



November 2024

HAZARDOUS WASTE

EPA Should Take Additional Actions to Encourage Treatment, Storage, and Disposal Facilities to Manage Climate Risks

GAO Highlights

Highlights of [GAO-25-106253](#), a report to congressional requesters

Why GAO Did This Study

More than 1,000 facilities across the nation treat, store, and dispose of hazardous waste that could harm human health and the environment if released. Natural hazards such as flooding—which may become more frequent and intense due to climate change—can lead to hazardous waste releases. RCRA governs the management of hazardous waste by facilities. EPA promulgates RCRA regulations to minimize the risk of releases from facilities and has authorized 48 states to implement these regulations in lieu of EPA. EPA regional offices assist and oversee states in implementing RCRA.

GAO was asked to review EPA's role in addressing climate risks to facilities. This report examines 1) the extent to which facilities are located in areas with selected natural hazards that may be exacerbated by climate change; 2) the extent to which EPA requires or encourages authorized states and facilities to manage risks to human health and the environment from climate change; and 3) challenges EPA, states, and facilities face in managing climate risks. GAO analyzed federal data on facilities and four natural hazards, reviewed agency documents, and interviewed officials from EPA headquarters and five regional offices, four state agencies, and eight stakeholder groups.

What GAO Recommends

GAO is making nine recommendations to EPA, including that it provide training and technical assistance and assess issuing regulations to clarify requirements and provide direction on managing facility climate risks. EPA agreed with our recommendations.

View [GAO-25-106253](#). For more information, contact J. Alfredo Gomez at (202) 512-3841 or gomezj@gao.gov.

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What GAO Found

Federal data on flooding, wildfires, storm surge, and sea level rise indicate that more than 700 hazardous waste treatment, storage, and disposal facilities, or about 68 percent, are located in areas with one or more of these hazards that could be exacerbated by climate change.

Hazardous Waste Storage Tanks at a Treatment, Storage, and Disposal Facility



Source: Photo used with permission. Source withheld. | GAO-25-106253

U.S. Environmental Protection Agency (EPA) regions, authorized states, and facilities need more clarity on whether managing climate risks to facilities is required or there is existing authority to do so under the Resource Conservation and Recovery Act of 1976, as amended (RCRA). EPA has taken steps to clarify authorities and requirements for managing climate risks as part of permitting but has not done so for compliance and enforcement efforts, such as inspections. In June 2024, EPA issued guidance on selected RCRA authorities that regions and states could use to develop facility permit requirements to manage climate risks. However, some states and facilities may not implement the guidance unless EPA amends regulations to explicitly clarify authorities and requirements. EPA officials said the agency could provide training and technical assistance to regions and states to help ensure they understand and implement the guidance, but EPA has not done so yet. Without providing this training and technical assistance and seeking further feedback to determine whether it should issue regulations to fully clarify authorities and requirements for managing climate risks, EPA may be unable to ensure effective and consistent management of these risks.

EPA regions, states, and facilities also face challenges in managing climate risks. For example, regions, states, and facilities need guidance on how to assess climate risks and face challenges in knowing what data they should use to do so, according to interviews with officials from EPA, states, and stakeholder groups. By issuing guidance to regions, states, and facilities on how to manage climate risks, along with providing data, tools, and training, EPA could better ensure these risks are managed sufficiently and that regions, states, and facilities have the direction and information necessary to do so.

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Abbreviations

CRRA	2014 Community Risk and Resiliency Act
EPA	U.S. Environmental Protection Agency
FEMA	Federal Emergency Management Agency
HELP	Hydrologic Evaluation of Landfill Performance
IRA	Inflation Reduction Act of 2022
DEC	New York Department of Environmental Conservation
NOAA	National Oceanic and Atmospheric Administration
OECA	Office of Enforcement and Compliance Assurance
OLEM	Office of Land and Emergency Management
RCRA	Resource Conservation and Recovery Act of 1976
TSDf	Treatment, Storage, and Disposal Facility

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November 14, 2024

The Honorable Tom Carper
Chairman
Committee on Environment and Public Works
United States Senate

The Honorable Cory A. Booker
United States Senate

More than 1,000 facilities across the nation treat, store, and dispose of various types of hazardous waste that would pose harm to human health and the environment if released. For example, trichloroethylene—a widely used industrial chemical and a known human carcinogen—is managed in treatment, storage, and disposal facilities (TSDFs). These facilities are engineered to prevent releases of hazardous waste into the environment and contamination of drinking water. However, these facilities could be at risk from natural hazards such as flooding and hurricanes, which the *Fifth National Climate Assessment* indicates may become more frequent and intense due to climate change.¹ These natural hazards may lead to hazardous waste releases, according to the Association of State and Territorial Solid Waste Management Officials and the Homeland Security Operational Analysis Center.²

The Resource Conservation and Recovery Act of 1976, as amended (RCRA) is the primary federal law governing the management of hazardous waste from generation to disposal to protect public health and

¹U.S. Global Change Research Program, *Fifth National Climate Assessment* (Washington, D.C.: 2023). The Global Change Research Act of 1990 requires the Committee on Earth and Environmental Sciences of the Federal Coordinating Council on Science, Engineering, and Technology to prepare and submit a scientific assessment of the current and projected effects and trends of global change at least every 4 years. Pub. L. No. 101-606, § 106, 104 Stat. 3096, 3101 (codified at 15 U.S.C. § 2936). The U.S. Global Change Research Program, which coordinates and integrates the activities of 15 participating federal departments and agencies that carry out research and support the nation's response to global change, conducts this national assessment, known as the National Climate Assessment.

²Association of State and Territorial Solid Waste Management Officials Investigation and Remedy Selection Focus Group, *Planning for Resiliency and Sustainability in a Changing Climate* (April 2022); Homeland Security Operational Analysis Center, *Assessing Risk to the National Critical Functions as a Result of Climate Change* (2022).

the environment.³ RCRA directs the U.S. Environmental Protection Agency (EPA) to establish regulations to ensure that hazardous waste is managed safely throughout its life cycle. Under RCRA, EPA may authorize states to administer and enforce the RCRA hazardous waste program within their jurisdiction provided the state program is at least as stringent as the federal requirements.⁴ EPA regional offices work with authorized states to implement and enforce the RCRA hazardous waste program within their regions. However, EPA regions, authorized states, and TSDFs themselves may face challenges in managing climate risks (e.g., future changes to natural hazard conditions due to climate change, such as more frequent or intense weather events) at these facilities.

You asked us to review EPA's role in addressing climate risks at TSDFs regulated under RCRA.⁵ This report examines the (1) extent to which TSDFs are located in areas with selected natural hazards that may be exacerbated by climate change; (2) extent to which EPA requires or encourages authorized states and TSDFs to manage risks to human health and the environment from climate change; and (3) challenges that EPA, authorized states, and TSDFs face in managing risks to human health and the environment from climate change, and opportunities for EPA to address these challenges.

To examine the extent to which TSDFs are located in areas with selected natural hazards that may be exacerbated by climate change, we reviewed documents such as the *Fifth National Climate Assessment* and interviewed EPA officials to identify natural hazards that may be exacerbated by climate change and that could affect TSDFs. We identified nationwide federal datasets on four natural hazards that the National Climate Assessment and other sources reported may be exacerbated by climate change in some areas of the country:

³Resource Conservation and Recovery Act of 1976, Pub. L. No. 94-580, 90 Stat. 2795 (codified as amended at 42 U.S.C. §§ 6901-6987).

⁴42 U.S.C. § 6926(b). See also 40 C.F.R. pt. 271. RCRA defines a "state" as any of the 50 states, the District of Columbia, the Commonwealth of Puerto Rico, the Virgin Islands, Guam, American Samoa, and the Commonwealth of the Northern Mariana Islands. 42 U.S.C. § 6903(31).

⁵Our report reviews EPA's role in addressing climate risks to operating and post-closure TSDFs and related hazardous waste release prevention efforts. For the purposes of our review, this report does not evaluate EPA's actions related to TSDFs subject to corrective action (i.e., requirements to clean up a hazardous waste release that has already taken place at a facility).

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- flooding, with data from the Federal Emergency Management Agency (FEMA);
 - wildfires, with data from the U.S. Forest Service;
 - storm surge from hurricanes, with data from the National Oceanic and Atmospheric Administration (NOAA); and
 - sea level rise, with data from NOAA and an interagency report.

For wildfires, flooding, and hurricane storm surge, the federal data are based on existing or historical weather patterns and data (which do not incorporate climate projections). For sea level rise, we used data for coastal regions and sea level rise projections from an interagency report covering sea level rise scenarios. Throughout this report, we refer to these four hazards as selected natural hazards that may be exacerbated by climate change.

We also analyzed EPA and state data on the locations and other characteristics of TSDFs and used mapping software to identify TSDFs located in areas that may experience the selected natural hazards. For our analysis, we used EPA and state data to identify operating TSDFs with permits that allowed them to actively handle hazardous waste and nonoperating TSDFs with post-closure care permits for units with waste in place. We assessed the reliability of the data sources used and found the data to be sufficiently reliable for the purposes of our analysis.⁶ For more detailed information on our scope and methodology and the steps we took to assess the reliability of the data used in this report, see appendix I. For more detail on data sources used in this report, see appendix II.

To examine the extent to which EPA requires or encourages authorized states and TSDFs to manage risks to human health and the environment from climate change, we analyzed documentary and testimonial evidence from EPA headquarters and five selected EPA regional offices; four

⁶Our analysis is a screening-level analysis that estimated the number of TSDFs located in areas with selected natural hazards that may be exacerbated by climate change without site-specific information. Such a screening-level analysis evaluates whether TSDFs have exposure to climate-related hazards that could lead to facility risks but is not intended to provide estimates of actual risk for specific facilities. To evaluate the risk that a specific facility may face from existing natural hazard conditions or future conditions due to climate change (such as if climate change leads to an increase in the intensity or frequency of a natural hazard), site-specific information would need to be evaluated in conjunction with exposure information.

selected authorized states; and eight stakeholder groups.⁷ We also analyzed statutory and regulatory requirements, executive orders, and EPA policy documents to identify climate-related requirements and guidance. We reviewed guidance from the selected EPA regions that they provided to authorized states on developing annual work plans for their RCRA programs.

We assessed the extent to which the five selected EPA regions provided requirements or regional guidance for authorized states to include goals or commitments in their work plans related to managing climate risks to TSDFs. We reviewed all 25 state RCRA program work plans from the selected EPA regions to assess the extent to which these plans included commitments to incorporate climate-related risks into the state's RCRA oversight at TSDFs. We also reviewed RCRA permits, contingency plans, and compliance inspection reports for eight TSDFs.⁸ We assessed the extent to which the permits and contingency plans account for future projections of natural hazards that may be exacerbated by climate change. We also assessed the extent to which the inspection reports reflect climate risks present at the facilities.

To identify challenges that EPA, authorized states, and TSDFs face in managing risks to human health and the environment from climate change, and opportunities for EPA to address these challenges, we reviewed EPA documents, our prior work, and relevant documents from

⁷We selected EPA Regions 2, 4, 5, 6, and 9 based on multiple factors, including the total number of active and post-closure TSDFs within the region, geographical diversity, and variation of natural hazards that may be exacerbated by climate change. Using the same criteria, we selected one authorized state RCRA program from each selected EPA region: New Jersey (Region 2), Florida (Region 4), Illinois (Region 5), Texas (Region 6), and California (Region 9). We interviewed officials from four of these authorized states; state officials from Florida declined interview requests. Subsequently, we requested to meet with Georgia RCRA program officials, however they also declined our request for an interview. As a result, we did not interview officials from an authorized state in Region 4. We reviewed state work plans for all eight authorized states—including Florida and Georgia—within EPA Region 4. Stakeholder groups are state associations, an industry association, other nonprofit or research organizations, and a national TSDF operator and two of its facilities.

⁸We selected eight TSDFs and reviewed their current permits, contingency plans, and two most recent inspection reports. We also reached out to the operators of these eight TSDFs for interviews, and officials from two of these facilities agreed to be interviewed. We considered several factors in selecting these eight TSDFs, including whether the TSDF was actively handling hazardous waste or had a post-closure unit with waste in place, was located in an area with one or more natural hazards that may be exacerbated by climate change, provided geographic diversity, and was recommended or identified by EPA officials, authorized state program officials, or stakeholders.

other organizations, such as state associations. We also interviewed officials from EPA headquarters and the selected regions, selected authorized states, and stakeholder groups to obtain their views on the challenges EPA, authorized states, and TSDFs face in managing risks from climate change and opportunities for EPA to address these challenges. The views of selected EPA regions, authorized states, and stakeholder groups we interviewed are illustrative and not generalizable to all EPA regions, states, and stakeholder groups.

We conducted this performance audit from September 2022 to November 2024 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

Background

Types of Hazardous Waste and TSDFs

Under RCRA, a waste is hazardous when it exhibits the characteristic of ignitability, corrosivity, reactivity, or toxicity, or is listed as a hazardous waste in the RCRA regulations.⁹ These characteristics can make hazardous waste dangerous or capable of having a harmful effect on human health or the environment. Under RCRA, hazardous waste must be treated, stored, or disposed at permitted facilities, or TSDFs. See table 1 for examples of hazardous waste subject to RCRA.

Table 1: Examples of Hazardous Waste Subject to RCRA

<ul style="list-style-type: none"> Spent solvents (such as degreasing and cleaning solvents) Petroleum refinery oil/water separation floats and sludges Hazardous waste landfill leachates 	<ul style="list-style-type: none"> Veterinary pharmaceuticals Automotive paint waste Toxic metal-bearing dust from steel production 	<ul style="list-style-type: none"> Formulations in which the hazardous chemical is the sole active ingredient Residues, contaminated soil, water, or debris resulting from cleanup of spills of hazardous materials
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Source: GAO analysis of U.S. Environmental Protection Agency (EPA) documentation. | GAO-25-106253

Note: Hazardous waste excluded from Resource Conservation and Recovery Act of 1976, as amended (RCRA) hazardous waste regulations includes certain household waste, waste generated from growing and harvesting agricultural crops, and other types of solid wastes EPA has identified in regulation. See 40 C.F.R. § 261.4(b).

⁹40 C.F.R. § 261.3(a).

Example of Hazardous Waste Regulated under RCRA: 1,4-Dioxane Effects on Human Health

1,4-Dioxane is a clear liquid that easily dissolves in water and is considered hazardous waste under the Resource Conservation and Recovery Act of 1976, as amended (RCRA) when it is discarded as a commercial product. It is used primarily as a solvent in the manufacture of chemicals and as a laboratory reagent. 1,4-Dioxane is a trace contaminant of some chemicals used in cosmetics, detergents, and shampoos. However, manufacturers now reduce 1,4-dioxane from these chemicals to low levels before these chemicals are made into products used in the home. Exposure to 1,4-dioxane occurs from inhalation of contaminated air, ingestion of contaminated food and drinking water, and dermal contact with products such as cosmetics that may contain small amounts of 1,4-dioxane. Exposure to high levels of 1,4-dioxane in the air can result in damage to the nasal cavity, liver, and kidneys. Ingestion or dermal contact with high levels of 1,4-dioxane can result in liver and kidney damage. 1, 4-Dioxane sent to treatment, storage, and disposal facilities (TSDFs) is generally transported in 55-gallon drums. Once at the TSDF, 1,4-dioxane is commonly incinerated but can also be disposed of in landfills after treatment, recycled, or stored.

Source: GAO review of Environmental Protection Agency and the Agency for Toxic Substances and Disease Registry information. | GAO-25-106253

TSDFs can be operational—facilities that receive hazardous waste—and nonoperational—facilities serving as permanent sites for disposal of hazardous waste that are in closure and post-closure care and are not receiving waste.¹⁰ All facilities are subject to RCRA’s closure and post-closure requirements, whether they are owned or operated by private entities or federal, state, or local governments.¹¹

TSDFs can have different types of waste management units, depending on the hazardous waste handled at the facility. For example, some facilities have land treatment units to degrade, transform, or immobilize hazardous constituents present in hazardous waste so it is no longer toxic to human health and the environment. Other facilities may have tanks to store or treat large volumes of hazardous waste, boilers to burn hazardous waste while recovering usable materials for future use, or incinerators to destroy hazardous waste. Others have landfills that are used to dispose of hazardous waste—which requires the landfill to be monitored while operational and after it closes. In some cases, a single facility may be permitted for more than one unit type.

¹⁰Post-closure care is required for land disposal units that leave waste in place upon closure, such as landfills, land treatment units, or surface impoundments. Facilities that are undergoing post-closure care are commonly referred to as closed with waste in place. Post-closure care requires TSDF owners to monitor groundwater and maintain the waste containment system (e.g., covers, caps, and liners). See 40 C.F.R. §§ 264.117-264.120. Conversely, facilities completely removing all waste that was treated, stored, or disposed in a hazardous waste unit are referred to as clean closure, which requires TSDF owners to remove all wastes from the unit and decontaminate all equipment, structures, and surrounding soils. See 40 C.F.R. §§ 264.111-264.116.

¹¹RCRA requires government TSDFs to be inspected at a more frequent rate than privately owned TSDFs—annually for federally owned or state-operated TSDFs and at least once every 2 years for privately owned TSDFs. 42 U.S.C. § 6927(c)-(e).

RCRA Technical Standards and Requirements for Control Measures

RCRA requires EPA to issue regulations establishing technical standards and requirements for TSDFs to ensure that permits include adequate control measures to manage hazardous waste and prevent releases.¹² For example, EPA regulations require TSDF permits to include general facility standards and preparedness and prevention requirements to avoid a release from natural hazards, among other things. RCRA permits must be protective of human health and the environment, technically sound and accurate, and enforceable, and include all RCRA regulatory and state-specific requirements. See table 2 for selected RCRA regulations aimed at preventing or mitigating hazardous waste releases from natural hazards.

Table 2: Selected U.S. Environmental Protection Agency (EPA) RCRA Regulations to Prevent or Mitigate Hazardous Waste Releases from Natural Hazards

Facility siting standards [40 C.F.R. § 264.18(b)]	<p>RCRA regulations require treatment, storage, and disposal facilities (TSDFs) located within a 100-year floodplain to be designed to withstand washout from a 100-year flood event, should there be a flood.^a</p> <p>Surface impoundments, waste piles, land treatment units, and landfills must ensure no adverse effects on human health or the environment will result if washout occurs. Several factors must be considered, including the volume and physical characteristics of the waste in the facility and the impact of hazardous constituents on the sediments of affected surface waters or the soils of the 100-year floodplain that could result from washout, among other considerations.</p>
Containment and detection of releases [40 C.F.R. § 264.193]	<p>Secondary containment systems must have sufficient strength and thickness to prevent failure owing to climatic conditions, among other requirements.</p> <p>Secondary containment for tanks must include external liner systems that are designed and operated to prevent run-on or infiltration of precipitation into the secondary containment system unless the collection system has sufficient excess capacity to contain run-on or infiltration. Such additional capacity must be sufficient to contain precipitation from a 25-year, 24-hour rainfall event.^b</p>
Facility design and operations [40 C.F.R. § 264.31]	Facilities must be designed, constructed, maintained, and operated to minimize the possibility of a release of hazardous waste that could threaten human health or the environment.
Landfill design and operating requirements [40 C.F.R. § 264.301]	Landfills must have a liner system for all portions of the landfill. The liner material must be constructed with sufficient strength and thickness to prevent failure due to pressure gradients, physical contact with the waste or leachate, and climatic conditions, among other requirements.

Source: GAO analysis of Resource Conservation and Recovery Act of 1976, as amended (RCRA) regulations. | GAO-25-106253

^aA 100-year flood is a flood with a 1 percent chance of being equaled or exceeded in any given year. The 100-year floodplain designations are provided by the Federal Emergency Management Agency to support the National Flood Insurance Program. EPA defines “washout” as hazardous waste moving from the TSDF because of flooding. 40 C.F.R. § 264.18(b)(2)(ii).

^bA 25-year, 24-hour rainfall event refers to a storm with a 4 percent probability of occurring in any given year and is a minimum rainfall amount used to design containment systems at TSDFs to ensure stormwater does not release hazardous waste into the environment. Precipitation frequency data are

¹²See 42 U.S.C. § 6924(a); 40 C.F.R. pt. 264.

used to establish the design storm (or amount of rainfall in a period of time) and is expressed in terms of recurrence interval (e.g., 25-year) and duration (e.g., 24-hour).

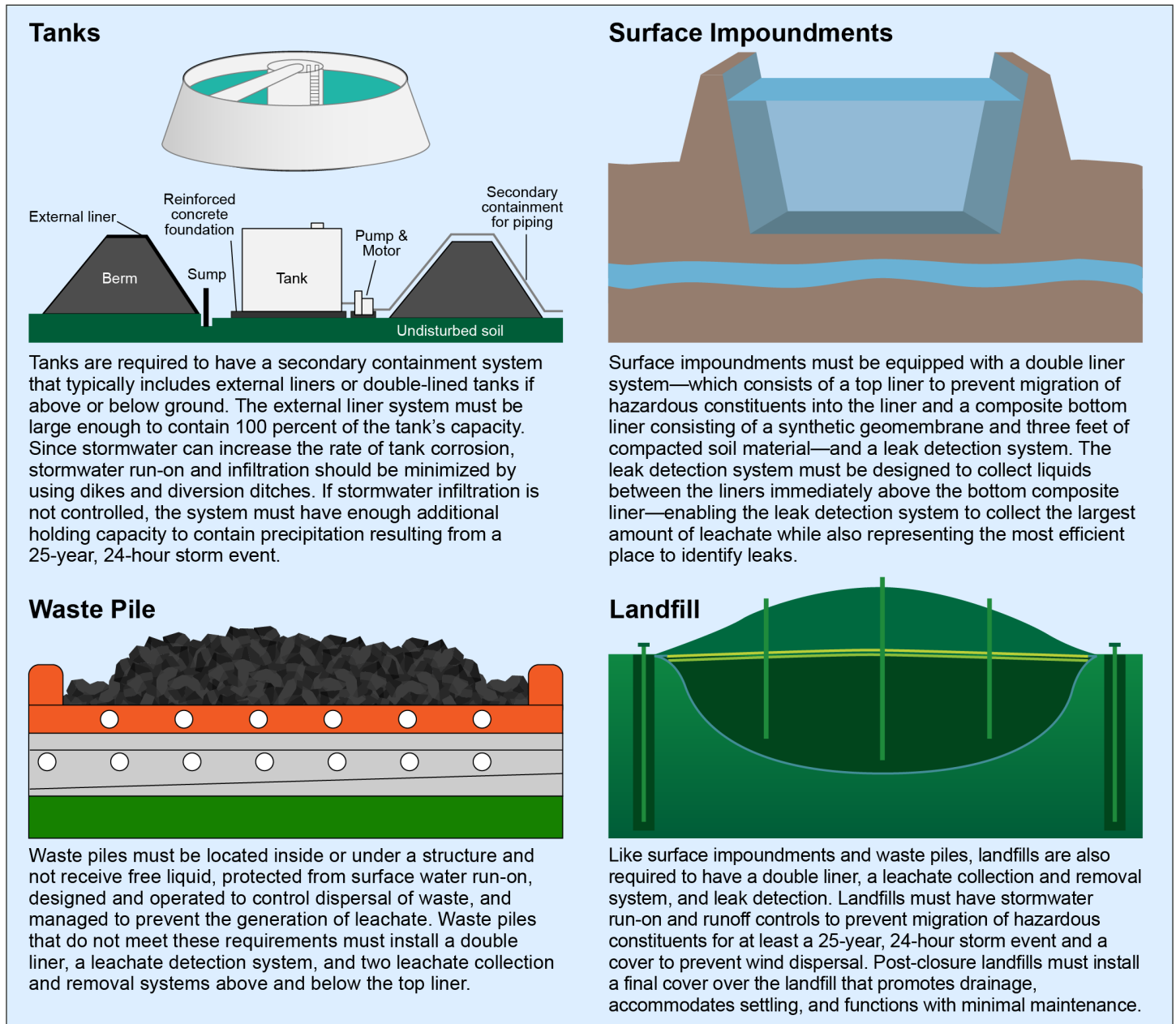
To secure a permit, each facility must have a contingency plan designed to minimize hazards to human health or the environment from fires, explosions, or any unplanned sudden or nonsudden release of hazardous waste.¹³ Regulations also require that facilities review and amend contingency plans, as necessary, when the applicable regulations or facility permits are revised, the plan fails in an emergency, or there are certain changes to the facility, the list of emergency coordinators, or the list of emergency equipment.¹⁴ Facilities are required to submit updated contingency plans to their regulatory authority—typically authorized states—for review and approval.

RCRA regulatory standards and control measures require TSDFs to safeguard their waste management units in a manner that will prevent hazardous waste releases that could threaten human health and the environment, including those caused by natural hazards. If waste management units are not properly maintained to withstand the effects of natural hazards or if control measures fail over time, the hazardous waste stored within these units can leak into the environment, contaminating groundwater and drinking water sources. See figure 1 for selected features of TSDF waste management units to prevent or mitigate hazardous waste releases.

¹³40 C.F.R. § 264.51. As part of contingency plans, TSDF operators plan for and respond to emergencies caused by natural hazards, such as hurricanes, according to officials from EPA, two authorized states, and two stakeholder groups. For example, hurricane emergency response procedures can include preparing flood control infrastructure, such as closing sea walls that protect the facility from storm surge, and taking other proactive measures, such as shipping storage drums inland, securing tanks that cannot be moved, and moving mobile water pumping equipment into place to pump out excess water from facility areas to prevent releases due to flooding, according to officials from one stakeholder group.

¹⁴40 C.F.R. § 264.54.

Figure 1: Selected Features of Waste Management Units Required by Resource Conservation and Recovery Act of 1976, as Amended (RCRA) Regulations to Prevent Hazardous Waste Releases



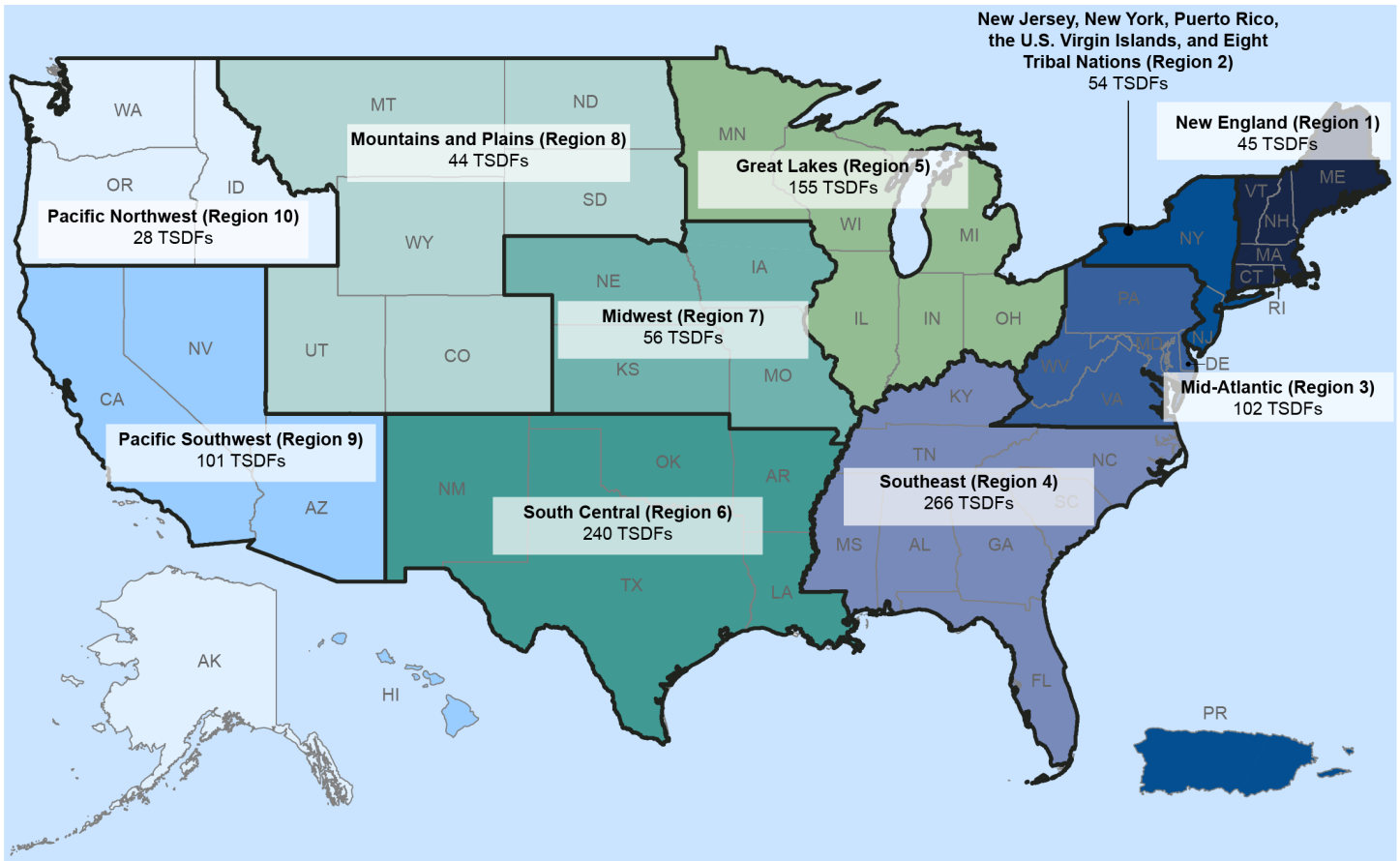
Sources: GAO analysis of Environmental Protection Agency guidance; GAO (icons). | GAO-25-106253

EPA and Authorized State Roles and Responsibilities

Under RCRA, EPA may authorize states to administer and enforce the RCRA hazardous waste program in their jurisdiction. To receive authorization, RCRA requires a state hazardous waste program to be at least equivalent to and consistent with the federal program. States may adopt the federal regulations verbatim or adopt state laws that are equivalent to or more stringent than the federal regulations. In addition, states enter into a memorandum of agreement with their EPA regional office that identifies each party's roles, responsibilities, and oversight powers. The memorandum of agreement also defines the coordination between the authorized state and EPA in implementing and enforcing the program. As of April 2024, EPA had authorized 48 states to administer their own RCRA hazardous waste programs.¹⁵ Figure 2 shows the number of TSDFs per EPA region.

¹⁵EPA has authorized 48 states, the District of Columbia, and Guam to implement the RCRA hazardous waste "base program," which EPA describes as hazardous waste requirements that were in effect as of July 1982. EPA directly implements the RCRA program in unauthorized states (Alaska and Iowa), other territories, and on tribal lands. To maintain their authorizations, states must continue to revise their approved state hazardous waste programs to adopt additional RCRA regulations promulgated by EPA. 40 C.F.R. § 271.21.

Figure 2: Number of Treatment, Storage, and Disposal Facilities per EPA Region, as of July 2023



Sources: GAO analysis of U.S. Environmental Protection Agency (EPA) data and Map Resources. | GAO-25-106253

Notes: To identify TSDF locations, we used EPA and state data from EPA's RCRAInfo database, as of July 2023. In this figure, TSDFs refer to operating facilities that are permitted to actively receive and handle hazardous waste and nonoperating facilities with at least one permitted post-closure unit with waste in place. The RCRAInfo database is EPA's comprehensive information system that provides access to data supporting the Resource Conservation and Recovery Act of 1976, as amended (RCRA). The data we used do not include any updates to TSDF information in the RCRAInfo system that were made after July 2023. As a result, we did not include TSDFs in our analysis if they did not have a relevant operating or nonoperating status code as of July 2023.

Under RCRA, authorized states oversee the issuance and maintenance of permits for TSDFs located within their jurisdiction. EPA regions and authorized states have issued RCRA permits for a variety of hazardous waste management units at more than 1,000 TSDFs. In addition, authorized states are required to conduct compliance evaluation inspections at TSDFs. Compliance evaluation inspections are conducted on-site and designed to assess compliance of the whole facility, including

process-based inspections that comprehensively evaluate the facility's waste management practices. These inspections evaluate a facility's compliance with all applicable RCRA regulations and permit requirements. Authorized states are expected to annually inspect at least 50 percent of nongovernment TSDFs to ensure inspections are performed no less often than once every 2 years, according to EPA's *RCRA Compliance Monitoring Strategy*.¹⁶ If EPA or the authorized state determines through an inspection that a TSDF is not in compliance with RCRA permit conditions or program requirements, they have authority to take enforcement action to bring the facility into compliance.

While authorized states administer their own RCRA programs, EPA maintains certain oversight authorities to ensure state compliance with RCRA regulations. All EPA regional offices and two EPA national program offices contribute to EPA's management and oversight of the RCRA program:

- **EPA Office of Land and Emergency Management (OLEM)** provides policy, guidance, direction, and oversight, and distributes funding for the implementation of the RCRA hazardous waste program. OLEM issues national regulations, defines solid and hazardous wastes, and imposes standards on entities that generate, transport, treat, store, or dispose of hazardous waste. OLEM also provides guidance to EPA regional offices on overseeing the RCRA program in authorized states.
- **EPA Office of Enforcement and Compliance Assurance (OECA)** issues enforcement and compliance guidance for all EPA programs, including RCRA, to regional offices and authorized states. For example, OECA issues the *RCRA Compliance Monitoring Strategy*, which is designed to provide strategic guidance for EPA regions and RCRA-authorized states and create national consistency in how EPA and states perform compliance monitoring. The strategy does so in part by providing a minimum set of expectations and a decision logic

¹⁶U.S. Environmental Protection Agency, *Compliance Monitoring Strategy for the Resource Conservation and Recovery Act* (Washington, D.C.: December 2021).

and structure for targeting inspections.¹⁷ OECA and EPA regional offices retain authority to enforce RCRA in authorized states, and EPA inspections are a key aspect of EPA's oversight of state programs and TSDFs, according to the strategy.

- **EPA regional offices** implement EPA programs, policy, and regulations in their respective regions, including for the RCRA program. Regional offices coordinate this work with authorized states and provide oversight of them to ensure effective implementation of RCRA. In addition, regions provide guidance and meet with authorized state managers to discuss grant funding, annual work planning, and inspection strategy development, among other things. EPA regions may conduct oversight inspections with or after state inspectors to monitor the quality of the states' TSDF inspections.¹⁸ As a component of oversight inspections, EPA regions may review state inspection reports to ensure that inspections are conducted properly, appropriate inspection procedures are followed, and sufficient evidence is collected. EPA regions enforce compliance in tribal lands and in states not authorized to implement the RCRA hazardous waste program. EPA regions also may review new and modified TSDF permit applications and draft permits, in coordination with authorized states.

According to EPA's *RCRA Compliance Monitoring Strategy* and EPA officials, formal oversight and evaluation of authorized states is generally performed in two ways—state work plans and the state review framework.

State work plans. State work plans are annual cooperative agreements between each authorized state and its EPA regional office. OLEM and OECA provide national program guidance and set minimum requirements

¹⁷Authorized states conduct most TSDF inspections, but EPA also conducts some TSDF inspections in authorized states to provide oversight of state programs, help build state program capacity to address emerging or complex issues, and assist states in meeting inspection coverage requirements. According to the strategy, EPA's compliance monitoring activities should complement and provide appropriate oversight of state activities. One way this is accomplished is by setting risk-based priorities for EPA compliance and enforcement resources and targeting EPA inspections of RCRA facilities, including TSDFs, based on legal requirements, policy goals, and the relative risk to human health and the environment.

¹⁸EPA regions conduct joint planning with authorized states to determine which inspections EPA will conduct and which inspections states will conduct. To use limited resources effectively, regions target their inspections of TSDFs based on state needs and to conduct oversight of state programs based on legal requirements, policy goals, and the relative risk to human health and the environment. Regions also have flexibility to target their inspections of TSDFs based on current compliance trends and environmental risks that are unique to their regions and may develop region-specific targeting methods.

for the state work plans. EPA regions use the guidance to negotiate and develop state work plan requirements with authorized states as part of their grant applications for federal funds to support their RCRA program activities.¹⁹ These plans detail the activities each state will perform in implementing the RCRA program to meet grant funding requirements and set expectations for what the state will accomplish over the following year. EPA reviews these work plans annually to ensure states meet their performance goals.

State review framework. This national framework, developed by EPA and states, provides a consistent process for evaluating the performance of and compliance with selected EPA programs, including RCRA, in authorized states.²⁰ Under the framework, each program is reviewed once every 5 years. EPA evaluates the performance of authorized programs for a 1-year period (typically the 1-year period prior to review) using a standard set of metrics in five areas: data, inspections, violations, enforcement, and penalties. For states' TSDF inspections, the framework evaluates the completeness and accuracy of inspection data, coverage, report quality, and timeliness. The state review framework evaluation verifies whether the states have submitted RCRA minimum data requirements, as shown in table 3.

¹⁹Authorized states can apply for Hazardous Waste Financial Assistance Grants to support state activities in administering the RCRA program. EPA uses a formula to allocate grant funding to each EPA region. The formula is based on several factors, including the number of RCRA facilities located in a region. According to OLEM's April 2020 memorandum, *Updated Hazardous Waste State Grant Distribution Methodology and FY 2021 Allocation*, each authorized state receives a minimum of \$400,000 to administer the RCRA program. Each EPA region may consider several factors when distributing additional funding to each state, including prior expenditure rates, program performance, or the relative need across the states within the region. State programs that are awarded funding are required to develop work plans.

²⁰The state review framework is used to evaluate state compliance monitoring and enforcement programs under the RCRA Subtitle C hazardous waste program, the Clean Air Act Title V stationary source program, and the Clean Water Act National Pollutant Discharge Elimination System program.

Table 3: Minimum Data Requirements for State Review Framework Evaluation Resource Conservation and Recovery Act of 1976, as Amended (RCRA) Data

Compliance evaluation performed
Compliance evaluation results (violation/compliance status)
Severity of violation
Notices of violation (informal enforcement)
Formal enforcement actions
Amount of assessed penalties

Source: U.S. Environmental Protection Agency, Office of Enforcement and Compliance Assurance, State Review Framework: Compliance and Enforcement Program Oversight Reviewer's Guide Round 5 (2024-2028) and EPA Enforcement and Compliance History Online Data Entry Requirements. | GAO-25-106253

Note: RCRAInfo—the federal database used to store and track RCRA information and activity—contains information on violations of federal RCRA requirements as well as violations of state hazardous waste management programs, which may be broader in scope or more stringent than the federal RCRA Subtitle C hazardous waste program.

Climate Adaptation Policies, Plans, and Strategies

Executive Order 14008, *Tackling the Climate Crisis at Home and Abroad*, states that it is the policy of the administration to deploy the full capacity of federal agencies to combat the climate crisis by implementing a government-wide approach that increases resilience to the impacts of climate change, among other things.²¹ The executive order also directs agencies to develop action plans with steps each agency can take to bolster adaptation and increase resilience to the impacts of climate change. It requires agencies to submit annual progress reports to the National Climate Task Force and the Federal Chief Sustainability Officer.²²

²¹Exec. Order 14008, 86 Fed. Reg. 7619, 7622 (Jan. 27, 2021).

²²The National Academies of Sciences, Engineering, and Medicine defines resilience as the ability to prepare and plan for, absorb, recover from, and more successfully adapt to adverse events. The National Academies of Sciences, Engineering, and Medicine, Committee on Increasing National Resilience to Hazards and Disasters and Committee on Science, Engineering, and Public Policy, *Disaster Resilience: A National Imperative* (Washington, D.C.: 2012). Two related sets of actions that can enhance resilience by reducing risk include hazard mitigation and climate change adaptation. Hazard mitigation refers to actions taken to reduce the loss of life and property by lessening the impacts of adverse events and applies to all hazards, including terrorism and natural hazards, such as health pandemics or weather-related disasters. Climate change adaptation or “climate adaptation” means taking action to prepare for and adjust to both the current and projected impacts of climate change, according to EPA. EPA also states that “climate resilience” can be generally defined as the capacity of a system to maintain function in the face of stresses imposed by climate change and to adapt the system to be better prepared for future climate impacts. In this report, we use the term “climate adaptation” for consistency and to encompass actions related to addressing climate risks to TSDFs, which could enhance their resilience to climate change.

In October 2021, EPA released its 2021 *Climate Adaptation Action Plan*.²³ The plan states that EPA will ensure its programs, policies, regulations, and compliance and enforcement efforts consider current and future impacts of climate change and how those impacts will disproportionately affect certain communities. In addition, the plan identifies five priority actions for the agency to implement and directs EPA national program offices and regional offices to develop implementation plans that will incorporate these priority actions over time (see table 4). In October 2022, all EPA national program offices and all 10 regional offices issued Climate Adaptation Implementation Plans to implement these priority actions.²⁴

Table 4: 2021 EPA *Climate Adaptation Action Plan* Priority Actions

Priority Action #1: Integrate climate adaptation into EPA programs, policies, rulemaking processes, and enforcement activities.

Priority Action #2: Consult and partner with states, Tribes, territories, local governments, environmental justice organizations, community groups, businesses, and other federal agencies to strengthen adaptive capacity and increase the resilience of the nation, with a particular focus on advancing environmental justice.

Priority Action #3: Implement measures to protect the agency's workforce, facilities, critical infrastructure, supply chains, and procurement processes from the risks posed by climate change.

Priority Action #4: Use measurement, data, and evidence to evaluate performance.

Priority Action #5: Identify and address climate adaptation science needs.

Source: U.S. Environmental Protection Agency's (EPA) Climate Adaptation Action Plan. | GAO-25-106253

In March 2022, EPA issued its strategic plan for fiscal years 2022 to 2026, which communicates the agency's priorities to address climate change.²⁵ The first goal of the strategic plan is to address the climate crisis. This goal includes an objective to accelerate resilience and adaptation to climate change impacts. In June 2024, EPA released its updated Climate Adaptation Plan for 2024-2027, which highlights EPA's planned actions from 2024 to 2027 to continue to make progress toward

²³U.S. Environmental Protection Agency, *Climate Adaptation Action Plan* (Washington, D.C.: October 2021).

²⁴To access EPA's 2021 Climate Adaptation Action Plan and EPA office and regional office 2022 Climate Adaptation Implementation Plans, see <https://www.epa.gov/climate-adaptation/climate-adaptation-plans>.

²⁵U.S. Environmental Protection Agency, *FY 2022-2026 EPA Strategic Plan* (Washington, D.C.: March 2022).

implementing its five priority action areas from the 2021 plan and strategic plan goals.²⁶

More than 700 TSDFs Are Located in Areas with Selected Natural Hazards That May Be Exacerbated by Climate Change

Available federal data on flooding, wildfire, storm surge, and sea level rise suggest that 743 of 1,091 TSDFs, or about 68 percent, are located in areas with one or more selected natural hazards that may be exacerbated by climate change.²⁷ Figure 3 shows the locations of these facilities. Climate change could exacerbate these natural hazards, such as by making them more frequent or intense. Climate change can also pose risks to TSDF waste management controls used to safeguard waste from being released, according to documents we reviewed and interviews with officials from EPA headquarters and regions, three authorized states, and four stakeholder groups.²⁸ For example, some TSDF landfills may face climate risks from sea level rise or increased flooding and are not designed and operated to account for how future natural hazard conditions may be different than historical data, according to an EPA report.²⁹

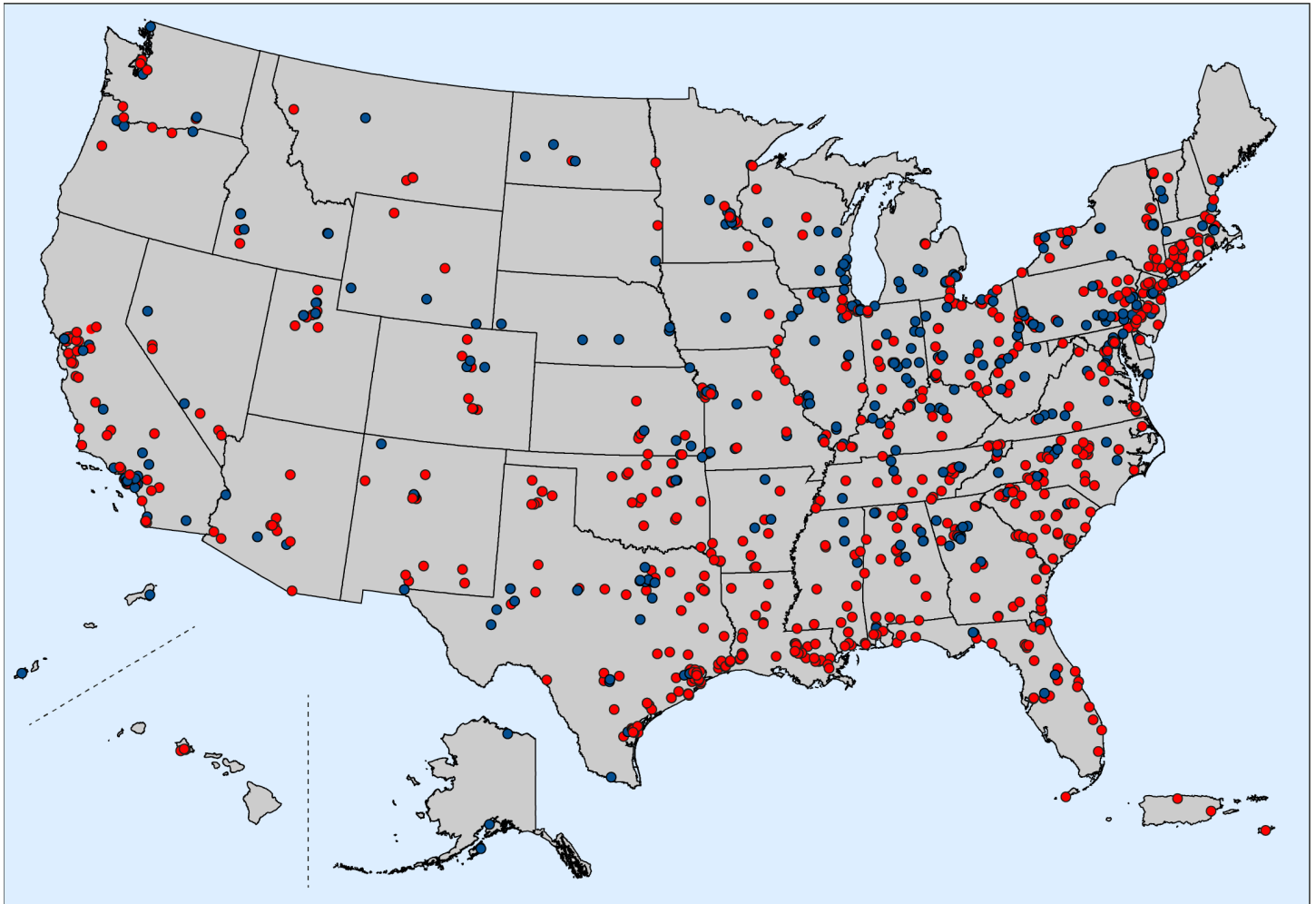
²⁶U.S. Environmental Protection Agency, *2024-2027 Climate Adaptation Plan* (Washington, D.C.: June 2024).

²⁷To identify TSDF locations, we used EPA and state data from EPA's RCRAInfo database, as of July 2023. When we refer to TSDFs in this analysis, we are referring to operating facilities that are permitted to actively receive and handle hazardous waste and nonoperating facilities with at least one permitted post-closure unit with waste in place. The data we used do not include any updates to TSDF information in the RCRAInfo system that were made after July 2023. As a result, we did not include TSDFs in our analysis if they did not have a relevant operating or nonoperating status code as of July 2023. The count of TSDFs includes facilities located in areas with at least one or more of the following natural hazards: 0.2 percent or higher annual chance of flooding or other flood hazards; storm surge from Category 4 or 5 hurricanes; moderate, high, or very high wildfire hazard potential; and regional sea level rise values for the 2100 Intermediate scenario from an interagency sea level rise technical report.

²⁸Documents we reviewed and officials from EPA headquarters and regions, four authorized states, and two stakeholder groups also cited examples of how TSDFs have already been damaged or adversely affected by these natural hazards. For example, officials from three state programs said that coastal or inland flooding had damaged TSDFs.

²⁹Further, the report stated that this could have serious consequences for the integrity of hazardous waste disposal facilities and protection of human health and the environment. The report recommended that TSDFs be evaluated with regard to both short-term and long-term hazards, such as climate change, and that additional research was needed on the long-term vulnerability of closed landfills. U.S. Environmental Protection Agency, *Post-Closure Performance of Liner Systems at RCRA Subtitle C Landfills*, EPA 600/R-17/205 (Cincinnati, OH: November 2017).

Figure 3: More than 700 Treatment, Storage, and Disposal Facilities Are Located in Areas That May Be Affected by Flooding, Wildfire, Storm Surge, or Sea Level Rise, as of July 2023



Treatment, storage, and disposal facilities (TSDFs)

- Located in an area with one or more of these natural hazards
- Located in an area without one or more of these natural hazards

Sources: GAO analysis of U.S. Environmental Protection Agency, Federal Emergency Management Agency, National Oceanic and Atmospheric Administration, and U.S. Forest Service data; U.S. Census Bureau (map). | GAO-25-106253

Notes: We analyzed actively operating TSDFs and nonoperating TSDFs that have waste in place. To determine if a TSDF is located in an area with exposure to flooding, wildfire, storm surge, or sea level rise, we identified overlap between an estimated radius around a facility's primary coordinates provided by the U.S. Environmental Protection Agency (EPA) and federal data for each of these selected hazards. Overlap indicates that a facility is located in an area that may be affected by one or more of these selected hazards. This analysis includes facilities that are located in areas with at least one or more of the following natural hazards: 0.2 percent or higher annual chance of flooding or other flood hazards; storm surge from Category 4 or 5 hurricanes; moderate, high, or very high wildfire hazard potential; and regional sea level rise values for the 2100 intermediate scenario from an interagency sea level rise technical report. This analysis is based on the most recently available data

from EPA, the Federal Emergency Management Agency, the National Oceanic and Atmospheric Administration, and the U.S. Forest Service, as of 2023. We approximated the boundaries of TSDFs using a radius around each facility's primary geographic coordinates based on acreage data for the facility that EPA provided. Facility boundaries based on these data do not account for where hazardous waste is specifically handled at facilities and we did not analyze site-specific information for these TSDFs, such as steps that specific facilities have taken to manage potential risks from selected natural hazards. See appendix I for more details on our data analysis.

Our analysis, however, may not fully account for the number of TSDFs that may be affected by these hazards for several reasons. First, data are not available for some areas. For example, FEMA has not mapped some areas of the country to determine exposure to flooding, and FEMA maps do not account for pluvial flooding (which occurs when rainfall creates a flood independent of an existing body of water). Additionally, sea level rise data are not available for Alaska, and some storm surge data are not available for areas of California. Second, we approximated the boundaries of TSDFs using a radius around each facility's primary geographic coordinates based on acreage data for the facility, which may not precisely reflect its area or account for where hazardous waste is specifically handled at the facility.

Third, we did not analyze site-specific information for these TSDFs that may mitigate risks from natural hazards, such as steps specific facilities have taken to manage potential risks from selected natural hazards.³⁰ Our analysis is a screening-level analysis that evaluates whether TSDFs have exposure to climate-related hazards that could lead to facility risks, but it is not intended to provide estimates of actual risk for specific facilities. To evaluate the risk that a specific facility may face from existing natural hazard conditions or future conditions due to climate change (such as if climate change leads to an increase in the intensity or frequency of a natural hazard), site-specific information would need to be evaluated in

³⁰For example, we previously noted that TSDFs may put in place control measures or have emergency response procedures to address risks to human health and the environment from certain natural hazards. For example, RCRA regulations require TSDFs located within a 100-year floodplain to be designed to withstand washout from a 100-year flood event. Our mapping analysis did not evaluate the extent to which TSDFs located in areas with exposure to the selected natural hazards have put in place resilience measures to mitigate risk from these hazards or whether those measures would be sufficient to address either (1) risks from current natural hazard conditions, or (2) risks from natural hazard conditions that may be exacerbated in the future due to climate change (such as sea level rise or if climate change leads to an increase in the intensity or frequency of a selected natural hazard, such as flooding). However, our mapping analysis shows that TSDFs located in these areas have exposure to the selected natural hazards and, according to the National Climate Assessment, those hazard conditions may change over time. As a result, any facility or unit control measures that are designed to mitigate risk from current natural hazard conditions may not be sufficient to address future climate risks.

conjunction with exposure information. Such site-specific analyses would be necessary to determine whether there is a risk to human health and the environment at TSDFs as a result of these hazards.

Fourth, while our analysis identifies facilities that are located in areas with natural hazards that may be exacerbated by climate change, our analysis does not reflect when, how, or at what rate conditions in these areas may change as the climate changes. The federal datasets we used in our analysis on flooding, wildfire, and storm surge are based on current or past conditions. Further, the National Climate Assessment has reported that climate change may exacerbate flooding, wildfire, storm surge, and sea level rise differently in certain regions of the U.S. According to NOAA officials, the regional average values we used in our analysis for sea level rise are more accurate than the national average; however, these officials said there may still be local variations of sea level rise of about 1 foot within each region.

Moreover, other natural hazards that may be exacerbated by climate change may also impact TSDFs, based on our review of the National Climate Assessment, EPA documents, previous GAO reports, and interviews with officials from EPA, authorized states, and stakeholder groups. These natural hazards include potential increases in saltwater intrusion (the movement of saline water into freshwater aquifers), permafrost melt, drought, hurricane winds, and extreme heat or cold temperatures. For example, more frequent or intense extreme heat conditions could lead to power outages that affect TSDFs, contribute to increased fire hazards, or cause high pressures in closed hazardous waste tanks that could lead to a release, according to documents we reviewed and interviews with officials from EPA, authorized states, and stakeholder groups. Increased drought conditions could increase wildfire risk or increase erosion of soil from landfill covers that protect against waste releases. Strong winds from hurricanes could damage facilities or units, such as hazardous waste tanks.

We did not analyze these other potential climate-related hazards as part of our mapping analysis because we did not identify relevant federal datasets for these hazards that fit the criteria for our analysis, such as being national in scope. See appendix II for more information about available federal data on the selected natural hazards that we analyzed for this report.

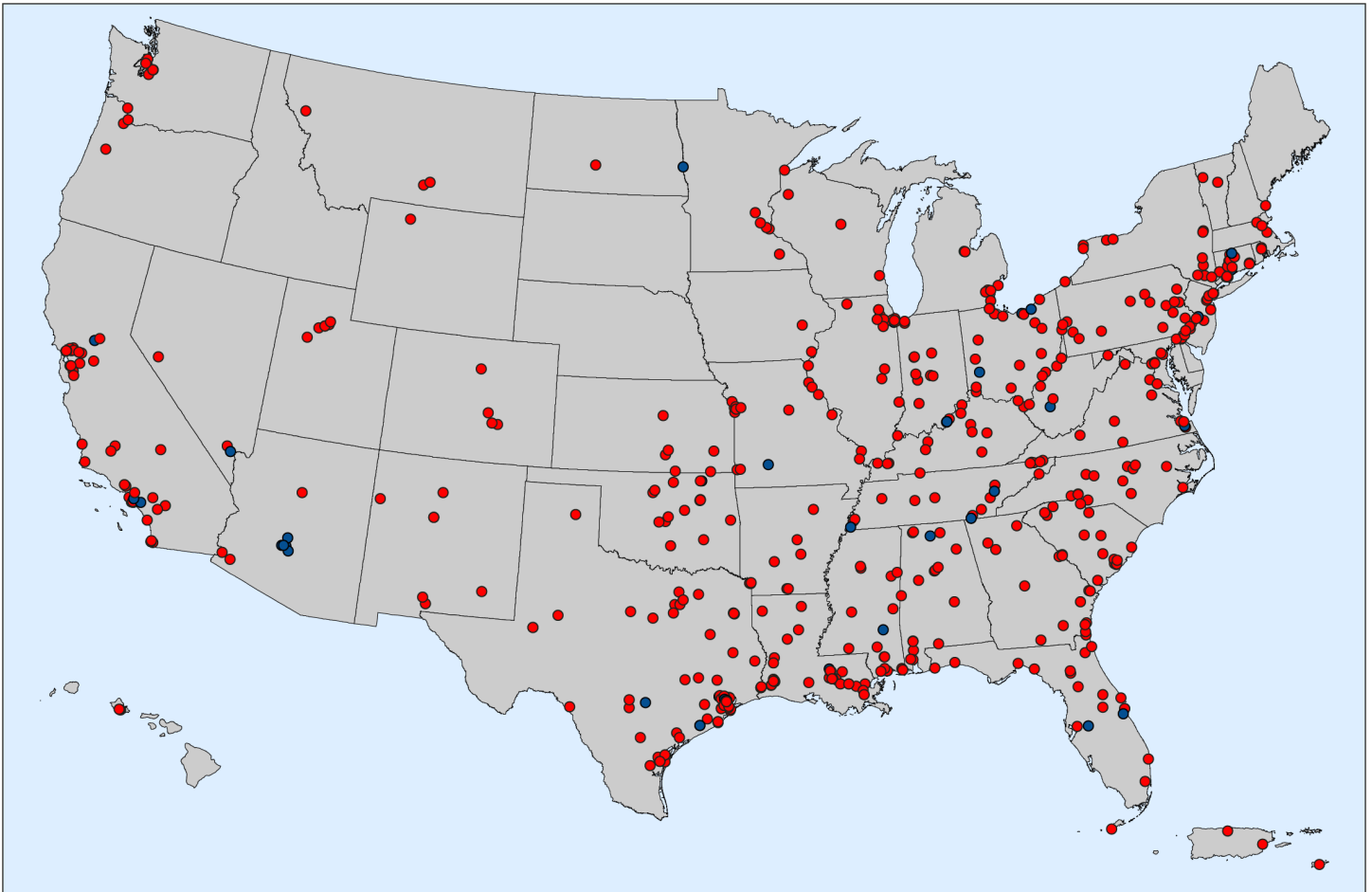
More Than 500 TSDFs Are Located in Areas That May Be Affected by Flooding

We identified 550 TSDFs—approximately 50 percent—that are located in areas that FEMA identified as having either high flood hazard or moderate flood hazard, as of 2023.³¹ Of the 550 TSDFs that may be affected by flooding, 504 are located in areas with high flood hazard or a combination of high and moderate flood hazard, and 46 are located in areas with moderate flood hazard only (see fig. 4).³² See appendix III for regional maps for flood and other hazards.

³¹We analyzed FEMA data from 2023. For our analysis, high flood hazard corresponds to areas in 100-year floodplains (areas with a 1 percent or higher annual chance of flooding), moderate flood hazard corresponds to areas in 500-year floodplains (areas with a 0.2 percent or higher annual chance of flooding), and “no/low” corresponds to areas with minimal, unknown, or other flood hazards, including areas with reduced risk because of levees as well as areas with flood hazard based on the future implementation of land-use plans.

³²Specifically, we identified 504 facilities that are located in areas that FEMA identified as having high flood hazard. Of these facilities, 319 of them are also located in areas that have moderate flood hazard. Given the size of these facilities, it is possible that part of a facility is located in an area of high hazard and another part of the facility is in an area with a moderate flood hazard.

Figure 4: More Than 500 TSDFs Are Located in Areas That May Be Affected by Flooding, as of July 2023



Treatment, storage, and disposal facilities (TSDFs)

- Located in an area with a 1 percent or higher annual chance of flooding
- Located in an area with a 0.2 percent or higher annual chance of flooding

Sources: GAO analysis of U.S. Environmental Protection Agency and Federal Emergency Management Agency data; U.S. Census Bureau (map). | GAO-25-106253

Notes: We analyzed actively operating TSDFs and nonoperating TSDFs that have waste in place. To determine if a TSDF is located in an area with exposure to moderate or high flood hazard, we identified overlap between an estimated radius around a facility's primary coordinates provided by the U.S. Environmental Protection Agency (EPA) and flood hazard data provided by the Federal Emergency Management Agency (FEMA). Overlap indicates that a facility is located in an area that may be affected by the selected hazard. To show exposure to flooding, we use FEMA's National Flood Hazard Layer, which estimates several levels of flood hazard, including high flood hazard (areas with a 1 percent or higher annual chance of flooding), and moderate flood hazard (areas with a 0.2 percent or higher annual chance of flooding). We approximated the boundaries of TSDFs using a radius around each facility's primary geographic coordinates based on acreage data for the facility that EPA provided. Facility boundaries based on these data do not account for where hazardous waste is specifically handled at facilities and we did not analyze site-specific information for these TSDFs, such as steps that specific facilities have taken to manage potential risks from selected natural hazards. See appendix I for more details on our data analysis.

According to the National Climate Assessment, heavy rainfall is increasing in intensity and frequency across the United States and is expected to continue to increase, which may lead to an increase in flooding in the future. Flooding, including from extreme precipitation events, can affect TSDFs and pose risks to engineering or other waste management controls used to safeguard waste from being released.³³ For example, TSDF landfills have been damaged from storm events that surpassed their design standards for withstanding extreme precipitation, according to EPA regional officials and documents we reviewed. Additionally, secondary containment systems that are designed to manage rainfall and prevent releases from certain waste management units, such as tanks, or other TSDF stormwater management systems could be at risk of failure due to more frequent or intense precipitation events, according to documents we reviewed and interviews with state officials and a stakeholder group.

Nearly 400 TSDFs Are Located in Areas That May Be Affected by Wildfire

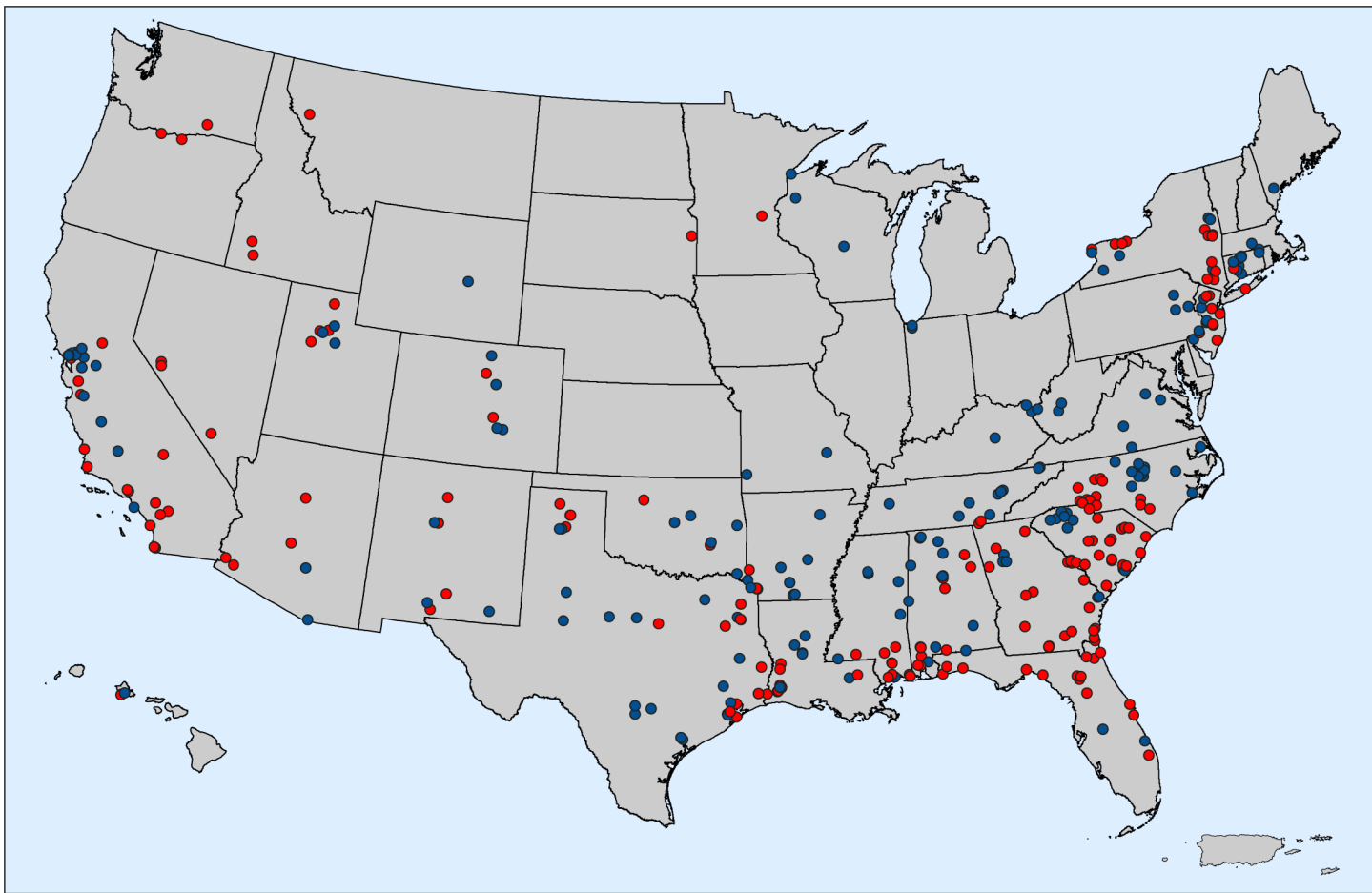
We identified 370 TSDFs—approximately 34 percent—that are located in areas that have very high, high, or moderate wildfire hazard potential, based on a U.S. Forest Service model as of 2023.³⁴ Of these facilities, 188 are located in areas with high or very high wildfire hazard potential, meaning they are more likely to burn with a higher intensity. An additional 182 facilities are located in areas with moderate wildfire hazard potential, which means they are less likely to experience high-intensity wildfire but could still be at significant risk of a wildfire occurring, according to U.S. Forest Service officials (see fig. 5). According to the National Climate Assessment, incidents of large forest fires are projected to increase in

³³Site-specific factors can also affect the overall level of risk to TSDFs from flooding, according to an EPA handbook on TSDF and other waste management site vulnerabilities to extreme weather events. For example, TSDFs that handle reactive wastes may face higher risks from flooding because these wastes could react with floodwater, which could lead to release of toxic gases or an explosion under certain conditions.

³⁴The U.S. Forest Service maps wildfire hazard potential based on landscape conditions and other observations. These maps include an index of wildfire hazard potential for the United States that is based on, among other factors, annual burn probabilities and the potential intensity of large fires. The wildfire potential index is a relative ranking. The U.S. Forest Service categorizes the wildfire hazard potential index into five classes: very low, low, moderate, high, and very high. The U.S. Forest Service designates areas with wildfire hazard potential index from the 67th to the 85th percentile as “moderate,” areas with wildfire hazard potential index from the 85th to the 95th percentile as “high,” and areas above the 95th percentile as “very high.” For this analysis, we combined the high and very high wildfire hazard categories; we did not identify the number of facilities in each of these categories separately.

some parts of the United States, such as the southeastern and western United States and Alaska.

Figure 5: Nearly 400 TSDFs Are Located in Areas That May Be Affected by Wildfire, as of July 2023



Treatment, storage, and disposal facilities (TSDFs)

- Located in an area with high or very high wildfire hazard potential
- Located in an area with medium wildfire hazard potential

Sources: GAO analysis of U.S. Environmental Protection Agency and U.S. Forest Service data; U.S. Census Bureau (map). | GAO-25-106253

Notes: We analyzed actively operating TSDFs and nonoperating TSDFs that have waste in place. To determine if a TSDF is located in an area with wildfire hazard potential, we identified overlap between an estimated radius around facility coordinates provided by the U.S. Environmental Protection Agency (EPA) and wildfire hazard potential data. Overlap indicates that a facility is located in an area that may be affected by the selected hazard. We used the U.S. Forest Service Wildfire Hazard Potential Map to show exposure to wildfire hazard potential. The map categorizes wildfire hazard potential into five classes: very low, low, moderate, high, and very high. We analyzed the moderate, high, and very high wildfire potential layers and combined results for the high/very high layers. We approximated the boundaries of TSDFs using a radius around each facility's primary geographic coordinates based on acreage data for the facility that EPA provided. Facility boundaries based on

these data do not account for where hazardous waste is specifically handled at facilities and we did not analyze site-specific information for these TSDFs, such as steps that specific facilities have taken to manage potential risks from selected natural hazards. See appendix I for more details on our data analysis.

Increasingly frequent or intense wildfire could increase the risk of contaminant releases from TSDFs, according to documents we reviewed and interviews with officials from EPA, one state program, and two stakeholder groups. Wildfire poses several risks to TSDFs. These include increasing the potential for on-site fires that could damage facility infrastructure or engineering controls used to safeguard waste, such as damage to landfills; overheating equipment; or causing high pressure in hazardous waste tanks. Some facilities may also handle ignitable wastes on-site, which could lead to explosions due to wildfire heat or flames. Further, wildfire could also disrupt electricity grids, causing a loss of power that could disrupt TSDF operations.

Nearly 200 TSDFs Are Located in Areas That May Be Inundated by Storm Surge

We identified 185 TSDFs—about 17 percent—located in coastal areas that may be inundated by storm surge corresponding to Category 4 or 5 hurricanes, the highest categories, based on NOAA’s storm surge model that uses data as of November 2023.³⁵ One-hundred seventeen TSDFs are located in areas that may be inundated by storm surge corresponding to a Category 1 hurricane (see fig. 6).

³⁵Our analysis of NOAA storm surge data is based on a model that estimates the maximum extent of storm surge at high tide. NOAA provides estimates of hurricane storm surge using a model called Sea, Lake, and Overland Surges from Hurricanes. This model includes hypothetical hurricanes under different storm conditions, such as landfall location, trajectory, and forward speed. Hurricanes reaching Category 3 and higher are considered major hurricanes because of the potential for significant loss of life and damage. In our analysis, we used the maximum extent of storm surge from Category 1 hurricanes (the lowest possible category) and Category 5 hurricanes (the highest possible category) to show a range of potential climate change effects. Category 4 hurricanes carry sustained winds of 130 to 156 miles per hour. Category 5 hurricanes have sustained winds exceeding 156 miles per hour.

Figure 6: Nearly 200 TSDFs Are Located in Areas That May Be Inundated by Storm Surge, as of July 2023



Treatment, storage, and disposal facilities (TSDFs)

- Located in an area that may be inundated by a Category 1 hurricane
- Located in an area that may be inundated by a highest Category (4 or 5) hurricane

Sources: GAO analysis of U.S. Environmental Protection Agency and National Oceanic and Atmospheric Administration data; U.S. Census Bureau (map). | GAO-25-106253

Notes: We analyzed actively operating TSDFs and nonoperating TSDFs that have waste in place. To determine if a TSDF is located in an area with exposure to hurricane storm surge, we identified overlap between an estimated radius around a facility's primary coordinates provided by the U.S. Environmental Protection Agency (EPA) and storm surge data. Overlap indicates that a facility is in an area that may be affected by the selected hazard. To show exposure to hurricane storm surge, we use the National Oceanic and Atmospheric Administration's Sea, Lake, and Overland Surges from Hurricanes Model, which estimates storm surge heights resulting from the various categories of hurricanes. We approximated the boundaries of TSDFs using a radius around each facility's primary geographic coordinates based on acreage data for the facility that EPA provided. Facility boundaries based on these data do not account for where hazardous waste is specifically handled at facilities, and we did not analyze site-specific information for these TSDFs, such as steps that specific facilities have taken to manage potential risks from selected natural hazards. See appendix I for more details on our data analysis.

Treatment, Storage, and Disposal Facility (TSDf) Emergency Response Measures to Prevent Hazardous Waste Releases from Hurricanes

To secure a permit to handle hazardous waste, TSDFs must have a contingency plan designed to minimize hazards to human health or the environment from fires, explosions, or any unplanned sudden or nonsudden release of hazardous waste.

As part of contingency plans, TSDf operators plan for and respond to emergencies caused by natural hazards, such as hurricanes, according to officials from two authorized states and a TSDf company we spoke with that operates two facilities along the Gulf Coast. For example, the TSDf officials that operate these two coastal facilities said they monitor hurricane predictions and begin implementing emergency response procedures several days in advance of a hurricane making landfall.

These procedures include preparing flood control infrastructure, such as closing sea walls that protect the facility from storm surge, and taking other proactive measures, such as shipping storage drums inland to higher ground, securing tanks that cannot be moved, and moving mobile water pumping equipment into place. As a hurricane arrives, TSDf operations shut down and a small number of staff stay at the facility to manage emergency response actions, such as monitoring storm water management systems and pumping out excess water from facility areas to prevent hazardous waste releases due to flooding.

Source: Interviews with authorized state officials and stakeholders, including a TSDf company that manages coastal facilities affected by hurricanes. | GAO-25-106253

According to the National Climate Assessment, climate change is expected to heighten hurricane storm surge, wind speeds, and rainfall rates.³⁶ Additionally, hurricanes are intensifying more rapidly and decaying more slowly due to climate change, leading to stronger storms that will extend farther inland and leave less time for preparing emergency measures. Storm surge from hurricanes can cause coastal flooding that may damage TSDFs and increase the risk that facility infrastructure or waste management controls will fail and lead to a release, according to EPA and documents we reviewed.³⁷ For example, hurricane storm surge could compromise the integrity of hazardous waste drums or flood indoor areas used to store waste piles, according to documents we reviewed. Further, more extreme coastal flooding could prevent emergency response personnel, equipment, and supplies from reaching a facility, according to documents we reviewed and interviews with a stakeholder group.

³⁶Climate change leads to warmer ocean surface temperatures. This, in turn, makes hurricanes more powerful because the temperature increase causes more water to evaporate from the ocean. Evaporation adds moisture to the air, and warmer air temperatures can hold more water vapor. The increased moisture in the air leads to more intense rainfall. In a hurricane, spiraling winds draw moist air toward the center, fueling the thunderstorms that surround it.

³⁷U.S. Environmental Protection Agency, "Effects of Coastal Sea Level Rise on US Hazardous Waste" (Washington, D.C.: May 18, 2023), accessed April 12, 2024, <https://rcrapublic.epa.gov/rcra-public-web/action/posts/5>.

Over 100 TSDFs Are Located in Areas That May Be Affected by Sea Level Rise

We identified 103 TSDFs—about 9 percent—located in coastal areas that may be inundated by sea level rise, according to our analysis of sea level rise projections from an interagency report covering sea level rise scenarios.³⁸ Of the 103 TSDFs that may be affected by sea level rise, 89 are located in areas that could be inundated by sea level rise by 2050 under the Intermediate sea level scenario. Two additional TSDFs may be affected by 2100 under the Low sea level scenario, and 12 additional TSDFs may be affected by 2100 under the Intermediate sea level scenario. Twenty-one additional TSDFs are located in areas that may be inundated by 2100 under the High sea level scenario (see fig. 7).³⁹ We analyzed the number of facilities in areas that may be affected by several different sea level rise scenarios because, according to the interagency report, relative sea levels along the U.S. coastline are projected to rise by

³⁸To analyze potential exposure to sea level rise, we used federal data for the Intermediate sea level rise scenario for the year 2050 and three sea level rise scenarios—Low, Intermediate, and High—for the year 2100. These federal data on sea level rise comes from an interagency report developed by six federal agencies (see app. II for more details on the report). We used three scenarios for 2100 because of greater uncertainty for scenarios further in the future. These scenarios provide information on a range of potential outcomes that affect whether TSDFs will be exposed to this hazard. As a result, these scenarios are subject to uncertainty. NOAA officials told us that, currently, the Intermediate scenarios for 2050 and 2100 are more likely to occur than either the Low or High scenarios, based on observational data and modeling projections. We used the Intermediate scenario for 2100 to identify the number of TSDFs located in areas that may be inundated by sea level rise but also report the number of TSDFs that would be affected under a High scenario for 2100. The two primary limitations the interagency report discusses for the sea level rise estimates we use include process uncertainty and emission uncertainty. Process uncertainty refers to uncertainty about the impact of greenhouse gas emissions on ice sheet loss, ocean expansion, and local ocean dynamics. Emission uncertainty refers to the uncertain amount of greenhouse gas emissions that will enter the atmosphere, trap heat, and affect temperature and sea level rise.

³⁹Our analysis used NOAA map layers with a baseline of zero-foot sea level rise, which is equivalent to the water level at typical high tide for each location, according to NOAA officials. Specifically, the typical high tide for these locations is equivalent to the average of the highest of the two daily high tides, which is calculated based upon NOAA tide gauge observational data from 1983 to 2001 and a NOAA model. NOAA officials told us that the intermediate sea level rise scenario for 2050 was a most likely scenario to occur, based on observational data and modeling projections. According to the interagency report and the National Climate Assessment, sea level is expected to rise on average as much over the next 30 years as it has over the last 100 years. In response, coastal flooding will occur five to 10 times more often by 2050 than occurred in 2020 in most locations, according to the National Climate Assessment.

about 2 feet to 7 feet by 2100, depending on the scenario.⁴⁰ Sea level rise is expected to increase coastal flooding by contributing to higher tides and storm surges that reach further inland.

⁴⁰By 2050, relative sea levels along the U.S. coastline are projected to rise by about 1 foot in the contiguous United States, according to the interagency report and NOAA officials. W. V. Sweet, B. D. Hamlington, R. E. Kopp, C. P. Weaver, P. L. Barnard, D. Bekaert, W. Brooks, M. Craghan, G. Dusek, T. Frederikse, G. Garner, A. S. Genz, J. P. Krasting, E. Larour, D. Marcy, J. J. Marra, J. Obeysekera, M. Osler, M. Pendleton, D. Roman, L. Schmied, W. Veatch, K. D. White, and C. Zuzak, *2022 Global and Regional Sea Level Rise Scenarios for the United States: Updated Mean Projections and Extreme Water Level Probabilities Along U.S. Coastlines*, NOAA Technical Report NOS 01 (Silver Spring, MD: February 2022).

Figure 7: Over 100 TSDFs Are Located in Areas That May Be Affected by Sea Level Rise, as of July 2023



Treatment, storage, and disposal facilities (TSDFs)

- Located in an area inundated by sea level rise by 2100 under a Low sea level scenario
- Located in an area inundated by sea level rise by 2100 under an Intermediate sea level scenario
- Located in an area inundated by sea level rise by 2100 under a High sea level scenario

Sources: GAO analysis of U.S. Environmental Protection Agency and National Oceanic and Atmospheric Administration data; U.S. Census Bureau (map). | GAO-25-106253

Notes: We analyzed actively operating TSDFs and nonoperating TSDFs that have waste in place. To determine if a TSDF is located in an area with exposure to sea level rise, we identified overlap between an estimated radius around a facility's primary coordinates provided by the U.S. Environmental Protection Agency (EPA) and sea level rise projections from an interagency report covering sea level rise scenarios. Overlap indicates that a facility is located in an area that may be affected by the selected hazard. To show potential exposure to sea level rise, we used federal data for three sea level rise scenarios—Low, Intermediate, and High—for the year 2100. We used three scenarios for 2100 because of greater uncertainty for scenarios further in the future. These scenarios provide information on a range of potential outcomes that affect whether TSDFs will be exposed to this hazard. As a result, these scenarios are subject to uncertainty. The two primary limitations the report discusses for the sea level rise estimates we use include process uncertainty and emission uncertainty. Process uncertainty refers to uncertainty about the impact of greenhouse gas emissions on ice sheet loss, ocean expansion, and local ocean dynamics. Emission uncertainty refers to the

uncertain amount of greenhouse gas emissions that will enter the atmosphere, trap heat, and affect temperature and sea level rise. We approximated the boundaries of TSDFs using a radius around each facility's primary geographic coordinates based on acreage data for the facility that EPA provided. Facility boundaries based on these data do not account for where hazardous waste is specifically handled at facilities, and we did not analyze site-specific information for these TSDFs, such as steps that specific facilities have taken to manage potential risks from selected natural hazards. See appendix I for more details on our data analysis.

Storm surge coupled with sea level rise can lead to increased risk of hazardous waste releases from TSDFs due to flooding, according to documents we reviewed and interviews with officials from EPA, one state program, and two stakeholder groups. Additionally, sea level rise could lead to saltwater intrusion and changes to nearby groundwater levels, which threaten land-based units and post-closure unit hazardous waste control measures, according to officials from two EPA regions, one stakeholder group, and one authorized state.

EPA Has Efforts Underway to Manage Climate Risks to TSDFs, but Has Not Fully Clarified Its Authorities or Requirements or Assessed Risk Management Efforts

As part of meeting its strategic goal to tackle the climate crisis, EPA has started taking actions to incorporate climate adaptation into the RCRA hazardous waste program. For example, EPA has released climate adaptation implementation plans that identify the need to manage climate risks to TSDFs in permitting and compliance and enforcement efforts and issued guidance that directs EPA regions and authorized states to manage these risks. However, while EPA believes it has broad authority under RCRA to manage climate risks, EPA officials said regions and states needed more clarity and guidance on their authority and requirements to be able to do so. EPA has taken steps to clarify these authorities and requirements for RCRA permitting by issuing guidance that identifies broad authorities that regions and authorized states can use to develop permit requirements that require TSDFs to manage these risks.

However, some states and TSDFs may not implement this guidance unless EPA amends regulations to explicitly clarify authorities and requirements. EPA officials said that another way the agency could address this concern would be to develop and provide training and technical assistance to EPA regions and states to help them implement the guidance, but EPA has not developed and provided such training to them. Additionally, EPA officials said that, as part of upcoming rulemaking, they are considering seeking feedback on potential revisions to regulations to further clarify requirements and authorities for managing climate risks, but had not determined whether they would revise the regulations.

In addition, EPA has not assessed the extent to which authorized states and TSDFs have managed climate risks, nor has it developed metrics to do so.

EPA Has Set Broad Priorities to Manage Climate Risks Across the Agency and Taken Some Actions to Implement Them in the RCRA Hazardous Waste Program

As discussed above, in October 2021, EPA released its updated *Climate Adaptation Action Plan* with the goal of integrating climate adaptation into EPA programs, policies, rulemaking processes, and compliance and enforcement efforts. As required by the plan, all EPA national program and regional offices issued office-specific implementation plans, which outline each office's plan to incorporate climate adaptation into their programs. As part of these efforts, in October 2022, EPA's Office of Land and Emergency Management (OLEM) and Office of Enforcement and Compliance Assurance (OECA) issued implementation plans that include incorporating climate adaptation into their programs, including the RCRA hazardous waste program for TSDFs.⁴¹ In June 2024, EPA released its updated *Climate Adaptation Plan for 2024-2027*. The plan highlights EPA's planned actions for 2024 to 2027 to continue to make progress toward implementing its five priority action areas from the 2021 plan and strategic plan goals.⁴²

OLEM and OECA have begun taking actions to incorporate climate adaptation into RCRA hazardous waste permitting (OLEM) and compliance and enforcement efforts (OECA). In addition, OLEM is collaborating with EPA's Office of Research and Development to develop climate vulnerability screening tools for TSDFs. Table 5 shows actions that OLEM, OECA, and the Office of Research and Development have taken to incorporate climate adaptation into the RCRA program for TSDFs to prevent the release of hazardous waste.

⁴¹U.S. Environmental Protection Agency, Office of Enforcement and Compliance Assurance, *Climate Change Adaptation Implementation Plan* (Washington, D.C.: October 2022); U.S. Environmental Protection Agency, Office of Land and Emergency Management, *2022-2023 Climate Adaptation Implementation Plan* (Washington, D.C.: October 2022).

⁴²U.S. Environmental Protection Agency, *2024-2027 Climate Adaptation Plan*.

Table 5: EPA Actions Taken to Incorporate Climate Adaptation into the Resource Conservation and Recovery Act Hazardous Waste Program

Office of Land and Emergency Management (OLEM)	<ul style="list-style-type: none">• August 2022: OLEM issued national program guidance for fiscal years 2023 and 2024 that requires authorized states to (1) discuss in their work plans how they will address current EPA priorities, (2) describe how the states' work plan tasks link to EPA's Strategic Plan, and (3) include appropriate metric requirements in the grant criteria and workplan. This guidance encourages—but does not require—EPA regions and states to support and implement efforts to consider climate change when issuing permits to treatment, storage, and disposal facilities (TSDFs).• May 2023: OLEM launched an interactive map of sea level rise around TSDFs along the U.S. coastline. According to EPA, EPA developed this climate screening tool to help states, regions, and TSDFs prepare for the impacts of climate change, independently assess their sea level rise vulnerabilities, and help inform actions they can take to become more resilient to climate change.• February 2024: To ensure that RCRA permits for TSDFs are adequately protective in a changing climate, OLEM issued guidance to all EPA regions that will require regions to include a term and condition on climate adaptation in RCRA grants issued to authorized states. The guidance notes that EPA regions may alter the wording of the term and condition slightly in negotiation with states, as long as the purpose of the term and condition is met. The term and condition language will require that permit decisions consider the potential for threats such as sea level rise, flooding, and extreme weather events, among other requirements. According to OLEM officials, the term and condition will be implemented in authorized state RCRA grant agreements from 2024 through 2027, given that authorized states will be applying for new grant agreements during this time frame.• June 2024: OLEM issued a memorandum to EPA regional division directors: "Implementing Climate Resilience in Hazardous Waste Permitting Under the Resource Conservation and Recovery Act (RCRA)." The memorandum identifies selected RCRA regulatory authorities that EPA regions and authorized states could use to support additional permit requirements for TSDFs to manage climate risks. It also recommends site-specific screening analyses and more detailed vulnerability assessments as part of the TSDF permitting process to determine if adaptation measures are necessary to ensure TSDFs are resilient to climate risks. EPA states that it plans to release further policy and guidance regarding how permits can incorporate climate change adaptation considerations through a rulemaking currently in development. In addition, the memorandum notes that climate vulnerability screening tools and assessment methodologies are currently under development. OLEM officials said they plan to finalize these tools and assessment methodologies in January 2025.• July 2024: OLEM issued national program guidance for fiscal years 2025 and 2026. The guidance directs EPA headquarters to provide technical or policy support for regions and authorized states to do necessary climate adaptation work. It also directs headquarters to provide a tool for climate change hazard screening at the TSDF level using updated climate hazard data. The guidance also directs EPA regions and authorized states to ensure that RCRA permits issued to TSDFs are protective of human health and the environment for the duration of the permit, including under changing climate conditions.• Ongoing: OLEM is updating a guide to help EPA region and authorized state permit writers draft and review RCRA permit conditions that incorporate consideration of climate risks into TSDF permits. This guide—known as a model permit—is based on example language from actual permits and is expected to reduce the time to issue permits to TSDFs, promote national consistency, and result in clearer, more readily implementable and enforceable permit conditions. According to OLEM officials, sections of the model permit will address climate risks to TSDFs and will be made available to EPA regions, states, and TSDFs as they are completed. As of August 2024, OLEM had completed the permit cover page, which does not include information on climate risks.• Ongoing: OLEM is in the process of updating RCRA regulations to incorporate EPA policy changes and technical corrections and is considering revising the regulations to clarify requirements and authorities related to managing climate risks to TSDFs as part of this effort, according to OLEM officials. EPA expects to publish revisions for public comment in 2025.
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Office of Enforcement and Compliance Assurance (OECA)

- **August 2022:** OECA issued national program guidance for fiscal years 2023 and 2024. The guidance states that OECA intends to use RCRA authorities to proactively investigate and prevent threatened hazardous releases in climate-sensitive communities, which may include hazardous waste releases from TSDFs.
- **September 2023:** OECA issued a memorandum on EPA’s climate compliance and enforcement strategy. This memorandum requires all EPA compliance and enforcement offices, including those that oversee and enforce the RCRA hazardous waste program, to address climate change in every matter within their jurisdiction, as appropriate. For example, the memorandum states that enforcement staff should ensure consistent consideration of climate change in the case development process and incorporate relevant climate adaptation considerations in administrative, civil, and criminal enforcement actions, which could apply to enforcement actions against TSDFs.
- **March 2023:** OECA released updated guidance for state review framework evaluations conducted in fiscal years 2024 through 2028. The state review framework provides a consistent process for evaluating the performance of and compliance with selected EPA programs, including RCRA, in authorized states. The guidance encourages EPA regions to incorporate climate change as an optional state review framework evaluation criteria associated with inspections, noncompliance, and enforcement actions for states that have specifically incorporated climate change into their state’s compliance monitoring strategy.
- **July 2024:** OECA issued national program guidance for fiscal years 2025 and 2026. The guidance states that OECA and EPA regions will continue to use RCRA authorities to proactively investigate and prevent hazardous waste releases in climate-sensitive communities, among other directives.

Office of Research and Development

- **2023:** The Office of Research and Development established the Integrated Climate Sciences Division. According to EPA documentation, the division provides client services to EPA regional offices and delivers quantitative assessments of climate changes, regionally relevant assessments, technical assistance, and capacity building to support climate adaptation planning. According to OLEM officials, the division also advises states on making climate-smart investments, including investments relevant to the RCRA hazardous waste program.

Source: GAO analysis of U.S. Environmental Protection Agency (EPA) documentation and interviews with EPA officials. | GAO-25-106253

Note: The EPA actions described relate to preventing hazardous waste release from operating TSDFs and nonoperating TSDFs with waste in place. EPA actions related to corrective action are not included.

Stormwater and Erosion Analysis by EPA's Region 9 and Office of Research and Development

Officials from the U.S. Environmental Protection Agency's (EPA) Region 9 noted that the region has recently experienced several high-intensity storm events that exceeded the federal minimum design standard of controlling stormwater from a 25-year, 24-hour storm. As a result of such storms, stormwater controls and landfill covers at hazardous waste landfills were damaged.

For example, a treatment, storage, and disposal facility (TSDF) located in Region 9 experienced a down-drain failure and stormwater flowed down the landfill slope instead of through the drains, causing ruptures in the soil and a potential breach of hazardous waste.

Region 9 has initiated an Inflation Reduction Act-funded contract with EPA's Office of Research and Development to conduct research that assesses stormwater and erosion controls at three TSDF landfills in Region 9. The research is expected to provide design recommendations, including revised landfill design for storm events that take into account potential climate change.

Source: GAO analysis of EPA Region 9 information. | GAO-25-106253

Selected EPA regions have also begun taking various actions to build their capacity to manage climate risks to TSDFs or encourage authorized states and TSDFs to manage climate risks. For example, in June 2022, Region 9 issued a memorandum to implement climate change resiliency into the region's permitting process.⁴³ This memorandum directs Region 9 RCRA project managers to require TSDFs to evaluate permitted facilities for climate change threats. It also directs project managers to take appropriate actions to ensure that control measures to address these risks are included in EPA approvals of permits. In addition, Region 9 is working with the EPA Office of Research and Development to conduct a stormwater and erosion analysis to assess controls at TSDF landfills and provide design recommendations to account for climate risks. Region 5 developed a checklist specifically for TSDF inspections that includes climate risk considerations.

⁴³U.S. Environmental Protection Agency, Region 9, *Implement Climate Change Resiliency into Remedy Protectiveness at RCRA and TSCA PCB Cleanup Sites, Permitted Facilities, and Tribal Underground Storage Tanks* (San Francisco, CA: June 15, 2022). This memorandum provides interim guidelines pending development of an EPA national policy addressing how to implement climate change resiliency into RCRA permitted facilities and certain cleanup sites.

EPA Believes It Has Broad Authority to Manage Climate Risks but Has Not Fully Clarified These RCRA Authorities or TSDF Requirements

While EPA believes the agency has broad authority under RCRA to manage climate risks to TSDFs, we found that regions, states, and TSDFs need more clarity on RCRA authorities and requirements for managing climate risks. EPA officials agreed that more clarity would be helpful. EPA also has not fully clarified these requirements as part of its key RCRA oversight mechanisms of authorized state programs. Further, some authorized states and TSDFs may not manage these risks until EPA revises regulations to include explicit authorities or requirements for states and TSDFs to manage these risks.

EPA Believes RCRA Regulations Grant Broad Authority to Manage Climate Risks, with Some Limitations on Compliance and Enforcement Efforts

While RCRA regulations do not include explicit requirements on climate change, EPA officials believe that RCRA grants EPA and authorized states broad authority to manage climate risks to TSDFs. EPA's RCRA regulations do not include any standards and requirements that specifically mention climate change or that are directly intended to manage climate risks to TSDFs. However, while RCRA regulations do not explicitly mention climate risks, officials from EPA headquarters and regions and three stakeholder groups said that existing regulations could be interpreted as broad enough to address some climate risks that TSDFs face. These officials also said that some states and TSDFs may already be addressing climate risks as part of broad risk management efforts to prevent hazardous waste releases. For example, EPA headquarters and regional officials said that TSDF contingency plans are required to prevent or mitigate the release of hazardous waste from any potential cause—which could include consideration of climate risks.⁴⁴

Additionally, officials from EPA's Office of General Counsel and OLEM said that EPA has extensive authority under RCRA to address risks to human health and the environment related to hazardous waste management, including from climate change. These EPA officials said that there are both general and specific RCRA provisions that give EPA regions authority to require authorized states and TSDFs to manage climate risks. For example, there are broad requirements for TSDFs to minimize the possibility of hazardous waste releases. The officials noted that authorized states or EPA regions could use these requirements to

⁴⁴These plans can include emergency response actions that account for natural hazards that may be exacerbated by climate change, such as moving storage drums to higher ground during flooding or bringing in water pump systems to manage heavy precipitation from hurricanes, according to officials from one EPA region and one stakeholder group.

justify including permit requirements for these facilities that would address climate risks that could affect the potential for a release.⁴⁵

Officials from EPA's Office of General Counsel said that authorized states would have the same broad authorities as EPA regions to manage climate risks as part of both permitting and compliance and enforcement, given that they are authorized to implement the federal hazardous waste program for TSDFs in lieu of EPA. Additionally, OLEM officials said that RCRA regulations should be seen as setting minimum standards and requirements for TSDFs. They noted that EPA regions and authorized states have authority to develop permit conditions that go above these standards, if additional measures are needed to manage climate risks.

OECA officials also said that some RCRA regulations could be interpreted as broad enough to provide authority for EPA regions and authorized states to manage climate risks to TSDFs as part of compliance and enforcement efforts. For example, OECA officials said that RCRA inspectors might be able to evaluate whether TSDFs are managing climate risks as part of their facilities' contingency plans. Additionally, officials from one EPA region said that regions might be able to require TSDFs to manage climate risks as part of compliance and enforcement efforts if certain conditions are met.⁴⁶ There also could be opportunities for EPA regions and authorized states to manage climate risks to TSDFs through the settlement negotiation process during enforcement actions, according to officials from two EPA regions, one state program, and one stakeholder group.

Although compliance and enforcement efforts may present opportunities for EPA regions and states to manage climate risks at TSDFs, OECA

⁴⁵For example, see 42 U.S.C. § 6925(c)(3): "omnibus" authority allows EPA or an authorized state to include any term or condition in a TSDF permit deemed necessary to protect human health and the environment; 40 C.F.R. § 264.31: facilities must be designed, constructed, maintained, and operated to minimize the possibility of a release of hazardous waste or hazardous waste constituents that could threaten human health and the environment; 40 C.F.R. § 271.19: EPA regions may review state draft permits for TSDFs, provide comments explaining why issuing the permit would be inconsistent with the authorized state hazardous waste program, and require the state to take action on the comments. The EPA region may take enforcement action against a TSDF permit holder if the permittee is not complying with comments on the draft permit, whether or not the state included a condition addressing the comments in the final permit.

⁴⁶For example, these regional officials said that RCRA § 7003 provides EPA with broad enforcement authority that can be used if facility conditions may present an imminent and substantial endangerment to health or the environment. 42 U.S.C. § 6973.

EPA Regions, Authorized States, and TSDFs Need More Clarity on Authorities or Requirements for Managing Climate Risks under RCRA

officials said the lack of explicit RCRA requirements to manage these risks places some limitations on EPA's and states' authority to do so.

While OLEM believes that EPA has broad authority to manage climate risks as part of the permitting process, OLEM officials also said that EPA regions and authorized states needed more clarity on their authority to manage climate risks to TSDFs and guidance on interpreting which regulations could be used to develop requirements. Additionally, OECA officials said that there is not a uniform practice for managing these risks as part of RCRA compliance and enforcement efforts. They noted that OLEM is in the process of defining requirements and developing guidance related to managing climate risks to prevent hazardous waste releases.⁴⁷ As a result, OECA officials said the extent to which regions or states are managing these risks as part of compliance and enforcement efforts could vary, given there are not currently any explicit national requirements.

We also found that EPA regions, authorized states, and TSDFs need more clarity on whether managing climate risks is required under RCRA regulations or they have authority to do so as part of RCRA hazardous waste permitting and compliance and enforcement. For example:

- Officials from four of the five EPA regions in our review said they had not taken any specific actions to manage climate risks to TSDFs as part of permitting or compliance and enforcement. They said they needed more clarity on RCRA authorities and requirements to be able to ensure authorized states and facilities manage these risks. For example, officials from three regions said they did not have any formal direction on authorities or requirements for managing climate risks to TSDFs and are waiting for EPA headquarters to provide guidance.

We did not identify any examples of EPA regions using RCRA authorities or requirements to manage climate risks to TSDFs, including those that OLEM and OECA cited as potential sources of authority. For example, we did not find that any selected EPA regions had reviewed or required any updates to TSDF contingency plans in order to manage climate risks as part of compliance and enforcement efforts. According to OECA officials, one EPA region is considering

⁴⁷See Table 5 for examples of EPA initiatives that are related to further defining requirements and guidance.

conducting comprehensive reviews of flood risk during inspections but has not yet done so.

- Officials from three authorized states told us that EPA had not clarified what requirements exist for states or TSDFs to manage climate risks as part of the RCRA hazardous waste program. They said their authorized state programs had not taken any specific actions to manage these risks as part of permitting and compliance and enforcement. For example, officials from one authorized state said they had not had any communication with EPA on managing climate risks to TSDFs or what requirements may exist. Further, one stakeholder group said EPA had not clarified what authorized states would specifically be required to do in order to manage these risks to TSDFs. Officials from two EPA regions also said that they did not believe it was clear to states or TSDFs if managing climate risks was required under RCRA or if states had the authority to do so.
- TSDFs have not been required to manage climate risks by EPA or authorized states, according to officials from two stakeholder groups, including a TSDF industry association. We reviewed permits, contingency plans, and inspection reports from eight TSDFs located within the five selected states and found that none of the documents identified, assessed, or addressed any future climate change risks on the facility or waste management units or included any specific requirements for the TSDF to do so. All eight TSDFs in our review accounted for at least some current natural hazard risks in their contingency plans or permits. However, none of the plans or permits we reviewed identified how climate change might exacerbate natural hazard risks or described any climate adaptation measures or other controls being taken to specifically address any future climate risks.⁴⁸ For example, no plans or permits described climate adaptation measures that would address additional hazard risks above what may be expected from current weather and natural hazards the facility may face.

⁴⁸Our analysis did not evaluate whether all existing natural hazards were covered as part of contingency plans. However, in one case, we found that a selected TSDF was unaware that it is located in a 100-year floodplain. As a result, this TSDF had not taken any measures to address flood risk to the facility or any waste management units. We requested but were unable to obtain one of the TSDF's contingency plans, so we relied on the permit and inspection reports for this TSDF in our analysis.

EPA Has Not Fully Clarified Requirements for Regions or Authorized States on Managing Climate Risks as Part of Key Oversight Mechanisms

EPA also has not fully clarified requirements on managing climate risks as part of its key oversight mechanisms used to ensure state compliance with RCRA requirements. Both OLEM and OECA provided national program guidance for fiscal years 2023 and 2024 to EPA regions and authorized states that reflect minimum requirements for the state work plans. However, this guidance does not include requirements to manage climate risks to TSDFs in the hazardous waste program.⁴⁹ In addition, we found that four out of the five selected EPA regions did not have requirements or regional guidance for authorized states to include work plan goals or commitments to manage climate risks to TSDFs.⁵⁰

Furthermore, authorized state work plans for the hazardous waste program generally did not include commitments or goals related to managing climate risks. For example, 20 of the 25 state hazardous waste program work plans we reviewed had no climate-related goals for TSDFs. The other five states included commitments or goals that could relate to managing climate risks to TSDFs. OLEM officials said some of EPA's regions face challenges convincing some states to commit to goals on managing climate risks in work plans. They said this is because climate change is a politically charged issue for these states and their programs may not consider it a priority or requirement to manage climate risks to TSDFs.

Additionally, OECA uses the state review framework as a primary oversight tool to evaluate whether authorized state compliance monitoring and enforcement programs are ensuring TSDF compliance with RCRA

⁴⁹OLEM's national program guidance for fiscal years 2023 and 2024 encourages—but does not require—EPA regions and states to support and implement efforts to consider climate change in RCRA permitting. In April 2024, OECA's national program guidance for fiscal years 2023 and 2024 states that it intends to use RCRA authorities to proactively investigate and prevent threatened releases in climate-sensitive communities but neither encourages nor requires states to manage climate risks as part of RCRA's compliance and enforcement efforts. OLEM and OECA issued national program guidance for fiscal years 2025 and 2026. This guidance directs (1) EPA headquarters to provide technical or policy support for regions and authorized states to do necessary climate adaptation work; (2) OECA and EPA regions to use RCRA authorities to proactively investigate and prevent hazardous waste releases in climate-sensitive communities; and (3) EPA regions and authorized states to ensure that RCRA permits are protective of human health and the environment for the duration of the permit, including under changing climate conditions.

⁵⁰Two of the four EPA regions that did not issue regional guidance on managing climate risks as part of work plans provided either technical assistance related to general inquiries on climate change or more targeted feedback on work plan drafts to incorporate managing climate risks to TSDFs. For example, Region 2 provided feedback on draft work plans for New York and New Jersey to encourage both programs to incorporate how the states are managing climate risks into their work plans.

requirements. However, OECA officials said the framework does not include reviewing whether states manage climate risks for TSDFs because there are no national RCRA policies, guidance, or regulatory requirements that require regions or states to manage these risks as part of their compliance and enforcement programs.⁵¹ Table 6 summarizes our findings on the extent to which climate risks are mentioned in TSDF and key EPA oversight documents we reviewed.

Table 6: TSDF and Key EPA Oversight Documents and the Extent to Which Climate Risks are Mentioned

TSDF and key EPA oversight documents	Extent climate risks are mentioned
TSDF permits, contingency plans, and compliance inspection reports	<p>Treatment, storage, and disposal facility (TSDF) permits, contingency plans, and compliance inspection reports we reviewed do not identify, assess, or address the impact of any future climate change risks on the facility or waste management units or include any specific requirements for the TSDF to do so. However, of the TSDF documents we reviewed, we found evidence that TSDFs account for natural hazards based on current conditions or historical data. For example:</p> <ul style="list-style-type: none"> • One TSDF’s contingency plan notes that after Hurricane Sandy, the Federal Emergency Management Agency adjusted the region’s 100-year flood elevation level. In response, the facility is building a flood protection perimeter wall to protect the facility against a 100-year flood.^a • One TSDF’s permit notes that it uses 100-year flood information from 1988 to meet the facility’s design requirements to prevent hazardous waste releases. Similarly, another facility’s permit relied on rainfall data collected from a storm in January 1956 to design its secondary containment system to meet minimum RCRA requirements to withstand a 24-hour, 25-year storm. • All compliance inspection reports included observations of the operating condition of waste management units to ensure they can sufficiently prevent releases. For example, one TSDF was inspected to ensure the post-closure landfill at the facility had a perimeter fence, groundwater monitoring wells, and a vegetative cover in the landfill-capped areas—all of which are used to monitor possible effects of erosion on the landfill.

⁵¹As mentioned previously, OECA’s most recent guidance for the state review framework encourages regions to conduct optional assessments for states that have explicitly chosen to incorporate climate adaptation into their compliance and enforcement programs. However, EPA regions are not required to conduct these optional assessments for state RCRA programs, nor is there guidance for conducting such a review. Further, only state programs that have chosen to include climate-related activities in their programs would be subject to optional reviews.

TSDF and key EPA oversight documents**Extent climate risks are mentioned**

State work plans

We found that five of the 25 work plans we reviewed that support authorized states' hazardous waste program grants identify goals related to managing climate risks to TSDFs. For example:

- The New York work plan identifies a goal to promote climate adaptation in permit reviews.
- The New Mexico work plan considers preventative measures, such as adjustments to formerly identified 100-year flood plain maps and the construction of engineering controls to prevent damage related to the increased frequency and intensity of storms, to manage climate risks.
- The Nevada work plan commits to reporting to EPA on any climate change or environmental considerations taken in enforcement actions against TSDFs.
- The Hawaii work plan has multiple goals. For example, the state's hazardous waste program plans to consider how to encourage increased climate adaptation and resilience in TSDF site design and management of hazardous waste through recommendations to individual sites in inspection reports and other enforcement actions.

The other 20 state work plans we reviewed did not have any goals related to managing climate risks to TSDFs.

State review framework

The Environmental Protection Agency's (EPA) Office of Enforcement and Compliance Assurance (OECA) does not require authorized states to be reviewed on whether they are managing climate risks to TSDFs. However, the most recent framework for fiscal years 2024 through 2028 includes climate change as an optional consideration for EPA regions to include in state assessments if that state specifically includes climate change in its own RCRA compliance monitoring plan or strategy.

Sources: GAO analysis of TSDF and state documentation and OECA state review framework reviewer's guide. | GAO-25-106253

Notes: We reviewed permits, contingency plans, and compliance inspection reports for eight TSDFs to assess the extent to which these documents accounted for climate risks and used future projections of natural hazards exacerbated by climate change. We reviewed 25 state Resource Conservation and Recovery Act of 1976, as amended (RCRA) program work plans for fiscal year 2024 from the five selected EPA regions to assess the extent to which these plans include commitment to incorporate climate adaptation into their hazardous waste program's oversight of TSDFs. The results of our reviews of TSDF documentation and hazardous waste program work plans are illustrative and not generalizable to all TSDFs and authorized states.

^aA 100-year flood is a flood with a 1 percent chance of being equaled or exceeded in any given year. The 100-year floodplain designations are provided by the Federal Emergency Management Agency to support the National Flood Insurance Program.

Some Authorized States and TSDFs Might Not Consider Managing Climate Risks without Clarifying Requirements or Authorities in RCRA Regulation

We also found that some authorized states and TSDFs might not consider managing climate risks as a requirement under RCRA unless EPA clarifies this by revising RCRA regulations so that they include explicit requirements for states and TSDFs to manage these risks. For example:

- **Sufficiency of authority.** Some authorized states believe they would not have sufficient authority to manage climate risks to TSDFs without explicit regulatory requirements or authorities, according to officials from EPA headquarters and regions, two authorized states, and one stakeholder group. As a result, these officials said these states would not implement EPA guidance on managing climate risks or would face limitations in being able to do so unless EPA revises regulations to

clarify these requirements. For example, officials from two authorized states said that managing climate risks to TSDFs was not required under RCRA and that guidance alone may not be sufficient to require TSDFs to manage these risks. Officials from one of these states said that regulatory changes would be necessary to clarify that managing climate risks to TSDFs is required under RCRA or that states have authority to do so.

Officials from the other state said their program generally adheres to minimum standards and requirements that are explicit in regulation, and they were unsure whether their program would be able to implement EPA guidance on climate risks without a revision to regulations. Further, they said that any guidance would need to be detailed or specific enough for the state to be able to implement it, at least in part, without an explicit RCRA regulation.

- **Specific regulatory requirements.** Some TSDFs may not consider managing climate risks unless there is an explicit RCRA regulatory requirement that they do so, according to officials from EPA headquarters and regions, two authorized states, and two stakeholder groups. Without an explicit requirement, TSDFs could push back on EPA regions or authorized states seeking to require or enforce actions to manage climate risks, according to some of these officials. Further, these officials said that states may adhere to explicit requirements in RCRA regulation because regulatory requirements would take precedence over guidance in legal challenges to states' permitting actions.
- **Compliance and enforcement.** EPA and authorized states have limited authority to manage climate risks to TSDFs as part of compliance and enforcement efforts, according to officials from two regions, two authorized states, and two stakeholder groups. They said this is because there are no explicit regulatory requirements on managing these risks. Additionally, OECA officials said that EPA regions are limited in their ability to require that state compliance and enforcement programs manage these risks because the EPA regions are not able to ask states to go beyond what is explicitly required in regulation. All of these officials said that setting explicit requirements in regulation would allow EPA and states to manage climate risks as part of their compliance and enforcement efforts at TSDFs.

Setting explicit requirements in regulation would be the best way for EPA to fully clarify requirements and existing authority for managing climate risks to TSDFs, according to officials from two EPA regions, three authorized states, and two stakeholder groups. In addition, this could help provide consistency in implementation of RCRA across states because it

could reduce ambiguity and provide regulatory certainty. There are benefits to having greater clarity on requirements and consistency in RCRA implementation, said officials from two EPA regions, two authorized states, and two stakeholder groups. For example, officials from one authorized state and one stakeholder group said that having explicit language in regulations would lead to more efficient permitting and compliance and enforcement efforts across states and that TSDFs would also be able to make more informed business decisions related to managing climate risks.

OLEM officials said that, where feasible and appropriate, the office recognized that climate change needs to be addressed and written into regulation. They also acknowledged that revising RCRA regulations to include explicit requirements for managing climate risks to TSDFs could help clarify requirements and ensure these risks are managed consistently across authorized states and TSDFs. Additionally, OECA officials said that having an explicit requirement in regulation would help clarify for EPA regions and authorized states that they can manage climate risks to TSDFs as part of inspection and enforcement efforts.

EPA Has Not Fully Clarified RCRA Authorities or TSDF Requirements to Manage Climate Risks

OLEM recently took initial steps to clarify authorities and requirements for managing climate risks to TSDFs. For example, as discussed above, in June 2024, OLEM issued a memorandum to EPA regional division directors that identifies selected RCRA regulatory authorities that EPA regions and authorized states could use to support additional permit requirements for TSDFs to manage climate risks.⁵² OLEM officials said this memorandum provides guidance that helps clarify RCRA authorities and requirements for managing climate risks to prevent hazardous waste releases from TSDFs. However, as discussed previously, some states and TSDFs may not implement this guidance or would face limitations in being able to do so without explicit language in regulation. As a result, this could lead to inconsistent management of these risks across states and TSDFs.

However, OLEM officials said the memorandum would be able to help address concerns from EPA regions and state programs about the lack of an explicit requirement in regulation. For example, the EPA memorandum explains that there are existing regulations that can be used to develop permit requirements to manage climate risks to TSDFs. Additionally,

⁵²U.S. Environmental Protection Agency, *Implementing Climate Resilience in Hazardous Waste Permitting Under the Resource Conservation and Recovery Act (RCRA)* (Washington, D.C.: June 2024).

officials said EPA could also develop and provide training or other technical assistance—such as instructions on how to leverage existing RCRA authorities to develop requirements for managing climate risks—to EPA regions and authorized states to help them implement the guidance. OLEM officials said the memorandum, along with developing and providing training and technical assistance to regions and states to implement the memorandum, could help EPA regions and states understand that they have authority to manage these risks as part of the permitting process.

While OLEM believes that providing training and technical assistance to regions and authorized states could help address their concerns related to authorities and enable them to implement guidance in the memorandum, it has not yet developed and provided this training to them.

Additionally, OLEM is drafting RCRA rulemaking changes to codify established policies, reflect current standards, reduce ambiguity, and make technical corrections.⁵³ OLEM also plans to provide further policy and guidance on how TSDF permits can incorporate climate change adaptation considerations as part of this effort.

As part of this rulemaking effort, OLEM officials said they were considering seeking feedback on potential revisions to RCRA regulations to clarify requirements and authorities related to managing climate risks to TSDFs, but had not determined whether they would revise the regulations. Additionally, officials said this rulemaking was still under deliberation and what would be included for comment or proposed revisions would be subject to change. Amending regulations to explicitly require authorized states and TSDFs to manage climate risks could clarify requirements and help ensure all authorized states understand that they have sufficient authority to be able to manage these risks. Further, OLEM could use this rulemaking to seek feedback from authorized states, TSDFs, and other stakeholders as part of the public notice-and-comment process to assess whether the guidance in the June 2024 memorandum is sufficient to clarify requirements and existing authorities for managing climate risks to TSDFs or revisions to RCRA regulation is necessary to fully clarify authorities and requirements.

⁵³According to OLEM officials, RCRA regulations have not been substantively updated in 30 years, which is one of the factors that has led to the effort to update these regulations. OLEM officials expect to publish proposed RCRA rulemaking changes for public comment in 2025.

OECA issued broad guidance in September 2023 directing all EPA enforcement and compliance offices to address climate change as part of their inspections and enforcement efforts. However, the guidance does not specify how climate change will be incorporated into the RCRA program or clarify requirements and authorities for state RCRA compliance and enforcement programs. OECA officials said they are considering whether to issue additional guidance for the RCRA program related to managing climate risks to TSDFs. OECA is also participating in OLEM's effort to draft RCRA rulemaking changes to codify established policies, reflect current standards, reduce ambiguity, and make technical corrections, which also presents an opportunity for OECA to clarify requirements and authorities for managing climate risks to TSDFs for RCRA compliance and enforcement.

According to EPA's 2021 *Climate Adaptation Action Plan*, EPA offices are directed to integrate climate adaptation planning into EPA programs, policies, and rulemaking processes.⁵⁴ The plan states that EPA will account for the impacts of climate change as it designs, implements, and assesses its programs, policies, rules, and enforcement and compliance assurance activities, as much as possible and consistent with its authorities, to ensure they are effective and resilient to climate change. Further, it states that EPA will monitor and evaluate the actions it takes to integrate climate adaptation into EPA programs, policies, and rules to ensure that its program management and policy approaches are effective or that it adjusts how adaptation is integrated into its activities to improve its efforts to meet this goal.

Without developing and providing the training and technical assistance that regions and states need to implement recent guidance and seeking feedback to determine whether revising regulations is necessary to fully clarify RCRA authorities and requirements for managing climate risks to TSDFs, OLEM risks not being able to ensure effective and consistent management of these risks. Additionally, OECA may be unable to ensure effective and consistent management of climate risks as part of RCRA compliance enforcement efforts without issuing guidance to fully clarify authorities and requirements for managing climate risks to TSDFs as part of these efforts.

⁵⁴In June 2024, EPA released its updated Climate Adaptation Plan for 2024-2027, which highlighted EPA's planned actions from 2024 to 2027 to continue to make progress toward implementing its five priority action areas from the 2021 plan and strategic plan goals.

EPA Has Not Assessed Whether Authorized States and TSDFs Manage Climate Risks

State Regulatory Changes to Incorporate Climate Adaptation: New Jersey and New York

New Jersey: In October 2019, the governor of New Jersey issued Executive Order 89, which directs the state's executive agencies, including the New Jersey Department of Environmental Protection, to be proactive and coordinate efforts to protect human health and safety from both current and anticipated impacts of climate change. According to New Jersey state officials, New Jersey's authorized state program is going through the state rulemaking process to promulgate a new regulation that would require treatment, storage, and disposal facilities (TSDFs) to conduct climate vulnerability assessments and manage potential climate risks as part of the hazardous waste permitting process.

New York: The State of New York has undertaken several initiatives that require consideration of future climate conditions. The state's 2014 Community Risk and Resiliency Act (CRRRA), as amended by the 2019 New York State Climate Leadership and Community Protection Act, requires that hazardous waste permit applicants demonstrate consideration of future physical climate risk. In addition, the CRRRA requires that the New York Department of Environmental Conservation (DEC) consider future physical risk caused by storm surges, sea level rise, and flooding in certain facility-siting regulations, and that hazardous waste permit applicants also demonstrate consideration of such flooding risks. The CRRRA directed DEC to adopt science-based sea level rise projections by regulation, which DEC adopted in 2017 (N.Y. Comp. Codes R. & Regs. tit. 6, pt. 490). The regulation provides projections for three New York tidal coast regions: (1) Long Island, (2) New York City/Lower Hudson River, and (3) mid-Hudson River.

Source: GAO analysis of state laws and documents and interviews with New Jersey state officials. | GAO-25-106253

EPA has neither fully assessed the extent to which authorized states and TSDFs have managed climate risks, nor developed performance metrics to do so. For example, OLEM and OECA have not developed performance metrics for assessing whether states and TSDFs have managed climate risks as part of permitting or compliance and enforcement. Further, none of the five selected regions we spoke with had fully assessed whether states and TSDFs manage climate risks. In addition, OLEM and OECA have not incorporated any performance metrics into existing monitoring tools that could be used to assess EPA's, states', and TSDFs' progress in achieving climate adaptation goals in the hazardous waste program. For example:

- **EPA's climate adaptation measurement program.** EPA's Office of Policy maintains a database known as the climate adaptation measurement program. This program monitors EPA national program and regional office progress in implementing climate adaptation goals identified in their respective climate adaptation implementation plans. According to EPA officials, EPA national program and regional offices report implementation data quarterly to the measurement program. However, while the database captures some RCRA-related goals, it does not include any goals or metrics related to tracking whether authorized states and TSDFs manage climate risks. Further, the database does not collect information on EPA regional office efforts to encourage them to do so or on associated outcomes.
- **State work plans and review framework.** OLEM and the five selected EPA regions have not incorporated performance metrics into state work plans or the state review framework. For example, OLEM's *National Program Guidance* for fiscal years 2023 and 2024 encourages, but does not require, EPA regions and states to support and implement efforts to consider climate change in RCRA permitting. However, the guidance does not identify performance metrics for authorized states to report in work plans or specify metrics that could be applied to any state efforts to consider climate change in their programs. In addition, we found that 22 of the 25 state work plans we reviewed did not include any metrics related to tracking whether authorized states or TSDFs manage climate risks, though three states

had metrics for permitting or compliance and enforcement efforts.⁵⁵ Therefore, EPA does not use state work plans to assess the extent to which authorized states and TSDFs are managing climate risks.

As noted earlier, in February 2024, OLEM finalized a term and condition on climate adaptation and sent accompanying guidance to all EPA regions. EPA regions are now required to include the term and condition in RCRA grants issued to authorized states. As part of accepting the term and condition, authorized states would be required to provide information in their annual grant reports on how they considered potential climate-related threats in permitting for TSDFs. OLEM officials said the term and condition would be implemented in state work plans over the next 3 years and would help EPA assess the extent to which authorized states are managing climate risks. However, OLEM has not yet implemented the term and condition, and cannot use existing work plans to assess efforts to manage climate risks.

OECA recently added climate change as optional inspection criteria in its state review framework.⁵⁶ The state review framework for fiscal years 2024 through 2028 identifies data, TSDF inspections, violations, enforcement actions, and penalty evaluation criteria. But it does not include national climate change criteria or data metrics that could be consistently applied across or within EPA regions for evaluating authorized state hazardous waste programs. The data metrics used in the state review framework are derived from RCRAInfo data, which

⁵⁵While most state work plans do not track climate change metrics, it is possible that some states do monitor TSDF efforts to manage climate risks but do not report this information to EPA. Of the five states with commitments or goals related to managing climate risks to TSDFs in work plans, three states had climate change metrics for permitting or compliance and enforcement efforts. One state work plan commits to reporting any climate change or environmental considerations taken in enforcement actions. Another state work plan commits to making recommendations to encourage increased climate adaptation in the design of hazardous waste facilities via inspection reports and other enforcement actions. The third state work plan commits to meeting quarterly with EPA region officials to discuss progress implementing a multiyear permitting strategy for issuing closure and post-closure permits and considering climate change as part of these permitting efforts. We did not evaluate whether these climate change metrics for permitting or compliance and enforcement commitments in work plans would be sufficient to ensure authorized states are managing climate risks.

⁵⁶According to the state review framework guidance for fiscal years 2024 through 2028, if a state RCRA program has proactively set goals to manage climate change, EPA regions have the option to include a description of state program actions to manage climate risks within the program in the executive summary of the review.

contain information on violations of federal and state RCRA requirements.⁵⁷

According to OECA officials, the office does not have plans to update the state review framework requirements to include criteria or data metrics for evaluating whether states are managing climate risks to TSDFs as part of compliance and enforcement efforts.⁵⁸ OECA officials did note that if RCRA national policy requirements or regulations changed to include management of climate risks to TSDFs, they would consider whether the state review framework needed to be revised to reflect updated policy or regulatory requirements. As a result, EPA does not currently use state reviews under the state review framework to assess the extent to which authorized states and TSDFs are managing climate risks.

- **EPA region permit review and inspection metrics.** We found that none of the five selected EPA regions had developed performance metrics for assessing whether authorized states and TSDFs account for climate risks in permit applications or modifications.⁵⁹ For example, officials from one EPA region stated that the region's permit reviews include determining whether TSDFs are located in a floodplain, but the reviews do not assess whether permits adequately manage climate risks. Further, they said the region needed additional climate data to be able to prioritize permit reviews based on climate risk. In some cases, EPA regions use natural hazard vulnerabilities to prioritize which permits they will review but do not consider climate change vulnerability as a formal criterion. For example, officials from one EPA region stated that the region prioritizes its review of states' draft TSDF permits based on past erosion and other effects from storm events, among other factors, but does not consider climate change vulnerability as a factor in selecting which permits it reviews

⁵⁷As described previously, RCRAInfo is EPA's comprehensive information system used to store and track RCRA information, activity, and enforcement.

⁵⁸Currently, the state review framework measures the 2-year inspection coverage of operating TSDFs, according to OECA officials, which is based on RCRA statutory requirements to inspect commercial TSDFs once every 2 years. OECA officials also said that in the last round of state reviews, only Puerto Rico identified this metric as an area for improvement. These officials said that Puerto Rico only has two operating TSDFs, which were not inspected in the review year because of the COVID-19 pandemic.

⁵⁹While each partnership agreement between authorized states and EPA regions has unique provisions, several provisions are common to all agreements, including coordinating compliance and enforcement efforts between the state and EPA and specifying the types of permit applications that will be sent to the EPA Regional Administrator for review and comment.

as part of its oversight efforts. Another EPA region does not have a prioritization process to select draft state permits to review for oversight of authorized states because it only reviews permits if a state requests technical assistance, according to regional officials.

We found that EPA regions and authorized states may not be targeting TSDf inspections based on climate risk or monitoring climate risk management metrics for TSDf compliance and enforcement efforts. For example, OECA officials stated that while the office has been informally encouraging EPA regions and authorized states to use existing data tools to identify climate-vulnerable TSDfs for compliance assistance or targeting, it had not developed formal guidance or metrics for regions and states on doing so.⁶⁰ As a result, OECA officials said they were aware of some regions using existing data tools for targeting TSDf inspections based on climate risk, but the office does not track whether EPA regions or authorized states are doing so.

We also found that three EPA regions either needed additional climate screening tools for targeting inspections of TSDfs based on climate risk or did not use any climate data to target their inspections, according to documents we reviewed and interviews with officials from three EPA regions. Additionally, OECA officials said that only one region has reported that it will consider doing more comprehensive inspection reviews of flood risk that account for climate risks. Further, while one region provided regional guidance to authorized states to develop inspection targeting tools to identify TSDfs vulnerable to climate risks, the four other regions in our review did not provide any guidance on using climate risk as a factor in targeting inspections.

According to an OECA September 2023 memorandum, EPA compliance and enforcement staff will identify climate-vulnerable facilities and develop compliance assistance materials in cooperation with OLEM to help the regulated community, including TSDfs, better plan for extreme

⁶⁰OECA officials said that because privately owned and operated TSDfs are already required to be inspected once every 2 years, and state and federally owned facilities annually, EPA regions and authorized states may not be targeting TSDf inspections based on climate risk. However, as we mentioned previously, EPA oversight inspections of TSDfs are a key component of EPA oversight of state programs to monitor the quality of inspections and build state capacity to address emerging or complex issues. Given limited resources and that states conduct most inspections of TSDfs, EPA regions target their inspections based on legal requirements, policy goals, and the relative risk to human health and the environment. In 2018, EPA developed a TSDf Inspection Prioritization Scheme as part of EPA's *RCRA Compliance Monitoring Strategy* to help EPA regions target their inspections of TSDfs. However, this prioritization scheme does not include climate risk as a criterion, according to OECA officials and our review of the strategy.

weather events due to climate change. However, OECA officials stated this was still an ongoing effort and they were still in the process of developing plans for how EPA regions should identify vulnerable TSDFs.

EPA's 2021 *Climate Adaptation Action Plan* states that the agency will evaluate its climate adaptation actions on an ongoing basis to assess progress, learn how to effectively integrate climate adaptation into its activities, and adjust implementation based on these evaluations, including by tracking EPA's progress in supporting its partners to integrate climate adaptation into their programs.⁶¹ It further states that EPA will use performance measurement, data analysis, evaluation, and other evidence-building activities to evaluate the effectiveness of its activities, program management, and policy approaches. Further, EPA's *RCRA Compliance Monitoring Strategy* notes the importance of using oversight metrics that help ensure consistency between EPA and state programs and a level playing field for the regulated community.

According to OECA's *Climate Change Adaptation Implementation Plan*, regulatory revisions in response to a more extreme climate may require data development due to additional required monitoring, sampling, and testing, and new reporting requirements. In addition, the plan notes that developing regulations and recordkeeping requirements is critical to ensure compliance can be demonstrated and compliance status can be determined in the most efficient manner under adverse conditions. Adding climate change metrics to any of the monitoring tools led by EPA headquarters and regional offices could improve EPA's ability to assess such progress. Without OLEM and OECA developing metrics and assessing whether and how states and TSDFs are managing climate risks, EPA will lack needed insights into whether states and TSDFs are managing these risks sufficiently and whether EPA is making progress on agency goals.

⁶¹In June 2024, EPA released its updated Climate Adaptation Plan for 2024-2027, which highlights EPA's planned actions from 2024 to 2027 to continue to make progress toward implementing its five priority action areas from the 2021 plan and strategic plan goals.

EPA, Authorized States, and TSDFs Face Challenges in Managing Climate Risks, and Opportunities Exist for EPA to Address These Challenges

EPA, Authorized States, and TSDFs Face Various Challenges in Managing Climate Risks

EPA, authorized states, and TSDFs face various challenges in managing climate risks to TSDFs, according to documents we reviewed and interviews with officials from EPA, authorized states, and stakeholder groups. These challenges include (1) climate change may reduce the effectiveness of current facility standards and requirements used to prevent releases; (2) EPA regions, authorized states, and TSDFs need more direction and information on managing climate risks; and (3) EPA, authorized states, and TSDFs face resource constraints.

Climate Risks May Reduce the Effectiveness of TSDF Standards Used to Prevent Releases

Climate risks may reduce the effectiveness of certain RCRA standards and requirements for preventing releases of hazardous waste, according to documents we reviewed, prior GAO reports, and interviews with officials from EPA, four authorized states, and five stakeholder groups. For example, EPA's 2014 *Climate Adaptation Plan* found that location, design, and permitting requirements and standards may need to change to account for climate risks.⁶² In 2017, an EPA report on TSDF landfills also stated that some landfills may face climate risks, such as sea level

⁶²U.S. Environmental Protection Agency, *U.S. Environmental Protection Agency Climate Change Adaptation Plan*, EPA-100-K-14-001 (June 2014).

rise or increased flooding, and are not designed and operated to account for these impacts.⁶³

Additionally, officials from EPA headquarters and regions, three authorized states, and four stakeholder groups we interviewed cited examples of facility standards or requirements that may not be sufficient for managing climate risks. For example, these officials cited TSDF standards such as the 100-year floodplain, 25-year storm, and post-closure care standards. These standards were developed to prevent the release of hazardous waste to protect human health and the environment, but they do not explicitly account for climate change or incorporate forward-looking climate projections data.⁶⁴ For example, EPA established the current 100-year floodplain standard for TSDFs in 1981. This standard requires facilities located in the floodplain to prevent any releases caused by a 100-year flood. The 100-year flood standard relies on FEMA floodplain maps, which are generally static portrayals of flood risk that do not account for increasing hurricane intensities, frequent heavy precipitation, extreme flooding, and higher sea levels that may occur due to climate change, according to our prior work.⁶⁵ TSDF standards for landfills and tanks rely on the 25-year storm standard. This

⁶³Further, the report stated that this could have serious consequences for the integrity of hazardous waste disposal facilities and protection of human health and the environment. The report recommended that TSDFs be evaluated with regard to both short-term and long-term hazards, such as climate change, and that additional research was needed on the long-term vulnerability of closed landfills. U.S. Environmental Protection Agency, *Post-Closure Performance of Liner Systems at RCRA Subtitle C Landfills*, EPA 600/R-17/205 (Cincinnati, OH: November 2017).

⁶⁴Most decision-makers need a basic set of information to understand and make choices about how to adapt to climate change, according to a 2010 National Research Council report on making informed decisions about climate change and our October 2009 report on climate adaptation. This includes information about observed climate conditions, impacts, and vulnerabilities and projections of what climate change may mean for local areas. National Research Council, *America's Climate Choices: Panel on Informing Effective Decisions and Actions Related to Climate Change, Informing an Effective Response to Climate Change* (Washington, D.C.: 2010); and GAO, *Climate Change Adaptation: Strategic Federal Planning Could Help Government Officials Make More Informed Decisions*, [GAO-10-113](#) (Washington, D.C.: Oct. 7, 2009).

⁶⁵FEMA floodplain maps also face limitations related to capturing current flood risk. For example, FEMA floodplain maps do not include risk related to pluvial flooding, which occurs when an extreme rainfall event creates a flood independent of an overflowing water body. FEMA officials said that the exclusion of pluvial flooding from FEMA's floodplain maps creates the potential for greater flood risk than its maps represent. Additionally, FEMA recently developed a new methodology for assessing flood risk that incorporates use of a larger range of variables and models than floodplain maps. See GAO, *National Flood Insurance Program: Congress Should Consider Updating the Mandatory Purchase Requirement*, [GAO-21-578](#) (Washington, D.C.: July 30, 2021).

EPA Regions, States, and
TSDFs Need More Direction
and Information on Managing
Climate Risks

standard relies on historical weather data and does not consider climate impacts on flooding, such as more frequent or intense precipitation in some areas, according to documents we reviewed and interviews with officials from one EPA region, two authorized states, and two stakeholder groups.

Further, post-closure care standards and requirements for closed landfills located by rivers or coastal areas may not be sufficient to prevent releases due to climate change risks, according to officials from two authorized states and one stakeholder group. For example, state representatives from a stakeholder group said there are TSDFs at sea level that have waste buried in the ground, and it is unclear how to manage long-term climate impacts to these post-closure units, such as sea level rise and more intense storms that could flood these sites. Finally, contingency plan requirements may not adequately consider that climate change may affect emergency response assumptions, such as more intense hurricanes that form faster or the availability of water for fire suppression, according to officials from three stakeholder groups and documents we reviewed.

EPA regions and authorized states also face challenges in knowing how they should manage site-specific climate risks to prevent hazardous waste releases from TSDFs and what information they should use to do so, as part of permitting and compliance and enforcement efforts, according to documents we reviewed and interviews with officials from EPA headquarters and regions, authorized states, and stakeholder groups.

For example, officials from two EPA regions, two authorized states, and three stakeholder groups said that authorized states were unaware of what forward-looking climate data or information they should use to manage climate risks as part of permitting and compliance and enforcement efforts for TSDFs.⁶⁶ EPA headquarters and regional officials also said that it can be challenging for regions and authorized states to

⁶⁶In 2015, we found that existing federal efforts did not fully meet the climate information needs of federal, state, local, and private decision-makers. As a result, we recommended that the Executive Office of the President designate a federal entity to develop a set of authoritative climate change projections and observations and create a national climate information system with defined roles for federal and nonfederal entities. As of June 2024, the Executive Office of the President had not taken action in response to this recommendation. GAO, *Climate Information: A National System Could Help Federal, State, Local, and Private Sector Decision Makers Use Climate Information*, [GAO-16-37](#) (Washington, D.C.: Nov. 23, 2015).

know what climate information would be most appropriate to use for managing climate risks to TSDFs. This is because there are many potential data sources for this information, and it is not clear what data source should be used.

In addition, relevant data may not be readily available or in an accessible format that would enable decision-making. According to officials from EPA and one state program, there are also key data gaps—such as data on the extent to which climate change could exacerbate hurricane intensity and frequency or affect future permafrost conditions—that would be relevant for evaluating site-specific climate risks to TSDFs. Additionally, officials from one stakeholder group said existing EPA data tools may not be sufficient for managing climate risks to TSDFs and that regions, states, and TSDFs needed authoritative scientific data to manage these risks.

Further, EPA regions and authorized states may be unaware of climate data or have to rely on natural hazard risk information that does not account for climate impacts because that is what is available, according to officials from EPA regions, authorized states, and stakeholder groups. For example, information sources or data tools for evaluating flood risk are based on existing conditions or historical data, such as floodplain maps or rainfall data, according to documents we reviewed and officials from two regions, three authorized states, and three stakeholder groups. For example, officials from one authorized state and one stakeholder group said that having information or data that would allow them to understand how climate change may exacerbate flooding in the future would help them assess TSDF climate risks.

EPA regions and authorized states also need additional direction through guidance, related tools, or training on managing site-specific climate risks for TSDF permitting and compliance and enforcement efforts, according to officials from EPA, authorized states, and stakeholder groups we interviewed. For example, EPA officials from three regions told us they did not have formal direction on how to address climate risks to TSDFs and were waiting for EPA headquarters to provide guidance on how to integrate consideration of climate change into permitting and compliance and enforcement efforts.

Further, officials from two EPA regions, two authorized states, and two stakeholder groups said it was not clear how to manage site-specific climate risks, such as how to identify, assess, or respond to various climate risks, or what this would mean in practice for permitting and

compliance and enforcement. For example, according to these officials, detailed guidance on managing climate risks to specific hazardous waste units, how to determine appropriate climate adaptation measures, or how to use forward-looking climate projections data to conduct climate risk assessments would be helpful. To be able to manage climate risks to TSDFs, EPA regions and authorized states need detailed guidance on how to identify, assess, and respond to various climate risks, according to officials from two EPA regions, two authorized states, and two stakeholder groups.

Additionally, EPA regions and authorized states need decision-support tools or training on how to manage climate risks to TSDFs to prevent hazardous waste releases, according to officials from EPA headquarters and regions, authorized states, and stakeholder groups. For example, officials from OECA, one authorized state, and two stakeholder groups said that additional training for EPA and state RCRA inspectors is needed to help them become comfortable and knowledgeable on managing climate risks as part of TSDF inspections and enforcement efforts. Further, EPA and state inspectors do not have needed decision-support tools for managing climate risks, according to officials from two EPA regions, one state program, and one stakeholder group.

TSDFs face similar challenges with having sufficient information and direction on managing climate risks, according to officials from EPA and three stakeholder groups, including an industry association. Our review of permits, contingency plans, and inspection reports for eight selected TSDFs located in areas that may be exacerbated by climate change did not find any information, evaluations, or requirements related to identifying, assessing, or responding to future climate risks. This suggests that TSDFs might benefit from more information or direction to manage these risks.

EPA, States, and TSDFs Face Resource Constraints

EPA and authorized states face constraints in having the financial and staff resources to manage climate risks as part of their permitting and compliance and enforcement efforts. For example, EPA grant funding for states to administer their RCRA programs (\$98 million in fiscal year 2022) has remained stagnant since 1995. If funding had kept up with inflation, the amount of funding states receive annually would be about 75 percent

higher, according to our analysis of EPA grant funding data.⁶⁷ Further, some authorized states have had their funding reduced based on EPA's grant allocation formula, according to documents we reviewed and interviews with officials from one region, one authorized state, and one stakeholder group. One authorized state said that a grant allocation cut and inflation rates over time reduced the state's RCRA program budget by a third.

As a result of these factors and funding constraints, officials from EPA headquarters and regions, two authorized states, and three stakeholder groups told us that some authorized states struggle to have sufficient financial and staff resources to run their RCRA programs. They said these states might not have the capacity and resources to conduct additional work related to managing climate risks in permitting and compliance and enforcement efforts.

EPA and regions can also face resource constraints, according to documents we reviewed and EPA headquarters and regional officials. For example, regional offices are tasked with making progress on many emerging issues, including climate change, for all EPA program areas, according to officials from one EPA region. This has made it challenging for the region to have the resources necessary to devote to managing climate risks in permitting and compliance and enforcement efforts. TSDFs also face resource constraints, such as high costs to implement climate adaptation measures, according to officials from EPA headquarters and regions and two stakeholder groups, including a large TSDF company. For example, retrofitting or changing facility operations to safeguard against increasing risks from natural hazards due to climate change can require significant funding, according to these officials and stakeholder groups.

However, OLEM and some EPA regions plan to use recent funding they received from the Inflation Reduction Act of 2022 (IRA) to fund projects that will increase their capacity to manage climate risks to TSDFs. According to OLEM officials, OLEM received about \$3 million for the RCRA permitting program, among other things, from the over \$40 billion

⁶⁷The Association of State and Territorial Solid Waste Management Officials has also reported that the total cost of operating the RCRA Subtitle C hazardous waste program in the authorized state hazardous waste programs was \$186,807,140 in fiscal year 2022, which is similar to the amount we calculated states would receive if funding had kept up with inflation. The Association of State Territorial and Solid Waste Management Officials, *Hazardous Waste Management Program Implementation Costs Report* (November 2023).

in total IRA appropriations that EPA received. OLEM plans to use some of these funds to integrate consideration of climate risks to TSDFs in its RCRA model permit and distribute the rest of the funds to regions. Two EPA regions said they planned to use IRA funds from OLEM for efforts related to managing climate risks to TSDFs. For example, Region 5 is considering using some of these funds to hire contractors to conduct climate vulnerability assessments for some of their TSDF permit reviews. However, two stakeholder groups and state officials from one state said that some authorized states face resource constraints but have not received any additional funding from EPA or other federal sources, such as the IRA.

EPA Has Opportunities to Address Challenges Related to Managing Climate Risks to TSDFs

Evaluate and Update RCRA TSDF Standards

EPA could evaluate TSDF standards and requirements to determine whether they are sufficient for managing climate risks and, as necessary, update them to explicitly account for or address these risks, according to documents we reviewed and interviews with officials from EPA, state programs, and stakeholder groups. For example, by setting climate risk-related technical requirements, design criteria, or adaptation best practices as part of standards for facilities or specific units, these standards could increase resilience to climate change and serve as the basis for TSDF permits developed by EPA regions, authorized states, and TSDFs.⁶⁸ This could include updating the 100-year floodplain or 25-year storm standard with standards that incorporate forward-looking climate information or that require TSDFs to design facilities and units to protect waste from more intense or frequent flood or storm conditions, according to documents we reviewed and interviews with officials from one EPA region, one state program, and four stakeholder groups. Additionally, EPA could consider adopting a standard that requires facilities to plan for

⁶⁸Depending on EPA's evaluation and the context of the standard or requirement, there could be different options for updating standards. For example, a technical requirement could include requiring certain facilities to conduct a precipitation vulnerability analysis or plan for certain levels of sea level rise depending on risk. Design criteria could involve a standard to design facilities or units to withstand a flood of a certain size, such as a 500-year flood or higher.

certain levels of sea level rise based on risk, according to a federal standard on managing flood risk to federal projects.⁶⁹

Officials from three EPA regions, three authorized states, and three stakeholder groups said that EPA should take a collaborative approach with authorized states and TSDFs to evaluate and update standards. For example, EPA could form a work group on evaluating and updating RCRA TSDF standards that includes EPA program offices, regions, and authorized states, according to some of these officials and stakeholder groups. Generally, these officials and stakeholder groups said that input from authorized states and associations, TSDFs, or standards organizations would be critical to evaluating and updating standards. Additionally, officials from one authorized state and a stakeholder group said that the rulemaking process would enable states and TSDFs to provide input on any updates to standards.⁷⁰

EPA's 2021 *Climate Adaptation Action Plan* states that EPA will ensure its programs, policies, rules, compliance and enforcement efforts, and operations consider current and future impacts of climate change to

⁶⁹Executive Order 14030, *Climate-Related Financial Risk*, reinstated Executive Order 13690 establishing a Federal Flood Risk Management Standard. 86 Fed. Reg. 27967 (May 25, 2021). The Executive Office of the President also released a report that reviews and updates the science to be considered when implementing the Federal Flood Risk Management Standard (FFRMS) under Executive Order 13690. Executive Office of the President, Office of Science and Technology Policy (OSTP), *Federal Flood Risk Management Standard Climate-Informed Science Approach (CISA) State of the Science Report* (March 2023). The Commonwealth of Virginia has also drafted a flood risk management standard that requires new state-owned buildings to plan for sea level rise based on the National Oceanographic and Atmospheric Administration (NOAA) Intermediate-High scenario curve for 2100 or the best available data. New state-owned buildings must comply with sea level rise planning standards if they are located in a designated sea level rise inundation zone, which are denoted by the maximum inland boundary of anticipated sea level rise. Virginia partnered with the Virginia Institute of Marine Science to develop the state's sea level rise planning standards and map these inundation zones.

⁷⁰An agency may develop and propose a standard itself through the rulemaking process to incorporate it into regulation. See, e.g., 40 C.F.R. § 264.18(b) (TSDF facility location standard adopted in *Standards Applicable to Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities; Consolidated Permit Regulations*, 46 Fed. Reg. 2802 (Jan. 12, 1981)). Alternatively, federal agencies can also adopt voluntary standards developed by the private sector or nongovernmental organizations through a rulemaking process. See GAO, *National Institute of Standards and Technology: Additional Review and Coordination Could Help Meet Measurement Service Needs and Strengthen Standards Activities*, [GAO-18-445](#) (Washington D.C.: July 26, 2018).

ensure they are effective and resilient to climate change.⁷¹ OLEM's 2022 *Climate Adaptation Implementation Plan* states it will ensure forward-looking climate data are consistently applied in planning and decisions informing site operations.

However, OLEM has not conducted a formal review to assess whether TSDF standards will be sufficient to protect human health and the environment from climate risks. The office also has not determined whether any standards should be updated to more fully account for these risks, such as by incorporating forward-looking climate data into certain standards. Without assessing whether TSDF standards will be sufficient to prevent the release of hazardous waste from climate risks or whether certain standards should be updated to more fully account for climate risks, EPA cannot have assurance that RCRA standards will be sufficient to address these risks.

Provide Additional Information,
Guidance, and Training

Officials from four EPA regions, three authorized states, and six stakeholder groups we spoke with also said it would be helpful if OLEM and OECA could identify authoritative, forward-looking climate data sources or provide data tools that could be used to manage climate risks. For example, it would be helpful to have climate projections data for understanding how natural hazard risks may be exacerbated over time. For example, EPA could provide climate data tools that could be used to identify whether a TSDF may face certain climate risks, according to interviews with officials from EPA and two stakeholder groups. EPA could also provide or identify climate data or tools that would be appropriate to use for conducting more detailed climate risk assessments to understand site-specific risks to TSDFs and determine adaptation measures to respond to the risks, according to officials from EPA, two authorized states, and three stakeholder groups. Having clarity on which climate data or tools are most appropriate or authoritative to manage climate risks as part of the RCRA program would help regions, authorized states, and TSDFs manage climate risks, according to these officials and stakeholder groups.

Additionally, OLEM and OECA could provide guidance, related decision tools, and training on how regions, states, and TSDFs should manage climate risks, according to interviews with officials from EPA headquarters and regions, authorized state officials, and stakeholder groups. For

⁷¹In June 2024, EPA released its updated Climate Adaptation Plan for 2024-2027, which highlighted EPA's planned actions from 2024 to 2027 to continue to make progress toward implementing its five priority action areas from the 2021 plan and strategic plan goals.

example, EPA could provide guidance to regions, states, and TSDFs on how they should identify, assess, and respond to climate risks as part of the RCRA program, according to these officials and stakeholder groups. In particular, some of these officials and stakeholder groups said that guidance on how to develop or design adaptation measures to respond to climate risks would help them manage these risks. Further, two stakeholder groups said that it would be helpful to have tangible real-life examples of TSDFs that had taken climate adaptation measures, because this would help authorized states and TSDFs learn from success stories.

The Hydrologic Evaluation of Landfill Performance (HELP) Model

Disposal of hazardous waste in a landfill produces a contaminated liquid known as leachate that can migrate out of the landfill into adjacent areas. External water, such as water from rainfall entering the landfill and percolating through waste layers, affects the volume of landfill leachate.

Design features and maintenance of the landfill and the leachate control system can limit migration of the leachate from a landfill to a minimal volume. For example, landfill design features include liner systems to prevent leaks, drainage layers to capture liquid, and a final landfill cover to protect the landfill from water.

To ensure landfills meet regulatory requirements, the U.S. Environmental Protection Agency (EPA) developed the HELP model as a tool for landfill operators and regulatory reviewers to use for evaluating and selecting landfill designs that minimize leakage of leachate to adjacent areas and potential contamination.

The HELP model relies on historical weather data and does not use current or projected climate change data, according to documents we reviewed and interviews with officials from one EPA region.

Source: GAO review of EPA documents and interview with regional officials. | GAO-25-106253

Officials from EPA regions, authorized states, and stakeholder groups also said that in addition to guidance and training, related decision support tools would help them know how to manage climate risks as part of permitting or compliance and enforcement. For example, EPA officials from one region said that EPA could provide decision-support tools for regions, authorized states, and TSDFs to factor in climate risks for decisions on permitting and compliance and enforcement. For permitting, these officials recommended that EPA's permitting tool on landfill design be updated to include forward-looking climate information. This would help regions, states, and TSDFs automatically factor in consideration of climate risks, because they already use this tool to ensure landfills will remain protective of human health and the environment.

Additionally, EPA enforcement staff have a range of tools for developing supplemental environmental projects related to renewable energy that would also be beneficial when developing climate adaptation projects for

enforcement efforts.⁷² For example, officials said that having tools that provide an inventory of examples of adaptation projects would help them know what measures are available to address climate risks. Moreover, these tools could include technical criteria for when certain adaptation projects could be required in an enforcement case versus included in settlements as supplemental environmental projects.

EPA's 2021 *Climate Adaptation Action Plan* states that EPA will develop decision-support tools that enable EPA staff and partners to integrate climate adaptation planning into their work and will support states, communities, and businesses by producing and delivering the training, tools, technical support, data, and information they need to adapt and increase climate resilience.⁷³

OLEM is currently developing a Climate Hazard Screening Tool that will provide relevant climate change data that can be used to screen TSDFs to determine whether they may face climate risks, according to OLEM officials.⁷⁴ OLEM officials said they are designing the tool to be in an accessible format that will enable decision-making within the RCRA permitting context for TSDFs. Additionally, these officials said that OLEM is developing an accompanying guidance document that will address how EPA regions and authorized states can use the tool to conduct a climate change screening analysis to determine whether a facility may face climate risks. The guidance will also cover how regions and authorized states should conduct a site-specific climate vulnerability assessment to evaluate potential risks and inform climate adaptation measures at specific facilities. Further, OLEM plans to update the RCRA Model Permit to include guidance for regions and states on writing TSDF permit

⁷²Most EPA actions against businesses, which could include TSDFs, or individuals for failure to comply with the environmental laws, such as RCRA, are resolved through settlement agreements. As part of a settlement, a violator may propose to undertake a project to provide tangible environmental or public health benefits to the affected community or environment that is closely related to the violation being resolved but goes beyond what is required under federal, state, or local laws. The voluntary agreement to perform a supplemental environmental project is one factor that is considered in determining an appropriate settlement penalty. EPA supports the inclusion of supplemental environmental projects in settlement agreements, according to an EPA policy memorandum.

⁷³In June 2024, EPA released its updated Climate Adaptation Plan for 2024-2027, which highlighted EPA's planned actions from 2024 to 2027 to continue to make progress toward implementing its five priority action areas from the 2021 plan and strategic plan goals.

⁷⁴OLEM officials said the tool would use appropriate climate change data from federal and state sources.

conditions that consider climate change risks. OLEM officials said these efforts would help address challenges that regions, states, and TSDFs face in needing additional direction and guidance on managing these risks.

While OLEM has efforts underway to provide climate screening tools and assessment methodologies for managing climate risks to TSDFs, it has not yet developed the guidance, tools, and training that EPA regions, states, and TSDFs need to provide direction on how to manage climate risks as part of RCRA permitting. OECA also has not developed and provided specific guidance, tools, or training to EPA regions and authorized states on how to manage climate risks as part of EPA's RCRA compliance and enforcement program. Additionally, OECA officials said OECA is considering developing compliance assistance guidance for TSDFs but has not done so. Without OLEM and OECA issuing guidance on how to manage climate risks as part of the RCRA program—and identifying or providing related data, training, or tools—regions, authorized states, and TSDFs may not have the direction and information they need to manage these risks to prevent hazardous waste releases.

Identify Additional Sources of Resilience Funding for Authorized States and TSDFs

One opportunity for OLEM to address resource challenges is to determine whether authorized states and TSDFs may be eligible for additional financial resources from federal funding sources for climate adaptation, such as the IRA, and help them leverage or apply for these resources. For example, OLEM officials said that while most of the \$40 billion in IRA funding had already been allocated across EPA's programs, there might be opportunities for some of these funds to be reallocated over the next 2 years before the funds must be spent.

Further, these officials said there are other EPA offices with grant programs that received IRA funds, and authorized states or TSDFs might be eligible to apply for or receive funds for climate adaptation-related projects or activities from these programs, depending on the specific grant program requirements. Authorized states or TSDFs may be eligible to receive or apply for any reallocated IRA funds or these EPA grants for funding that could be used for climate adaptation-related projects or activities.

Additionally, there may be other federal agency grant programs that authorized states or TSDFs could leverage funding from to help provide resources for them to manage climate change risks. For example, authorized states may be eligible to receive funding from FEMA's Building Resilient Infrastructure and Communities program that would provide

them with resources to help them incorporate climate adaptation into their RCRA programs or fund adaptation projects to reduce risks to TSDFs. Another FEMA program that authorized states may be eligible for funding from to help manage climate risks is the Emergency Management Performance Grant program. See Table 7 for examples of authorized state activities that may be eligible for grant funding under FEMA's Emergency Management Performance Grant program.

Table 7: State Resource Conservation and Recovery Act (RCRA) Program Climate Adaptation Activities That May Be Eligible for Grant Funding under FEMA's Emergency Management Performance Grant Program

<p>State RCRA program climate adaptation activities that may be eligible for grant funding</p>	<ul style="list-style-type: none"> • Developing or updating state RCRA program climate adaptation plans or other internal plans that would cover climate resilience planning, risk assessment, and vulnerability reduction for their programs and prevention of treatment, storage, and disposal facility (TSDF) hazardous waste releases. • Conducting climate risk or vulnerability assessments for TSDFs and designing climate adaptation actions to include as part of permits or inspections. • Developing, adopting, evaluating, or enhancing state RCRA program standards for TSDFs that are related to reducing risks from natural hazards and that consider future effects from climate change. • Funding for technical assistance, contractor support, or climate data and modeling resources that authorized states need to be able to identify and assess climate risks to TSDFs and develop climate adaptation measures for permitting or inspections.
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Source: GAO analysis of responses from Federal Emergency Management Agency (FEMA) officials. | GAO-25-106253

OLEM officials said they were not aware of additional funding sources or grant programs from other federal agencies that authorized states and TSDFs could apply for or leverage to receive funding for climate adaptation efforts. However, OLEM officials said they were interested in learning if there were other sources and said that if they were made aware of additional funding resources or grant programs, they could inform regions and authorized states and potentially help them leverage these sources.

EPA's 2021 *Climate Adaptation Action Plan* states that EPA will support more climate-resilient investments by states with the goal of strengthening their adaptive capacity.⁷⁵ GAO's *Disaster Resilience Framework* states that federal efforts can increase resilience by helping decision-makers identify and combine available funding sources and

⁷⁵In June 2024, EPA released its updated Climate Adaptation Plan for 2024–2027, which highlighted EPA's planned actions from 2024 to 2027 to continue to make progress toward implementing its five priority action areas from the 2021 plan and strategic plan goals.

innovative methods for meeting disaster risk-reduction needs.⁷⁶ While OLEM plans to use some IRA resources for managing climate risks as part of the RCRA program, it has not identified and communicated to authorized states additional potential financial resources or assistance that may be available. By identifying and communicating with authorized states about potential resources, OLEM can take advantage of opportunities to address resource challenges that constrain the ability of states and TSDFs to manage climate risks.

Conclusions

Climate change may exacerbate natural hazards, such as flooding, storm surge, sea level rise, and wildfires, which could lead to releases of hazardous waste at TSDFs that threaten human health and the environment. EPA has the opportunity to reduce the risk of releases by ensuring that authorized states and TSDFs are managing climate risks.

However, we found that EPA regions, authorized states, and TSDFs need more clarity on whether managing climate risks is required under RCRA regulations and whether regions and states have authority to do so as part of RCRA permitting and compliance and enforcement. EPA has recently taken steps, such as issuing a guidance memorandum to EPA regional offices, to identify authorities and requirements for managing climate risks to TSDFs as part of RCRA permitting. However, some states and TSDFs may not implement this guidance without EPA amending regulations to explicitly clarify authorities and requirements. EPA officials believe that, in addition to the memorandum, it could provide training and technical assistance to regions and authorized states to address these concerns and help enable them to implement the guidance in the memorandum. However, EPA has not developed and provided this training or assistance to these regions and states.

Additionally, EPA officials said they are considering seeking feedback on potential revisions to RCRA regulations to clarify requirements and authorities related to managing climate risks to TSDFs but had not determined whether they would revise the regulations. EPA could use this rulemaking to seek feedback from states, TSDFs, and other stakeholders to assess whether the guidance in the June 2024 memorandum is sufficient or revisions to regulations would be necessary to fully clarify requirements and authorities for managing climate risks to TSDFs. Without developing and providing the training and technical assistance

⁷⁶GAO, *Disaster Resilience Framework: Principles for Analyzing Federal Efforts to Facilitate and Promote Resilience to Natural Disasters*, [GAO-20-100SP](#) (Washington D.C.: Oct. 23, 2019).

that EPA regions and states need to implement recent guidance and seeking feedback to determine whether revising regulations is necessary to fully clarify RCRA authorities and requirements for managing climate risks to TSDFs, OLEM risks not being able to ensure effective and consistent management of these risks.

While EPA has issued a memorandum directing all of its enforcement and compliance offices to manage climate risks, the guidance does not specify how managing climate risks will be incorporated into the RCRA program or clarify requirements and authorities for EPA regions and authorized states' RCRA compliance and enforcement programs. Without issuing guidance to clarify how and when to use RCRA authorities and requirements for managing climate risks to TSDFs as part of these efforts, EPA will be unable to ensure effective and consistent management of climate risks as part of RCRA compliance and enforcement for TSDFs.

Furthermore, EPA has not developed and implemented performance metrics for assessing whether and how states and TSDFs have managed climate risks as part of RCRA permitting or compliance and enforcement efforts. OLEM and OECA could incorporate such performance metrics into existing monitoring and oversight tools to assess progress in achieving climate adaptation goals in the hazardous waste program, but have not yet done so. OLEM has developed term and condition language for EPA regions to include in state grant agreements that would require states to provide information on how climate risks were considered in permitting for TSDFs. However, OLEM officials said the term and condition would take at least 3 years to fully implement. In the meantime, without EPA developing and implementing metrics to assess whether and how states and TSDFs are managing climate risks, EPA risks being unable to determine whether states and TSDFs are managing these risks sufficiently or if EPA is making progress on agency goals.

EPA regions, authorized states, and TSDFs also face several challenges in managing climate risks to TSDFs. For example, climate risks may reduce the effectiveness of certain RCRA TSDF standards that were developed to prevent hazardous waste releases. Additionally, regions, states, and TSDFs face challenges in knowing how they should manage climate risks and what information or data they should use to do so as part of RCRA permitting and compliance and enforcement. By evaluating and updating RCRA standards and other requirements, as needed, and issuing guidance on how to manage climate risks, along with providing data, tools, and training, EPA could better ensure these risks are

managed sufficiently and that regions, states, and TSDFs have the direction and information necessary to do so.

Finally, EPA and authorized states face constraints in having the financial and staff resources to manage climate risks as part of RCRA permitting and compliance and enforcement efforts. TSDFs can face resource constraints as well, such as high costs to implement climate adaptation measures. One opportunity for EPA to help address resource challenges is to identify additional financial resources from federal resilience funding sources that authorized states and TSDFs could apply for or leverage to help them manage climate risks. Without identifying and communicating potential resources to authorized states, EPA is missing opportunities to address resource challenges that constrain the ability of states and TSDFs to manage climate risks.

Recommendations for Executive Action

We are making the following nine recommendations to EPA:

The Assistant Administrator of the Office of Land and Emergency Management should develop and provide training and technical assistance to help EPA regions and authorized states implement recent guidance on using existing authorities and requirements to manage climate risks to TSDFs. (Recommendation 1)

The Assistant Administrator of the Office of Land and Emergency Management should use its upcoming rulemaking to seek feedback from authorized states, TSDFs, and other stakeholders to assess whether its recent guidance is sufficient or revising regulations would be necessary to clarify requirements for managing climate risks to TSDFs. (Recommendation 2)

The Assistant Administrator of the Office of Enforcement and Compliance Assurance should issue guidance to clarify RCRA authorities and requirements for managing climate risks to TSDFs as part of authorized states' and EPA regions' RCRA compliance and enforcement efforts. (Recommendation 3)

The Assistant Administrator of the Office of Land and Emergency Management, in consultation with EPA regional offices, should develop and implement monitoring metrics and assess whether and how authorized states and TSDFs are managing climate risks to TSDFs in RCRA permitting and oversight efforts. (Recommendation 4)

The Assistant Administrator of the Office of Enforcement and Compliance Assurance, in consultation with EPA regional offices, should develop and implement monitoring metrics and assess whether and how authorized states and TSDFs are managing climate risks to TSDFs in RCRA compliance monitoring and enforcement efforts. (Recommendation 5)

The Assistant Administrator of the Office of Land and Emergency Management, together with other relevant EPA offices and EPA regions, should assess the current RCRA TSDF standards and requirements to determine if they will be sufficient to manage climate risks and, if one or more of them need to be updated to ensure they remain protective of human health and the environment, develop a plan for any revisions or updates. (Recommendation 6)

The Assistant Administrator of the Office of Land and Emergency Management should issue guidance to EPA regions, authorized states, and TSDFs on how to manage climate change risks as part of RCRA program permitting efforts for TSDFs and identify or provide related data, training, or tools. (Recommendation 7)

The Assistant Administrator of the Office of Enforcement and Compliance Assurance should issue guidance to EPA regions, authorized states, and TSDFs on how to manage climate change risks as part of RCRA program compliance and enforcement efforts for TSDFs and identify or provide related data, training, or tools. (Recommendation 8)

The Assistant Administrator of the Office of Land and Emergency Management, together with other relevant EPA offices and regions, should identify and communicate additional financial resources and assistance from federal resilience funding sources that may be available to authorized states and TSDFs. (Recommendation 9)

Agency Comments

We provided a draft of this report to EPA for review and comment. EPA provided written comments, reproduced in appendix IV, and stated that it generally agrees with our findings, conclusions, and recommendations. EPA noted that it has already taken some action, and plans to take additional action, to implement the nine recommendations in the report. These actions, if fully implemented, should address the intent of our recommendations.

Related to the first recommendation, EPA said that it released guidance in June 2024 that calls for EPA regions and authorized states to consider climate risks in the hazardous waste permitting process for TSDFs,

among other things, and is in the process of developing four webinar trainings to assist EPA regions and authorized states in implementing this guidance memorandum. EPA stated that these webinars are planned to be held in November 2024 through January 2025. EPA also noted that the webinars will be widely available to states and the public and grouped by the Northeast, Northwest, Southeast, and Southwest sections of the country, so they may also target climate impacts of particular concern in distinct parts of the United States. Related to the second recommendation, EPA stated that, as part of an upcoming rulemaking, it plans to assess whether revisions to its RCRA permit regulations are needed to clarify requirements for managing climate risks to TSDFs.

Related to the third recommendation, EPA said it will work with EPA regions and authorized states to implement recent guidance memoranda on using existing RCRA authorities and requirements to manage climate risks to TSDFs on a site-specific basis in compliance and enforcement efforts, and also consider developing additional guidance explaining how climate change adaptation considerations should be incorporated into RCRA enforcement efforts.

Related to the fourth recommendation, EPA stated that it has directed authorized states to start providing information on how potential climate risks were considered in permitting for TSDFs and that this information will be incorporated in the states' grant work plans and annual reports as grants are renewed in fiscal years 2025 through 2027. Further, EPA said that, by May 2026, it plans to compile and summarize information from state grant annual reports on how potential climate risks were considered in RCRA permitting for TSDFs. Then, by May 2027, EPA plans to develop a procedure for monitoring and assessing on an ongoing basis how authorized states and TSDFs are managing climate risks to TSDFs.

Related to the fifth recommendation, EPA said that as national policy requirements or regulations are updated to include consideration of climate risks in the hazardous waste program, it will update enforcement and compliance guidance accordingly. EPA said that this could include developing compliance monitoring and enforcement metrics, new programs for EPA data systems, and providing training and guidance on how to measure compliance with any new requirements, among other things.

Related to the sixth recommendation, EPA said it is assessing the current RCRA TSDF regulations as part of its efforts to develop a rulemaking for RCRA permitting that it plans to publish in 2025. According to EPA, it is

considering proposing specific provisions to address climate risk as part of this rulemaking. Provisions may include requirements to assess and address climate change risk as part of facility permit applications; modify permits if climate change risk at a facility changes; implement facility design and operation standards to mitigate risk; and use portions of a federal standard to define flood risk requirements.

Related to the seventh recommendation, EPA said it plans to provide training and additional tools for managing climate risks as part of implementing its June 2024 permitting guidance mentioned above. Related to the eighth recommendation, EPA stated that it issued guidance directing all EPA enforcement and compliance offices to address climate change as a part of inspections and enforcement. EPA said it plans to obtain feedback from EPA regions and authorized states on the effectiveness of current compliance and enforcement efforts related to climate change and discuss additional tools and resources needed to achieve the goals of its September 2023 guidance, among other things.

Related to the ninth recommendation, EPA said that it is using funds provided through the Inflation Reduction Act to support RCRA climate training, climate vulnerability screening, and facility mapping to support climate assessments at facilities. Further, EPA said that it will continue to work to identify federal resilience funding sources that may be available to support consideration of climate change at TSDFs.

EPA also provided technical comments, which we incorporated as appropriate.

We are sending copies of this report to the appropriate congressional committees, the Administrator of the Environmental Protection Agency, and other interested parties. In addition, the report is available at no charge on the GAO website at <http://www.gao.gov>.

If you or your staff have any questions about this report, please contact me at (202) 512-3841 or gomezj@gao.gov. Contact points for our Offices of Congressional Relations and Public Affairs may be found on the last

page of this report. GAO staff who made key contributions to this report are listed in appendix V.

A handwritten signature in black ink that reads "Alfredo Gómez". The signature is written in a cursive style with a large, stylized 'G' at the end.

J. Alfredo Gómez
Director, Natural Resources and Environment

Appendix I: Objectives, Scope, and Methodology

This report examines the U.S. Environmental Protection Agency's (EPA's) role in addressing climate risks at treatment, storage, and disposal facilities (TSDFs) regulated under the Resource Conservation and Recovery Act of 1976, as amended (RCRA).¹ Specifically, it examines the (1) extent to which TSDFs are located in areas with selected natural hazards that may be exacerbated by climate change; (2) extent to which EPA requires or encourages authorized states and TSDFs to manage risks to human health and the environment from climate change; and (3) challenges that EPA, authorized states, and TSDFs face in managing risks to human health and the environment from climate change, and opportunities for EPA to address these challenges.

To examine the extent to which TSDFs are located in areas with selected natural hazards that may be exacerbated by climate change, we reviewed reports and documents on climate change; interviewed officials from EPA, authorized states, and stakeholder groups; and conducted a data analysis. The reports and documents on climate change we reviewed include the *Fifth National Climate Assessment*, EPA documents (such as EPA studies, EPA's agency-wide adaptation plan, and specific EPA office and regional climate adaptation implementation plans), academic literature, documents from standards-setting organizations, and our prior work on climate change.²

¹This report reviews EPA's role in addressing climate risks to operating and post-closure TSDFs and related hazardous waste release prevention efforts. For the purposes of this review, the report is not evaluating EPA's actions related to TSDFs subject to corrective action—requirements to clean up a hazardous waste release that has already taken place at a facility.

²U.S. Global Change Research Program, *Fifth National Climate Assessment* (Washington, D.C.: 2023). The Global Change Research Act of 1990 requires the Committee on Earth and Environmental Sciences of the Federal Coordinating Council on Science, Engineering, and Technology to prepare and submit a scientific assessment of the current and projected effects and trends of global change at least every 4 years. Pub. L. No. 101-606, §106, 104 Stat. 3096, 3101 (*codified at* 15 U.S.C. § 2936). The U.S. Global Change Research Program, which coordinates and integrates the activities of 15 participating federal departments and agencies that carry out research and support the nation's response to global change, conducts this national assessment, known as the National Climate Assessment. For prior GAO reports, see, for example, GAO, *Chemical Accident Prevention: EPA Should Ensure Regulated Facilities Consider Risks from Climate Change*, [GAO-22-104494](#) (Washington, D.C.: Feb. 28, 2022); *Superfund: EPA Should Take Additional Actions to Manage Risks from Climate Change*, [GAO-20-73](#) (Washington, D.C.: Oct. 18, 2019); *Climate Change: Better Management of Exposure to Potential Future Losses Is Needed for Federal Flood and Crop Insurance*, [GAO-15-28](#) (Washington, D.C.: Oct. 29, 2014); and *FEMA Flood Maps: Some Standards and Processes in Place to Promote Map Accuracy and Outreach, but Opportunities Exist to Address Implementation Challenges*, [GAO-11-17](#) (Washington, D.C.: Dec. 2, 2010).

Based on our review, we identified the following natural hazards that may be exacerbated by climate change:

- Increased intensity and frequency of heavy precipitation events, which may lead to increased local flooding;
- Increased intensity—including higher wind speeds, storm surge, and precipitation rates—and frequency of very intense hurricanes and typhoons;
- Increased incidence of large wildfires;
- Sea level rise, which may lead to increased frequency and extent of extreme flooding from coastal storms, saltwater intrusion, and higher groundwater table levels;
- Greater frequency and magnitude of drought;
- Increased frequency and intensity of extreme hot and cold temperatures and sustained increases in average temperatures;
- Decreased permafrost;

To determine which of these natural hazards could affect TSDFs, we interviewed officials from EPA, authorized states, and stakeholder groups and reviewed the National Climate Assessment, prior GAO reports, EPA documents, and other relevant documents or reports.

For our data analysis, we identified federal datasets available for four selected natural hazards—flooding, storm surge, wildfires, and sea level rise—and geographic location data for TSDFs. Through a review of federal agencies' documents and databases, the National Climate Assessment, other relevant literature, interviews, and previous GAO work, we identified available national federal datasets for the four selected natural hazards that may be exacerbated by climate change—flooding, storm surge, wildfires, and sea level rise—from the Federal Emergency Management Agency (FEMA), the National Oceanic and Atmospheric Administration (NOAA), and the U.S. Forest Service. For wildfires, flooding, and hurricane storm surge, the federal data are based on existing or historical weather patterns and data (which do not incorporate climate projections).³ For sea level rise, we used data for

³To analyze flood exposure, we used 2023 data from FEMA that categorizes flood exposure into high, moderate, minimal or other, and unknown flood hazard categories. To analyze exposure to hurricane storm surge, we used NOAA data on storm surge exposure from Categories 1, 4, and 5 hurricanes. To analyze exposure to wildfires, we used 2023 data from the U.S. Forest Service on wildfire hazard potential.

coastal regions and sea level rise projections from an interagency report covering sea level rise scenarios.⁴ In this report, we refer to these hazards collectively as selected natural hazards that may be exacerbated by climate change.

Data sources for each of the hazards we analyzed are as follows:

- **Wildfire.** To analyze exposure to wildfire hazard potential, we used 2023 data from the U.S. Forest Service’s Wildfire Hazard Potential Map. For reporting purposes, we grouped wildfire hazard potential into three categories: no/low, moderate, and high/very high.⁵
- **Flooding.** To analyze exposure to flood hazards, we used 2023 data from FEMA’s National Flood Hazard Layer. For reporting purposes, we grouped flood hazard zones into three categories: no/low, moderate, and high.⁶
- **Hurricane storm surge.** To analyze exposure to various levels of hurricane storm surge, we used data from NOAA’s Sea, Lake, and Overland Surges from Hurricanes model. In our analysis, we used data on storm surge from Category 1 hurricanes (the lowest possible category) and Categories 4 and 5 hurricanes (the highest possible categories) to show a range of climate change effects.
- **Sea level rise.** To analyze potential exposure to sea level rise, we used data from an interagency report covering sea level rise scenarios for 2050 and 2100 to illustrate regional climate projections

⁴W. V. Sweet, et al., *2022 Global and Regional Sea Level Rise Scenarios for the United States: Updated Mean Projections and Extreme Water Level Probabilities Along U.S. Coastlines*, NOAA Technical Report NOS 01 (Silver Spring, MD: February 2022).

⁵We combined layers of “high” and “very high” wildfire hazard potentials, which correspond to areas at the 85th percentile or greater for wildfire hazard potential. The no/low category includes plants that are in areas that are not covered by the “moderate,” “high,” or “very high” wildfire potential layers.

⁶No/low corresponds to areas with minimal, unknown, or other flood hazards, including areas with reduced risk because of levees as well as areas with flood hazard based on future conditions, such as the future implementation of land-use plans. Moderate flood hazard zones correspond to a 500-year floodplain, which indicates between 0.2 percent and 1 percent annual chance of flooding. High flood hazard zones correspond to a 100-year floodplain, which indicates a 1 percent or higher annual chance of flooding. In cases where a facility’s boundary intersected with both a 100-year floodplain and a 500-year floodplain, we counted the facility as located in the 100-year floodplain but also reported on the number of facilities located in both a 100-year floodplain and a 500-year floodplain.

for sea level rise in coastal regions.⁷ NOAA officials recommended using these projections for our analysis of sea level rise data.

To identify TSDf locations, we used EPA and state data from EPA's RCRAInfo database, as of July 2023, to identify operating TSDFs with permits that allowed them to actively handle hazardous waste and nonoperating TSDFs with post-closure care permits for units with waste in place.⁸ To determine if a TSDf is located in an area with exposure to flooding, wildfire, storm surge, or sea level rise, we identified overlap between an estimated radius around a facility's primary coordinates provided by EPA and federal data for each of these selected hazards. Overlap indicates that a facility is located in an area that may be affected by one or more of these selected hazards.⁹ We approximated the boundaries of TSDFs using a radius around each facility's primary geographic coordinates based on acreage data for the facility provided by

⁷To analyze potential exposure to sea level rise, we used federal data for one sea level rise scenario for the year 2050 and three sea level rise scenarios—Low, Intermediate, and High—for the year 2100. We used three scenarios for 2100 because of greater uncertainty for scenarios further in the future. These scenarios provide information on a range of potential outcomes that affect whether TSDFs will be exposed to this hazard. As a result, these scenarios are subject to uncertainty. NOAA officials told us that, currently, the Intermediate scenarios for 2050 and 2100 are more likely to occur than either the low or high scenarios, based on observational data and modeling projections. We used the Intermediate scenario for 2100 to identify the number of TSDFs located in areas that may be inundated by sea level rise but also report the number of TSDFs that would be affected under a High scenario for 2100. The two primary limitations the interagency report discusses for the sea level rise estimates we use include process uncertainty and emission uncertainty. Process uncertainty refers to uncertainty about the impact of greenhouse gas emissions on ice sheet loss, ocean expansion, and local ocean dynamics. Emission uncertainty refers to the uncertain amount of greenhouse gas emissions that will enter the atmosphere, trap heat, and affect temperature and sea level rise.

⁸The RCRAInfo database is an EPA information system that includes data for TSDFs, such as addresses for specific TSDFs, contact information, unique facility identification numbers, geographic information system coordinates for facilities, waste types and waste management units at facilities, and permitting status. These data would not include any updates to TSDf information in the RCRAInfo system that occurred after July 2023. As a result, we did not include TSDFs in our analysis if they did not have a relevant operating or nonoperating status code as of July 2023.

⁹Our analysis is a screening-level analysis that estimated the number of TSDFs located in areas with selected natural hazards that may be exacerbated by climate change without site-specific information. Such a screening level analysis evaluates whether TSDFs have exposure to climate-related hazards that could lead to facility risks but is not intended to provide estimates of actual risk for specific facilities. To evaluate the risk that a specific facility may face from existing natural hazard conditions or future conditions due to climate change (such as if climate change leads to an increase in the intensity or frequency of a natural hazard), site-specific information would need to be evaluated in conjunction with exposure information.

EPA. Facility boundaries based on these data do not account for where hazardous waste is specifically handled at facilities, and we did not analyze site-specific information for these TSDFs, such as steps specific facilities have taken to manage potential risks from selected natural hazards. Such site-specific analyses would be necessary to determine whether there is a risk to human health and the environment at TSDFs as a result of these hazards. This analysis is based on the most recently available data from EPA, FEMA, NOAA, and the U.S. Forest Service, as of 2023.

To assess the reliability of FEMA's National Flood Hazard Layer, NOAA's data on Sea, Lake, and Overland Surges from Hurricanes, and the U.S. Forest Service's Wildfire Hazard Potential data, we reviewed prior GAO data reliability assessments for reports using the same data.¹⁰ Then, through interviews and email correspondence with NOAA, FEMA, and U.S. Forest Service officials, we ensured that these data remained appropriate and reliable, considering any subsequent updates or changes made to the data. To assess the reliability and appropriate use of sea level rise data for use in our analysis, we reviewed regional sea level rise data in an interagency report covering sea level rise scenarios and interviewed NOAA officials knowledgeable about sea level rise data.

To assess the reliability of EPA's data on TSDFs from the RCRAInfo database, we reviewed agency manuals to understand data elements, reviewed prior EPA Office of Inspector General reports that used data on TSDFs from the database, and interviewed EPA headquarters and regional officials to assess the timeliness and accuracy of the data. As a result of the steps described above, we found the data from EPA, FEMA, NOAA, and the U.S. Forest Service to be sufficiently reliable for our purposes.

To examine the extent to which EPA requires or encourages authorized states and TSDFs to manage risks to human health and the environment from climate change, we analyzed documentary and testimonial evidence from EPA headquarters and five selected EPA regional offices, four

¹⁰GAO, *Chemical Accident Prevention: EPA Should Ensure Regulated Facilities Consider Risks from Climate Change*, [GAO-22-104494](#) (Washington, D.C.: Feb. 28, 2022) and *Superfund: EPA Should Take Additional Actions to Manage Risks from Climate Change*, [GAO-20-73](#) (Washington, D.C.: Oct. 18, 2019).

selected authorized states, and eight stakeholder groups.¹¹ We also analyzed statutory and regulatory requirements, executive orders, and EPA policy documents to identify climate-related requirements and guidance. We reviewed guidance that the selected EPA regions provided to authorized states on developing annual work plans for their RCRA programs. As part of this, we assessed the extent to which the selected regions provided requirements or regional guidance for authorized states to include work plan goals or commitments related to managing climate risks to TSDFs.¹² We reviewed all 25 state RCRA program work plans for fiscal year 2024 from the selected EPA regions to assess the extent to which these plans include commitments to incorporate climate-related risks into its RCRA oversight at TSDFs. We also reviewed RCRA permits, contingency plans, and compliance inspection reports for eight TSDFs.¹³ We assessed the extent to which these permits, contingency plans, and inspection reports identified, assessed, or addressed climate risks at the facilities, such as whether the documents accounted for future projections of natural hazards that may be exacerbated by climate change and how potential changes could affect the facilities.

¹¹We selected EPA Regions 2, 4, 5, 6, and 9 based on multiple factors, including the total number of active and post-closure TSDFs within the region, geographical diversity, and variation of natural hazards that may be exacerbated by climate change. Using the same criteria, we selected one state RCRA program from each selected EPA region: New Jersey (Region 2), Florida (Region 4), Illinois (Region 5), Texas (Region 6), and California (Region 9). We interviewed officials from four of these authorized states because state officials from Florida declined interview requests for our review. Subsequently, we requested to meet with Georgia RCRA program officials, however they also declined our request to interview. As a result, we did not interview an authorized state from Region 4. We reviewed state work plans for all eight authorized states—including Florida and Georgia—within EPA Region 4. Stakeholder groups are state associations, an industry association, other non-profit or research organizations, and a national TSDF operator and two of its facilities. We selected these stakeholder groups based on recommendations from other interviewees, the organization's relevance to our scope and objectives, among other considerations.

¹²We reviewed EPA and state documents for state work plans for fiscal year 2024 because they were the most recent documents available during the evidence-gathering phase of our review.

¹³We selected eight TSDFs and reviewed their current permits, contingency plans, and two most recent inspection reports. We also reached out to the operators of these eight TSDFs for interviews, and officials from two of these facilities agreed to be interviewed. We considered several factors in selecting these eight TSDFs, including whether the TSDF was actively handling hazardous waste or had a post-closure unit with waste in place, was located in an area with one or more natural hazards that may be exacerbated by climate change, provided geographic diversity, and was recommended or identified by EPA officials, authorized state program officials, or stakeholders. These eight TSDFs were located in each of the five selected EPA regions.

To identify challenges EPA, authorized states, and TSDFs face in managing risks to human health and the environment from climate change, and opportunities for EPA to address these challenges, we reviewed EPA documents, our prior work, and other relevant documents or reports (e.g., academic literature and reports or documents from nonprofit organizations). We also interviewed officials from EPA headquarters and selected regions, selected authorized states, and stakeholder groups to obtain their views on the challenges EPA, authorized states, and TSDFs face in managing risks from climate change and opportunities for EPA to address these challenges. We reviewed interviews and documents and identified common themes among the challenges cited by these sources. We further identified examples of challenges associated with these themes. The views of selected EPA regions, authorized states, and stakeholder groups we interviewed are illustrative and not generalizable to all EPA regions, states, and stakeholder groups.

We conducted this performance audit from September 2022 to November 2024 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

Appendix II: Available Federal Data on Wildfire, Flooding, Storm Surge, and Sea Level Rise

U.S. Forest Service Wildfire Hazard Potential Data

The U.S. Forest Service maps wildfire hazard potential based on landscape conditions and other observations. We previously reported that the primary intended use of the wildfire hazard potential map is to identify priority areas for hazardous fuels treatments from a broad, national- to regional-scale perspective. The data do not explicitly show wildfire threat or risk.¹

The U.S. Forest Service maps an index of wildfire hazard potential for the contiguous United States based on, among other factors, annual burn probabilities and potential intensity of large fires. The U.S. Forest Service categorizes the wildfire hazard potential index into five classes: very low, low, moderate, high, and very high. The U.S. Forest Service designates as “high” those areas with wildfire hazard potential index from the 85th to the 95th percentiles, and as “very high” those areas above the 95th percentile. The U.S. Forest Service also categorizes some areas as nonburnable (including agricultural lands, developed lands, and water).

As we previously reported, according to the U.S. Forest Service, areas with higher levels of wildfire hazard potential have fuels that are more likely to burn with high intensity under certain weather conditions. Areas with moderate wildfire hazard potential are less likely to experience high-intensity wildfire than those areas located in very high or high wildfire potential but could still be at significant risk of a wildfire occurring, according to U.S. Forest Service officials. Areas with low and very low wildfire hazard potential may also still experience wildfires, particularly near areas with higher wildfire hazard potential.

We used 2023 wildfire hazard potential data. These data incorporated methodological changes to the fire simulation modeling to better represent probabilistic components of wildfire hazard for the fuel and climate conditions as they exist today, according to U.S. Forest Service officials we interviewed. For our analysis, we combined the high and very

¹The objective of the wildfire hazard potential map is to depict the relative potential for wildfire that would be difficult for suppression resources to contain. The U.S. Forest Service’s Wildfire Hazard Potential map is available at <https://www.fs.usda.gov/rds/archive/catalog/RDS-2015-0047-4>.

high wildfire hazard potential categories; we did not identify the number of facilities in each of these categories separately.²

Federal Emergency
Management Agency
Flood Hazard Data

The Federal Emergency Management Agency's National Flood Hazard Layer provides data on the most current coastal and riverine flooding hazard data.³ Among other uses, the flood hazard data are used for flood insurance ratings and floodplain management. The National Flood Hazard Layer identifies areas with the highest risk of flooding, with a 1 percent or higher annual chance of flooding.⁴ In some locations, the National Flood Hazard Layer also identifies areas with a 0.2 percent or higher annual chance of flooding, which the Federal Emergency Management Agency considers moderate flood hazards, and other flood hazards.⁵ The National Flood Hazard Layer also identifies areas with minimal flood hazards, including those with less than 0.2 percent annual chance of flooding, and unknown flood hazards, including areas the Federal Emergency Management Agency has not assessed for flood hazards.

The National Oceanic and
Atmospheric
Administration Storm
Surge Hazard Data

The National Oceanic and Atmospheric Administration (NOAA) provides estimates of hurricane storm surge using a model called Sea, Lake, and

²We combined layers of "high" and "very high" wildfire hazard potentials, which correspond to areas at the 85th percentile or greater for wildfire hazard potential. The no/low category includes plants that are in areas that are not covered by the "moderate," "high," or "very high" wildfire potential layers.

³Riverine flooding is flooding related to or caused by a river, stream, or tributary overflowing its banks because of excessive rainfall, snowmelt, or ice. The Federal Emergency Management Agency provides a tool for viewing, downloading, and printing flood maps for specific locations. The Federal Emergency Management Agency's flood hazard maps are available at <https://www.fema.gov/flood-maps/national-flood-hazard-layer>. Federal law requires the Federal Emergency Management Agency to assess the need to revise and update the nation's floodplain areas and flood risk zones once every 5 years or more often as the Administrator determines necessary. 42 U.S.C. § 4101(e).

⁴These areas are known as Special Flood Hazard Areas. Under federal law, in communities that participate in the National Flood Insurance Program, homeowners are required to purchase flood insurance for properties located in Special Flood Hazard Areas that are secured by mortgages from federally regulated lenders. 42 U.S.C. § 4012a(b)(1).

⁵Other flood hazards include areas with reduced risk because of levees, as well as areas with flood hazard based on future conditions, for example, if land use plans were implemented. FEMA flood hazard data do not include information on future conditions due to climate change, according to FEMA officials.

Overland Surges from Hurricanes.⁶ Estimates for storm surge are available for coastal areas in the eastern United States from Texas to Maine as well as in Hawaii, Puerto Rico, and the U.S. Virgin Islands. As of November 2023, storm surge data for coastal areas in the western United States were only available for Southern California.

The model accounts for specific shorelines by incorporating bay and river configurations, water depths, bridges, roads, levees, and other physical features. It estimates the maximum extent of storm surge at high tide by modeling hypothetical hurricanes under different storm conditions, such as landfall location, storm trajectory, and forward speed.

NOAA models storm surge for Category 1 through Category 5 hurricanes for the Atlantic coast south of the North Carolina-Virginia border, the Gulf of Mexico, Puerto Rico, and the U.S. Virgin Islands; and Category 1 through Category 4 hurricanes for the Atlantic coast north of the North Carolina-Virginia border and Hawaii.⁷ As we previously reported, the model is to be used for educational purposes and to increase awareness of storm surge hazards at the city or community level.⁸ According to NOAA's website, the agency updates the model for portions of the shoreline each year to account for, among other changes, new data and the addition of flood protection devices, such as levees. The model does not account for future conditions such as erosion, subsidence (i.e., the sinking of an area of land), construction, or sea level rise.

2022 Interagency Sea Level Rise Technical Report Sea Level Rise Data

The 2022 Interagency Sea Level Rise Technical Report provides model-based global mean sea level scenarios to estimate future sea level rise.⁹ Model-based global mean sea level scenarios use emission scenarios to estimate future sea level rise. The 2022 Interagency Sea Level Rise Technical Report provides estimates for a range of sea level rise

⁶According to NOAA, "storm surge" is an abnormal rise of water generated by a storm, over and above the predicted tides. Storm surge is produced by water being pushed toward the shore by the force of the storm's winds. NOAA's storm surge hazard maps are available at <https://www.nhc.noaa.gov/nationalsurge/>.

⁷We previously reported that NOAA does not estimate storm surge for Category 5 hurricanes in areas where such hurricanes have not historically made landfall, such as areas north of the North Carolina-Virginia border.

⁸GAO, *Nuclear Power Plants: NRC Should Take Actions to Fully Consider the Potential Effects of Climate Change*, GAO-24-106326 (Washington D.C.: Apr. 2, 2024).

⁹The report also provides observation-based extrapolations of sea level rise to estimate the trajectory of sea level rise. The observation-based extrapolations are intended to serve as a comparison with the model-based global mean sea level scenarios.

scenarios, including estimates of sea level rise in 2050 and 2100 (relative to a baseline of the year 2000) for eight coastal regions of the United States. Formed by analyzing aggregated tide gauge data, the regional boundary data that NOAA provided our team include the Northeast (Maine to Virginia), the Southeast (North Carolina to the east coast of Florida), the Eastern Gulf (west coast of Florida to Mississippi), the Western Gulf (Louisiana to Texas), the Southwest (California), the Northwest (Oregon to Washington), the Hawaiian Islands, and the Caribbean.

The 2022 Interagency Sea Level Rise Technical Report providing the sea level rise estimates and coastal regions is intended to help inform federal agencies, Tribes, state and local governments, and stakeholders in coastal communities about current and future sea level rise.¹⁰ The two primary limitations that the report discusses for the sea level rise estimates we use include process uncertainty and emission uncertainty. Process uncertainty refers to uncertainty about the impact of emissions on ice sheet loss, ocean expansion, and local ocean dynamics. Emission uncertainty refers to the uncertain amount of greenhouse gas emissions that will enter the atmosphere, trap heat, and affect temperature and sea level rise.

¹⁰W. V. Sweet, et al., *2022 Global and Regional Sea Level Rise Scenarios for the United States: Updated Mean Projections and Extreme Water Level Probabilities Along U.S. Coastlines*, NOAA Technical Report NOS 01 (Silver Spring, MD: February 2022).

Appendix III: Regional Maps of Treatment, Storage, and Disposal Facilities

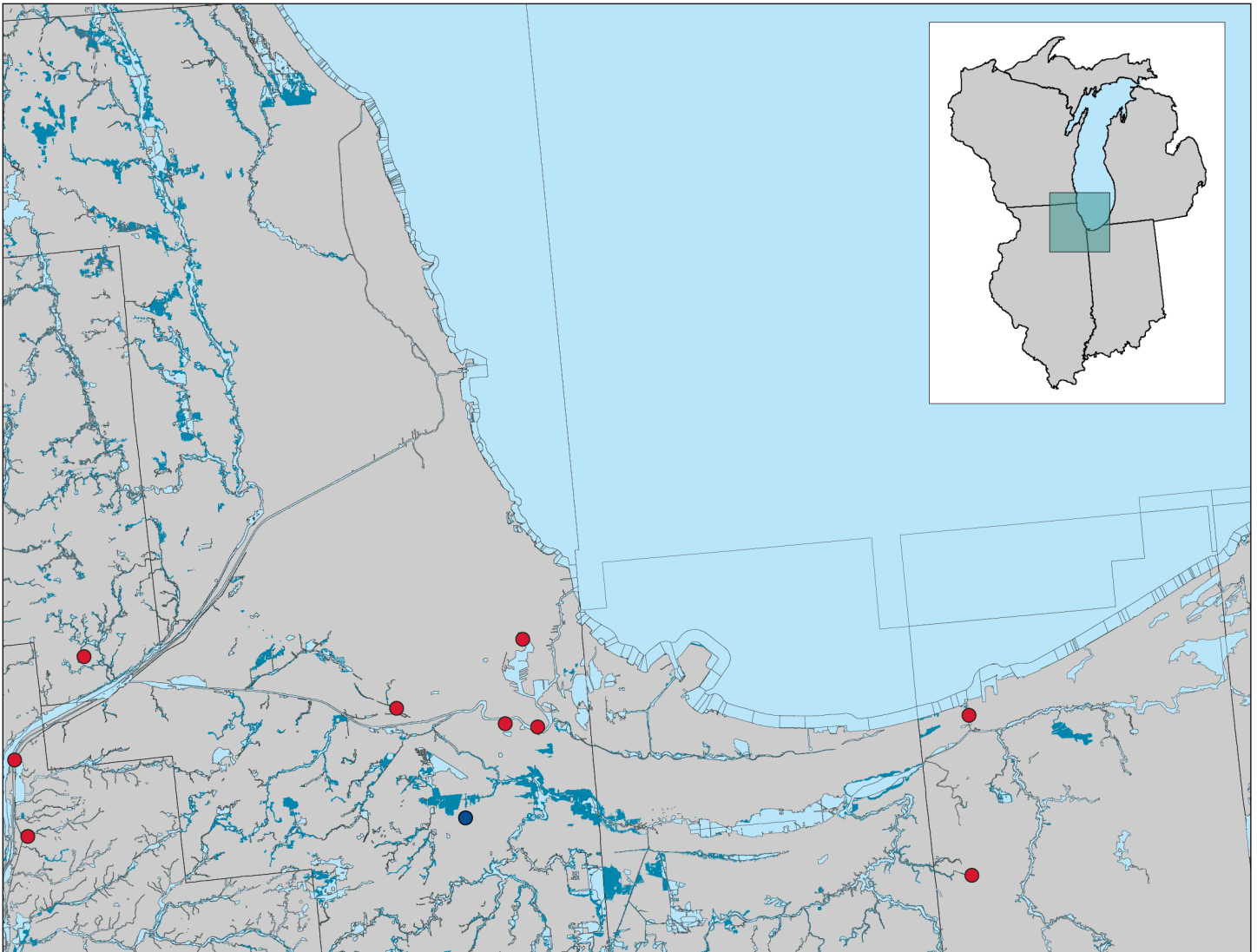
Figures 8 through 11 show regional maps of treatment, storage, and disposal facilities (TSDFs) that are located in areas with selected natural hazards that may be exacerbated by climate change, based on available federal data on flooding, wildfire, storm surge, and sea level rise. For more information about the methodology and data sources used to conduct this analysis, see appendixes I and II.

Flood Exposure Regional
Map: Midwestern United
States

Figure 8 shows facilities near Lake Michigan located in areas that may be affected by flooding.

Appendix III: Regional Maps of Treatment, Storage, and Disposal Facilities

Figure 8: TSDFs Located in Areas That May Be Affected by Flooding Near Lake Michigan, as of July 2023



Treatment, storage, and disposal facilities (TSDFs)

- Located in an area with 1 percent or higher annual chance of flooding
- Located in an area with 0.2 percent or higher annual chance of flooding

Flood hazard areas

- 1 percent or higher annual chance of flooding
- 0.2 percent or higher annual chance of flooding

Sources: GAO analysis of U.S. Environmental Protection Agency and Federal Emergency Management Agency data; U.S. Census Bureau (map). | GAO-25-106253

Notes: We analyzed actively operating TSDFs and nonoperating TSDFs that have waste in place. To determine if a TSDF is located in an area with moderate or high flood hazard, we identified overlap between an estimated radius around a facility's primary coordinates provided by the U.S. Environmental Protection Agency (EPA) and flood hazard data provided by the Federal Emergency Management Agency (FEMA). Overlap indicates that a facility is located in an area that may be affected by the selected hazard. To show exposure to flooding, we use FEMA's National Flood Hazard Layer, which estimates several levels of flood hazard, including high flood hazard (areas with a 1 percent or higher annual chance of flooding), and moderate flood hazard (areas with a 0.2

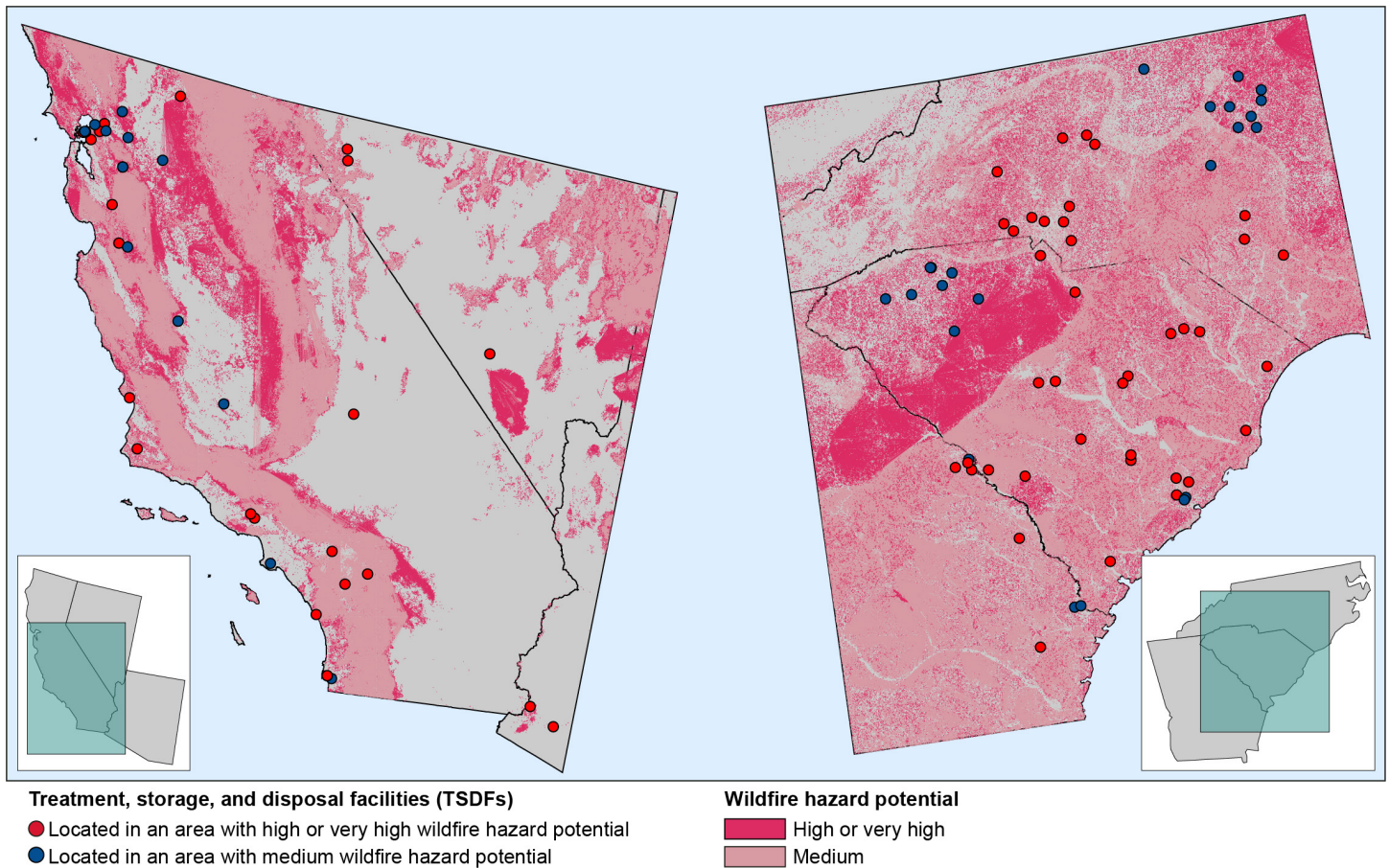
Appendix III: Regional Maps of Treatment, Storage, and Disposal Facilities

percent or higher annual chance of flooding). We approximated the boundaries of TSDFs using a radius around each facility's primary geographic coordinates based on acreage data for the facility that EPA provided. Facility boundaries based on these data do not account for where hazardous waste is specifically handled at facilities and we did not analyze site-specific information for these TSDFs, such as steps that specific facilities have taken to manage potential risks from selected natural hazards. See appendix I for more details on our data analysis.

**Wildfire Exposure
Regional Map: Western
and Southeast United
States**

Figure 9 shows facilities in or near southern California and South Carolina that are located in areas that may be affected by wildfire.

Figure 9: TSDFs Located in Areas That May Be Affected by Wildfire in or Near Southern California and South Carolina, as of July 2023



Sources: GAO analysis of U.S. Environmental Protection Agency and U.S. Forest Service data; U.S. Census Bureau (map). | GAO-25-106253

Notes: We analyzed actively operating TSDFs and nonoperating TSDFs that have waste in place. To determine if a TSDF is located in an area with exposure to wildfire hazard potential, we identified overlap between an estimated radius around facility coordinates provided by the U.S. Environmental

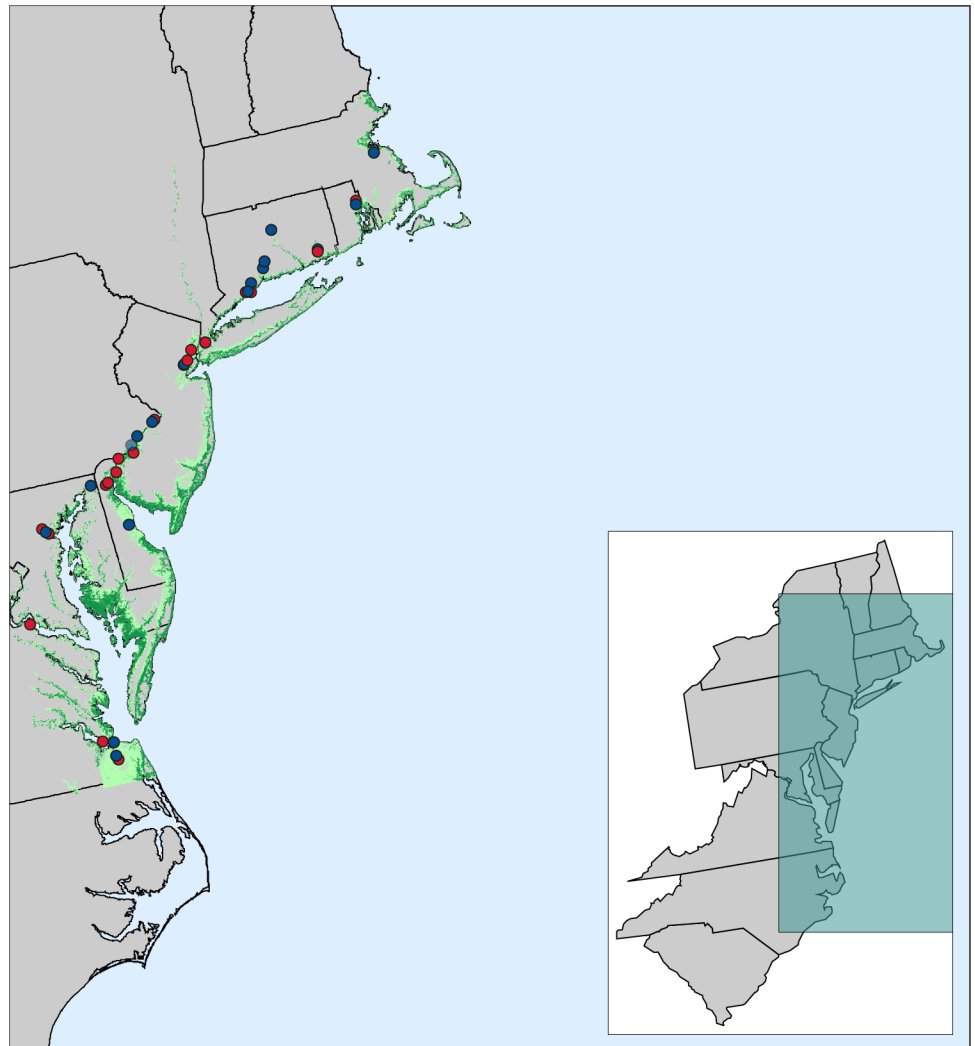
**Appendix III: Regional Maps of Treatment,
Storage, and Disposal Facilities**

Protection Agency (EPA) and wildfire hazard potential data. Overlap indicates that a facility is located in an area that may be affected by the selected hazard. We used the U.S. Forest Service Wildfire Hazard Potential Map to show exposure to wildfire hazard potential. The map categorizes wildfire hazard potential into five classes: very low, low, moderate, high, and very high. We analyzed the moderate, high, and very high wildfire potential layers, and combined results for the high and very high layers. We approximated the boundaries of TSDFs using a radius around each facility's primary geographic coordinates based on acreage data for the facility that EPA provided. Facility boundaries based on these data do not account for where hazardous waste is specifically handled at facilities and we did not analyze site-specific information for these TSDFs, such as steps that specific facilities have taken to manage potential risks from selected natural hazards. See appendix I for more details on our data analysis.

**Storm Surge Exposure
Regional Map: Northeast
Coastline**

Figure 10 shows facilities along the northeast coastline that are located in areas that may be inundated by storm surge.

Figure 10: TSDFs Located in Areas That May Be Inundated by Storm Surge Along the Northeast Coastline, as of July 2023



Treatment, storage, and disposal facilities (TSDFs)

- Located in an area that may be inundated by a Category 1 hurricane
- Located in an area that may be inundated by a highest Category (4 or 5) hurricane

Extent of maximum storm surge

- From a Category 1 hurricane
- From highest Category (4 or 5) hurricane

Sources: GAO analysis of U.S. Environmental Protection Agency and National Oceanic and Atmospheric Administration data; U.S. Census Bureau (map). | GAO-25-106253

Notes: We analyzed actively operating TSDFs and nonoperating TSDFs that have waste in place. To determine if a TSDF is located in an area with exposure to hurricane storm surge, we identified overlap between an estimated radius around a facility's primary coordinates provided by the U.S. Environmental Protection Agency (EPA) and storm surge data. Overlap indicates that a facility is located in an area that may be affected by the selected hazard. To show exposure to hurricane storm

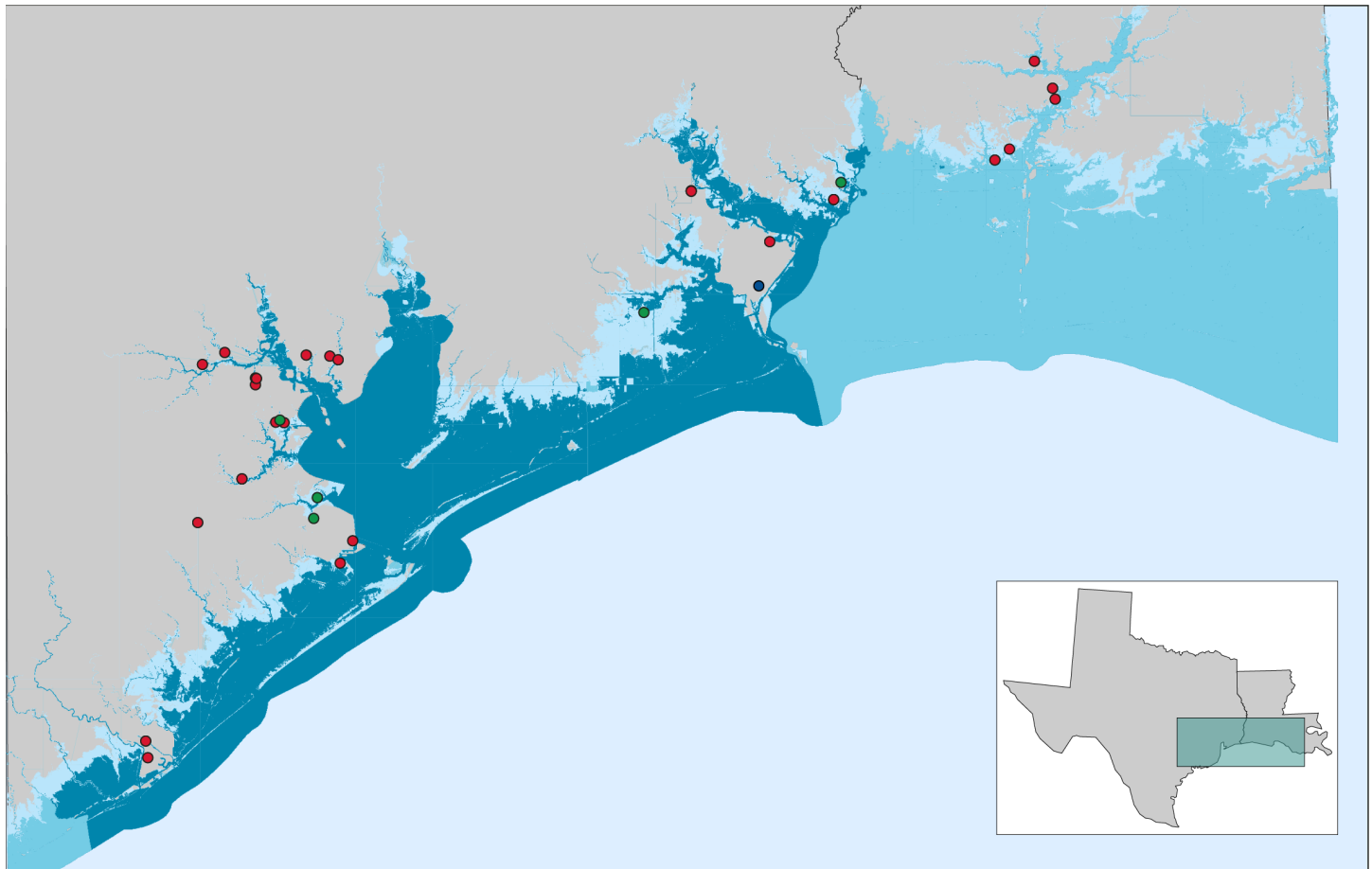
**Appendix III: Regional Maps of Treatment,
Storage, and Disposal Facilities**

surge, we used the National Oceanic and Atmospheric Administration's Sea, Lake, and Overland Surges from Hurricanes Model—which estimates storm surge heights resulting from the various categories of hurricanes. We approximated the boundaries of TSDFs using a radius around each facility's primary geographic coordinates based on acreage data for the facility that EPA provided. Facility boundaries based on these data do not account for where hazardous waste is specifically handled at facilities and we did not analyze site-specific information for these TSDFs, such as steps that specific facilities have taken to manage potential risks from selected natural hazards. See appendix I for more details on our data analysis.

**Sea Level Rise Exposure
Regional Map: Gulf Coast**

Figure 11 shows the locations of facilities on the Texas and Louisiana Gulf Coast and the extent to which they may be affected by sea level rise under certain scenarios for the year 2100.

Figure 11: TSDFs Located in Areas That May Be Inundated by Sea Level Rise near the Texas and Louisiana Gulf Coast, as of July 2023



Treatment, storage, and disposal facilities (TSDFs)

- Located in an area inundated by sea level rise by 2100 under a Low sea level scenario
- Located in an area inundated by sea level rise by 2100 under an Intermediate sea level scenario
- Located in an area inundated by sea level rise by 2100 under a High sea level scenario

Extent of sea level rise

- Low
- Intermediate
- High

Sources: GAO analysis of U.S. Environmental Protection Agency and National Oceanic and Atmospheric Administration data; U.S. Census Bureau (map). | GAO-25-106253

Notes: We analyzed actively operating TSDFs and nonoperating TSDFs that have waste in place. To determine if a TSDF is located in an area with exposure to sea level rise, we identified overlap between an estimated radius around a facility’s primary coordinates provided by the U.S. Environmental Protection Agency (EPA) and sea level rise projections from an interagency report covering sea level rise scenarios. Overlap indicates that a facility is located in an area that may be affected by the selected hazard. To show potential exposure to sea level rise, we used federal data for three sea level rise scenarios—Low, Intermediate, and High—for the year 2100. We used three scenarios for 2100 because of greater uncertainty for scenarios further in the future. These scenarios provide information on a range of potential outcomes that affect whether TSDFs will be exposed to this hazard. As a result, these scenarios are subject to uncertainty. The two primary limitations the report discusses for the sea level rise estimates we used include process uncertainty and emission uncertainty. Process uncertainty refers to uncertainty about the impact of greenhouse gas emissions on ice sheet loss, ocean expansion, and local ocean dynamics. Emission uncertainty refers to the

**Appendix III: Regional Maps of Treatment,
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uncertain amount of greenhouse gas emissions that will enter the atmosphere, trap heat, and affect temperature and sea level rise. We approximated the boundaries of TSDFs using a radius around each facility's primary geographic coordinates based on acreage data for the facility that EPA provided. Facility boundaries based on these data do not account for where hazardous waste is specifically handled at facilities and we did not analyze site-specific information for these TSDFs, such as steps that specific facilities have taken to manage potential risks from selected natural hazards. See appendix I for more details on our data analysis.

Appendix IV: Comments from the U.S. Environmental Protection Agency



WASHINGTON, D.C. 20460

Mr. Alfredo Gomez
Director
Natural Resources and Environment
U.S. Government Accountability Office
Washington, DC 20548

Dear Mr. Gomez:

Thank you for the opportunity to review and comment on GAO's proposed draft report entitled *Hazardous Waste: EPA Should Take Additional Actions to Encourage Treatment, Storage, and Disposal Facilities to Manage Climate Risks* (GAO-25-106253). The purpose of this letter is to provide the U.S. Environmental Protection Agency's response to the findings, conclusions, and recommendations in GAO's draft report. EPA generally agrees with GAO's findings, conclusions, and recommendations.

Listed below are GAO's Audit Recommendations, along with EPA responses that provide the Agency's general position, as well as a description of the current and planned actions for each recommendation. EPA is also enclosing technical comments pertaining to information in the draft report itself, which are distinct from our responses to the GAO recommendations discussed below.

GAO Recommendation 1: The Assistant Administrator of the Office of Land and Emergency Management should develop and provide training and technical assistance to help EPA regions and authorized states implement recent guidance on using existing authorities and requirements to manage climate risks to [Treatment, Storage, and Disposal Facilities (TSDFs)].

EPA Response:

EPA agrees with Recommendation 1. In June 2024, EPA issued a memorandum, "[Implementing Climate Resilience in Hazardous Waste Permitting Under the Resource Conservation and Recovery Act \(RCRA\)](#)," which provides guidance to EPA regions, states, and territories on when and how to consider potential adverse climate change impacts in the hazardous waste permitting process under RCRA. This guidance calls for working with RCRA facility owners and operators to integrate climate change adaptation considerations into the hazardous waste permitting process, and for conducting climate change vulnerability screenings and assessments to determine whether there are climate vulnerabilities that hazardous waste permits should address. EPA is currently in the process of developing four webinar trainings to assist EPA regions and authorized states in implementing the subject guidance memo. These four RCRA-focused webinars will be widely available to states and the public. The webinars will be grouped by the Northeast, Northwest, Southeast, and Southwest sections of the country, so they

**Appendix IV: Comments from the U.S.
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may also target climate impacts of particular concern in distinct parts of the United States. These training webinars are planned to be held in November 2024 through January 2025.

GAO Recommendation 2: The Assistant Administrator of the Office of Land and Emergency Management should use its upcoming rulemaking to seek feedback from authorized states, TSDFs, and other stakeholders to assess whether its recent guidance is sufficient or revising regulations would be needed to clarify requirements for managing climate risks to TSDFs.

EPA Response:

EPA agrees with Recommendation 2. As part of the development of the Permitting Updates Proposed Rule, which EPA expects to publish in 2025, EPA will assess whether revisions to its permit regulations are needed to clarify requirements for managing climate risks to TSDFs and will seek public comment on any revisions in the proposed rule.

GAO Recommendation 3: The Assistant Administrator of the Office of Enforcement and Compliance Assurance should issue regulations, guidance, or both to clarify RCRA authorities and requirements for managing climate risks to TSDFs as part of authorized states' and EPA regions' RCRA compliance and enforcement efforts.

EPA Response:

EPA agrees with Recommendation 3.¹ On September 29, 2023, the Office of Enforcement and Compliance Assurance (OECA) issued a memorandum on [Incorporating Sustainability Principles in Cleanup Enforcement Actions Under the Comprehensive Environmental Response, Compensation, and Liability Act and the Resource Conservation and Recovery Act](#).² The memorandum includes a case compendium that highlights enforcement settlement agreements that include sustainability principles and a resource library that provides access to EPA, other federal agencies, and external organizations information about sustainability principles. As mentioned in the response to Recommendation 1, EPA also issued guidance in FY24 on working with RCRA facility owners and operators to integrate climate change adaptation considerations into the RCRA corrective action process, and to conduct climate change vulnerability screenings and assessments to determine whether there are climate vulnerabilities that hazardous waste permits should address.

OECA will continue to work across the agency and EPA regions as well as with state and tribal governments to implement the recent guidance memorandums on using existing RCRA authorities and

¹ OECA does not issue regulations for TSDFs under RCRA. Within EPA, the Office of Land and Emergency Management (OLEM) is the office responsible for establishing and implementing regulatory standards for the RCRA program. OECA works with EPA regional offices, and in partnership with state and tribal governments and other federal agencies to enforce statutory and regulatory standards under RCRA. In this role, OECA supports OLEM in the implementation of the RCRA program through the development of tools and guidance related to enforcement of and compliance with RCRA's statutory provisions and regulations.

² This memorandum was issued publicly and reinforces EPA's positions on sustainability by encouraging cleanup enforcement staff to collaborate with their program office counterparts to incorporate applicable principles in RCRA cleanup enforcement work, including climate change adaptation, mitigation, and resilience. See U.S. Environmental Protection Agency "[Incorporating Sustainability Principles in Cleanup Enforcement Actions Under the Comprehensive Environmental Response, Compensation, and Liability Act and the Resource Conservation and Recovery Act](#)" (September 29, 2023) available at <https://www.epa.gov/system/files/documents/2023-10/sustainability-enforcement-mem-2023.pdf>.

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requirements to manage climate risks to TSDFs on a site-specific basis. Further, OECA will support the rulemaking efforts referenced in Recommendation 2. OECA will also consider developing additional guidance explaining how climate change adaptation considerations should be incorporated into RCRA enforcement efforts.

GAO Recommendation 4: The Assistant Administrator of the Office of Land and Emergency Management, in consultation with EPA regional offices, should develop and implement monitoring metrics and assess whether and how authorized states and TSDFs are managing climate risks to TSDFs in RCRA permitting and oversight efforts.

EPA Response:

EPA agrees with Recommendation 4. In February 2024, EPA directed authorized states to start providing information on how potential climate related threats were considered in permitting and corrective action. This information will be incorporated in the states' renewed grant workplans and annual reports, as grants are renewed in fiscal years 2025-2027.

By May 2026, EPA will compile and summarize information from state grant annual reports on how potential climate related threats were considered in RCRA permitting. Based on this information, by May 2027, EPA will develop a procedure for monitoring and assessing on an ongoing basis how authorized states and TSDFs are managing climate risks to TSDFs in RCRA permitting.

GAO Recommendation 5: The Assistant Administrator of the Office of Enforcement and Compliance Assurance, in consultation with EPA regional offices, should develop and implement monitoring metrics and assess whether and how authorized states and TSDFs are managing climate risks to TSDFs in RCRA compliance monitoring and enforcement efforts.

EPA Response:

EPA agrees with Recommendation 5. As RCRA national policy requirements or regulations are updated to include climate mitigation (as referenced in Recommendations 1-4), EPA will update enforcement and compliance guidance accordingly. Additionally, EPA will provide training and guidance on how to measure compliance with any new requirements. EPA will consider providing training for RCRA inspectors on how to evaluate whether TSDFs are managing climate risks with current requirements, such as part of contingency plans. EPA notes the implementation of compliance monitoring and enforcement metrics or procedures is contingent on the above mentioned, updated national policy requirements or regulations, and may necessitate the development of new programs for EPA data systems, the drafting of new guidance, and the provision of training.

GAO Recommendation 6: The Assistant Administrator of the Office of Land and Emergency Management, together with other relevant EPA offices and EPA regions, should assess the current RCRA TSDF standards and requirements to determine if they will be sufficient to manage climate risks and, if one or more of them need to be updated to ensure they remain protective of human health and the environment, develop a plan for any revisions or updates.

EPA Response:

EPA agrees with Recommendation 6. EPA is assessing the current RCRA TSDF regulations in development of the Permitting Updates Proposed Rule. As a result of this review, EPA is considering

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proposing specific provisions to address climate risk. These proposed provisions may include requirements: to assess and address climate change risk as part of facility permit applications; to modify permits if climate change risk at a facility changes; to implement facility design and operation standards to mitigate risk; and to use portions of the Federal Flood Risk Management Standard, as published by the Federal Emergency Management Agency, to define “floodplain.” EPA anticipates publishing the Permitting Updates Proposed Rule in 2025.

GAO Recommendation 7: The Assistant Administrator of the Office of Land and Emergency Management should issue guidance to EPA regions, authorized states, and TSDFs on how to manage climate change risks as part of RCRA program permitting efforts for TSDFs and identify or provide related data, training, or tools.

EPA Response:

EPA agrees with Recommendation 7. In June 2024, EPA issued a memorandum, “[Implementing Climate Resilience in Hazardous Waste Permitting Under the Resource Conservation and Recovery Act \(RCRA\)](#),” which provides guidance to EPA regions, states, and territories on when and how to consider potential adverse climate change impacts in the hazardous waste permitting process under RCRA. The memorandum is posted online and was publicly communicated through EPA’s Waste Management Updates Newsletter; EPA also shared this guidance with the Association of State and Territorial Solid Waste Management Officials and the Environmental Technology Council (a trade association for hazardous waste treatment, storage, and disposal facilities). EPA is also developing publicly available training (see response to Recommendation 1) to aid in the implementation of this subject memo; the training is scheduled to occur over the coming months, with additional tools to be released thereafter.

GAO Recommendation 8: The Assistant Administrator of the Office of Enforcement and Compliance Assurance should issue guidance to EPA regions, authorized states, and TSDFs on how to manage climate change risks as part of RCRA program compliance and enforcement efforts for TSDFs and identify or provide related data, training, or tools.

EPA Response:

EPA agrees with Recommendation 8. In September 2023, OECA issued guidance directing all EPA enforcement and compliance offices to address climate change as a part of inspections and enforcement.³ OECA will collaborate with and support OLEM as they develop guidance, or rulemakings as referenced in Recommendation 7. EPA will continue to encourage regional and state use of existing data tools to target climate vulnerable TSDFs and is working to provide instructions on available tools to identify these vulnerable TSDFs.

Moreover, EPA plans to meet more regularly with our region and state partners to confer and obtain information and feedback on the effectiveness of current compliance and enforcement climate change measures they are implementing, as well as discuss additional tools and resources needed to achieve the goals of the September 2023 guidance and OECA’s Climate Adaptation Implementation Plan.⁴

³ U.S. Environmental Protection Agency, EPA’s [Climate Enforcement and Compliance Strategy](#) (September 28, 2023).

⁴ [U.S. Environmental Protection Agency, Office of Enforcement and Compliance Assurance Climate Change Adaptation Implementation Plan](#) (October, 2022).

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GAO Recommendation 9: The Assistant Administrator of the Office of Land and Emergency Management, together with other relevant EPA offices and regions, should identify and communicate additional financial resources and assistance from federal resilience funding sources that may be available to authorized states and TSDFs.

EPA Response:

EPA agrees with Recommendation 9. The RCRA program has recently benefited from funding made available through the Inflation Reduction Act, which is being used in support of RCRA Climate Training, Climate Vulnerability Screening, and facility mapping to support climate assessments at facilities for example. EPA will continue to work to identify federal resilience funding sources that may be available to support consideration of climate change at TSDFs.

In closing, EPA generally agrees with GAO's findings, conclusions, and recommendations and thanks the GAO for the opportunity to review the draft report. Please contact Kecia Thornton in the Office of Land and Emergency Management at Thornton.Kecia@epa.gov or Loan Nguyen in the Office of Enforcement and Compliance Assurance at Nguyen.Loan@epa.gov with any further questions or informational needs.

Sincerely,

**BARRY
BREEN**

Digitally signed by
BARRY BREEN
Date: 2024.10.08
11:03:37 -0400

Barry N. Breen
Principal Deputy Assistant Administrator
Office of Land and Emergency Management

**DAVID
UHLMANN**

Digitally signed by DAVID
UHLMANN
Date: 2024.10.09
11:12:16 -0400

David M. Uhlmann
Assistant Administrator
Office of Enforcement and Compliance Assurance

Enclosure: Technical Comments

cc: Cliff Villa, OLEM
Rick Kessler, OLEM
Cecil Rodrigues, OECA
Stacey Geis, OECA
Kecia Thornton, OLEM
Loan Nguyen, OECA
EPA GAO Liaison Team

Appendix V: GAO Contact and Staff Acknowledgments

GAO Contact

J. Alfredo Gómez at (202) 512-3841 or gomezj@gao.gov

Staff Acknowledgments

In addition to the contact named above, Barbara Patterson (Assistant Director), Eli Harpst (Analyst in Charge), Adrian Apodaca, Ben Atwater, Aiden Baldree, Austin Barvin, Breanne Cave, Ellen Fried, Courtney LaFountain, Amy Mackay, Matthew McLaughlin, John Mingus, Evonne Tang, and Linda Tsang made key contributions to this report.

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Strategic Planning and External Liaison

Stephen J. Sanford, Managing Director, spel@gao.gov, (202) 512-4707 U.S. Government Accountability Office, 441 G Street NW, Room 7814, Washington, DC 20548



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