

2025 Report Card for America's Infrastructure

Solid Waste

July 15, 2026





Agenda

- Overview of ASCE Report Card
- Solid Waste Overview and Criteria
 - Condition and Capacity
 - Funding and Future Need
 - Resilience and Innovation
- Panel Perspectives
- Q&A

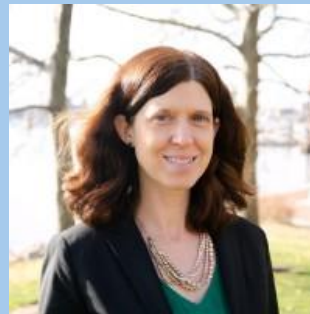
Speakers



David Sonne, PE
Senior Project
Manager, Tetra
Tech



Dana Blumberg,
Vice President,
SCS Engineers



Kristyn Oldendorf,
Senior Director of
Public Policy &
Communications,
SWANA



Suzie Boxman,
PhD, Senior
Director of
Programs, EREF



Joe Wilder,
Director, Public
Works, Frederick
County Virginia



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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



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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

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What the Grades Mean



MEDIOCRE
Requires attention



EXCEPTIONAL
Fit for the future



POOR
At risk



GOOD
Adequate for now



FAILING/CRITICAL
Unfit for purpose

Methodology

CAPACITY

OPERATION AND MAINTENANCE

CONDITION

PUBLIC SAFETY

FUNDING

RESILIENCE

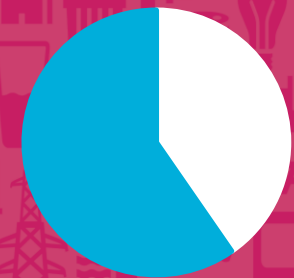
FUTURE NEED

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

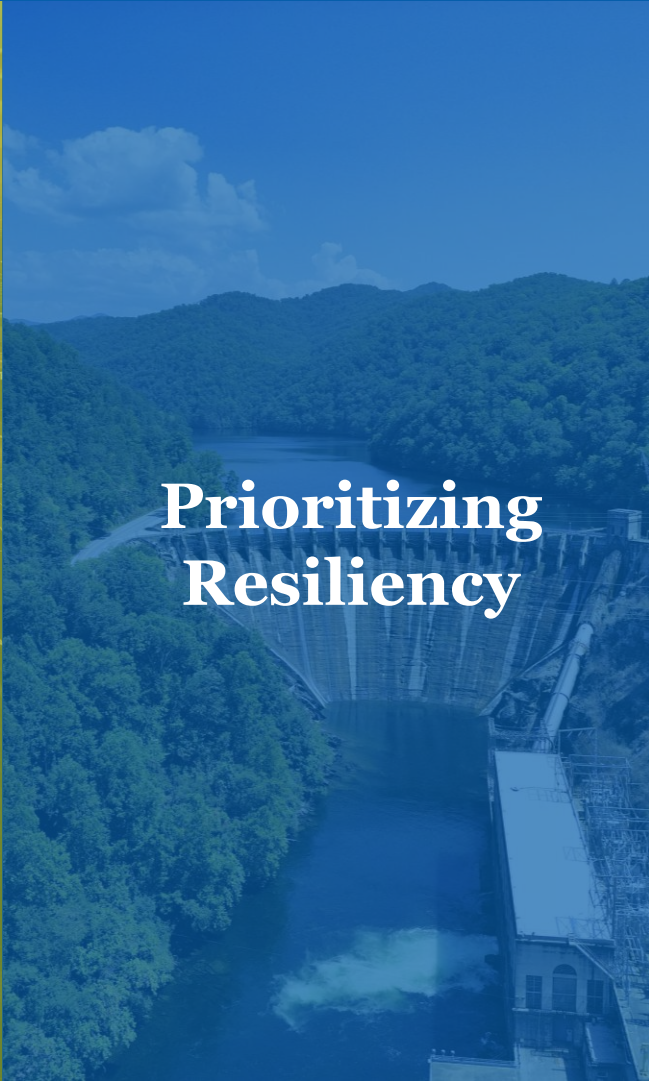
**\$3.7
Trillion
needed**



CURRENT FUNDING | FUNDING GAP



**Sustaining
Investment**



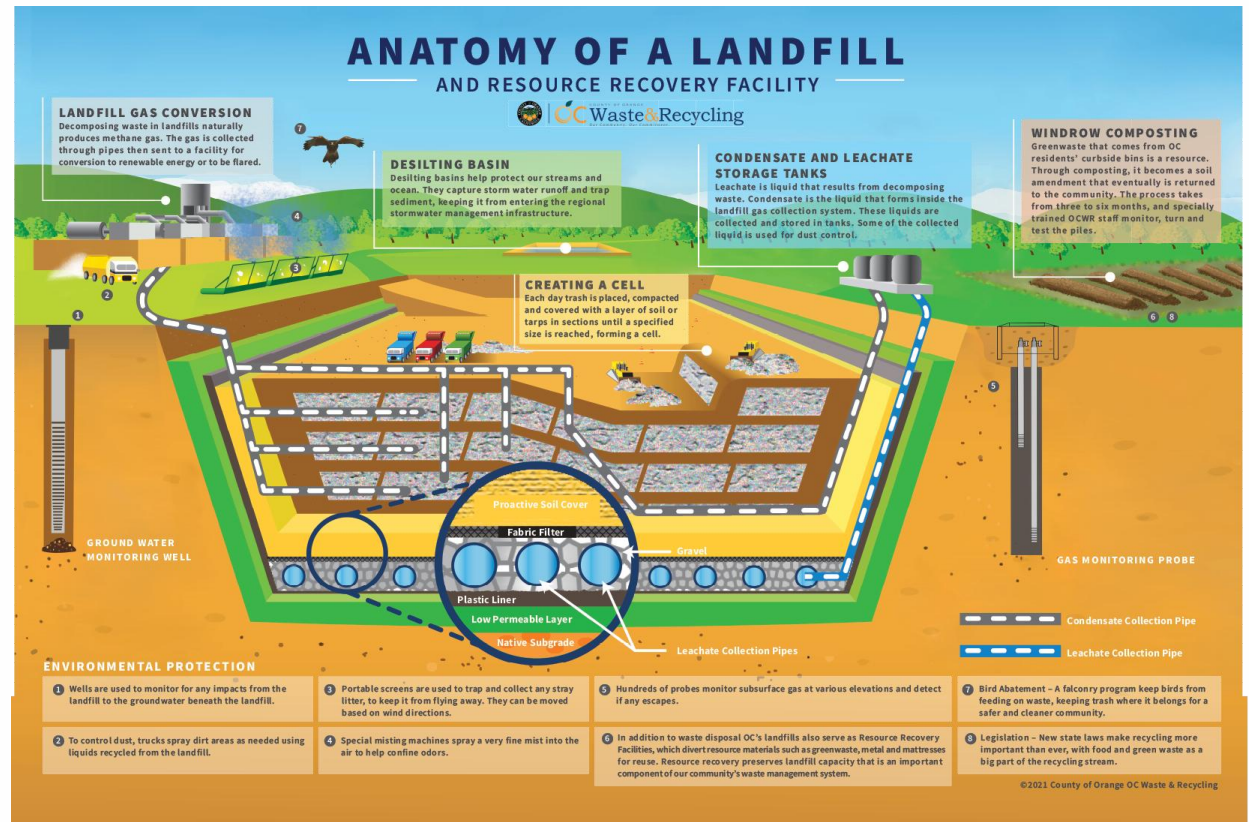
**Prioritizing
Resiliency**



**Advancing
Policy &
Innovation**

Solid Waste Category History

2013: B-
2017: C+
2021: C+
2025: C+



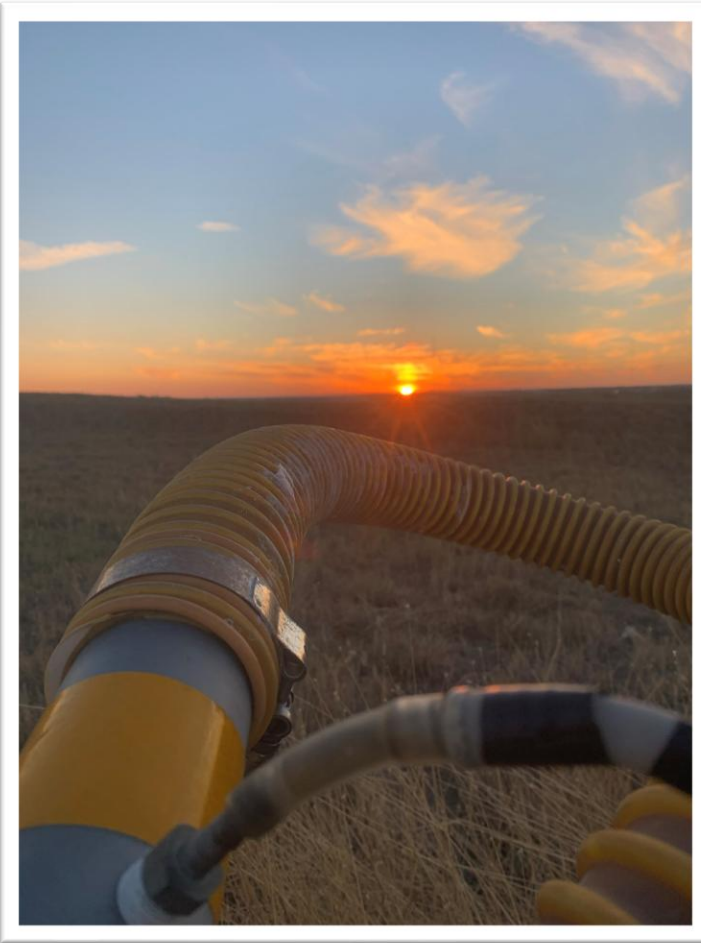
National Trends in Solid Waste that Shaped the Grade

- **Capacity**
 - The MSW system is self-funded
 - Managed by both private and public sectors
 - MSW volume has steadily increased
 - Growth from 251 million tons to 292 million tons (as of 2018)
 - Current funding is sufficient
 - Existing capacity meets immediate need
- **Condition (2018)**
 - Americans generate about 292.4 million tons of MSW
 - 4.9 pounds per person per day.
 - Approximately 129 million ton or 44% of generated MSW was productively reused
 - 69 million tons of MSW were recycled
 - 25 million tons were composted
 - 35 million tons were combusted for energy recovery



National Trends in Solid Waste that Shaped the Grade

- **Funding:**
 - U.S. waste/recycling industry: \$91B revenue (2022), 135K employees
 - Avg. landfill fee: \$56.80 (2023), down 3% from 2022; up from \$55.36 (2019)
 - IIJA: \$350M over 5 years for solid waste R&D
- **Future Needs:**
 - Current funding meets near-term needs
 - Limited funding beyond IIJA for innovation and R&D
 - Shrinking global market for recycled materials needs replacement



National Trends in Solid Waste that Shaped the Grade

- **Operations and Maintenance:**
 - ~27,000 local waste organizations (55% public, 45% private)
 - Landfills regulated by EPA for safety and environmental protection
 - Multi-layer designs prevent groundwater and soil contamination
- **Public Safety:**
 - SWM depends on other infrastructure; disruptions can impact waste collection and public health
 - PFAS contamination in landfills is rising and needs to be addressed



National Trends in Solid Waste that Shaped the Grade

- **Resilience:**
 - Landfills vulnerable to natural disasters; risks to groundwater and public health
 - Infrastructure damage (roads, rail, power, waterways) can disrupt MSW collection and harm public health



National Trends in Solid Waste that Shaped the Grade

- **Innovation:**
 - New technologies are playing a role in improving landfill operations' efficiency, safety, and sustainability
 - Machine learning algorithms can be used to identify types of waste being dumped at the landfill
 - The continued under-use of waste-to-energy practices highlights the need for research and development of new policies



Solutions to Raise the Grade

- **Accelerate** and increase investment in PFAS research
- **Oppose** efforts to ban the interstate movement of MSW to regional solid waste facilities
- **Promote** materials as reusable with a life cycle beyond initial use
- **Strengthen** domestic markets for recycled materials in the U.S



Solutions to Raise the Grade

- **Encourage** programs that educate on the reduction of food waste and the composting of what is generated.
- **Emphasize** source reduction through redesigning the manufacturer's packaging of goods & setting standards for recyclable materials
- **Develop** cost-effective recycling and sustainable waste handling options
- **Promote**, enhance, or facilitate the development of resource recovery facilities





SWANA: State of the industry

Kristyn Oldendorf, Senior Director, Communications and
Public Policy

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TRANSFORMING WASTE
INTO A RESOURCE

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**SWANA is the leading
association for waste and
resource management
professionals.**

SWANA's Members Represent

Landfills

Transfer Station

Recycling

Waste to Energy

Landfill Gas

Resource Recovery

Energy Recovery

Collections

Disaster and Debris Management

Hazardous Waste

Organics





Waste and Resource Management Requires Diverse and Complex Infrastructure





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Anatomy of a Landfill

Typical Landfill Final Cover System

Vegetation (Erosion Control Layer)
12 inch Thick Top Soil
36 inch Compacted Final Cover Soil
12 inch Thick Compacted Foundation Soil
Compacted Waste

CLOSED CELLS
A cell that has reached full capacity as permitted

FEE BOOTH/SCALE
Weighs garbage trucks and other vehicles in order to determine the amount of garbage deposited in the landfill. The tipping fee is also collected at the Fee Booth.

FLARE STATION
A facility where landfill gas is siphoned and burned

TRANSFER TRUCK
Trucks used to transport garbage from transfer stations

REAR LOADER
One of the many types of trucks used to transport garbage to the landfill.

COMPACTOR
A machine with heavy steel wheels used to spread and compact garbage.

GROUNDWATER MONITORING WELL
Wells used to monitor and test groundwater conditions.

LANDFILL GAS EXTRACTION SYSTEM
A vacuum extraction system of collector wells and pipes in the landfill used to extract gas from the landfill. Landfill gas is produced by the anaerobic decomposition of garbage.

DOZER
A machine used to spread and compact garbage and dirt.

LEACHATE COLLECTION AND CONVEYANCE SYSTEM
A system installed to collect and remove leachate from the landfill.

SOLID WASTE

DAILY COVER SOIL

Compacted Waste
2 Feet Protective Soil Layer
16 oz/sy Geotextile Fabric
9 inches Gravel Drainage Layer
Leachate Collection Pipe
12 oz/sy Geotextile Fabric
60mil HDPE Geomembrane
Geosynthetic Clay Liner
60mil HDPE Geomembrane
1 Foot Compacted Clay
Prepared Subgrade

Compacted Waste
2 Feet Protective Soil Layer
Protective Membrane
16 oz/sy Geotextile Fabric
80mil HDPE Geomembrane
Geosynthetic Clay Liner
Prepared Subgrade

Typical Side Slope Liner System

Typical Bottom Liner System



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SYANA
FOR SUSTAINABLE MANAGEMENT OF SOLID WASTE

JUNE 2025

AGING WASTE-TO-ENERGY FACILITIES: REFURBISH OR REPLACE?

Case Studies from Florida Facilities



Hillsborough County
Solid Waste
Energy Recovery Facility



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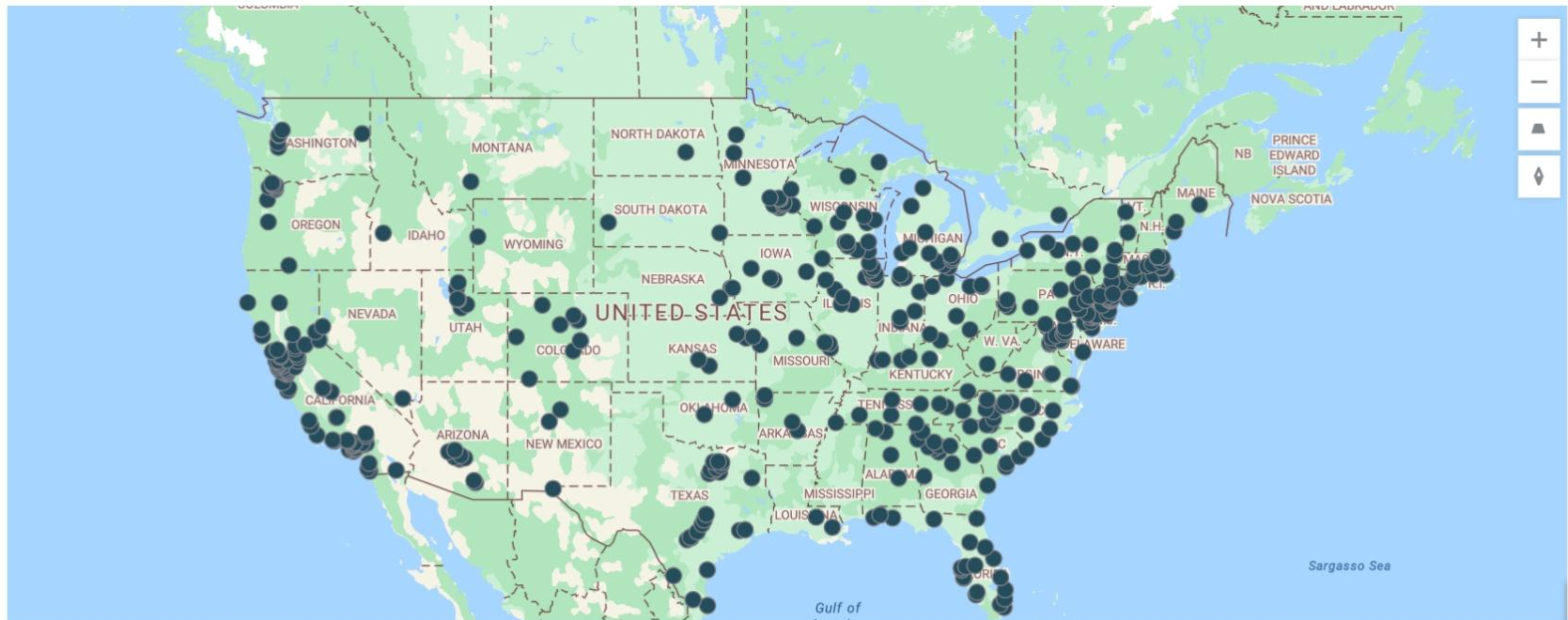
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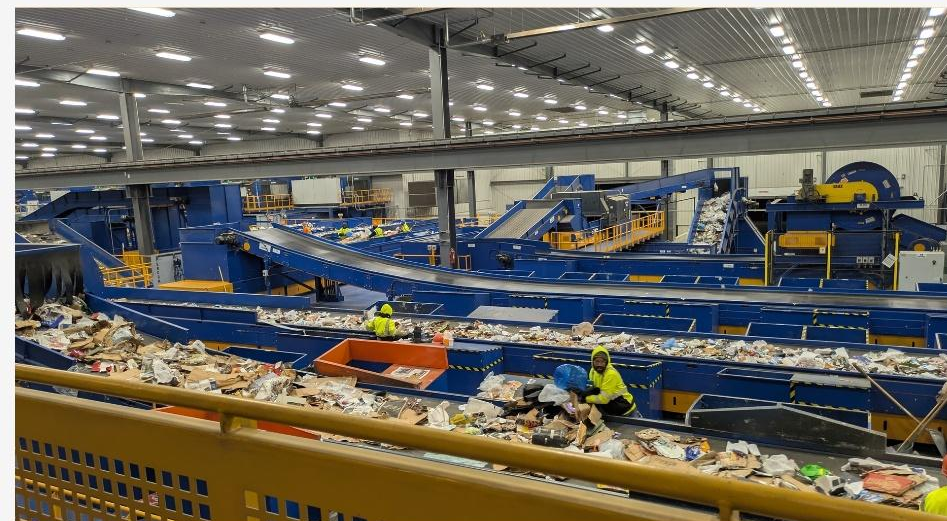
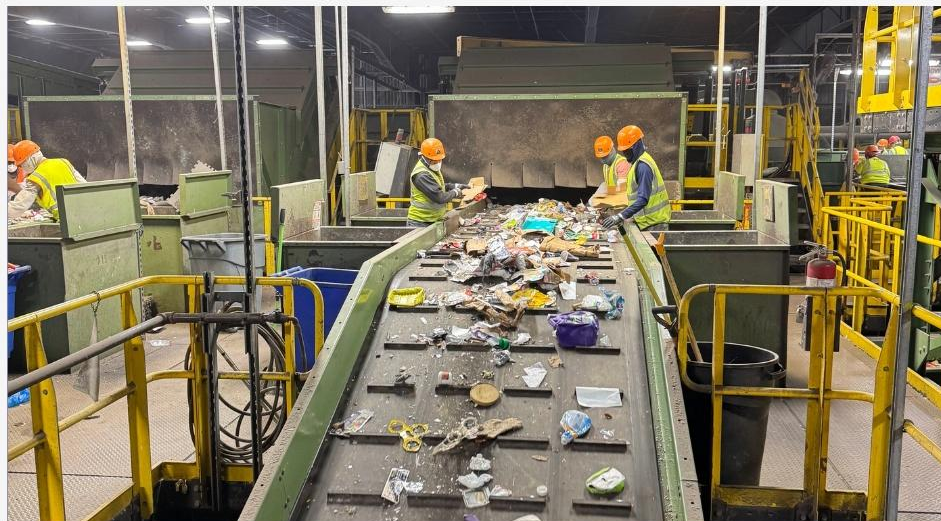
The Recycling Partnership Map of Residential MRFs

Residential MRFs in US

Last refreshed: Jul 8, 2026









US EPA Strategies

National Recycling Strategy

Part One of a Series on Building a Circular Economy for All

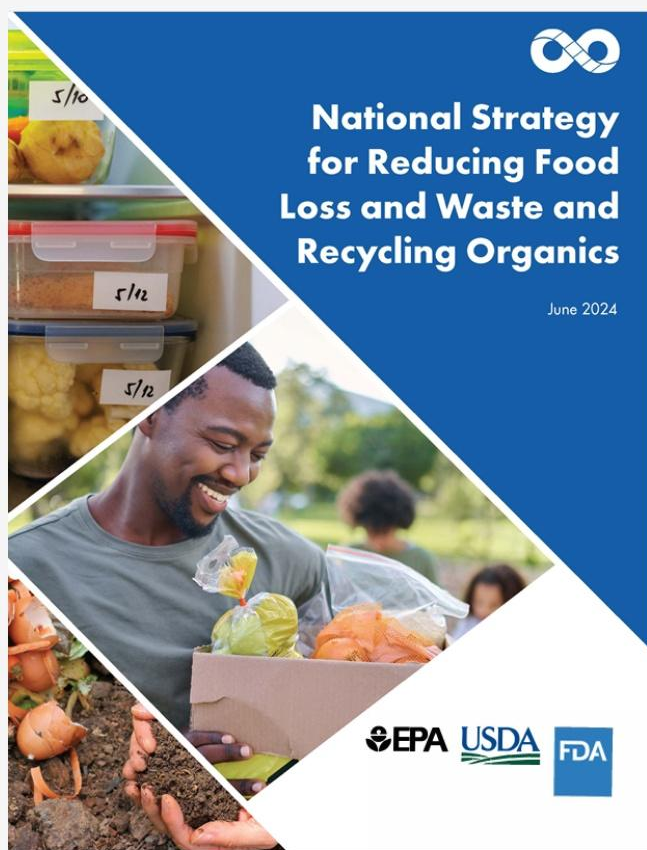


November 15, 2021

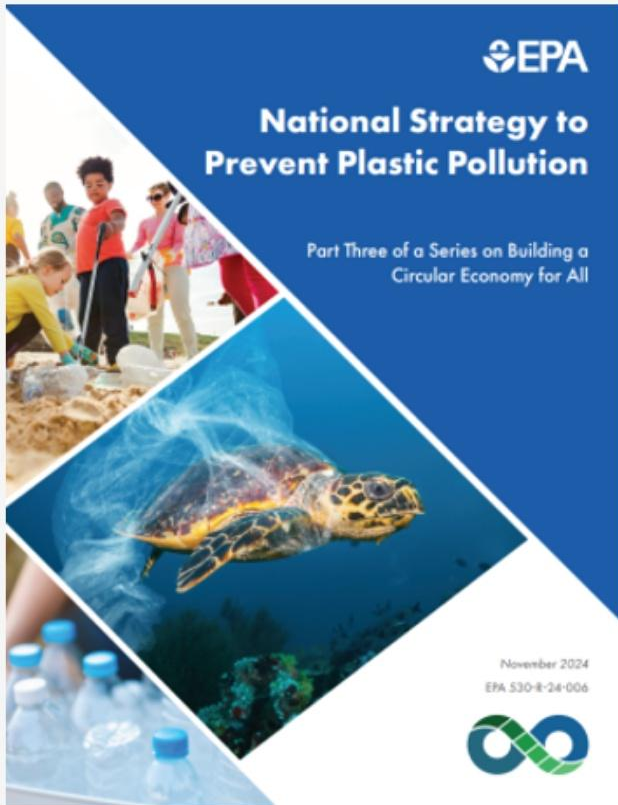
- US EPA "National Recycling Strategy"
 - November, 2021
 - Supports implementation of the National Recycling Goal to increase the recycling rate to 50 percent by 2030
 - Objectives
 - A. Improve Markets for Recycling Commodities.
 - B. Increase Collection and Improve Materials Management Infrastructure.
 - C. Reduce Contamination in the Recycled Materials Stream.
 - D. Enhance Policies to Support Recycling.
 - E. Standardize Measurement and Increase Data Collection.

US EPA Strategies

- US EPA, USDA, FDA "National Strategy for Reducing Food Loss and Waste and Recycling Organics"
 - June, 2024
 - Objectives
 - Prevent food loss.
 - Prevent food waste.
 - Increase recycling rate for organics waste.
 - Support policies that incentivize the prevention of food loss and waste and support organics recycling.



US EPA Strategies



- US EPA "National Strategy to Prevent Plastic Pollution"
- November, 2024
- Objectives
 - Reduce Pollution from Plastic Production.
 - Innovate Material and Product Design.
 - Decrease Waste Generation.
 - Improve Waste Management.
 - Improve Capture and Removal of Plastic Pollution.
 - Minimize and Impacts to Waterways and the Ocean



US EPA Circular Economy Plan



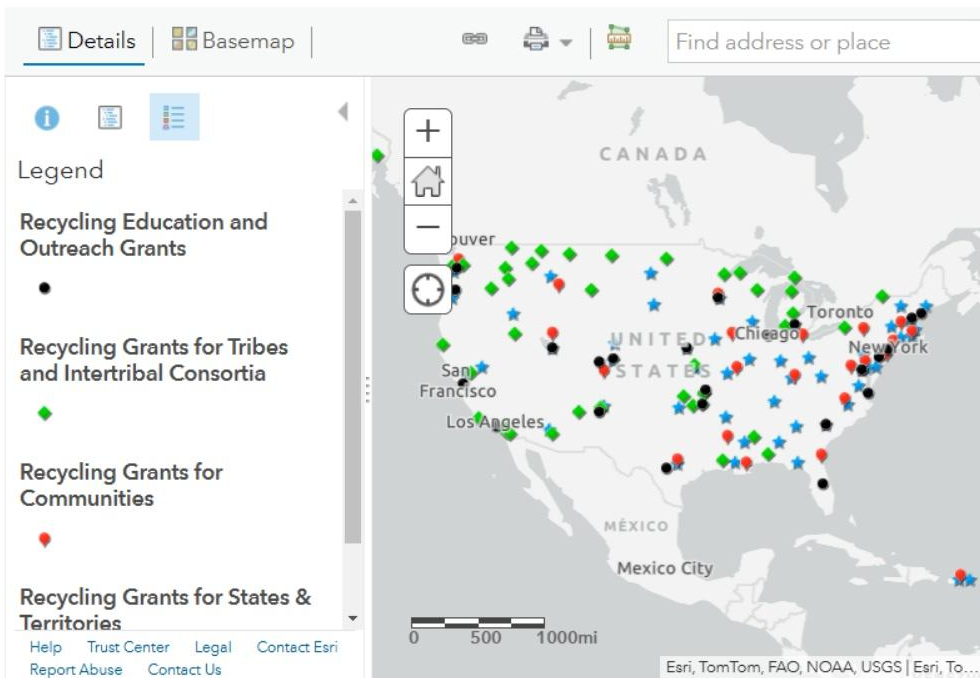


Federal Funding

- Solid Waste Infrastructure for Recycling (SWIFR) Grant Program
- Consumer Recycling Education and Outreach (REO) Grant Program
- Authorized by the Save Our Seas Act 2.0 (SOS Act 2.0)
- Funded by the Bipartisan Infrastructure Law

Federal Funding

Home ▾ Recycling Grants Map Open in Map Viewer Modify Map 8



Solid Waste Infrastructure for Recycling (SWIFR) Grant Program

- Funding to improve post-consumer materials management and infrastructure.
- Eligible entities include political subdivisions of states and territories.

Consumer Recycling Education and Outreach (REO) Grant Program

- Eligible activities include those that will provide education about local recycling and composting programs and focus on increasing collection rates and decreasing contamination.

<https://www.epa.gov/infrastructure/recycling-grant-selectees-and-recipients>



CIRCLE Act

- Cultivating Investment in Recycling and Circular Local Economies, or CIRCLE Act (H.R. 4466)
- Recycling Infrastructure Investment Tax Credit for investments in infrastructure to recycle paper, metals, glass, aluminum, and other materials.
- Public entities (municipalities) would be eligible for a rebate equal to the credit.
- Investments could include machinery, operational equipment, or software

<https://recyclingpartnership.org/circle-act>

Policy Drivers

- Extended Producer Responsibility (EPR)
 - A policy construct that holds that Producers are responsible and accountable for the lifecycle of their product
 - [SWANA Guiding Principles on EPR](#) and [SWANA Technical Policy on EPR](#)
- Container Deposit Return Systems (DRS)
 - Incentivizes the return of the containers through a financial mechanism, with the goal of increased collection rates and a corresponding reduction in litter
 - [SWANA Technical Policy on DRS](#)



SWANA EPR Guiding Principles

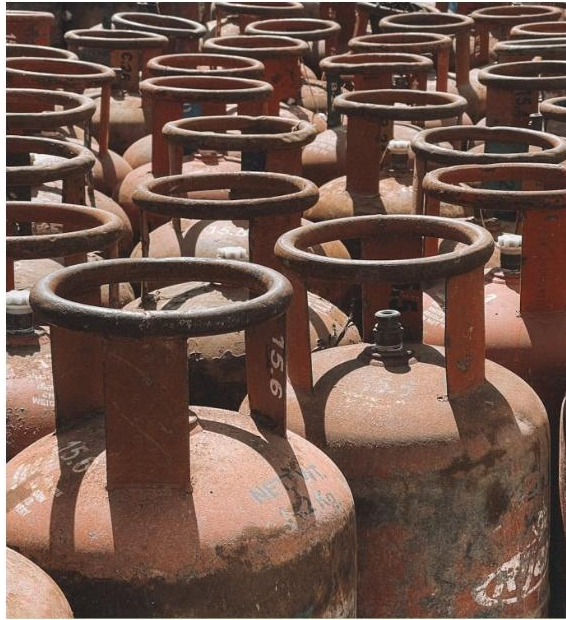
- **Safety**: Includes design changes and/or use of funds to address potentially harmful contaminants.
- **Commonality**: Comprehensive, broadly defined categories of items, and consistent metrics and measurements.
- **Data**: Policy should be informed by current data and needs assessments, including targets.

- **Funding Structure**: Funds generated should be used in support of the system.
- **Current System**: Any current/future EPR policies should acknowledge, protect, and integrate systems.
- **Materials Covered**: Materials regulated should be afforded on/off ramps based on performance standards.

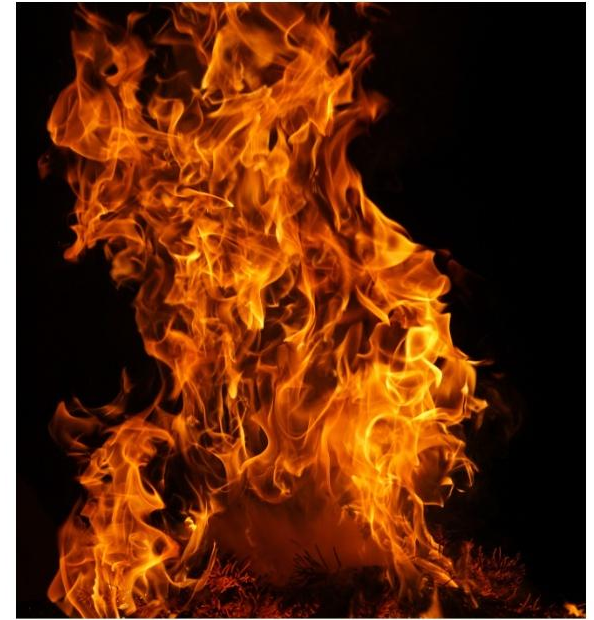
Battery and Product Safety



Batteries



Compressed gas cylinders and other explosive or flammable materials



When crushed or otherwise damaged, materials start fires







GUIDE FOR ESTABLISHING LITHIUM-ION BATTERY MANAGEMENT PRACTICES AT MATERIALS RECOVERY FACILITIES

Final 9/11/2025



SWANA

SWANA Safety Resources Guide to Developing Lithium Battery Management Practices at MRFs developed with SWANA, NWRA and ReMA



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Product Safety: Product Safety Statement

- The SWANA SMM Technical Division Advocacy Committee recommended that SWANA create a statement to address the issue of items that explode and catch fire, including batteries, compressed gas cylinders, marine flares, fireworks, and more.
- SWANA issued a statement calling for Coordination on Product Safety and Responsible End of Life Management for dangerous products.
- "SWANA calls on producers and policy makers to join us and prioritize safety and responsible end-of-life (EOL) management in the design, labeling, and marketing of hazardous products to protect the safety of our workers and the long-term viability of our waste and recycling infrastructure."

Battery Safety Webpage



[Drop-Off Locations](#) [Partnership](#) [Articles](#) [Submit Fire Report](#)

(844) 417-6837

Advancing Safe Management of Batteries and Preventing Fires

This site is the go-to place for waste and resource management professionals seeking to prevent fires caused by lithium-ion batteries. Use this site to look up battery collection locations near you, to report fires, and to access helpful videos and resources.

[Battery Drop-Off Locations](#)

[Submit an Anonymous Fire Report](#)



FireRover
DETECT | EXTINGUISH | PROTECT



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Future Needs

- Long-term government funding opportunities and incentives for investment.
- Policies that support resource recovery.
- Long-term financial planning for sufficient maintenance and operating budgets.

Can't wait to hear from you.

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kristyn-oldendorf/



Trends in Solid Waste Management

Material Recycling Facilities

AI and Automation Recycling Operations

- AI-enabled sorting, robotics, and contamination detection
 - Lower contamination
 - Sorting robots, optical sorters and machine learning technologies
- Sensor data and dashboards to improve throughput and reduce labor pressure
- Automation is becoming a margin, resilience, and service-quality lever

Rumpke Columbus, Ohio MRF



Organics Management

Organics diversion results in methane reduction

Yard and landscaping materials

- Leaves, grass
- Woody material

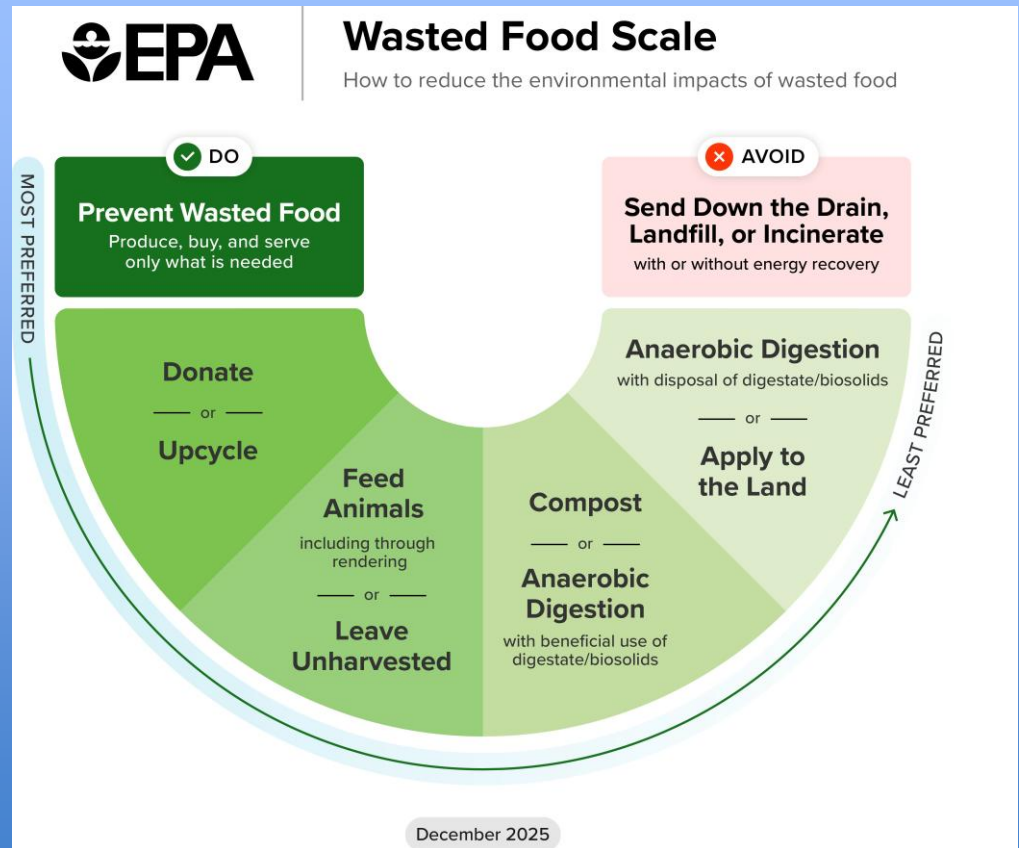
Food scraps

- Grocery stores and markets
- Restaurants
- Institutional

Animal manure

Industrial byproducts

What Can We Do?



Composting

Local *Solution*

- Home and community options
- Reduce trucking of waste and finished compost
- Reduce landfilling
- Cost effective

Healthy Soil *Solution*

- Improve soil organic matter, nutrients
- Reduce/eliminate synthetic nitrogen fertilizer and its issues

Climate *Solution*

- Avoid methane emissions
- Sequester carbon

Private, FL – Open Windrow (36 ac)



Pipe-on-Grade ASP - CA



ASP - NYC



Sustainable Generation; BIG!Compost NYC; 300 TPY food/yard

ASP Bunker - VT



ASP Bunker - MD



Covered ASP - MD



In-Vessel - NM



Landfill Gas Monitoring and Measurement

Landfill Gas Monitoring and Measuring Trends

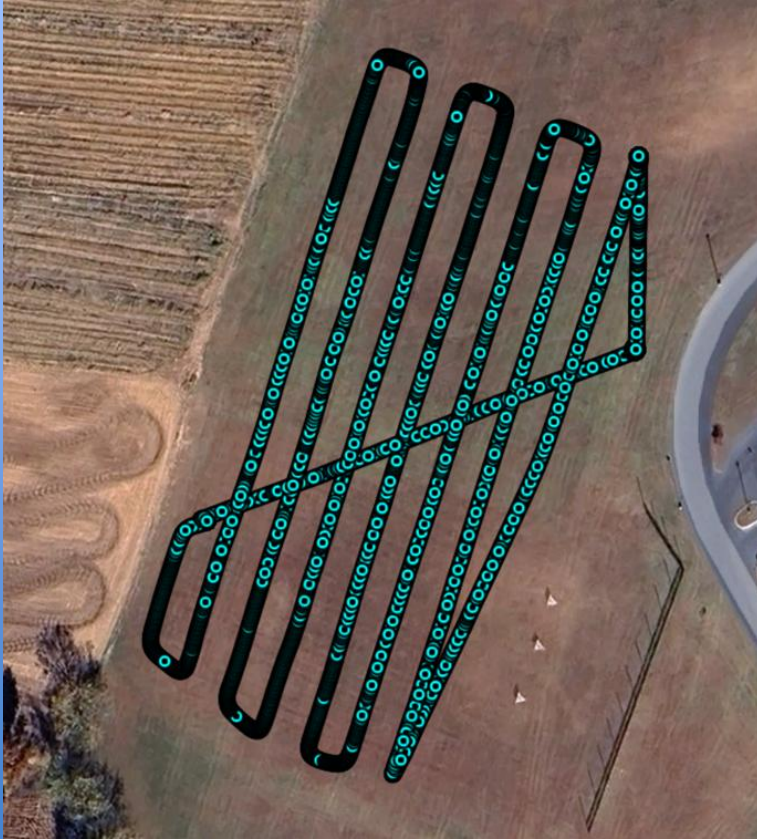
- Periodic checks versus frequent or continuous monitoring
- Continuous methane monitoring
 - Fix sensor networks
 - Automated alerts
- Drone, aircraft, and mobile platforms
- Measured versus estimated

Drone Tech for Solid Waste

- Thermal Imagery
- Structural Integrity
- Photogrammetry
- LiDAR
- GIS Integration
- Methane Monitoring



Fixed Sensor vs Motorized Gimbal

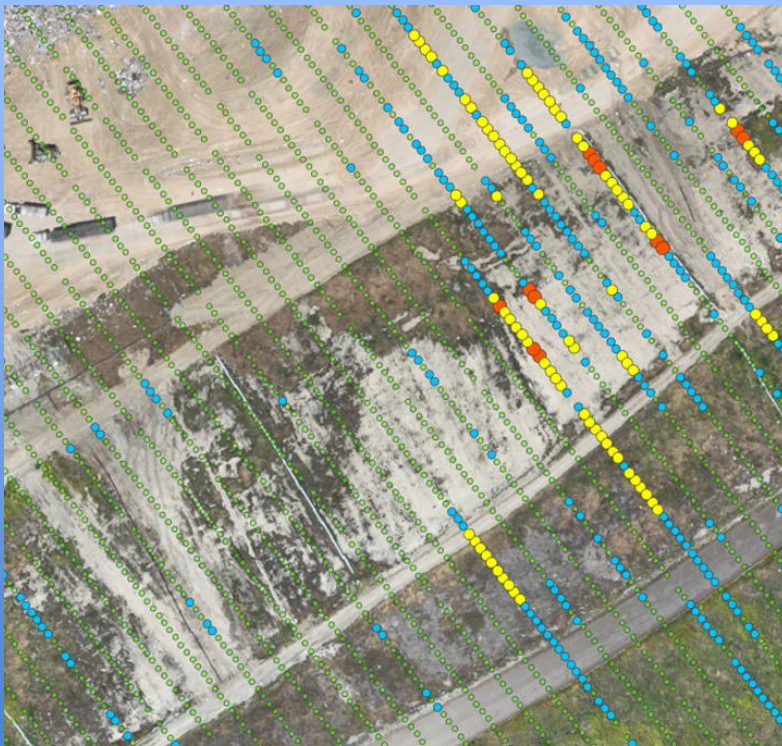


Fixed

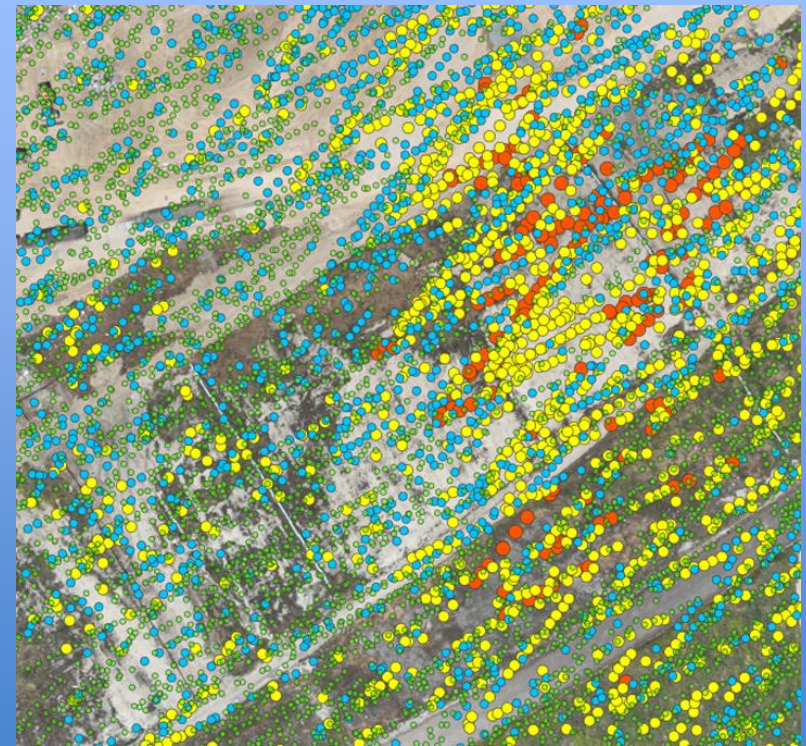


Sweeping

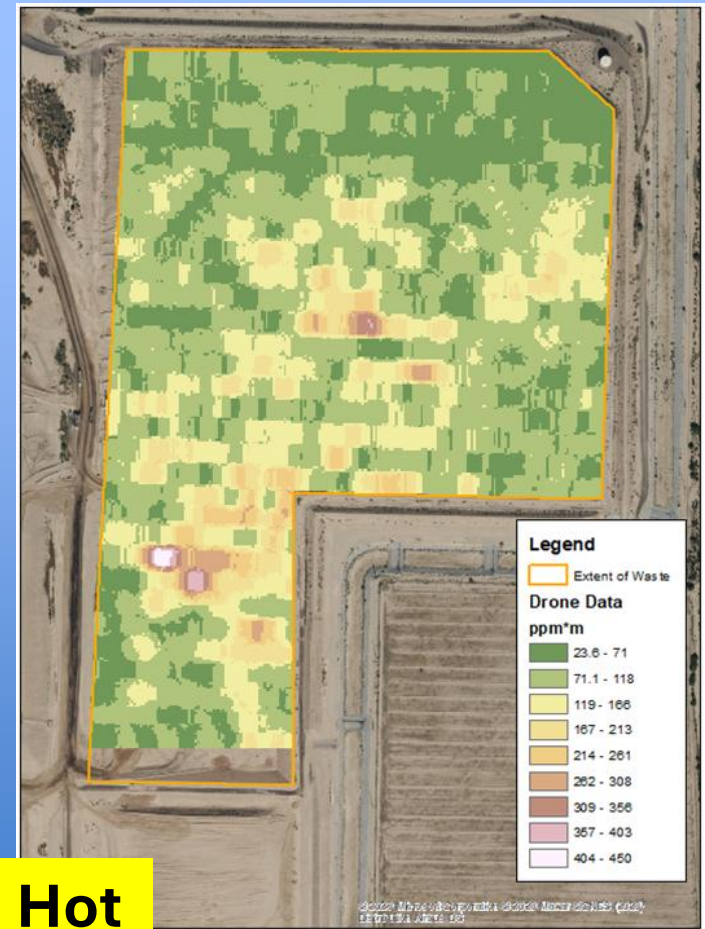
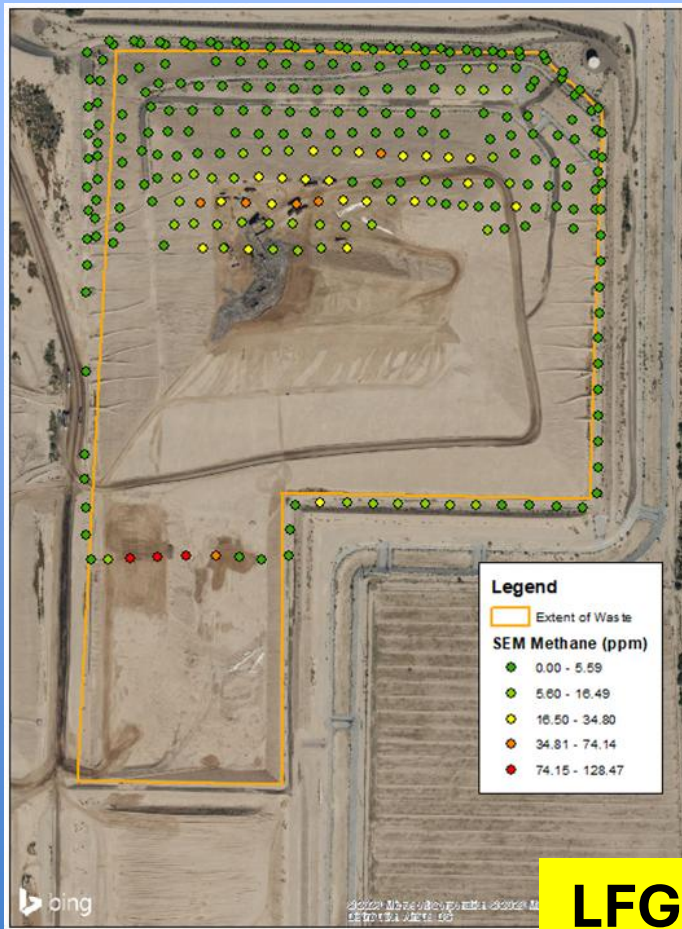
Denser, More Accurate Data



Fixed



Sweeping



LFG/Methane Hot Spot

Comparison to Regulatory SEM

Drone TDL

- ▶ Autonomous Flight Pattern
- ▶ Reaches Inaccessible Areas
- ▶ Autonomous Sweeping or Rotating Motion
- ▶ PIC from 30m AGL
- ▶ More Frequency w/1 Pilot
- ▶ Internal Self Calibration
- ▶ Alarming
- ▶ Data Redundancy
- ▶ Built-In Reporting
- ▶ Same Day Turnaround

VS

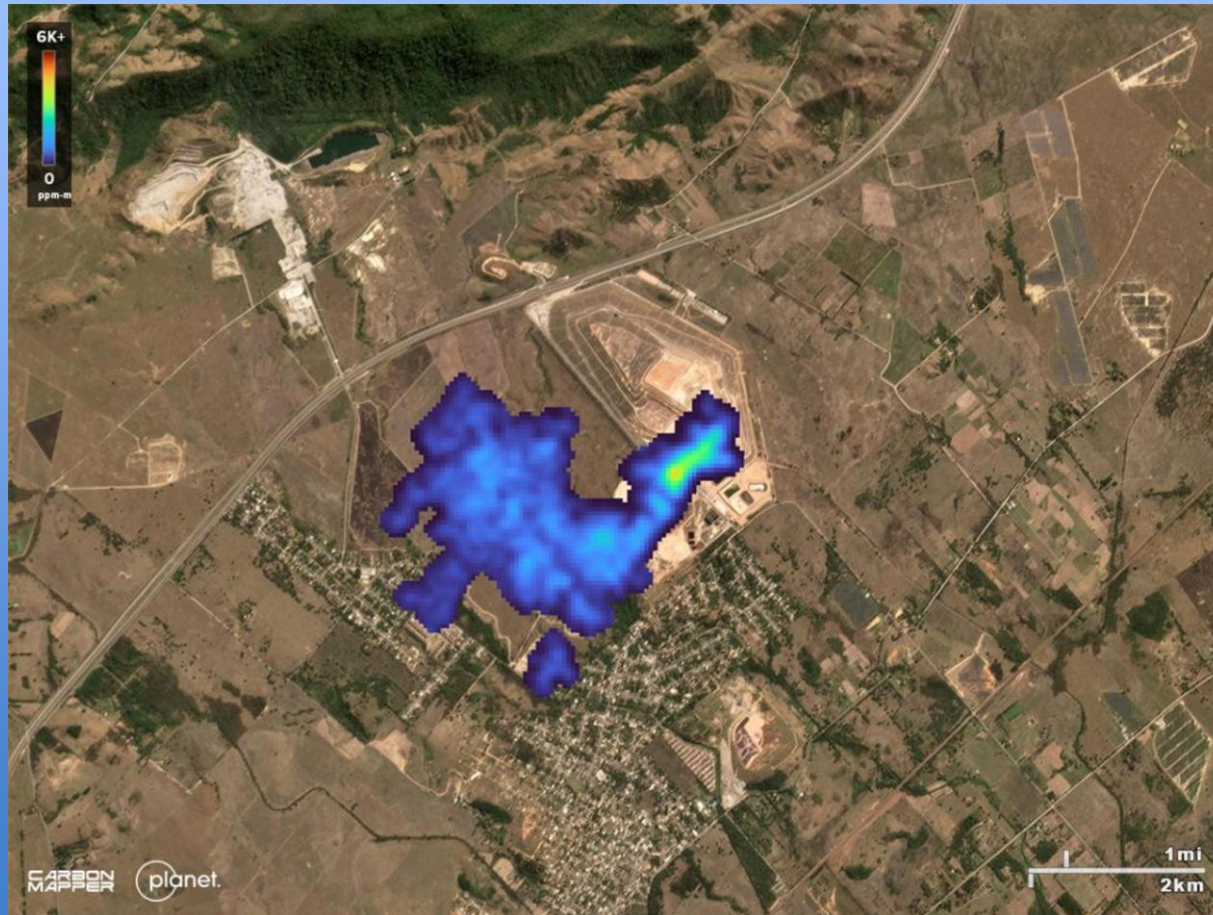
Method 21

- ▶ Walking Pattern
- ▶ Avoids Steep Terrain, Open Face and Vegetation
- ▶ Manual Sweeping Motion
- ▶ Probe 5cm above surface
- ▶ Quarterly Frequency w/Crew
- ▶ Calibrate w/Gas
- ▶ Alarming
- ▶ ~~Data Redundancy~~
- ▶ ~~Built-In Reporting~~
- ▶ ~~Same Day Turnaround~~

Satellite data and enforcement are raising the performance bar

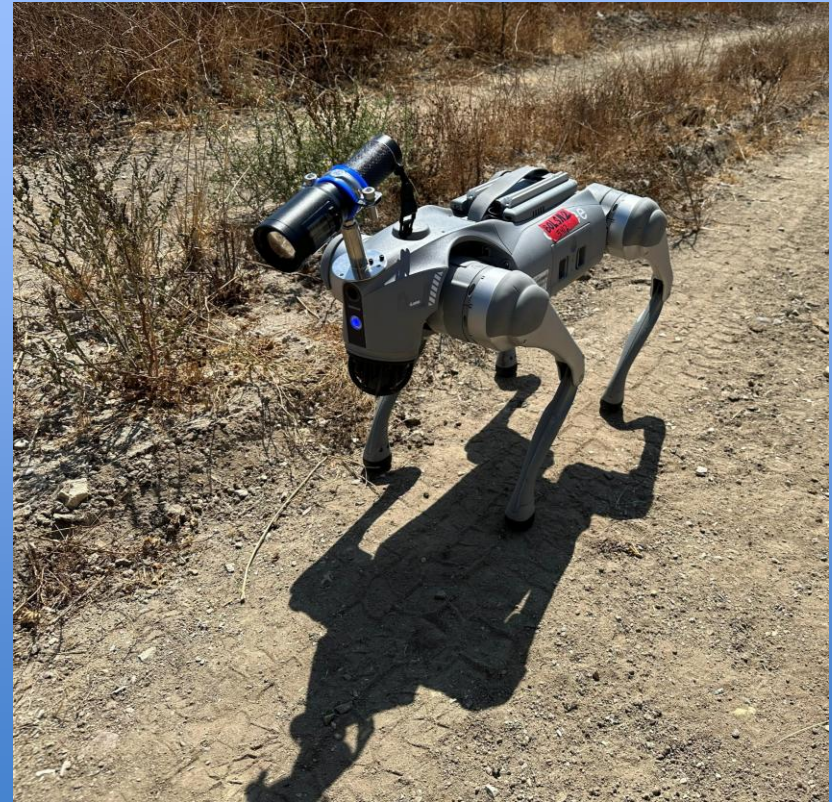
- Satellite observations and aerial surveys
- EPA enforcement and state-level regulatory activity

Satellite Image of a Methane Release



Robot Dog with Methane Sensor

- Patrols the landfill to detect methane emissions
- Can follow difficult terrain
- Preprogrammed routing
- Autonomous
 - 5m/s or 11 mph
- Weather resistant
- LiDAR sensing
 - Obstacle avoidance
- Future use in Surface Emissions Monitoring (SEM) for compliance?





Automated Wellhead

- Sensors
 - Methane
 - Temperature
 - Pressure
- Automated Control Systems
- Wireless or wired data transmissions
- Off-the-shelf parts



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Vice President
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A Solid Plan:



Managing Today's Wastes with Tomorrow in Mind

Frederick County, Virginia Regional Landfill

Case study of a modern Sanitary Landfill

- Basic summary of landfill service area, demographics and costs
- Overview of landfill site and timeline
- Landfill permitting requirements in Virginia
- Tour of landfill facility/ discuss potential hazards at landfill
- Moving into the Future

Location of Landfill

Virginia USA Map



Landfill Service area, demographics

- Landfill is managed by Frederick County Department of Public Works
- Serves the Counties of Frederick and Clarke and City of Winchester
- Estimated population of service area over 140,000 people
- Current annual tonnage of solid waste received is 220,000 tons
- The landfill is managed as an Enterprise fund budget

Landfill site information

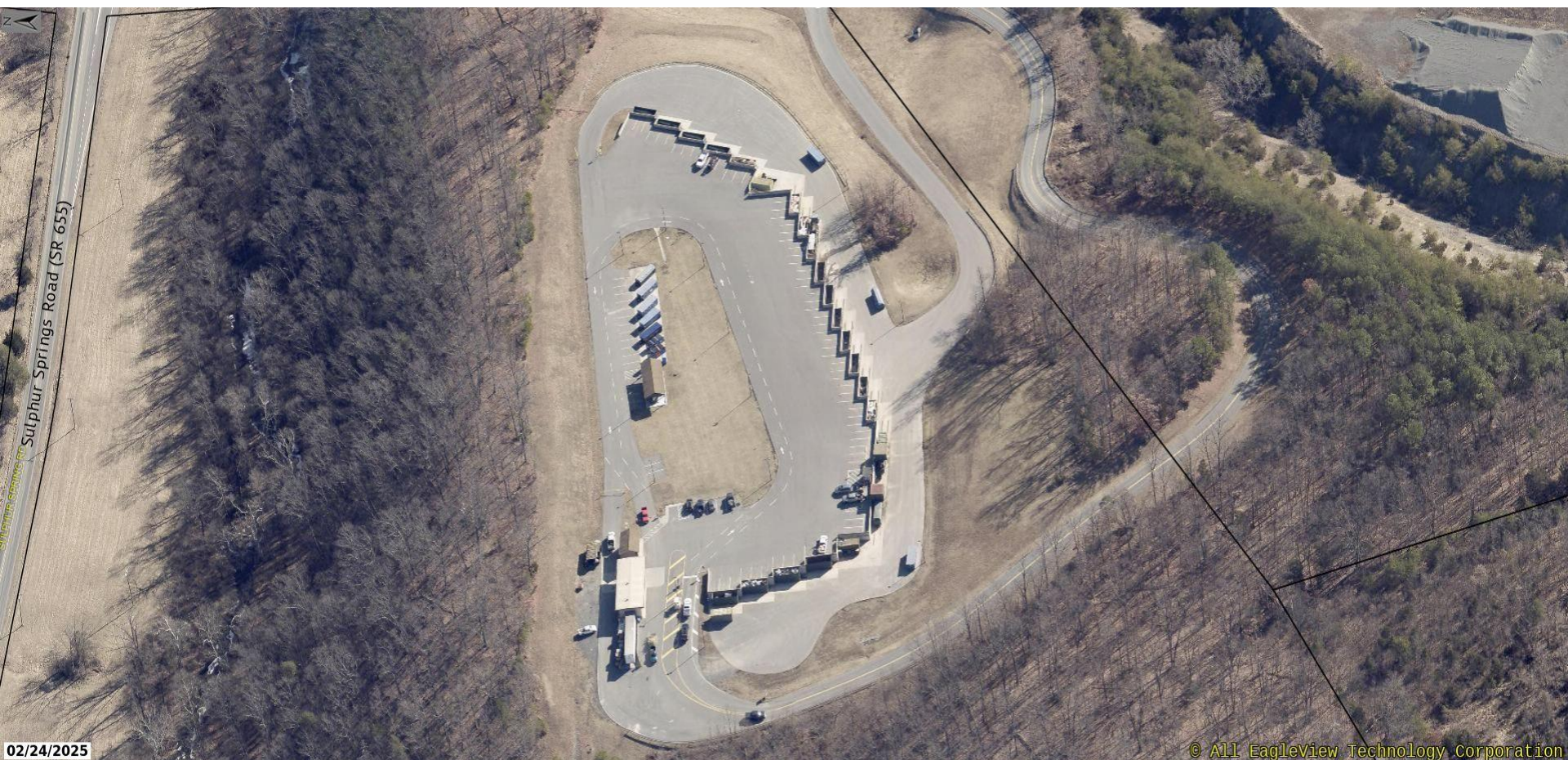
- Landfill site began operations in the mid 1970's
- Operate two active landfills – MSW Permit #529, CDD Permit #591
- Have a closed landfill with ongoing monitoring – Permit#40
- The site has permitted life expectancy of over 30 years
- Landfill has approximately 30 full time employees
- Current FY 2027 budget is approximately \$18 million including on-going CDD expansion project (operating budget approx. \$8.2 million)
- Tipping fees: MSW: \$64/ ton; CDD: \$58/ ton



Overall landfill facility – 1,200 acres

Landfill permitting requirements

- Virginia Solid Waste permits: MSW#529, CDD#591, Closed#40
- Virginia Pollutant Discharge Elimination System #VAR051409
- Virginia Title V Air Operating Permit #VRO 81312
- Virginia Water Permit #22-0662
- Leachate pretreatment permit w/ local POTW
- Permits require full-time environmental staff to perform in-house testing and to manage testing with consultants



Landfill citizen convenience center

Citizen Convenience Center

- Large site with multiple drop-off containers for source separation of waste, use by citizens only
- Types of recycling options available at site:
- Plastic bottles, jugs and jars, different types of paper, aluminum and steel cans, cardboard, glass, tires, appliances, motor oil, antifreeze, cooking oil, electronics, yard waste, bulky metals
- Provide monthly events for household hazardous wastes and electronics
- Convenience site helps minimize citizen traffic within landfill



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Active MSW Landfill – Permit 529



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02/24/2025

Active CDD Landfill – Permit 591

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Leachate pretreatment lagoons



Leachate management



Groundwater monitoring well



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Landfill Gas to Electricity Generation Plant

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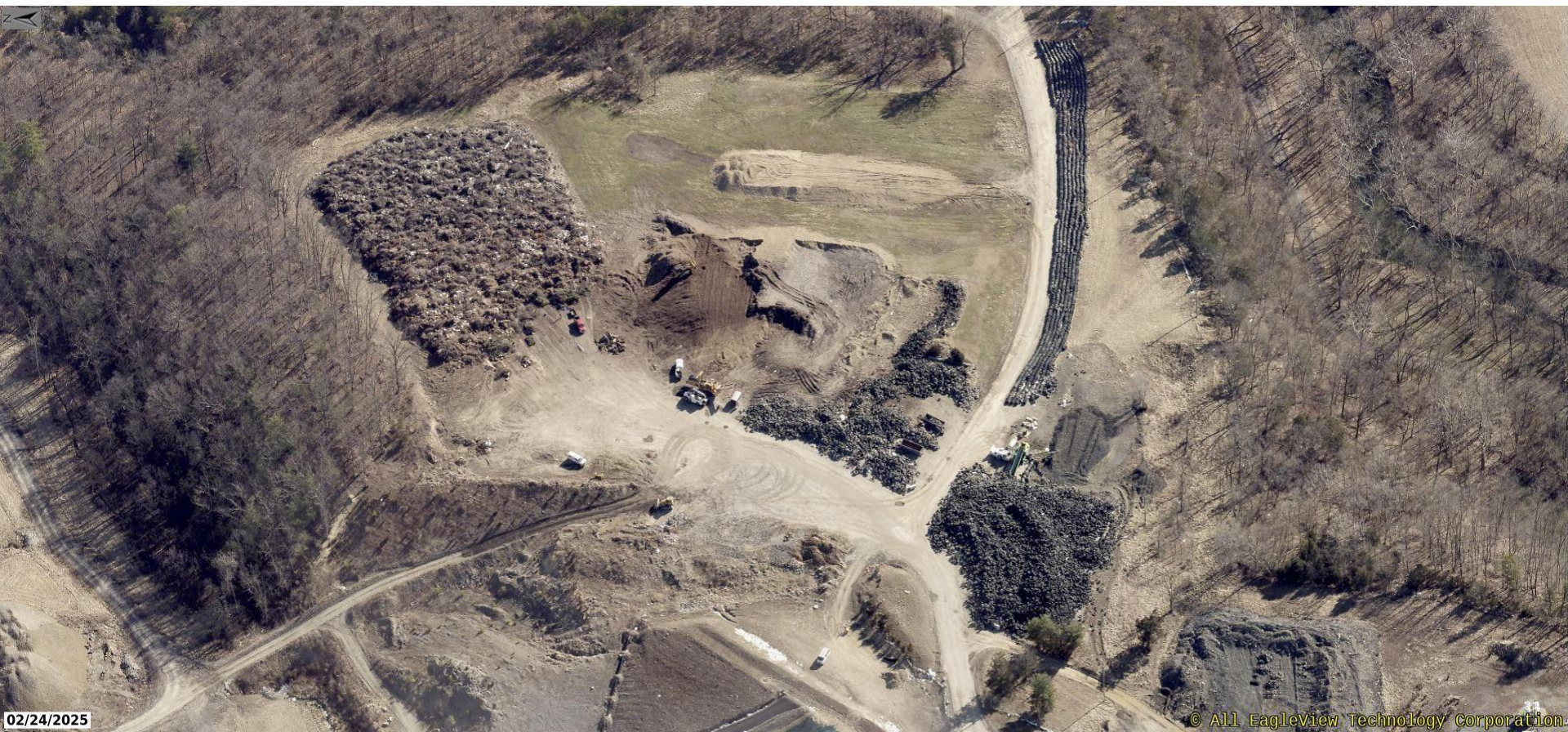
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Landfill gas monitoring probe



Yard waste and used tire recycling areas



Stormwater management

Moving into the future

- Permitting of expansion of CDD landfill
- Construction of CDD landfill – area 2
- Expansion of landfill gas collection system – MSW Landfill
- Expansion of tire operations program

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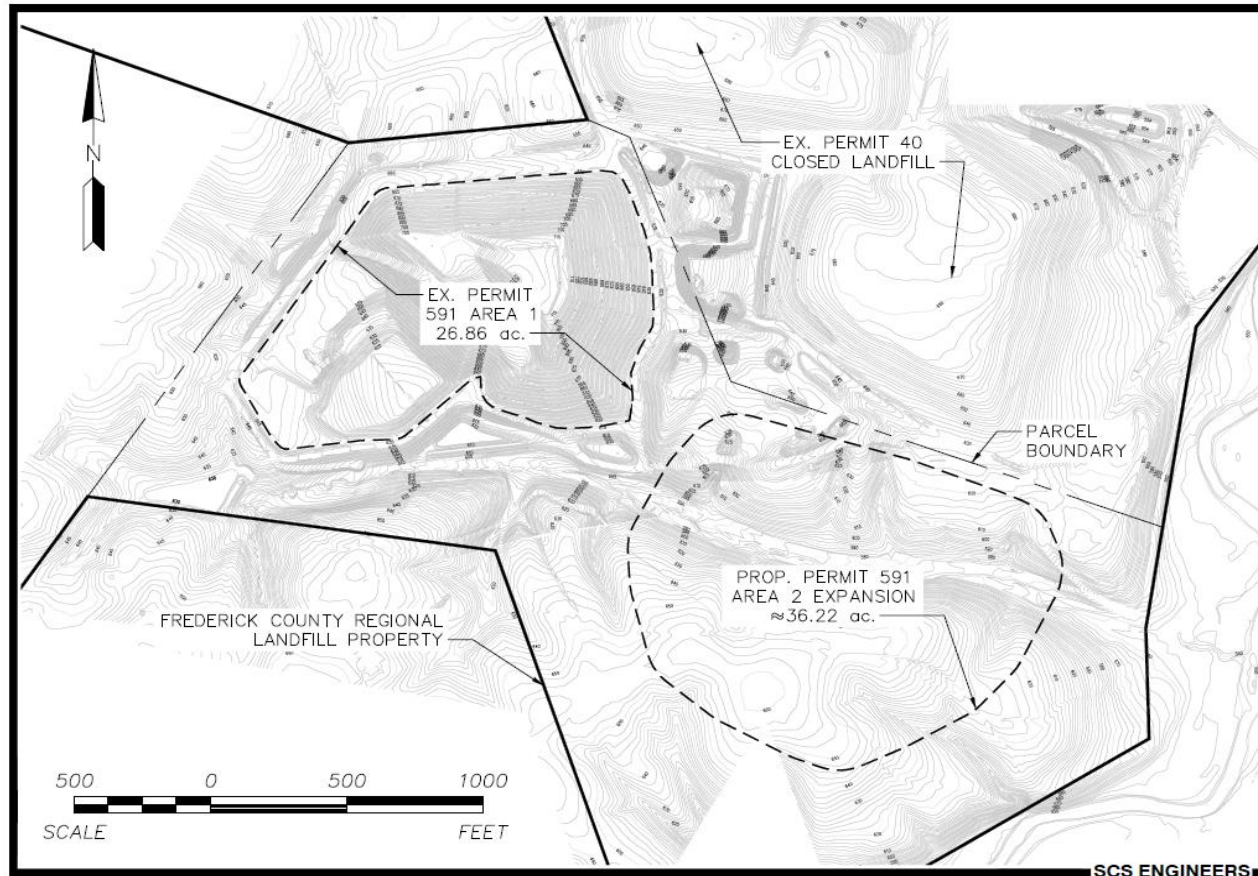


FIGURE 2. AREA MAP



CDD Landfill – Area 2

Expansion of MSW Landfill Gas System



**SWIFR Grant:
Regional Tire Operations Program**

Existing Conditions

Program Overview

- Program established in 1994. Originally operated as a mobile unit that traveled to landfills throughout the region.
- Currently housed, maintained, and operated at the Frederick County Landfill by County employees.
- Current machine is a 10-year old, refurbished model
- Receives roughly 200,000 tires per year
- Processes 10,000 tires per month on average
- Final Product: 2inx2in tire chip with steel remaining

Challenges

- Not located in an enclosed space and subject to the elements
- Can only accept passenger and regular truck tires
- Must change shredding knives every 100,000 tires (10 months)



Figure 2: Current Tire-Shoulder. Located at Frederick County Landfill

- Requires a 4-5 man team operate
- Limited reuse markets and applications
- Frequent repairs required
- Consistent operation subject to staffing levels and weather conditions.

Proposed Changes



Figure 2: CM H-250 Hybrid Shredder



Figure 3: CM Liberator Zero Waste Steel-Cleaning System



Figure 4: Desired End Product – Rubber Mulch

Equipment Upgrades

- Heavy duty, high capacity shredder that can accommodate a higher volume and wider variety of tires (Figure 2)
- Liberator system that separates the tire from the steel wire, reduces residual fiber, and breaks tire rubber down to mulch size (Figure 3, Figure 4)
- New tire deripper to accommodate larger tires
- Facility to house equipment in order to protect machinery from the elements and allow for consistent operations

Program Goals

- Create sustainable and marketable end products in the form of mulched rubber (Figure 4) and steel wire for scrap sale
- Increase efficiency and capacity of shredding operations
- Divert all tires from landfilling and landfill applications

Expected Outputs/Outcomes

- Diversion of over 750 tons of tires from landfilling
- Introduction of 936 tons or more of mulched rubber into reuse market annually
- Additional 360 tons or more of tires shredded annually
- 195 tons or more of scrap steel captured per year

Funding

- \$2,361,799 in SWIFR Grant funds for purchase and installation of equipment
- \$500,000 in matching funds from RTOP program for equipment purchase
- Construction of equipment enclosure funded by participating RTOP localities estimated at \$750K-\$1M

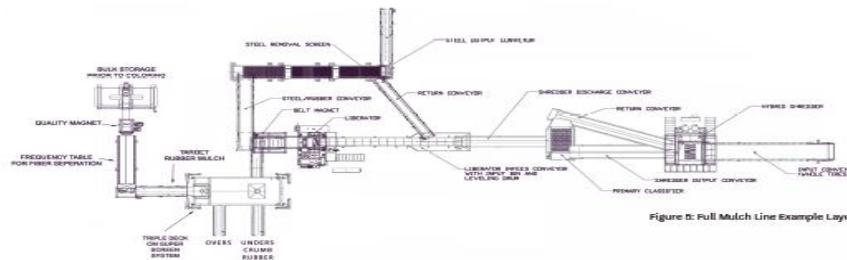


Figure 5: Full Mulch Line Example Layout

Future concerns

- Long-term view regarding solid waste (50 years and beyond)
- Emerging contaminants
- Adequate funding
- Addressing changes in laws and regulations
- Unknowns ???

Contact information

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Future Look at Solid Waste Infrastructure and Research Needs

Suzie Boxman

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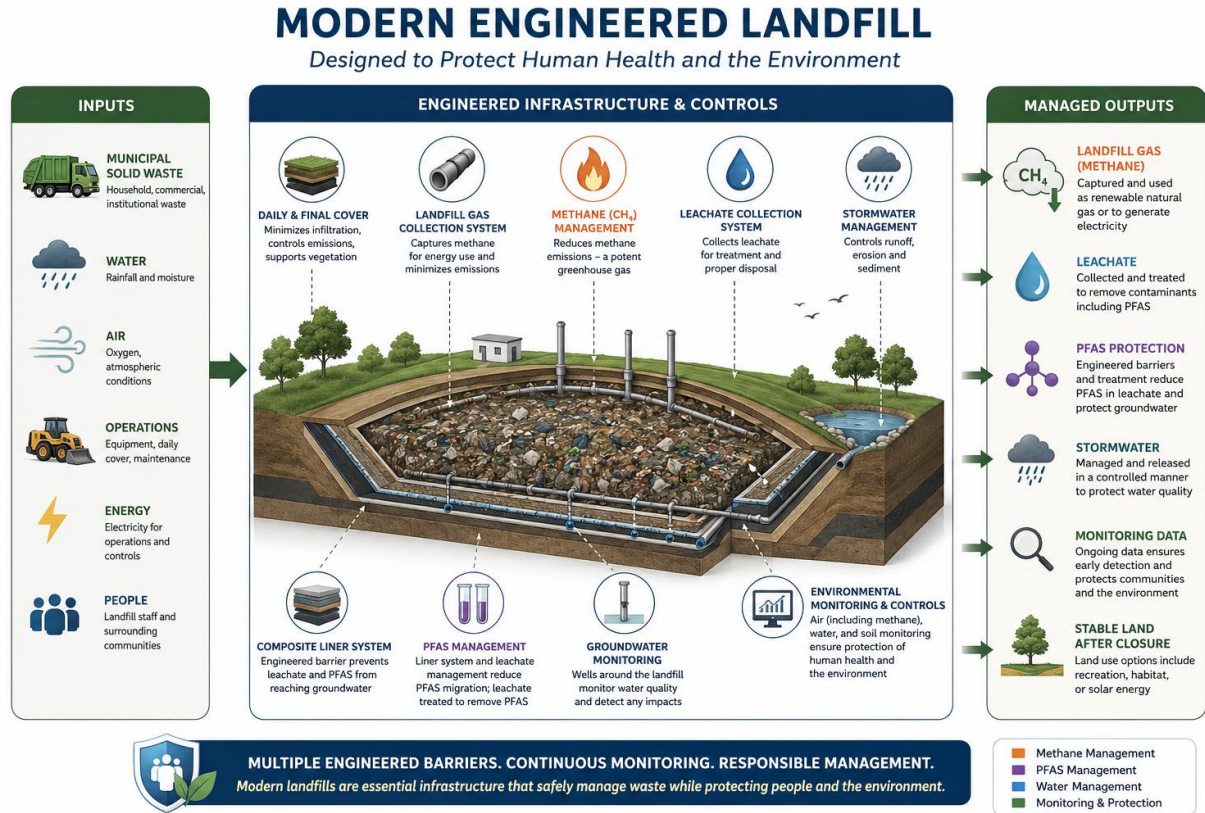


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Future Look at Solid Waste Infrastructure and Research Needs

- Basic function of landfills are to protect human health & the environment.



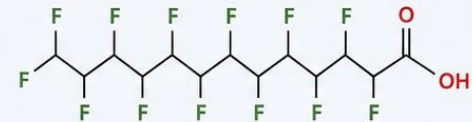
What is PFAS?

A large class of human-made chemicals used since the 1940s

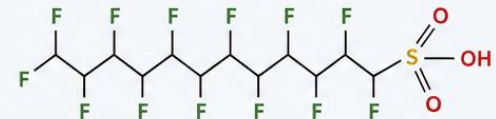
- PFAS stands for Per- and Polyfluoroalkyl Substances.
- They are a large class of thousands of synthetic chemicals containing carbon-fluorine bonds.
- These bonds are some of the strongest in nature making PFAS extremely stable
- Because of these properties, PFAS are used in a wide variety of industrial and consumer products
- PFAS are persistent in the environment and the human body.

PFAS CHEMICAL STRUCTURE

Perfluorooctanoic acid (PFOA)



Perfluorooctane sulfonic acid (PFOS)



● Carbon ● Fluorine ● Oxygen ● Sulfur — Bond

PFAS USES

PFAS are used in a wide variety of industrial and consumer products and applications.



STAIN & WATER RESISTANT PRODUCTS



- Waterproof outdoor gear
- Stain-resistant carpets and fabrics
- Upholstery



FOOD PACKAGING & COOKWARE



- Grease-resistant food packaging
- Microwave popcorn bags
- Non-stick cookware



FOAM & FIREFIGHTING PRODUCTS



- Aqueous film-forming foams (AFFF)
- Firefighting foams



PERSONAL CARE PRODUCTS



- Cosmetics (e.g., lipstick)
- Dental floss
- Shampoo, lotions, sunscreen



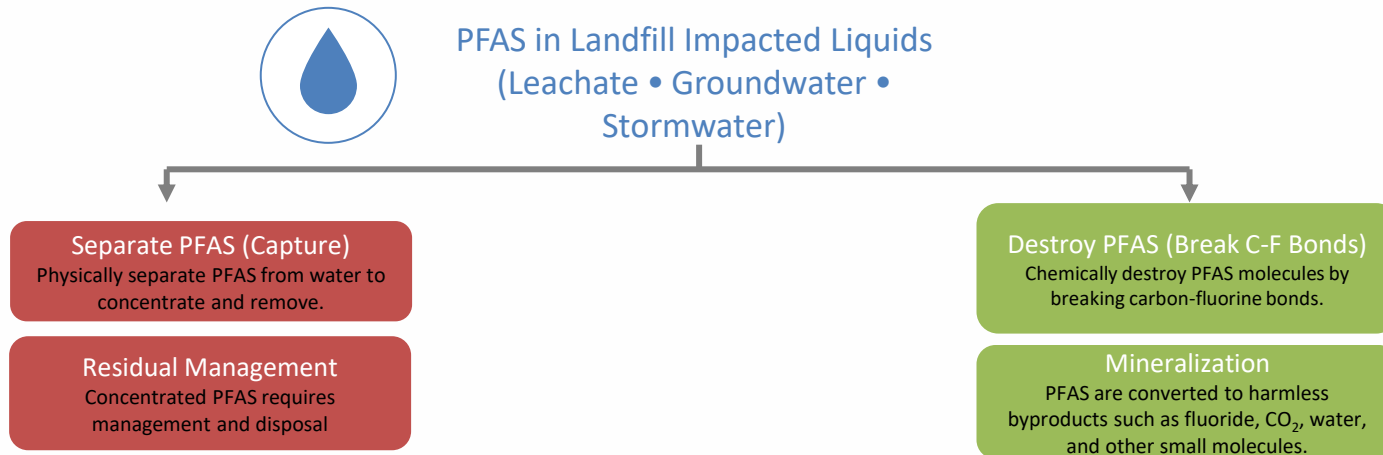
INDUSTRIAL & OTHER APPLICATIONS



- Electronics manufacturing
- Metal plating
- Oil & gas
- Aviation, automotive and more

PFAS Treatment Technologies

Managing PFAS in Landfill Liquids



Commercial/Established Technologies

Foam Fractionation	Separate PFAS into a concentrated foam phase using air bubbles.
Reverse Osmosis	Pressure-driven membrane process that removes a wide range of PFAS compounds.
Granular Activated Carbon (GAC)	Adsorbs PFAS onto porous carbon media.
Ion Exchange Resin (IEX)	Binds PFAS to charged resin beads for removal from water.

Emerging/ Innovative Technologies

Electrochemical Oxidation (EO)	Uses electricity to generate oxidants that break PFAS molecules.
Photodegradation	Uses light energy (UV/visible) to break PFAS chemical bonds.
Plasma	High-energy plasma destroys PFAS through reactive species.
Supercritical Water Oxidation (SCWO)	High temperature and pressure water oxidizes PFAS to benign byproducts

Comparing Treatment Technologies

No single technology fits every landfill

Technology	Best Application	Separation or Destruction	Relative Cost	Key Limitation
Foam Fractionation	Leachate	Separation (Removes PFAS)	\$\$	Most effective for long-chain PFAS; concentrate management required.
Reverse Osmosis	Leachate	Separation (Removes PFAS)	\$\$\$\$	High energy use; produces large volume of concentrate.
Granular Activated Carbon (GAC)	Groundwater / Stormwater	Separation (Removes PFAS)	\$	Less effective for raw leachate; pretreatment often needed.
Electrochemical Oxidation	Concentrated residuals	Destruction (Breaks C-F Bonds)	\$\$\$	Emerging technology; energy intensive.
Photodegradation	Concentrated residuals	Destruction (Breaks C-F Bonds)	?	Early-state technology; pilot-scale development.

KEY FACTORS IN TECHNOLOGY SELECTION



Advancing PFAS Research: EREF's Role

2025 ASCE Infrastructure Report Card Identified the following:

*“Accelerate and increase investment in **PFAS research** aimed at the **characterization, treatment, and analysis** of these compounds and understanding their **health impacts**.”*

EREF is Working to Address this Need

CHARACTERIZE

Measure PFAS in waste and the environment

- PFAS concentrations in MSW and fluxes to landfills
- PFAS in landfill leachate and landfill gas
- Concentrations of PFAS in landfill impacted liquids

UNDERSTAND

Improve understanding of PFAS behavior within landfill materials management systems

- Compare PFAS concentrations in different materials management systems
- Special waste impacts on landfill PFAS
- Impacts at operating landfills

DEVELOP SOLUTIONS

Evaluate practical management options

- State of Practice: PFAS Treatment Technologies
- Development of Supercritical water oxidation technology
- Monitor PFAS release from spent GAC

INFORM DECISIONS

Provide science to facility operators and policy makers

- PFAS resource website
- Develop technical guidance documents
- Fund research and data to support future treatment and management options

From characterization to treatment, EREF research is helping to improve PFAS management

Advancing Methane Measurement & Modeling

Can we accurately measure emissions?

Controlled release studies have compared multiple measurement technologies.

- Evaluate accuracy and uncertainty
- Identify strengths and limitations
- Evaluate performance in different atmospheric conditions

Which technology works best for which situation?

Not all technologies are right for all situations.

- Multiple technologies can provide complementary information
- Technologies perform differently depending on site conditions

How do operations influence emissions?

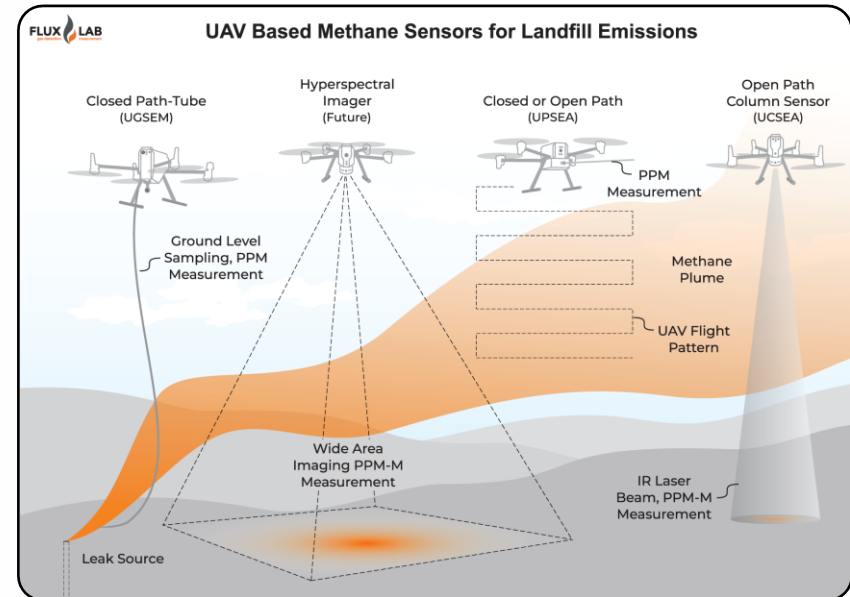
Operational and environmental factors impact emissions and measurement.

- Gas collection and efficiency
- Cover materials and operational activities
- Weather and atmospheric conditions

Can models be improved?

Better data leads to better models and supports decision makers

- EREF supported SWICS model incorporates operational data
- Supports improved emissions reporting



Martin Lavoie, Chelsea Fougère, David Risk, A review of landfill methane emission detection, localization, and quantification systems, Elementa: Science of the Anthropocene, 2026, Figure 2.



Better Measurements
Understand Emissions



Better Models
Improve Accuracy



Better Operational Decisions
Optimize Performance



Lower Methane Emissions
Protect the Environment

Research Investment Drives Creation of Better Tech

Controlled release studies support improved methane measurement technologies for landfills.

Download the Key Findings Report

Benchmarking and Improving Landfill Methane Measurement Technologies with Field-Based Controlled Release Experiments



BENCHMARK

Controlled-release experiments provide a common basis for evaluating methane measurement technologies.



IMPROVE

Technology developers use the results to refine instruments, algorithms, and deployment approaches.



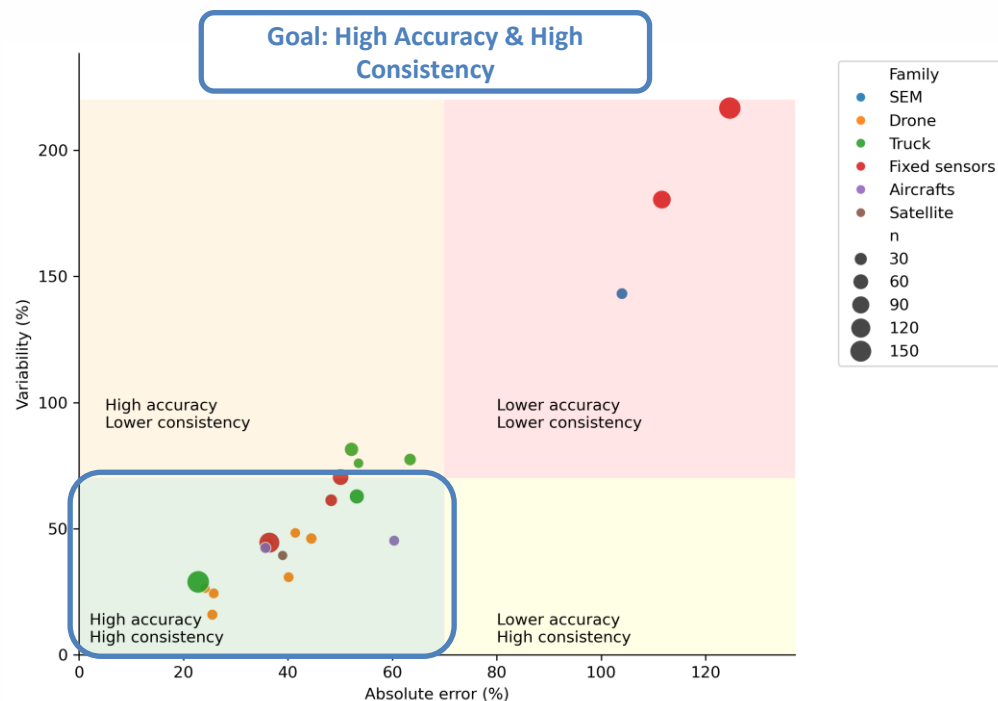
COLLABORATE

EREF brings together researchers, technology developers, landfill operators, and regulators to advance measurement science.



IMPACT

Better measurements support improved emissions inventories, more informed operational decisions, and future methane mitigation strategies.



Raising the Grade – Improving US Solid Waste Infrastructure



Advancing Circularity & Recycling

- Extended producer responsibility (EPR)
- Li-Battery management
- Fleet electrification
- Organics diversion and impacts on waste composition



Emerging Contaminants

- PFAS treatment and tracking
- Microplastics
- Other emerging chemicals
- Human health and exposure concerns



Climate Change & GHG Emissions

- Improved methane measurement
- Emissions modeling
- Climate impacts of operations and waste transportation
- Organics diversion



Data & Innovation

- Developing essential materials management datasets
- Improving models and decision support tools
- Data-driven research and operational insights
- Knowledge sharing and transfer

Research

Identify knowledge gaps and industry needs



Innovation

Develop new tools, methods, and technologies



Implementation

Apply solutions in operations, policy, and infrastructure



Impact

Create stronger infrastructure that protects people and the environment



Contact Information

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Questions?



A decorative border at the top and bottom of the slide features a repeating pattern of various engineering and construction icons in a light blue color. These icons include a bridge, a train, a factory, a lightbulb, a crane, a gear, a propeller, a rocket, a wind turbine, a power line, a building, a tree, a truck, a ship, a plane, a crane, a gear, a propeller, a rocket, a wind turbine, a power line, a building, a tree, a truck, a ship, and a plane.

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