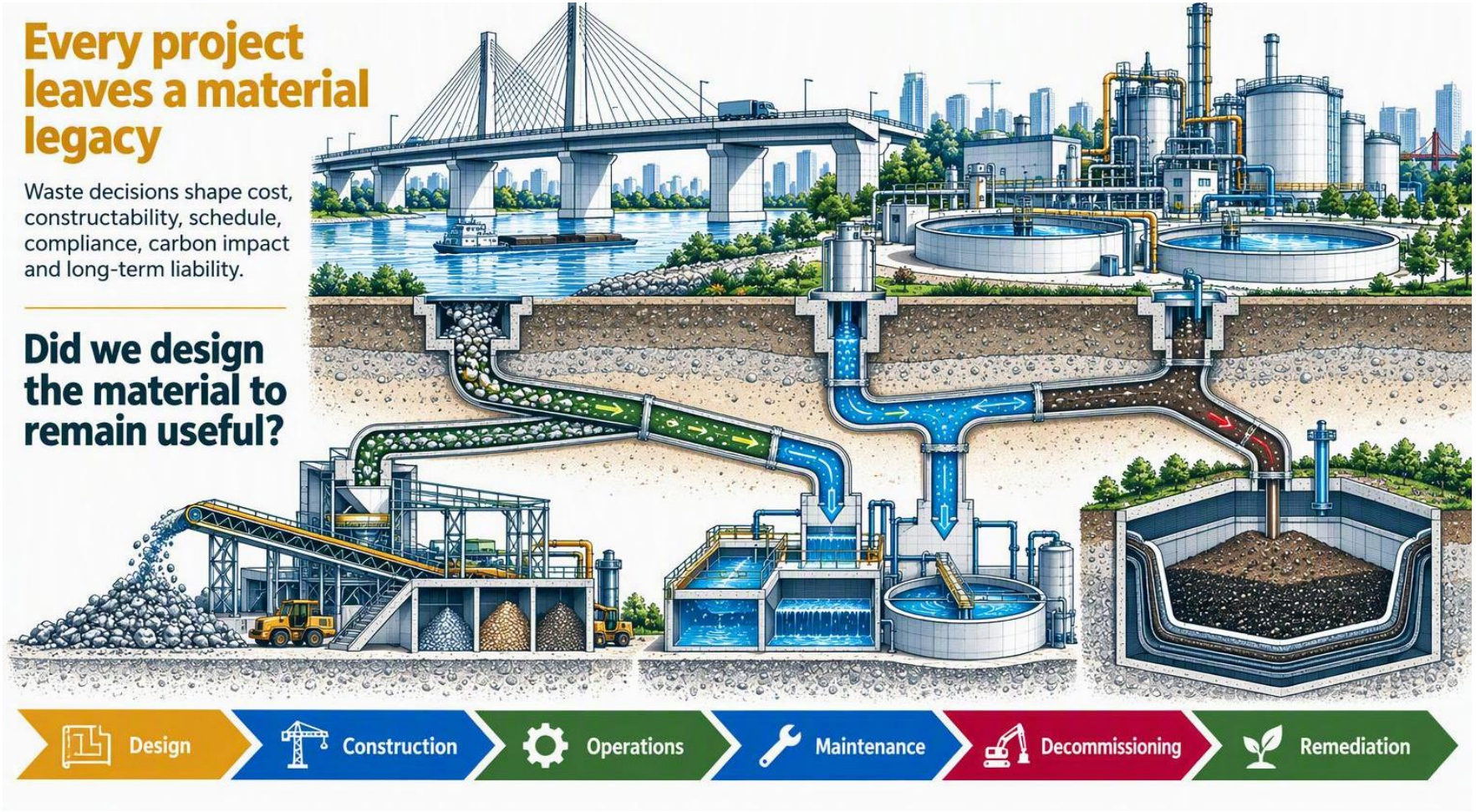
Civil & Environmental Consultants, Inc.

Collect Recycle Innovate
National Waste & Recycling Association®

EREF
Environmental Research & Education Foundation™
Lighting the way towards a more circular economy

REPUBLIC SERVICES
Sustainability in Action

ASCE
AMERICAN SOCIETY OF CIVIL ENGINEERS



Civil & Environmental Consultants, Inc.

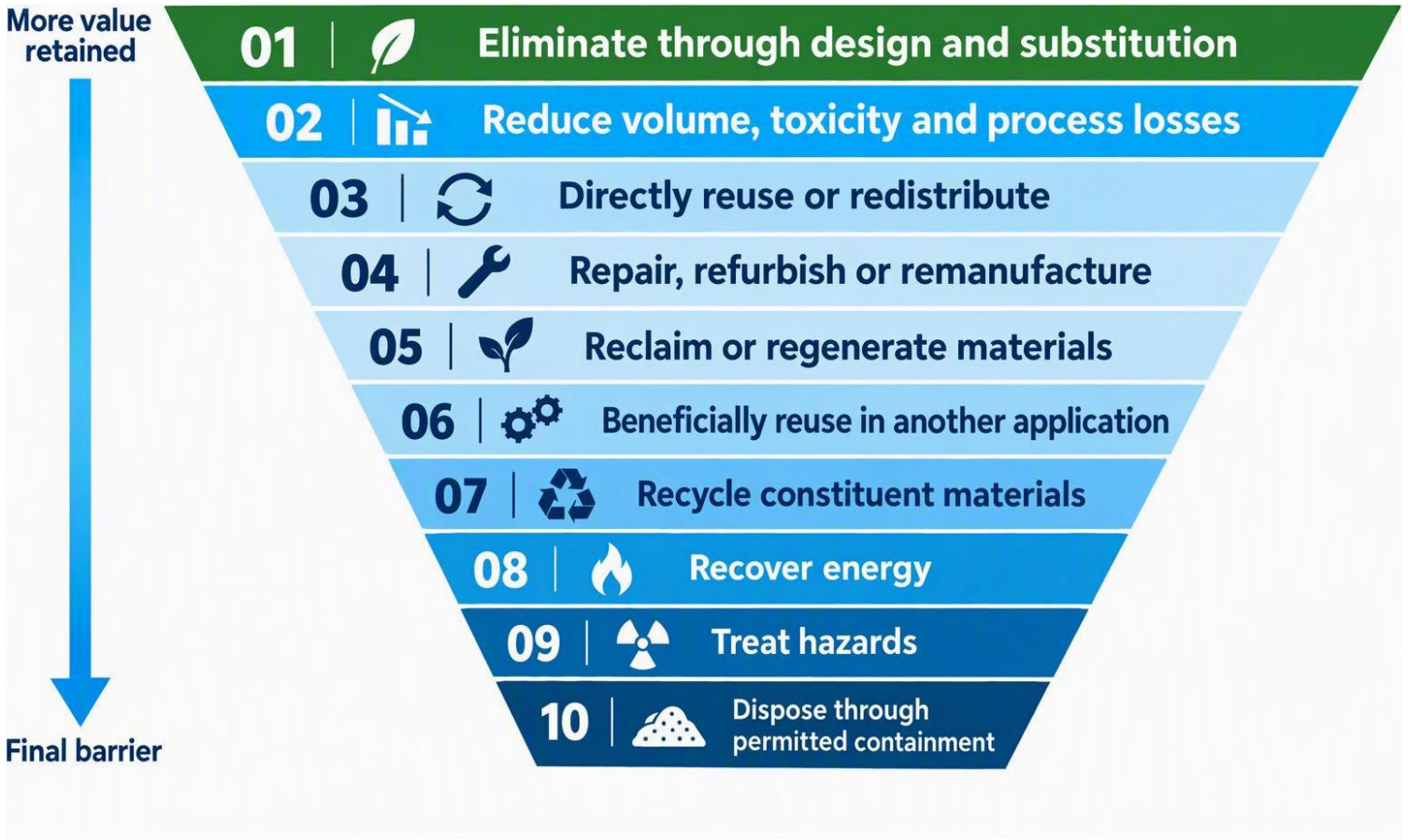
Collect Recycle Innovate
National Waste & Recycling Association®

EREF
Environmental Research & Education Foundation™
Lighting the way towards a more circular economy

REPUBLIC SERVICES
Sustainability in Action

ASCE
AMERICAN SOCIETY OF CIVIL ENGINEERS

Waste Hierarchy Inspired by the Ellen MacArthur Foundation



Civil & Environmental Consultants, Inc.

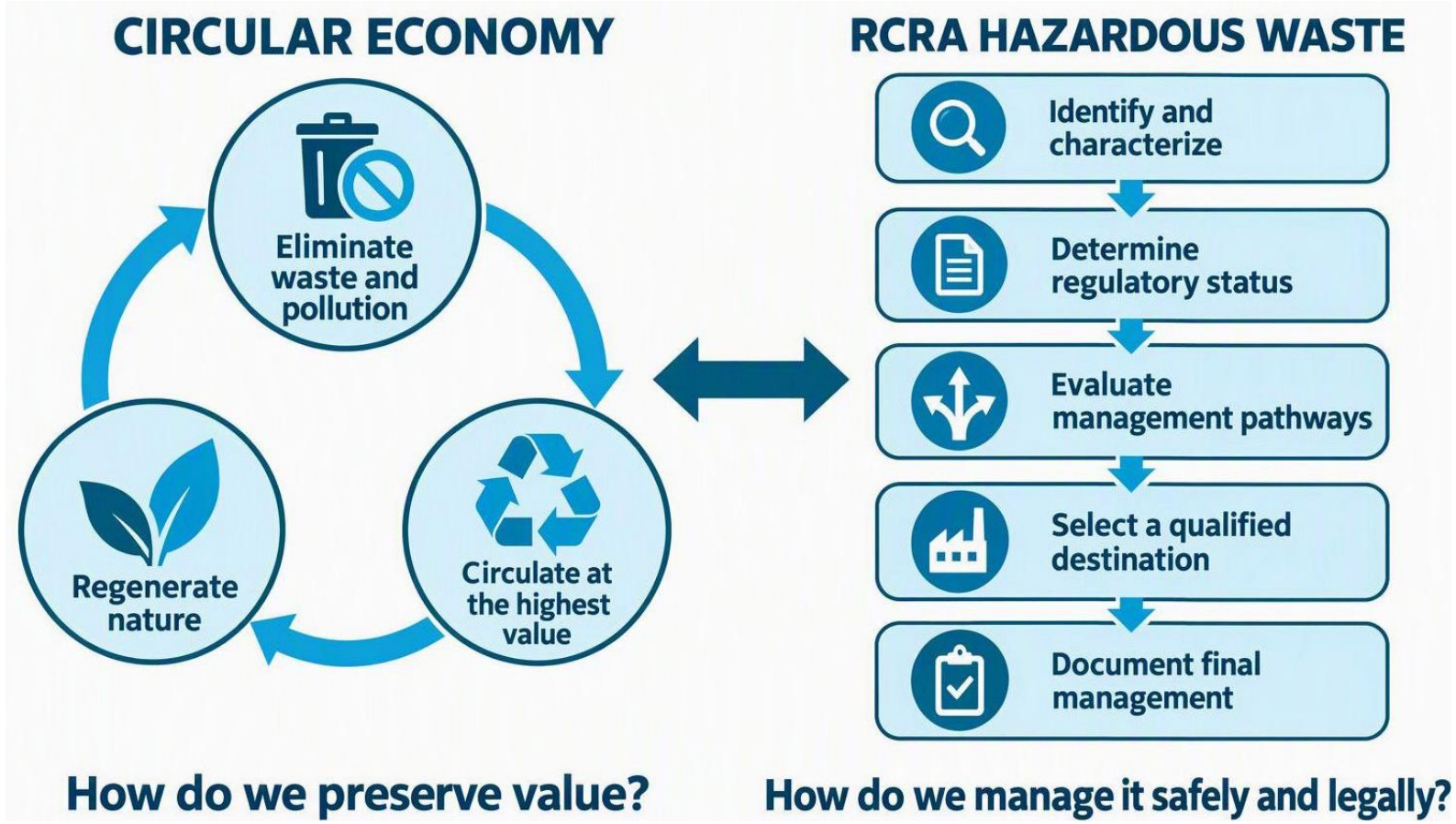
Collect Recycle Innovate
National Waste & Recycling Association®

EREF
Environmental Research & Education Foundation™
Lighting the way towards a more circular economy

REPUBLIC SERVICES
Sustainability in Action

ASCE
AMERICAN SOCIETY OF CIVIL ENGINEERS

Two Systems to Connect



Civil & Environmental Consultants, Inc.

Collect Recycle Innovate
National Waste & Recycling Association

EREF
Environmental Research & Education Foundation
Lighting the way towards a more circular economy

REPUBLIC SERVICES
Sustainability in Action

ASCE
AMERICAN SOCIETY OF CIVIL ENGINEERS

Decoding Method Management Codes

An H-code describes the management activity

Code family	Management activity
H010–H039	Reclamation and recovery
H040–H129	Destruction, energy recovery or treatment
H130–H137	Disposal or discharge
H141	Storage / transfer without substantive management



Civil & Environmental Consultants, Inc.

Collect Recycle Innovate
National Waste & Recycling Association®

EREF
Environmental Research & Education Foundation™
Lighting the way towards a more circular economy

REPUBLIC SERVICES
Sustainability in Action

ASCE
AMERICAN SOCIETY OF CIVIL ENGINEERS

Characterization Comes First



Civil & Environmental Consultants, Inc.

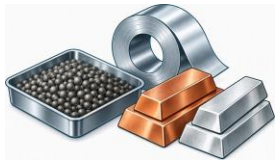
Collect Recycle Innovate
National Waste & Recycling Association®

EREF
Environmental Research & Education Foundation™
Lighting the way towards a more circular economy

REPUBLIC SERVICES
Sustainability in Action

ASCE
AMERICAN SOCIETY OF CIVIL ENGINEERS

Reclamation and Recovery









Code	Management Method	Typical application
H010	Metals Recovery	Sludge, catalysts, plating residuals
H011	Mercury Recovery	Lamps, switches, mercury equipment
H020	Solvents Recovery	Distillation or extraction of spent solvents
H039	Other Reclamation	Acid regeneration, organics and other recovery

Civil & Environmental Consultants, Inc.

Collect Recycle Innovate
National Waste & Recycling Association®

EREF
Environmental Research & Education Foundation™
Lighting the way towards a more circular economy

REPUBLIC SERVICES
Sustainability in Action

ASCE
AMERICAN SOCIETY OF CIVIL ENGINEERS

Energy Recovery and Fuel Blending

H061 Fuel Blending



Preparation before energy recovery at another site

H050 Energy Recovery



Recovery at the reporting site, including on-site blending

Civil & Environmental Consultants, Inc.

Collect Recycle Innovate
National Waste & Recycling Association®

EREF
Environmental Research & Education Foundation™
Lighting the way towards a more circular economy

REPUBLIC SERVICES
Sustainability in Action

ASCE
AMERICAN SOCIETY OF CIVIL ENGINEERS

Thermal Destruction and Desorption

H040 INCINERATION



Waste → **Combustion** → Gases + ash

Destroys organic contaminants

H042 THERMAL DESORPTION



Soil / sludge → **Heating** → Solids + vapors

Separates contaminants for capture and further treatment

H041 covers permitted open burning / open detonation for specialized reactive or explosive wastes.

Civil & Environmental Consultants, Inc.

Collect Recycle Innovate
National Waste & Recycling Association®

EREF
Environmental Research & Education Foundation™
Lighting the way towards a more circular economy

REPUBLIC SERVICES
Sustainability in Action

ASCE
AMERICAN SOCIETY OF CIVIL ENGINEERS

Chemical and Biological Treatment









Code	Management Method	Application
H070	Reduction, oxidation, destruction or precipitation	Organics, Cr(VI), metals, cyanides
H081	Biological treatment	Biodegradable organic constituents
H090	Polymerization as an LDR method	Applicable LDR treatment
H121	Neutralization only	Acid and caustic wastes

Civil & Environmental Consultants, Inc.

Collect Recycle Innovate
National Waste & Recycling Association®

EREF
Environmental Research & Education Foundation™
Lighting the way towards a more circular economy

REPUBLIC SERVICES
Sustainability in Action

ASCE
AMERICAN SOCIETY OF CIVIL ENGINEERS

Physical Treatment and Residuals









Code	Management Method	Application
H100	Physical treatment only	Filtration, sludge dewatering, oil/water separation
H120	Combined chemical / biological / physical	Chemical precipitation followed by filtration
H122	Evaporation	Concentrating aqueous waste by removing water
H129	Other treatment*	Other processes without a dedicated method code

Civil & Environmental Consultants, Inc.

Collect Recycle Innovate
National Waste & Recycling Association®

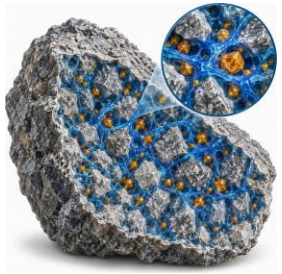
EREF
Environmental Research & Education Foundation™
Lighting the way towards a more circular economy

REPUBLIC SERVICES
Sustainability in Action

ASCE
AMERICAN SOCIETY OF CIVIL ENGINEERS

Stabilization and Solidification

Stabilization



Reduces mobility and leachability

Solidification



Improves physical form and handling

Code	Management method	Typical applications
H110	Stabilization before land disposal at another site	Contaminated soil, sludge or ash before off-site land disposal
H113	Stabilization to remove hazardous characteristics or achieve delisting levels	Metal-bearing wastes treated to meet characteristic or delisting thresholds

Immobilization does not destroy the contaminant

Verify strength, permeability, leachability, durability, volume and acceptance.

Civil & Environmental Consultants, Inc.

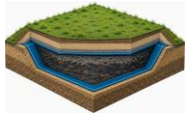
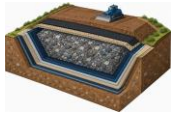
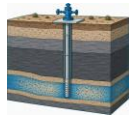
Collect Recycle Innovate
National Waste & Recycling Association®

EREF
Environmental Research & Education Foundation™
Lighting the way towards a more circular economy

REPUBLIC SERVICES
Sustainability in Action

ASCE
AMERICAN SOCIETY OF CIVIL ENGINEERS

Land Disposal and Injection

	Code	Management method
	**H130**	Surface impoundment that will close as a landfill
	**H131**	Land treatment or application
	**H132**	Landfill, with applicable prior treatment / stabilization
	**H134**	Deepwell or underground injection
	**H136**	Sewer / POTW discharge after prior storage, ± treatment
	**H137**	NPDES-permitted discharge after prior storage, ± treatment

Land disposal must meet applicable LDR standards

Treatment standards: 40 CFR 268.40. LDR also restricts disposal, dilution and storage.

Civil & Environmental Consultants, Inc.

Collect Recycle Innovate
National Waste & Recycling Association®

EREF
Environmental Research & Education Foundation™
Lighting the way towards a more circular economy

REPUBLIC SERVICES
Sustainability in Action

ASCE
AMERICAN SOCIETY OF CIVIL ENGINEERS

Five Decisions for Circular Waste Management

1 Eliminate	2 Reduce	3 Reclaim	4 Treat	5 Protect
Can design or procurement eliminate waste?	Can the source reduce volume or toxicity?	Can it remain in use or be reclaimed?	Which treatment controls the hazard?	Which permitted destination protects reliably?



COMPARE EACH PATHWAY

Circular value retained • Hazard reduction • EPA method code • Residuals and transport
Receiving specifications • LDR and permit implications • Lifecycle cost and liability

Civil & Environmental Consultants, Inc.

Collect Recycle Innovate
National Waste & Recycling Association®

EREF
Environmental Research & Education Foundation™
Lighting the way towards a more circular economy

REPUBLIC SERVICES
Sustainability in Action

ASCE
AMERICAN SOCIETY OF CIVIL ENGINEERS

Presenter

- Adam Mehevec, P.E.
- 30 Years of Consulting Experience
- CEC Vice President
- Expertise in:
  - Cell and Final Cover Design
  - Permitting
  - Unauthorized Waste Remediation



Civil & Environmental Consultants, Inc.

Collect Recycle Innovate
National Waste & Recycling Association®

EREF
Environmental Research & Education Foundation™
Lighting the way towards a more circular economy

REPUBLIC SERVICES
Sustainability in Action

ASCE
AMERICAN SOCIETY OF CIVIL ENGINEERS

Today's Topic

Installation of Synthetic Turf as a Landfill Final Cover System in Texas



Unless otherwise stated, all photos in this section of the presentation are produced and owned by Civil & Environmental Consultants, Inc. (CEC)

Civil & Environmental Consultants, Inc.

Collect Recycle Innovate
National Waste & Recycling Association®

EREF
Environmental Research & Education Foundation™
Lighting the way towards a more circular economy

REPUBLIC SERVICES
Sustainability in Action

ASCE
AMERICAN SOCIETY OF CIVIL ENGINEERS

Introduction

- CEC performed CQA on the final closure of an approximately 40-acre hazardous waste landfill in Texas
- The site was closed using ClosureTurf® and is the first TCEQ-regulated landfill in Texas that has a synthetic final cover
- We will discuss the ClosureTurf® process and lessons learned during the project



Civil & Environmental Consultants, Inc.

Collect Recycle Innovate
National Waste & Recycling Association®

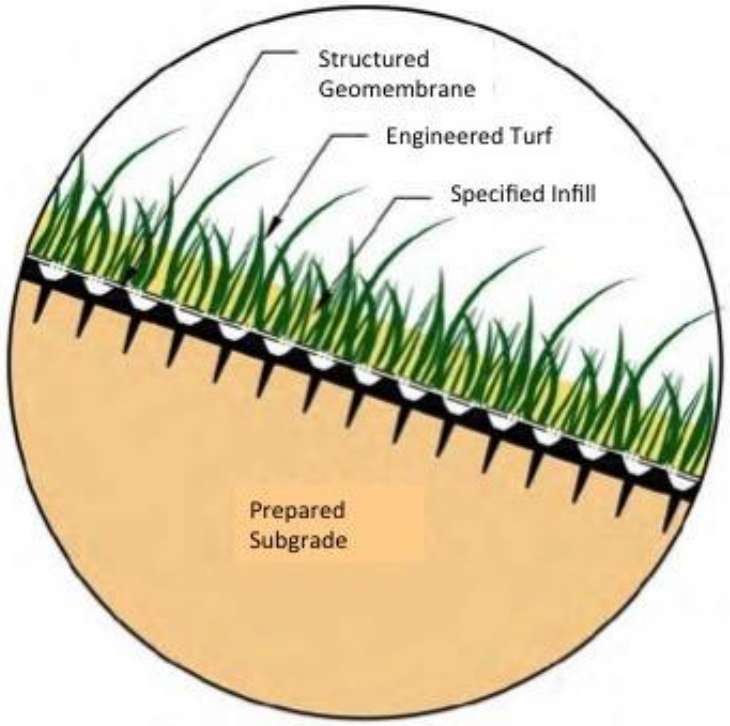
EREF
Environmental Research & Education Foundation™
Lighting the way towards a more circular economy

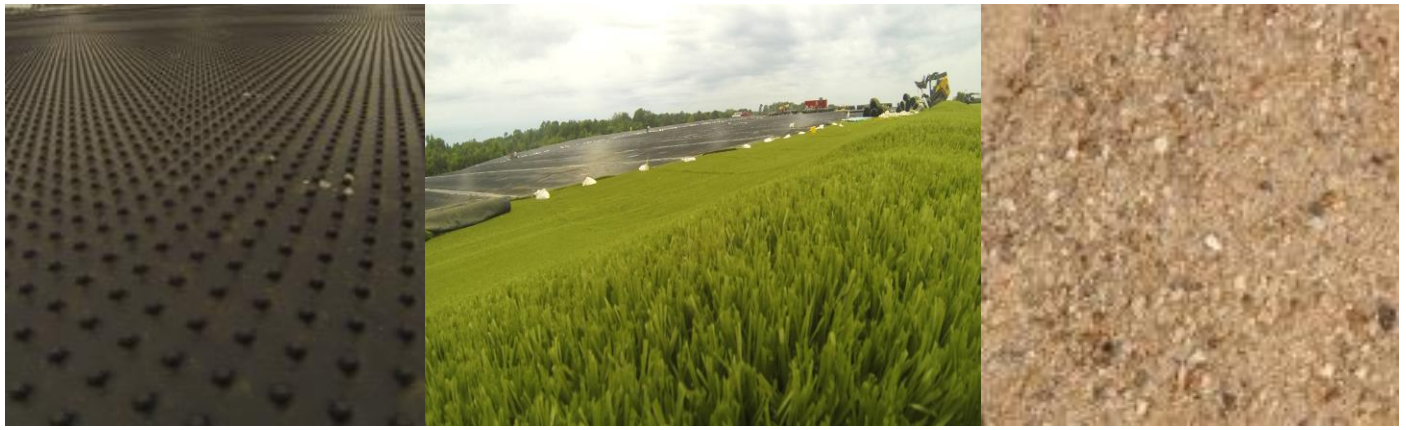
REPUBLIC SERVICES
Sustainability in Action

ASCE
AMERICAN SOCIETY OF CIVIL ENGINEERS

ClosureTurf® Final Cover Design

Graphics Courtesy of ClosureTurf®





- Structured Geomembrane – Environmental Containment (HDPE or LLDPE). Could also include CCL or GCL below membrane.
- Engineered Synthetic Turf – covers and protects the underlying geomembrane
- Infill – Sand or Sand with HydroBinder®

Civil & Environmental Consultants, Inc.

Collect Recycle Innovate
National Waste & Recycling Association®

EREF
Environmental Research & Education Foundation™
Lighting the way towards a more circular economy

REPUBLIC SERVICES
Sustainability in Action

ASCE
AMERICAN SOCIETY OF CIVIL ENGINEERS

Advantages



- Shorter construction duration
- Requires less soil
- No need to establish vegetation
- Eliminates maintenance issues such as repairing erosion rills and re-establishing vegetation
- A gas collection layer can be added beneath the membrane to increase landfill gas removal

Civil & Environmental Consultants, Inc.

Collect Recycle Innovate
National Waste & Recycling Association®

EREF
Environmental Research & Education Foundation™
Lighting the way towards a more circular economy

REPUBLIC SERVICES
Sustainability in Action

ASCE
AMERICAN SOCIETY OF CIVIL ENGINEERS

Challenges



- May have higher initial construction cost
- Wrinkles may form during construction and after completion
- Sometimes difficult to achieve even distribution of sand infill
- Regulatory agency may require modified post-closure period or final assurance
- More difficult to correct settlement areas after installation

Civil & Environmental Consultants, Inc.

Collect Recycle Innovate
National Waste & Recycling Association®

EREF
Environmental Research & Education Foundation™
Lighting the way towards a more circular economy

REPUBLIC SERVICES
Sustainability in Action

ASCE
AMERICAN SOCIETY OF CIVIL ENGINEERS

Geomembrane Liner

- Geomembrane installation follows normal methods and testing
- Wrinkle management is very important, and panels should be evaluated at different temperatures to determine the best tension for the membrane
- Aggressive texturing may be used to increase friction between the layers
- HDPE may be a better material than LLDPE in this application



Civil & Environmental Consultants, Inc.

Collect Recycle Innovate
National Waste & Recycling Association®

EREF
Environmental Research & Education Foundation™
Lighting the way towards a more circular economy

REPUBLIC SERVICES
Sustainability in Action

ASCE
AMERICAN SOCIETY OF CIVIL ENGINEERS

Turf Installation



- Turf is delivered on rolls similar to geomembrane
- Turf is rolled inside-out and can't be deployed directly onto the slope
- Selvage must be removed from one of the turf panel edges prior to welding
- Panels are welded using wedge welders

Civil & Environmental Consultants, Inc.

Collect Recycle Innovate
National Waste & Recycling Association®

EREF
Environmental Research & Education Foundation™
Lighting the way towards a more circular economy

REPUBLIC SERVICES
Sustainability in Action

ASCE
AMERICAN SOCIETY OF CIVIL ENGINEERS

Turf Installation



Panel selvage removal must be performed with mechanical trimming devices. No box blades or knives are allowed due to geotextile fraying and consistent cutting patterns.



Welding must be carefully monitored to ensure even seams and prevent over-melting of the turf.

Civil & Environmental Consultants, Inc.

Collect Recycle Innovate
National Waste & Recycling Association®

EREF
Environmental Research & Education Foundation™
Lighting the way towards a more circular economy

REPUBLIC SERVICES
Sustainability in Action

ASCE
AMERICAN SOCIETY OF CIVIL ENGINEERS

Turf Installation



- Top anchor trenches should be backfilled as soon as practical to avoid migration down slope
- Backfilling bottom anchor trenches should be avoided until sand infill is completed
- Leaving the bottom anchor trenches during sand infill allows potential slack turf to be pulled/worked into the bottom trench

Civil & Environmental Consultants, Inc.

Collect Recycle Innovate
National Waste & Recycling Association®

EREF
Environmental Research & Education Foundation™
Lighting the way towards a more circular economy

REPUBLIC SERVICES
Sustainability in Action

ASCE
AMERICAN SOCIETY OF CIVIL ENGINEERS

Sand Infill







Graphics Courtesy of ClosureTurf®

Civil & Environmental Consultants, Inc.

Collect Recycle Innovate
National Waste & Recycling Association®

EREF
Environmental Research & Education Foundation™
Lighting the way towards a more circular economy

REPUBLIC SERVICES
Sustainability in Action

ASCE
AMERICAN SOCIETY OF CIVIL ENGINEERS

Sand Infill

After sand is placed and evenly distributed, the depth is measured to ensure enough sand is in place to withstand design winds (1/2" to 3/4" min.)







Civil & Environmental Consultants, Inc.

Collect Recycle Innovate
National Waste & Recycling Association®

EREF
Environmental Research & Education Foundation™
Lighting the way towards a more circular economy

REPUBLIC SERVICES
Sustainability in Action

ASCE
AMERICAN SOCIETY OF CIVIL ENGINEERS

Sand Infill

- HydroBinder® is a proprietary cement-based mix used in areas of high water velocity to reduce erosion of infill
- Installed at approximately 3/4"; should not exceed 1"
- Water should be applied to hydrate the HydroBinder® the same day
- Used in downchutes and along diversion berms





Civil & Environmental Consultants, Inc.

Collect Recycle Innovate
National Waste & Recycling Association®

EREF
Environmental Research & Education Foundation™
Lighting the way towards a more circular economy

REPUBLIC SERVICES
Sustainability in Action

ASCE
AMERICAN SOCIETY OF CIVIL ENGINEERS

Lessons Learned



- An experienced crew is essential for seaming the turf
- Good planning needs to occur related to the sand infill and HydroBinder®
  - The sand material on this project was delivered too early and it rained on the pile and made it difficult to spread
  - The HydroBinder® can only be deployed in dry weather; light rain or high humidity makes it clump up
- If the thickness of the sand infill is too low, the wind will create wrinkles in the turf
- Good settlement calculations should be performed to ensure that the topdeck will have long-term positive drainage after closure

CEC Civil & Environmental Consultants, Inc.
Collect Recycle Innovate National Waste & Recycling Association®
EREF Environmental Research & Education Foundation™ Lighting the way towards a more circular economy
REPUBLIC SERVICES Sustainability in Action
ASCE AMERICAN SOCIETY OF CIVIL ENGINEERS

Overarching Policy Concerns

- Funding drives outcomes
- Industry consolidation
- Emerging waste streams
- Artificial intelligence and security
- Demand for resilience



Getty Images: photo credit Ilona Nagy

Civil & Environmental Consultants, Inc.

Collect Recycle Innovate
National Waste & Recycling Association®

EREF
Environmental Research & Education Foundation™
Lighting the way towards a more circular economy

REPUBLIC SERVICES
Sustainability in Action

ASCE
AMERICAN SOCIETY OF CIVIL ENGINEERS

Funding Drives Outcomes



- Federal investments have improved pace of clean-up
  - Backlog remains
  - Superfund excise taxes short of need and some sunset
- State hazardous waste programs are underfunded
  - States administer hazardous waste programs: staffing, permitting, inspections, enforcement, technical assistance
  - Federal RCRA grants provide funding but are not growing with inflation or demand
- Need investment in facilities, technology, research

Civil & Environmental Consultants, Inc.

Collect Recycle Innovate
National Waste & Recycling Association®

EREF
Environmental Research & Education Foundation™
Lighting the way towards a more circular economy

REPUBLIC SERVICES
Sustainability in Action

ASCE
AMERICAN SOCIETY OF CIVIL ENGINEERS

Industry Consolidation



- Corporate acquisitions leave fewer major players
- Waste directed to fewer large commercial facilities
  - Increases efficiency and cost effectiveness
  - Increases vulnerability to shutdowns and outages
- Long run-up for new facilities to come online
  - Capital expenditures
  - Siting constraints – exclusions, environmental concerns, opposition
  - Slow permitting processes
- Manufacturers rely on available disposal capacity

Civil & Environmental Consultants, Inc.
Collect Recycle Innovate National Waste & Recycling Association®
EREF Environmental Research & Education Foundation™ Lighting the way towards a more circular economy
REPUBLIC SERVICES Sustainability in Action
ASCE AMERICAN SOCIETY OF CIVIL ENGINEERS

Emerging waste streams



- Remediation: PFAS compounds under CERCLA
- Producers continue innovating
  - Pharmaceuticals
  - Semi-conductors
  - Batteries: Li-ion, EV
  - ???
- Current capacity projections may underestimate future demand
- Unexpected problems: fires, remediation

Civil & Environmental Consultants, Inc.

Collect Recycle Innovate
National Waste & Recycling Association®

EREF
Environmental Research & Education Foundation™
Lighting the way towards a more circular economy

REPUBLIC SERVICES
Sustainability in Action

ASCE
AMERICAN SOCIETY OF CIVIL ENGINEERS

Artificial Intelligence and security



- More automation in processes
  - Inputs controlled, shifted
  - Problem materials
- Routine tasks handled by AI, not people
  - How do we get experienced mid-level people when entry level jobs are done by AI?
- Vulnerabilities
  - Power and water availability and outages
  - AI-driven cyber espionage (hackers)

Civil & Environmental Consultants, Inc.

Collect Recycle Innovate
National Waste & Recycling Association®

EREF
Environmental Research & Education Foundation™
Lighting the way towards a more circular economy

REPUBLIC SERVICES
Sustainability in Action

ASCE
AMERICAN SOCIETY OF CIVIL ENGINEERS

Demand for Resilience



- EPA adds climate resilience to Superfund planning
  - 60% non-federal Superfund sites in areas exposed to flooding, storm surge, sea-level rise, wildfires
- Disaster clean-up consumes capacity faster than planned
- Potential for damage and disruption to facilities
  - Extreme weather
  - Power outages
  - Water availability
  - Workforce constraints – aging, immigration controls, fewer CDL drivers

Civil & Environmental Consultants, Inc.

Collect Recycle Innovate
National Waste & Recycling Association®

EREF
Environmental Research & Education Foundation™
Lighting the way towards a more circular economy

REPUBLIC SERVICES
Sustainability in Action

ASCE
AMERICAN SOCIETY OF CIVIL ENGINEERS

Thank you!



Sara Bixby
Director of Regulatory and Environmental Affairs
National Waste & Recycling Association
sbixby@wasterecycling.org

Getty Images: photo credit Ilona Nagy

Civil & Environmental Consultants, Inc.

Collect Recycle Innovate
National Waste & Recycling Association®

EREF
Environmental Research & Education Foundation™
Lighting the way towards a more circular economy

REPUBLIC SERVICES
Sustainability in Action

ASCE
AMERICAN SOCIETY OF CIVIL ENGINEERS

Questions?



ASCE
AMERICAN SOCIETY OF CIVIL ENGINEERS

Thank you to today's sponsor!



Civil & Environmental Consultants, Inc.

ASCE
AMERICAN SOCIETY OF CIVIL ENGINEERS



Find more details, please visit InfrastructureReportCard.org.