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24 March 2021

UNIFIED FACILITIES CRITERIA (UFC)

LANDFILLS IN SUPPORT OF MILITARY OPERATIONS

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LANDFILLS IN SUPPORT OF MILITARY OPERATIONS

Indicate the preparing activity beside the Service responsible for preparing the document.

U.S. ARMY CORPS OF ENGINEERS (Preparing Activity)

NAVAL FACILITIES ENGINEERING COMMAND

AIR FORCE CIVIL ENGINEER CENTER

Record of Changes (changes are indicated by **1**\ ... /**1**/)

Change No.	Date	Location

FOREWORD

The Unified Facilities Criteria (UFC) system is prescribed by MIL-STD 3007 and provides planning, design, construction, sustainment, restoration, and modernization criteria, and applies to the Military Departments, the Defense Agencies, and the DoD Field Activities in accordance with USD (AT&L) Memorandum dated 29 May 2002. UFC will be used for all DoD projects and work for other customers where appropriate. All construction outside of the United States is also governed by Status of Forces Agreements (SOFA), Host Nation Funded Construction Agreements (HNFA) and, in some instances, Bilateral Infrastructure Agreements (BIA). Therefore, the acquisition team must ensure compliance with the most stringent of the UFC, the SOFA, the HNFA, and the BIA, as applicable.

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UFC are effective upon issuance and are distributed only in electronic media from the following source:

- Whole Building Design Guide web site http://dod.wbdg.org/.

Refer to UFC 1-200-01, *DoD Building Code (General Building Requirements)*, for implementation of new issuances on projects.

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UNIFIED FACILITIES CRITERIA (UFC)
NEW SUMMARY SHEET

Document: UFC 3-240-11, *Landfills in Support of Military Operations*

Superseding: None

Description: This UFC provides guidance for planning, design, construction, and operation of landfills at contingency locations. This UFC describes appropriate practices for land disposal of non-hazardous solid waste. This UFC is applicable to contingency locations outside the United States.

Reasons for Document:

- This document provides guidance for military engineers to design and construct landfills at contingency locations or have the necessary landfill specifications available so a contracting officer can incorporate these specifications in contracts for landfill construction and operation during contingency operations.
- This document fills the need for UFC construction specifications for landfill facilities in support of contingency operations.

Impact:

- This document provides guidance that will protect force health by diverting solid waste from burn pits to landfills in contingency operations and avoid long-term health effects through best use of engineering principles.
- This document provides typical design specifications that can be tailored to fit site-specific needs and that will save repetitive costs for planning and designing landfills during contingency operations.
- This document provides guidance that will balance Service members' health and safety, environmental protection, and field-expedient practices.

Unification Issues: There are no unification issues.

TABLE OF CONTENTS

FIGURES

TABLES

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CHAPTER 1 INTRODUCTION

1-1 BACKGROUND.

1-1.1 General.

This UFC describes waste streams generated during contingency operations in theater and provides design guidance on landfill construction. Solid waste disposal can be a significant problem. Proper planning for and management of solid waste is critical to protect the health of Service members and the environment. Improper handling and disposal of solid waste can create unhealthy working conditions and impact mission accomplishment. Generated waste, if not dealt with properly, can contaminate food and water sources, contribute to spread of disease, cause varying degrees of harm to the environment, and generate ill feelings with the host nation (HN). Experiences in Iraq and Afghanistan have demonstrated some of the consequences when waste generation is not considered early in the planning phase or when DoD does not effectively respond to problems related to waste generation or disposal. These include health concerns associated with trash burning and the residual negative environmental impacts related to base camp transfers and closures.

The extent to which the environment can directly affect military operations and the resulting need to consider environmental considerations in its plans and operations depends on the specifics of the operation, including the situation on the ground, the military objectives, and the ultimate goals of the operation. Some information on this topic is available in DoDI 4715.22, *Environmental Management Policy for Contingency Locations*. ATP 3-34.5, *Environmental Considerations*, can also help commanders make informed decisions about environmental issues during a contingency operation. The longer forces must remain in the theater of operations, the more complex environmental issues can become.

1-1.2 Future Operations.

Recent experience suggests that ongoing and future contingencies will feature large stability, security, transition, and reconstruction (SSTR) components, will involve longer stays in theater, and require forces to perform functions that have historically been managed by U.S. government agencies, international organizations, or non-governmental organizations (NGO). These factors elevate the importance of treating environmental issues more explicitly and systematically in planning, operations, and training[1].

Future operational environments will likely be complex. Local or HN waste recycling, disposal, or treatment facilities (or services) may be nonexistent or beyond reach due to proximity, security, or political considerations. Thus, the burden for waste management falls on DoD. Commanders must consider the various operational impacts of waste generation early in the planning phase and throughout each phase of the operation. Commanders must also protect their Service members from long-term exposure to

[1] Mosher et al. 2008

waste, pollution, and diseases, whether those exposures are from conditions in the base camp or from conditions endemic to the area of operations. Consequently, it will be necessary to consider more comprehensive solutions to base camp wastes, disease vectors, and health protection for all on the base camp.

1-1.3 Concurrence with Integrated Solid Waste Management (ISWM) Program.

An integrated solid waste management (ISWM) program assesses various aspects of waste management, including the collection, storage, and disposal of waste, source reduction, recycling and composting, facility management, and budgeting and financing. It identifies existing waste systems, assesses needs, and sets forth the ways to design, implement, and monitor a more effective and sustainable waste management program. (See TM 3-34.56, *Waste Management for Deployed Forces*, for more information on ISWM program development.)

Since all methods of waste disposal can affect the environment to some degree, waste minimization should be of primary importance within every operation. Commanders should continually seek to reuse and recycle waste materials. Composting is one identified option that can also reduce materials that go into the landfill. Also evaluate reducing the amount of packaging materials sent into theater. Disposal of solid waste in a landfill is an option in ISWM programs. Current UFC construction specifications for landfills are designed to meet standards in CONUS; therefore, this UFC was developed to provide the necessary guidance for landfill construction in theater operations.

1-2 PURPOSE AND SCOPE.

1-2.1 Purpose.

This UFC describes appropriate practices for land disposal of non-hazardous solid waste during contingency operations for base camps with temporary and semi-permanent construction levels. (See UFC 1-201-01, *Non-Permanent DoD Facilities in Support of Military Operations*, for construction levels.) The goal is to balance Service members' health and safety, environmental protection, and field-expedient practices. If the HN does not have adequate infrastructure for managing solid waste, it is recommended that a contingency landfill be considered when a camp population is projected to grow to more than 500, when there is potential that the life expectancy of the base camp will be two years or more, and when, depending on combatant command (CCMD) policy, there are site conditions, resources, and logistics available to construct a landfill.

1-2.2 Scope.

This UFC covers land disposal of:

- Non-hazardous solid waste as defined below
- Non-hazardous byproducts of other waste management processes

This UFC does not cover:

- Management and disposal of hazardous waste (HW)
- Management and disposal of medical waste

For the purpose of this UFC, a contingency landfill is a landfill that accepts less than 20 tons per day of waste. This quantity of waste would be the maximum expected from a camp of 2000 people. Contingency landfills will only be developed in regions that experience less than 64 centimeters (cm) (25 inches [in.]) of rainfall each year.

1-2.3 Additional Information.

Refer to TM 3-34.56 for additional information on waste management for deployed forces. Chapter 5 of the TM details information on HW and special waste. This chapter also provides information on the six-step process to develop an HW and special waste management plan. Chapter 6 of the TM provides an overview of medical waste and describes some unique requirements that must be considered in developing a plan for collecting, storing, transporting, and disposing of medical waste.

1-3 APPLICABILITY.

This UFC is applicable to contingency locations outside the United States when a landfill is required and where other alternatives such as incineration or local hauling are not feasible.

1-4 WASTE MANAGEMENT OPTIONS.

Generated waste places a significant demand on a unit’s resources. Municipal waste disposal or treatment facilities will likely be nonexistent, incapacitated, substandard, or beyond reach due to security or logistical considerations. DoD is responsible for the entire waste management process. To reduce the amount of waste generated, it is essential to employ the principles of “reduce, reuse and recycle,” i.e., to manage daily operations to reduce the amount of waste generated.

1-4.1 Open-Air Burn Pit.

A burn pit is an area designated for burning trash in open air while not using an incinerator. DoD policy prohibits the use of open-air burn pits during contingency operations except in circumstances in which no alternative disposal method is feasible (see DoDI 4715.19, *Use of Open-Air Burn Pits in Contingency Operations*). Incinerators, engineered landfills, or other accepted solid waste management practices must be used whenever feasible. When open-air burn pits are used, they will be operated in a manner that prevents or minimizes risks to human health and safety of DoD personnel and, where possible, harm to the environment.

For each contingency operation, the operational commander must develop and approve an ISWM plan. The use of open-air burn pits is not allowed unless included within this plan. For additional information on procedures and minimum requirements for an open-air burn pit, refer to Section 3 of DoDI 4715.19.

1-4.2 Incineration.

A solid waste incinerator is any DoD-approved furnace used to burn solid waste for the purpose of destruction of and reduction of the volume of waste. Incineration is a waste treatment process that involves the combustion of organic substances (e.g., paper, plastic, wood, food) in waste materials. Incineration and other high-temperature waste treatment systems can be described as “thermal treatment.” Incineration of waste material converts the waste into ash, flu gas, and heat. Solid waste incinerators are maintained and operated in accordance with the manufacturer’s specifications. The majority of solid waste typically incinerated includes wastes from dining and life support area facilities and other non-recyclable materials including office waste and packaging waste. Incinerator operators must maintain a daily log and, at minimum, record the time, date, and amount of waste incinerated and the primary and secondary chamber temperatures during incineration. Consult command environmental staff for current requirements on air monitoring.

1-4.3 Composting.

Composting is nature’s process of recycling decomposed organic materials into a rich soil known as compost. A large percentage of solid waste is organic, like packaging materials (cardboard and paper) and waste food. Four tasks are central to the design of a solid waste composting facility: collection, contaminant separation, sizing and mixing, and biological decomposition. Composting reduces the amount of materials that must be collected, transported, and disposed of in a landfill. It will also reduce fuel costs associated with burning solid waste if wet wastes are removed from the burn pit or incinerator.

1-4.4 Recycling.

Recycling is the process of converting waste materials into reusable objects to prevent waste of potentially useful materials, reduce the consumption of fresh raw materials, and reduce energy usage by decreasing the need for conventional waste disposal. Recycling also brings economic advantages, i.e., costs associated with solid waste disposal can be reduced if recycled materials can be sold. Examples of materials that can be recycled include plastics, cardboard, wood, mixed paper, aluminum cans, other metals, glass bottles and jars, and milk and juice cartons. Materials that have been sorted for recycling need to be stored in a facility so they do not create a fire, health, or safety hazard. These materials should also be bundled or contained to avoid spillage. Since recycling relies on the local economy, options might be limited in contingency operations.

1-4.5 Landfill.

Landfills are engineered disposal sites, designed to protect health and the environment. They are permanent facilities that will be in place for a long time; they require maintenance and may require long-term monitoring. While landfills may be preferable to burn pits, they should only be constructed where no other alternative is feasible, such as incineration or local hauling.

1-5 LAWS, REGULATIONS, AND POLICY.

Regulatory compliance may not seem relevant in many contingency operations, where U.S. laws do not apply, HN laws may be minimal or nonexistent, and local environmental conditions may be degraded. It is the commander’s and leaders’ responsibility at each contingency location to ensure ISWM is incorporated throughout all operations to minimize the harmful effects of waste on human health, the environment, and the mission. Even though U.S. regulations do not apply to contingency operations, similar environmental considerations, as reflected in the contingency location environmental standards (CLES), on properly managing and disposing waste can be applied in the operational area, to the extent practical, without impacting the mission. In contrast, units stationed at permanent bases overseas must comply with established final governing standards (FGS) that respect local HN laws.

1-5.1 Treaties, if Applicable.

Another body of laws that affect U.S. military forces are international treaties that govern armed conflict, known collectively as Environmental Laws of War (ELOW). Various international treaties, federal policies, and U.S. military Service regulations provide direction on conducting operations by preventing certain operations (such as environmental modification as prohibited by the Convention on the Prohibition of Military or Any Other Hostile Use of Environmental Modification Techniques) and regulating others (such as cross-border movement of hazardous material regulated by the Basel Convention) (see ATP 3-34.5). According to the conventions, combatants are required to protect the natural environment against widespread, long-term, and severe damage during war.

1-5.2 DoDD 3000.10, Contingency Basing Outside the United States.

This directive establishes policy and assigns responsibilities for DoD contingency basing outside the United States. It states that it is DoD policy to pursue increased effectiveness and efficiency in contingency basing by promoting scalable interoperable capabilities that support joint, interagency, intergovernmental, and multinational partners. Use operational energy efficiently in accordance with DoD operational energy strategy and DoD directives, minimize waste, and conserve water and other resources. Minimize adverse impacts on local populations. Refer to Enclosure 2 of DoDD 3000.10 for an extensive list of responsibilities for various DoD organizations.

1-5.3 DoDI 4715.22, Environmental Management Policy for Contingency Locations.

This directive establishes policy, assigns responsibilities, and provides direction for environmental management at contingency locations in accordance with DoDD 4715.1E, *Environment, Safety, and Occupational Health (ESOH).* DoDI 4715.22 applies to all phases in the lifecycle of contingency locations, including planning and design, establishment, operation and management, and transition or closure. It establishes policy and provides oversight of a multi-DoD component work group to identify, develop, and revise the CLES as required. The CLES will include minimum environmental compliance standards and best management practices, including those that avoid or mitigate adverse effects.

1-5.4 Manuals.

For Army:

FM 3-34, *Engineer Operations*, provides overall doctrinal guidance and direction for conducting engineer activities. This FM provides information on engineer support to stability operations, which includes the task of constructing waste treatment and disposal facilities.

ATP 3-34.5, *Environmental Considerations*, serves as a guide for planners in identifying environmental-related issues as they pertain to operations and enables the integration of these issues into the operations planning process. Appendix B of this ATP provides information on international laws and treaties.

TM 3-34.56, *Waste Management for Deployed Forces*, gives guidance on planning and construction of waste management services and infrastructure. It covers expeditionary and large camps, and covers planning and roles and responsibilities.

1-5.5 DoDM 4715-05, Volumes 1–5, Overseas Environmental Baseline Guidance Document (OEBGD).

The primary purpose of DoD 4715-05G (OEBGD), composed of multiple volumes, is to provide standards to protect human health and the environment on enduring installations under DoD control outside the United States. The OEBGD is used by DoD lead environmental components (LEC) to establish and update FGS. The OEBGD establishes baseline environmental standards for installations in countries where an FGS is not required or has not been developed. While it does not technically apply to contingency locations, it still provides broad guidance on good environmental practices.

DoDM 4715.05, Volume 5, *Overseas Environmental Baseline Guidance Document: Waste*, contains definitions and criteria to ensure solid wastes are identified, classified, collected, transported, stored, treated, and disposed of safely and in a manner protective of human health and the environment. These criteria apply to residential and commercial solid waste generated at the installation level.

1-5.6 Summary.

Current policy regarding environmental issues impacts planning, design, construction, and operation and maintenance of contingency operations. DoDI 4715.22 establishes policy, assigns responsibilities, and provides direction for environmental management at contingency locations in accordance with DoDD 4715.1E and DoDD 3000.10. TM 3-34.56 provides guidance for conducting waste management operations while deployed on brigade level and below. In addition, standard operating procedures (SOP) are also available (e.g., Iraq, Afghanistan) that provide procedures for environmental compliance and guidance to the multi-national corps. These procedures are appropriate for use in the theater of operations.

1-6 GLOSSARY.

Appendix A contains acronyms, abbreviations, and terms.

1-7 REFERENCES.

Appendix B contains a list of references used in this document. The publication date of the code or standard is not included in this document. Unless otherwise specified, the most recent edition of the referenced publication applies.

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CHAPTER 2 PLANNING

2-1 WASTE REDUCTION.

Waste management operations involve collection, segregation, recycling, composting, reduction, transportation, and disposal of waste materials. Recycling and reuse programs should be initiated for plastics, cardboard, paper, batteries, tires, wood, aluminum cans, and other metals. This will require conducting source segregation, sorting, reuse, and a recycling program to make it effective. Sorting/source segregation of materials should be part of waste management from the beginning, even if the recycling program is not yet established. Especially sorting/segregation of demilitarized (DEMIL), HW, and medical waste must be in place from the very beginning as part of ISWM. Composting of food waste will also need to be considered, based on the size and volume of waste generated. Efforts should be made to reuse materials, such as construction materials, wood pallets, and packaging material, whenever possible. Reusable materials can be given away to locals at no cost, subject to the approval of the base commander or CCMD policy. Location of trash cans, recycle bins, and signs that explain separation of waste should be clear and simple to follow.

2-2 SOLID WASTE DISPOSAL DETERMINATION.

Following waste reduction measures, if disposal is required, determine if the HN has an existing landfill within reasonable distance with a capacity to accept additional solid waste. If the HN landfill can be used, an agreement must be developed for the terms, conditions, and requirements. If an HN landfill is not available and it is not possible to use an incinerator, identify a site that will host the new landfill. The site selection and planning processes will begin with a review of any existing environmental baseline survey (EBS) or environmental condition report (ECR); a review of local laws that might affect the construction of a landfill should also be conducted. Understanding the local geographic, geologic, hydrologic, environmental, and population conditions will significantly contribute to the planning process.

2-3 INTEGRATED SOLID WASTE MANAGEMENT PLAN

To achieve the best overall results, a camp should have an ISWM plan that identifies waste types and sources, recycling and recycling options, and safe treatment or disposal practices for all materials. At a minimum, this plan will describe the operation of the landfill, including procedures for excluding receipt of hazardous waste, PCBs, bulk liquid waste, and non-containerized liquids into the landfill.

2-4 ENVIRONMENTAL MANAGEMENT PLAN.

Develop a location-specific plan to identify potential environmental risks and associated resources needed to protect the environment and comply with applicable international agreements, DoD policy, and environmental compliance requirements, as appropriate.

2-5 DETERMINING SCOPE OF LANDFILL.

2-5.1 Primary Considerations.

There are five primary considerations when planning a landfill for in-theater operations.

- Feasibility
- Duration
- Capacity
- Sizing
- Future sizing

2-5.2 When to Construct a Landfill.

A decision by the lead Service or combatant commander to construct a landfill should be based on the definite advantages the landfill will bring to the deployed forces, whether those advantages are environmental, operational, or economical (i.e., cost-savings). Therefore, if the in-theater operations are expected to increase and a landfill is deemed necessary, a feasibility investigation should be conducted. Feasibility investigations assess projected future waste disposal demands and compare these demands with the current method of waste management. As stated in paragraph 1-6, it is recommended that a contingency landfill be considered when a camp population is projected to grow to more than 500, when there is a potential that the life expectancy of the base camp will be two years or more, and when, depending on CCMD policy, there are site conditions, resources, and logistics available to construct a landfill. The feasibility investigation should analyze and document existing conditions and final conditions; the topography at the proposed landfill site; surface drainage; quantity and location of cover material; supporting facility requirements; and recommended operational procedures. All of these aspects are outlined in this UFC.

The size of a landfill must be designed to accommodate the duration of the military operation and any future growth of the facilities it serves. The capacity of the landfill must meet the projected future demands of the base camp it is supporting. Capacity estimates should consider other waste management options such as recycling, volume reduction, and waste minimization. Equation 3-1 in Chapter 3 can be used to calculate the volume of a landfill; required area can be calculated once the landfill depth is determined based on site condition, including depth of groundwater table.

2-5.3 Waste Characteristics.

Data on the solid waste destined for disposal is needed for the accurate design of a landfill. That data includes the types of waste, amounts, and variations in delivery rates. For in-theater operations, that data can be estimated from an analysis of the population to be served and the operations conducted at a facility.

2-5.4 Mission Duration.

Consider the expected duration of the mission and nature of the operation. In addition, identify types and amounts of waste that will be generated (based on type, size, and function of units within the organization). The expected duration of the mission will determine appropriate design, performance, and construction standards. An analysis can be made of the population to be served and other major sources of solid waste.

2-5.5 Operational Methods.

The three most commonly used methods of operating a landfill are the area method, trench method, and ramp. Selecting the most appropriate method for a proposed landfill depends on local site conditions. Selection criteria, design, construction, and operation of all three methods are explained in Chapters 3, 4, and 5.

2-5.6 Operational Equipment.

Determine the types of operational equipment needed to collect, deliver, and operate the landfill. The equipment needed is determined by the projected types and estimated quantity of solid waste being disposed of in the proposed landfill. The capabilities of the equipment must be considered in evaluating factors such as access roads, grades, drainage, operation in severe climates, and feasibility of operation in a war zone. Generally, a waste-hauling truck, tracked or wheeled tractor with dozer, front-end loader, and trash blade are needed for daily operations of the landfill. A wheeled compactor and scraper also add value to the daily operations of a landfill. The specific equipment requirement will be mostly dictated by the site condition and availability of equipment in theater.

2-5.7 Closure.

Planning the closure of the landfill is a critical step when developing the design and operations of a landfill. This includes selecting the leachate collection and gas collection systems (if dictated) and final cover material as well as any maintenance that might need to be conducted after closure. Closure activities must begin soon after the last load of waste is received.

2-6 SITE SELECTION.

Landfills are site-specific and their design must take into consideration the unique environmental and land use qualities of a region. Additionally, the landfill site selection process should include careful planning that takes into account minimizing hauling distances while maximizing distances from bed-down areas and other inhabited locations in addition to locating the landfill away from living quarters, airfields, helipads, and access control points. Site selection should also consider the climate and environmental attributes of a location to ensure the landfill is properly designed to meet those conditions. The first stage in site selection is determining where a landfill should be optimally located. A landfill must be located downwind and downward from the bed-down area and dining facility. A safe distance must be maintained from all other activities of the base camp in accordance with a theater-specific SOP. In absence of theater-specific guidance, a distance of 400 meters (m) (1,312 feet [ft]) must be maintained downwind from the nearest bed-down area. Table 2-1 lists other landfill standoff distances that must be maintained[2]. No landfill should be constructed within a floodplain of major rivers, a 100-year floodplain area, or within 90 m (295 ft) of a navigable river or stream.

Table 2-1 Landfill Standoff Distances

Sensitive Areas	Distance m (ft)
Lake or pond	300 (984)
River	90 (295)
Highway	300 (984)
Public park	300 (984)
Water well	365 (1198)

2-6.2 Solid Waste Types and Quantities.

Estimate the types of waste and quantities expected for the life of the landfill operations. This estimate will determine the size of the landfill and scope of the operations.

2-6.3 Cover.

There should be a sufficient quantity of on-site soil suitable for use as cover material for the duration of landfill operations at the selected site.

2-6.4 Existing Site Utilities.

Sites with underground pipes or conduits (e.g., sewage, stormwater) must be rejected. If no other site is available, the underground infrastructure must be relocated before landfill construction.

2-6.5 Access.

Sites that can be directly accessed by existing all-weather roads are preferred. Direct routes to the landfill provide time and cost savings. Routes that use primary roads, go through residential areas, or cross major highways create safety hazards and should be avoided.

2-6.6 Agricultural Land.

If possible, locate landfills away from agricultural land.

[2] Bagchi, A. 1994

2-6.7 Airports.

All parts of a landfill complex must be located away from airports so the landfill does not pose a bird hazard to aircraft. A theater-specific SOP must be followed to identify a safe distance for the landfill site from the airports. If possible, follow UFC 3-260-01, *Airfield and Heliport Planning and Design*, which prescribes a lateral clearance zone of 152 m (500 ft) on both sides of the runway and a clear zone (CZ) of 915 m (3,000 ft) from the end of the runway with a 60-m (200-ft) approach/departure clearance. In general, for airports used by turbojet aircraft, the landfill must be 3 kilometers (km) (10,000 ft) from the end of the runway. For airports used only by piston-type aircraft, the landfill should not be closer than 1.5 km (5,000 ft) from the end of the runway. If a landfill site under consideration is within 8 km (5 miles) of any runway end, the commander or his/her representative must notify the affected airport authority.

2-6.8 Environmental Considerations.

The location of a landfill determines its level of environmental impact. Locations with features favorable to landfill design are more acceptable. Favorable features that might contribute to less-engineered landfill designs include naturally occurring clay soils, deep groundwater levels, remote or absent surface water sources, and limited surface run-off. Other environmental factors to consider are:

- Ground and surface water conditions
- Geology
- Soils
- Topographic features
- Floodplains
- Permafrost
- Cultural sites (Cultural property will be respected during armed conflict in accordance with the 1954 Hague Convention as ratified by the U.S. Senate in 2009.)
- Critical habitats of endangered species
- Aesthetic impacts

Environmentally sensitive areas such as wetlands, 100-year floodplains, permafrost areas, critical habitats of endangered species, and recharge zones of sole source aquifers should be classified as lowest-level priority for siting in-theater landfills.

2-6.8.1 Wetlands.

In theater, avoid all wetlands and wetlands buffer areas.

2-6.8.2 Unstable Areas.

Avoid karst terrain and other unstable areas.

2-7 CLIMATE.

The effects of heavy rains or snow should be considered and their effects on operations analyzed. Other factors to consider are litter problems and dust blowing from mounds of cover material. If the site is in an area where freezing temperatures will inhibit excavation, space for storing cover material needs to be incorporated into the facility. If adverse weather will disrupt operations, a landfill should not be constructed.

2-7.1 Cold Weather.

Extremely cold weather can greatly reduce the biological activity in a landfill. In areas where winter temperatures are lower than -34 °C (-30 °F), only minimal waste stabilization occurs. Frozen soil is another serious problem. In cold climates, excavate fill during the summer season and stockpile cover material to be used during the winter.

2-7.2 Hot Weather.

Extremely hot weather has no real adverse effects on landfill operations.

2-7.3 Wet Weather.

A major problem during wet weather is maintaining maneuverability of vehicles and equipment used to handle solid waste. Selecting a site that is well drained and has soil that provides adequate vehicle handling helps mitigate problems during wet weather. It may be necessary to import gravel to maintain roadways.

2-7.4 Dry Weather.

Dry weather does not cause operational problems at landfills although extremely dry weather limits the amount of biological activity taking place. Blowing refuse should be controlled by promptly covering waste materials and by erecting portable fences downwind of the working face, which is where waste is being dumped into the landfill and compaction and covering are ongoing.

CHAPTER 3 DESIGN GUIDELINES

3-1 GENERAL.

The proper design of a landfill that is adequate to the conditions in a theater environment is a challenging task because every site location is different and, in most cases, unfamiliar to the designer. An appropriate design that meets the site-specific need for disposal of solid waste generated at the contingency base while protecting human health and environment is the key. If needed, add additional protective measures, depending on site-specific requirements, topography, and geology and if required by the combatant commander. As a basis for the design of the landfill, review available information including, but not limited to, topographic maps, geological information, floodplain area, wetlands, faults, seismic impact zones, unstable areas, and surrounding area land use, including airports and helipads in the vicinity. In addition, verify the contingency operation cooperates with HN officials where applicable, to the extent possible in the ISWM planning process. Important factors to consider while designing the landfill are:

- Contingency operations
- Number of personnel
- Security of forces leaving the secured contingency operation
- Vehicles used for hauling waste
- Access road to the landfill
- Land area to be used for landfilling
- Landfilling method: area method, ramp method, or trench method, depending on the terrain
- Surface drainage to divert runoff water
- Protection of surface and groundwater
- Landfill gas and leachate

3-2 HEALTH AND SAFETY CONSIDERATIONS.

3-2.1 Landfill Workers.

Landfill workers face health and safety risks throughout the life of the landfill and even into closure. To minimize risks, depending on site-specific conditions, the design of the landfill will take into consideration the following hazards:

- Construction hazards
- Traffic accidents (e.g., rollovers during ramp or trenched operations)
- Heavy equipment operations during construction, operation, and closure
- Workers' exposure to:

- Waste material
- Dangerous gases
- Unknown chemicals
- Disease vectors, including birds
- Austere environment
- Noise

Appropriate personal protective equipment (PPE) must be provided to landfill workers as the contingency situation permits, including clothing, steel-toe working boots, air-filtering headgear, and puncture-proof hand gloves.

3-2.2 Neighboring Inhabitants.

A landfill design that does not threaten the health and safety of nearby inhabitants in general precludes the following:

- Pollution of surface and groundwater from landfill-generated leachate
- Air pollution from dust or smoke
- Infestation by rats, flies, or other vermin
- Other nuisance factors, such as odors and noise
- Fires and combustion of refuse materials
- Explosives hazards from methane gas generated within the landfill
- FOD (foreign object debris) and bird strike hazard to aircraft
- Uncontrolled traffic from landfill construction/operation

3-3 SITE LAYOUT.

3-3.1 Road Access.

Although the siting of the landfill is influenced by many factors and in many cases will be dictated by the contingency location and mission type, the design must take into consideration the convenience and safety of the collection vehicles. The landfill must be easily accessible by an all-weather road with the shortest hauling distance possible considering other factors. The access road plan must also be aligned with existing terrain to minimize new construction and avoid the path of the natural drainage system.

3-3.2 Buffer Zones.

A buffer zone is the separation distance (both horizontal and vertical) between the landfill and any sensitive areas including, but not limited to, drinking water sources, Service members’ bed-down areas, critical habitats, and historic and archeological sites. Buffer zones provide several benefits, including:

- Preventing migration of contamination off-site from accidental release
- Protecting drinking water sources
- Minimizing health effects on Service members and other contingency location residents

3-3.3 Fencing.

The landfill design may include a perimeter fence. The contingency location standard must be followed for type and height of the fence. In absence of a contingency standard, at a minimum, a 1.8-m (6-ft) -high chain link fence may be installed to catch blowing litter, prevent unauthorized landfill use, and maintain security.

3-4 LANDFILLING METHODS.

Generally, there are three methods used for solid waste landfilling—trench/cell method, area method, and ramp method—depending on site topography, geology, availability of land, groundwater level, availability of cover material, and any other site-specific condition.

3-4.1 Trench Method.

The trench or cell method is suited where the groundwater table is deeper and excavated soil can be used as cover material (Figures 3-1 and 3-2). Excavated trenches can be square or rectangular, depending on the site-specific condition and soil types, and will be constructed as mission requirements dictate to minimize earthwork. Trench cells should be separated by a 1- to 1.5-m (3- to 5-ft) path to ensure wall stability, surrounded by a movable fence to prevent littering caused by blowing waste. Table 3-1 lists recommended design criteria for trench cells. It is especially important in contingency operations to only dig as the mission requires to economize earthwork, considering the demand of solid waste generation.

Figure 3-1 Layout of a Trench Landfill

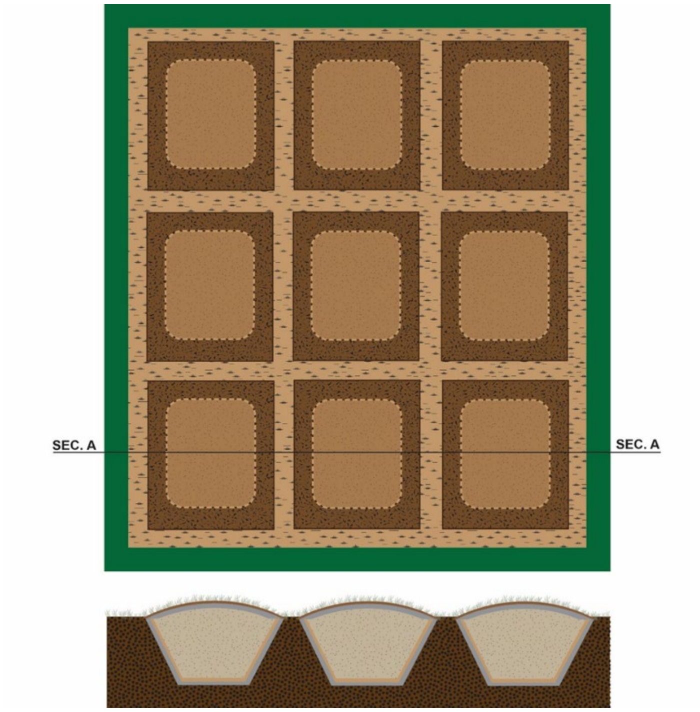


Figure 3-2 Trench Method of Burying Waste

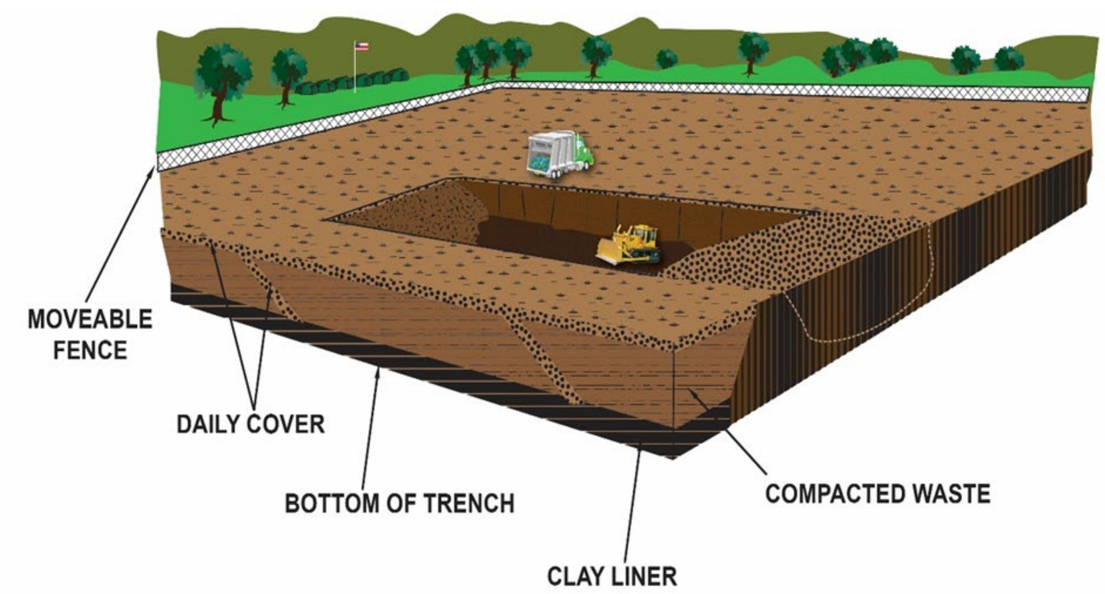


Table 3-1 Trench Landfill Design Factors

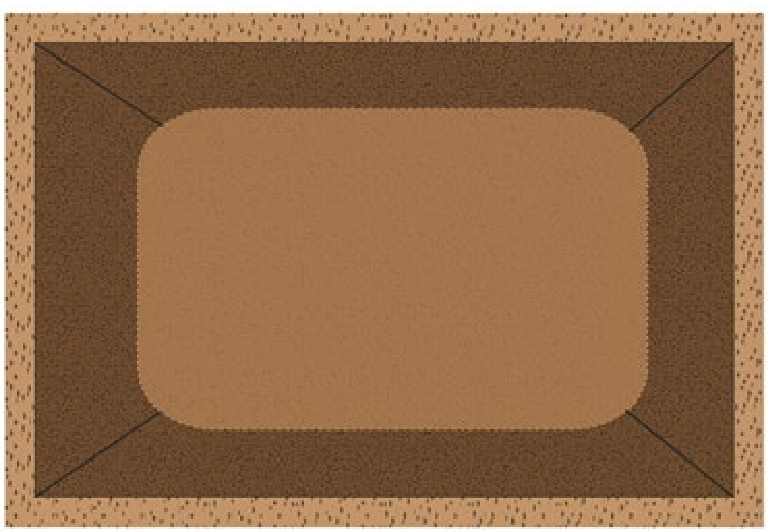
Parameter	Cell Criteria
Daily waste generation	7.2 kg (16 lb) per person[3]
Side slope	1.5 – 3:1
Depth (max)	6 m (20 ft)
Width (max)	6 m (20 ft)
Width (max)	As needed
Compaction	356 kg/m^3 (600 lb/yd^3)

Source: EM 1110-3-177

3-4.2 Area Method.

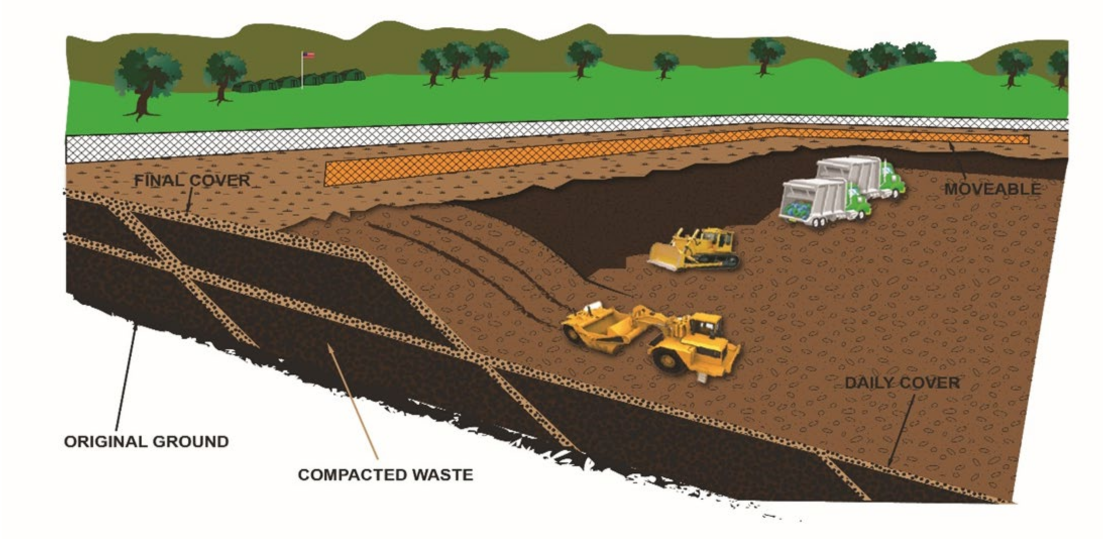
The area method is used where the terrain is not suitable for deep digging due to the presence of a high groundwater table or when encountering bedrock. Depending on the site-specific condition, the area method may or may not require excavation to meet the requirement to maintain a 150-cm (59-in.) buffer zone between the bottom of the landfill and highest seasonal groundwater level (Figures 3-3 and 3-4). However, the cover material may be hauled in or be collected from a nearby borrow pit. Using this method, the total area required for the landfill is estimated based on the current contingency population and the operational life of the landfill, based on the need to serve the current and projected contingency population.

Figure 3-3 Layout of the Area Method



[3] Cosper et al., 2013

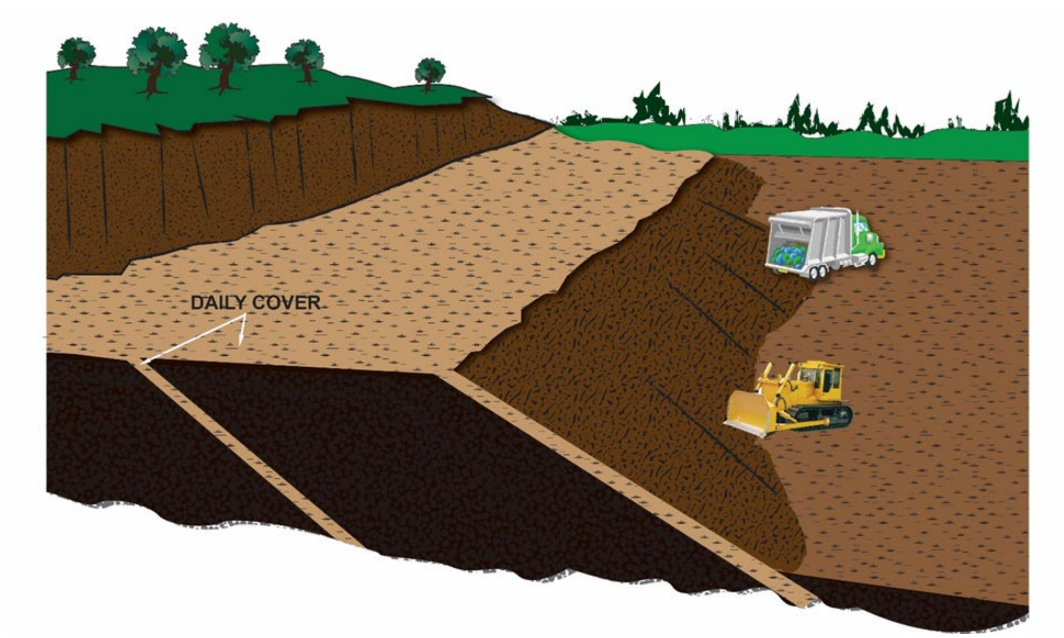
Figure 3-4 Area Method of Burying Waste



3-4.3 Ramp Method.

The ramp/canyons or ravines method is suitable for mountainous or hilly areas or rolling land with progressive slope. Old borrow pits/quarries also fit this category. When using this method, cover material is obtained from the daily working face and compacted. The procedures to place daily waste and compact it may vary, depending on the site condition. Site geology and hydrogeology and the need to control surface drainage, place leachate, and collect gas (if required) may further complicate site development in a contingency situation using the ramp method; therefore, landfilling using the ramp method is the least-preferable method in a contingency situation.

Figure 3-5 Ramp Method of Burying Waste



3-5 LANDFILL DESIGN.

3-5.1 Capacity.

Daily per capita solid waste generation must be known or estimated to calculate the required landfill volume. In current theaters, daily per capita solid waste generation varies from 4.5 to 9 kilograms (kg) (10 to 20 pounds [lb]), depending on contingency site locations and time of the year. However, for simplicity of the design for a contingency landfill, a total of 9 kg/day/capita (20 lb/day/capita) solid waste generation is recommended to be used as the planning factor to calculate the number of tons to be disposed of at a proposed landfill. Appropriate compacting equipment may not always be available in a contingency situation; therefore, a lower value of 240 kg (529 lb) of waste per cubic meter (m^3) (35 cubic feet [ft^3]) of density is recommended to calculate the total volume required for a landfill. The following equation can be used to calculate the required volume of landfill space for any size population.

Equation 3-1. Required Volume of Landfill Space

$$Q = Peck/d$$

Where:
Q = cubic meter (m^3)/year
P = population of the base (person)
e = ratio (cover material to compacted solid waste, 1.25)
c = per capita waste generation rate, kg/day/person
k = number of days in a year, 365 day/year
d = compacted waste density, kg/m^3

For example, a base with a population of 2,000, including Service members and contractors, will require a landfill space of about 34,000 m^3 (1,200,699 ft^3) per year.

P = 2,000
e = 1.25
c = 9 kg/day
k = 365 day/year
d = 240 kg/m^3
Q = (2,000 x 1.25 x 9 kg/day x 365 days/year)/240 kg/m^3 = 34,218 m^3/year

3-5.2 Landfill Liners.

Solid waste landfills require a lining system installed on the side slopes and floor of the landfill to provide a protective layer for the environment, including the soil and surface and groundwater. The selected lining system must be compatible not only with the expected waste to be disposed of but also the surrounding area. Typical lining systems are constructed of either compacted clay or a synthetic material such as high-density polyethylene (HDPE). If a locally sourced natural clay of low permeability is not available and a synthetic liner cannot be obtained and installed, landfilling should not be considered as an option for solid waste disposal.

3-5.2.1 Compacted Clay Liners

Constructing the landfill liner from a natural clay (i.e., clay, silty clay, clayey silt) is most economical and advantageous for contingency locations. This preferred option allows the use of locally available material for construction of the liner. Laboratory measurements, including particle size and Atterberg limits, should be conducted to investigate the suitability of the local soil as the liner material prior to constructing the liner. The constructed liner should have a hydraulic conductivity of less than or equal to 1×10^{-9} meters per second (m/s) (3.9×10^{-8} inches per second [in./s]). The total thickness of the liner should be no less than 1 m (3 ft), placed in 250-millimeter (mm) (10-in.) compacted lifts. Table 3-2 lists recommended design criteria and soil specifications.

Table 3-2 Specification for Clay Liners

Criteria	Value	Standard
Liner thickness	1 m (3 ft)	
Lift thickness	250 mm (10 in.)	
Hydraulic conductivity	1×10^{-9} m/s (3.9×10^{-8} in./s)	ASTM D5084
Soil specifications		
% passing No 200 sieve[4] Clay content	> 50% > 10%	ASTM D2487
Atterberg limits:[5] Plasticity index Liquid limit	 10% to 30% > = 30%	ASTM D4318

3-5.2.2 Synthetic Liners

If site conditions do not favor the use of a compacted clay liner, the use of a synthetic liner should be investigated. The manufacturer of the synthetic liner must be consulted regarding the compatibility of the liner to the waste, soil conditions, and the potential extreme weather conditions present in theater as well as the possibility for delivery and support of the installation of the liner at the site. It is recommended that the synthetic liner have a thickness of 1 to 2 mm (40 to 80 mil).

The subsurface of the soil will need to be carefully prepared and free from rocks to prevent damage to the liner. A leachate collection system will also be required for all synthetically lined landfills. Contact your Service-specific subject matter expert for support in leachate collection system design.

[4] Daniel and R. M. Koerner 1993 (EPA/600/R-93/182)
[5] Ibid.

3-5.3 Final Cover.

The final cover of the landfill consists of 45 cm (18 in.) of compacted earthen material with a hydraulic conductivity less than 10^{-7} centimeters per second (cm/s) (10^{-7} 3.937 in./s) with 15 cm (6 in.) of earthen material capable of sustaining native plant growth and be graded with 2 percent slope top to form a crown. The landfills must be kept as dry as possible to minimize leachate and gas formation. To minimize infiltration of rainwater into the landfill, the final cover must not be less permeable than the bottom liner. In accordance with EM 1110-3-177, *Sanitary Landfill - Mobilization Construction*, slopes longer than 7.5 m (25 ft) may require additional erosion-control measures, such as construction of horizontal terraces. The final soil cover on a completed landfill disposal facility must be seeded or otherwise vegetated to minimize erosion.

3-5.4 Ultimate Use of a Landfill Site.

It is up to the combatant commander (CCDR) to decide how the land of a closed landfill will be used once it is closed in accordance with the closure plan. Typically, a closed landfill is off limits to heavy vehicles. Also, other agreements with the HN like a SOFA may play a critical role in decisions regarding the ultimate use of a closed landfill site. A closure plan must be developed early in the life of the landfill—potentially during the design or site development phase.

3-5.5 Access Road.

An access road must lead to the main access control point of the landfill from the public road system. The road must be capable of carrying the load of the collection trucks in all weather conditions and should consist of a minimum of two lanes, 7.5 m (25-ft) wide, for two-way traffic. The slope of the road should be no more than the design specification of service vehicles or any other equipment that will use the road. The access road may also lead to the vicinity of the working area; however, the access road should not cross completed cells.

Secondary or branch roads are used to deliver wastes to the working face from the access road due to the fact that working faces are continuously changing. A secondary or branch road is temporary and will be used only until the area or cell is filled. Therefore, a secondary or branch road can be constructed by compacting natural soil and topping it with gravel, crushed stone, crushed concrete, or asphalt binder, depending on the site condition and availability of the material.

3-6 LEACHATE CONTROL.

3-6.1 General.

Landfill leachate is the liquid that percolates through the strata of solid waste deposited in the landfill. The source of water to form leachate comes from either infiltration of water through the refuse or groundwater movement through the landfill. Landfill refuse will absorb a certain amount of water and remaining water will percolate through the liner out to the environment. If the landfill is located on or near a drinking water source then management of leachate is critical to protect both surface and groundwater.

3-6.2 Composition of Leachate.

Table 3-3 lists characteristics of common leachate constituents from a typical municipal solid waste landfill[6]. The composition of the leachate can vary considerably based on the type of waste buried, amount of infiltration, and age of the landfill. The composition of the leachate varies from landfill to landfill and mostly depends on what type of waste is buried in the landfill. A non-hazardous solid waste landfill will produce leachate mostly consisting of organic content (carbon and hydrogen).

Table 3-3 Leachate Characteristics and Average Values of Common Constituents

Constituents (in mg/L except pH)	Average Concentration in Newer Landfills (in mg/L except pH)	Average Concentration in Older Landfills (in mg/L except pH)
pH	6	8
Biological oxygen demand (BOD_5)	13,000	180
Chemical oxygen demand (COD)	22,000	3,000
Calcium	1,200	60
Iron	780	15
Ammonia	740	740
Total phosphorus	6	6
Chloride	2120	2120

3-6.3 Leachate Collection.

A landfill carefully constructed using a clay liner should not require a leachate collection system. The landfill site should be carefully selected to ensure the bottom of the landfill is 1.5 m (5 ft) above the highest seasonal groundwater level and not located on top of a groundwater aquifer or nearby surface water that serves as a source of potable water for local inhabitants. Note that geotechnical expertise is required to make this determination.

3-6.4 Leachate Treatment.

When landfill leachate is collected, it should be treated onsite in a wastewater treatment lagoon or wastewater collection system. If onsite treatment is not available, offsite treatment of the collected leachate should be considered. In an arid region, build an evaporation bed for disposal of collected leachate. Excavate the top 7.5 cm (3 in.) of the evaporation bed quarterly and use as daily cover in the landfill. In other regions or in

[6] Kjeldsen et al. 2002

any other situation, discharge leachate to the local municipal wastewater plant, with prior approval. Final disposal of the leachate through a contractor should not be considered until all the options described above are evaluated.

3-7 METHANE GAS CONTROL.

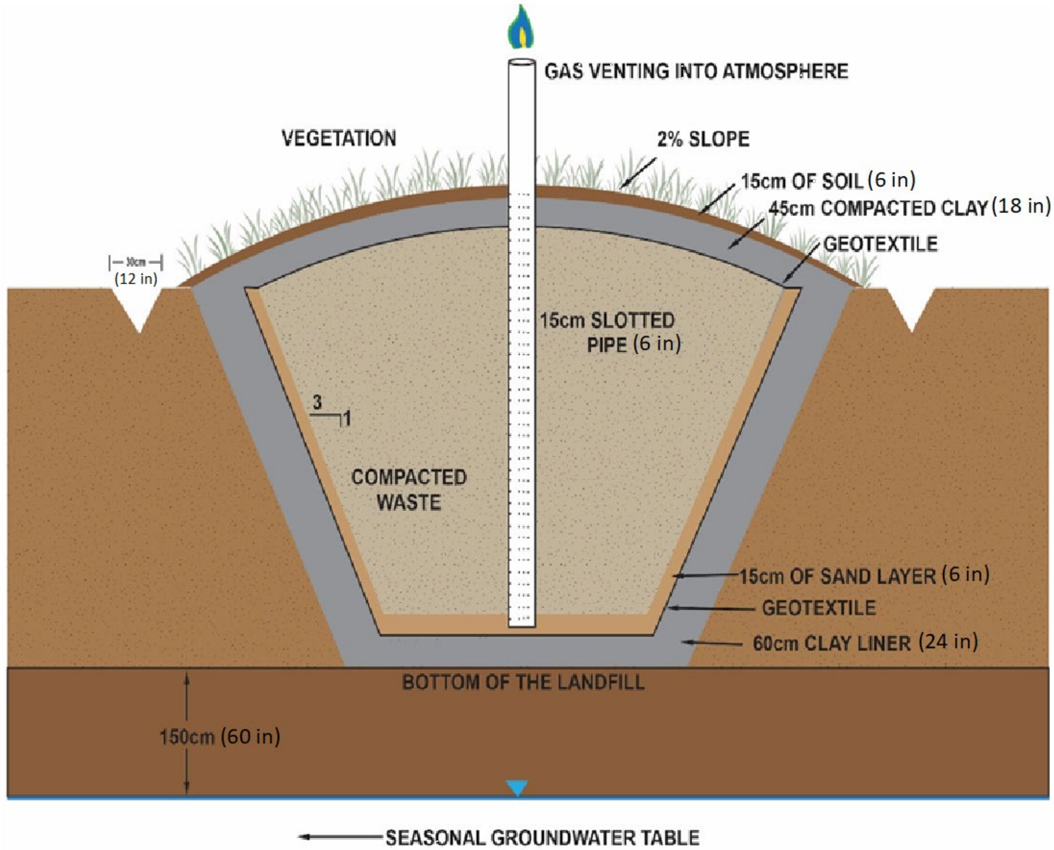
3-7.1 Production.

Methane gas production in a landfill is part of the natural process. Initially, the waste decomposes aerobically, depletes the available oxygen in the refuse, and produces carbon dioxide. Later in the process, in absence of oxygen, an anaerobic condition is created and methane gas is produced. Carbon dioxide and methane are two major gases produced from the decomposition of solid waste in landfills. The volume of gas generated depends on the quantity and quality of the waste disposed. Minimization of gas production must be the goal of the landfill designer. Gas reduction can be accomplished by controlling moisture in wastes. Anaerobic bacteria require nutrients and moisture to produce methane gas. Consider minimizing infiltration of runoff water into the solid waste through better compaction and slope, which will reduce gas generation. The drier the waste, the less amount of gas will be produced. Methane gas collection should not be the goal in a contingency situation unless otherwise directed by the CCDR.

3-7.2 Gas Disposal.

Consider a system to vent gas to the atmosphere through passive venting. Install a venting pipe with a perforated bottom through the waste depth at time of landfill closure up through the clay liner of the landfill to release gas into the atmosphere. One vent per 7,645 m^3 (10,000 cubic yards [yd^3]) of waste or approximately one vent for every 1,400 m^2 (⅓ acre) of land area may be needed to release gas into the environment. See Figure 3-6 for diagram. An observation monitor may be used at the landfill boundary to monitor methane concentration. The methane concentration should not exceed the lowest explosive limit (LEL) of 5 percent in facility structures on the landfill perimeter or at the landfill property boundary. The preventive medicine (PM) team should monitor LEL or any other health effects of landfill gas at least quarterly.

Figure 3-6 Design for Passive Gas Venting



3-8 STORMWATER CONTROL.

Controlling run-off water at a landfill site is critical to prevent environmental contamination and damage to the landfill structure. Specifically, runoff water can carry siltation to the working face of the landfill, add additional moisture to the refuse, and cause excessive leachate and increase gas generation. The landfill final cover must be compacted and sloped to the maximum extent to prevent infiltration of precipitation and minimize leachate and gas generation. The final soil cover on completed portions of the landfill must be seeded or otherwise vegetated to minimize erosion. A stormwater control system must be in place to prevent surface water run-on discharge into the working face of the landfill using berms, dikes, or ditches. Such structures must be designed to protect the landfill from a 24-hour, 25-year storm.

3-9 SUPPORT FACILITIES.

Support facilities required for support of landfill operations will vary, depending on contingency location, operation of the landfill, and availability of resources. The requirement will be different if a landfill is operated by Service members versus operated by a contractor. For example, if the landfill is contractor operated, a scale will be required if the contract is based upon the quantity of the disposed solid waste. The facilities described in the following sections may be required to operate and maintain a landfill.

3-9.1 Administration Facility.

A building or semi-portable containerized unit with a sanitary system will be required on the perimeter of the landfill to manage and run day-to-day operations of the landfill.

3-9.2 Control Facility.

A control facility should be located at the entrance of the landfill at a strategic location for truck inspection. Any unwanted materials should be denied entry at this point.

3-9.3 Sort and Separation Buildings.

All solid waste must be brought to a central location for manual sort and separation before going to the landfill. A manual sort and separation must be conducted to remove any sensitive materials such as ammunition even if the refuse is source separated.

3-9.4 Truck Scales (If Required).

If there is a need for the waste to be weighed, a truck scale must be located next to the control room.

3-9.5 Utilities.

Power, potable water, shower, and latrines are recommended for the landfill workers, as appropriate. A fire hydrant or other means of fire control should be available near the landfill.

3-9.6 Processing Equipment.

An equipment shed or facility should be centrally located for all equipment used for major operations involved in spreading waste after dumping, compacting waste, and spreading and compacting daily and final cover. Generally, a front-end loader, waste transportation truck, dozer, and compactor are needed for landfill operations. The dozer can serve as a compactor.

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CHAPTER 4 CONSTRUCTION

4-1 GENERAL.

Engineering plans will be developed based on technical specifications following the design criteria in Chapter 3. The first cell and half of the second cell will be excavated at the outset of the project, which minimizes the amount of initial excavation. As one cell is filled with waste, the next cell will be partially excavated; the excavated soil will then be used to support construction of the cap system over the filled cells. This process will continue throughout the life of the landfill.

4-2 TRENCH METHOD.

Before excavation, the area for the landfill should be cleared of all trees, shrubs, and grass. The topsoil should be removed and stockpiled for future use. Excavation using heavy equipment will follow the specifications identified in the engineering plans. The landfill cell should be sufficiently over-excavated to accommodate the compacted clay liner. Throughout the excavation process, rocks, gravel, and other soil and materials not suitable for the landfill should be removed.

During the excavation process, soils should be segregated and stockpiled based on their properties, paying close attention to segregate the soil layer identified in the technical specifications to be used for the clay liner. Prior to the installation of the liner, clay, or synthetic, the subgrade should be free from large clods and soft spots.

Trenches should be aligned perpendicular to the prevailing wind; this orientation can greatly reduce the amount of blowing litter. Refer to Figure 3-1 for layout of the trench method and Figure 4-1 for construction and operation of the trench and area methods of landfill.

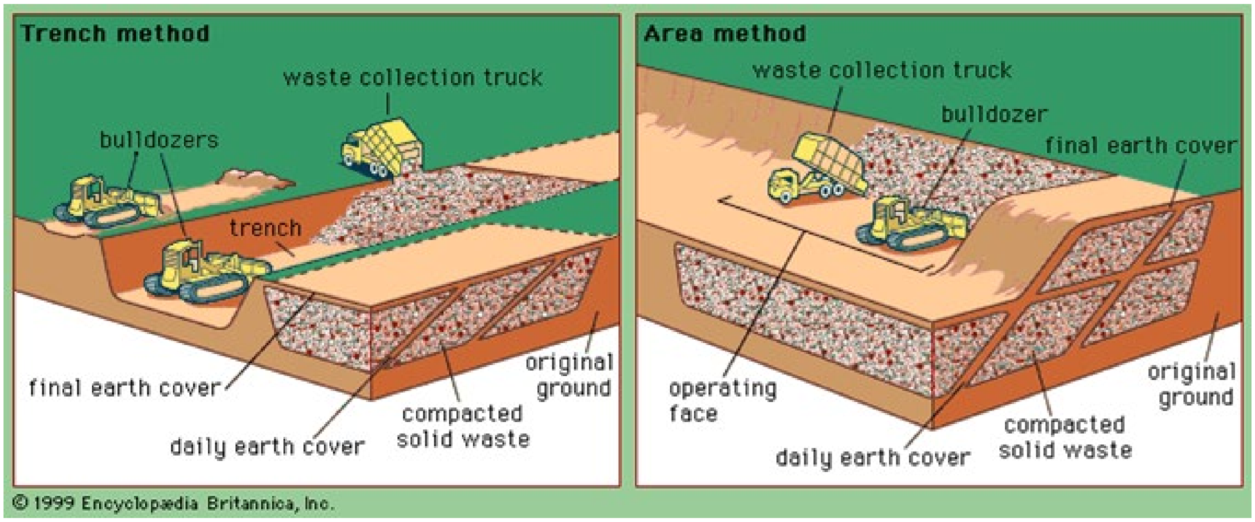
4-3 AREA METHOD.

The area method is used when the terrain is unsuitable for the excavation of trenches in which to place the solid waste and/or when the groundwater table is close to the ground surface. In this method, the waste is spread and compacted on the natural surface of the ground and cover material is spread and compacted over it. The area method is used on flat or gently sloping land and requires the least excavation. Daily cover soil may be available onsite or it may be hauled in and stockpiled from offsite sources. The filling operation is usually started by building an earthen levee against which wastes are placed in thin layers and compacted. The length of the uploading varies with site conditions and size of the operation. The width over which the wastes are compacted varies from 2.5 m to 6 m (8 ft to 20 ft), depending on the terrain (see TM 5-634, *Solid Waste Management*, paragraphs 4.2.7.2 and 4.2.7.3).

4-4 RAMP METHOD.

In this method, solid wastes are placed and compacted as described for the area method and partially or wholly covered with earth scraped from the base of the ramp. This technique makes a pit in which to place the next day's waste. Additional soil must be hauled in as in the area method. Due to the increasing costs and problems associated with obtaining usable cover material, the use of the ramp method must be based on an economic feasibility study and may not be a suitable method for a contingency operation.

Figure 4-1 Trench and Area Methods



The designer of a landfill should prescribe the method of construction and the procedure to be followed for solid waste disposal, as there is no “best method” for all sites. The method selected depends on the physical conditions and the amount and type of solid waste to be handled.

The cell is the building block common to both the trench and the area method. All solid waste received is spread and compacted in layers within a confined area. The dimensions of the cell are determined by the volume of the compacted waste, which in turn depends on the density of the in-place solid waste. Cells should be divided by berms or other means and stormwater should be eliminated from the working portion of the landfill.

4-5 CONSTRUCTION PRACTICES.

There are several important things to consider during construction.

- Depending on site-specific conditions, compacted clay is recommended to use as liner material
- All soil and layers on waste must be pushed ahead of equipment as operations progress. Even foot traffic should be kept to a minimum on liners.
- A good access road must be provided and maintained in the trench, with additional subbase installed.
- Access roads must be designed to support the anticipated volume of truck traffic.

- Grades should not exceed equipment limitations.
- If membrane liners are used, it is noted that they are highly susceptible to expansion and contraction during temperature changes and must be laid in such a way as to avoid stress on the seams.
- Liners should be held in place by anchor trenches, sand bags, or soil cover.
- Anchor trenches are commonly used at the top of the side slopes but should not be firmly compacted.
- It is better for the liner to slip slightly than to cause stress.
- If it is anticipated that a liner will be excavated and extended to cover a new cell at a later date, a minimum of 1.5 m (5 ft) edge of liner material should be protected to provide a clean, smooth surface for future seaming.
- Seaming of wet membrane surfaces is not allowed.

4-6 CONSTRUCTION QUALITY ASSURANCE.

The construction quality assurance program should describe expected performance by the closure contractor, such as removal or demolition of onsite structures, installation of fencing, repair or construction of sediment ponds, litter pick-up, etc. All piping systems (if any) and compacted clay liner must be inspected. If a membrane liner is used, the construction contractor must be required to submit field installation directions for the flexible membrane liner, in addition to manufacturer quality control guidelines. In addition, the gas generated within the landfill should be monitored. The quantity of gas generated depends on waste volume, waste composition, and time since deposition of waste in the landfill. Gas pressure, stress on vegetation, and toxicity of the gas are some of the venting issues that should be considered. Passive or active venting systems can be installed, which consist of a series of isolated gas vents.

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CHAPTER 5 OPERATION AND MAINTENANCE

5-1 LANDFILL OPERATIONS.

This chapter provides information to guide landfill construction and operation. Landfill operating procedures are determined by many site variables. The operational plan provides the landfill's technical details and procedures for constructing various engineered elements. The landfill could potentially be operated for months to years as needed during the contingency operation; therefore, personnel need to consult the plan to ensure long-term conformance. If necessary, methods can be used to extend the useful life of a landfill. Such methods include reducing the volume of materials before placing them in landfills and finding more efficient methods for depositing waste in landfills. Methods of operating a landfill could have an effect on landfill design; therefore, the desired method of operation should be reviewed before design commences.

5-1.1 Restrictions.

In general, only wastes for which the facility has been specifically designed will be accepted for disposal. Other waste types may be accepted if it has been demonstrated that they can be satisfactorily disposed of within the design capability of the landfill or after appropriate modifications have been made.

5-1.2 Cover Requirements.

Volume requirements for cover material depend on the surface area of waste to be covered and the thickness of soil needed to perform particular functions. Cell configuration can greatly affect the volume of cover material needed; therefore, the surface area needed should be kept to a minimum. Most soil materials can satisfy the purpose of cover soil. However, if minimization of infiltration is necessary, relatively low-permeability cover material should be used and placed at the steepest allowable grade to encourage runoff. Low-permeability soils will remain effective only if the soil has a low shrink-swell potential or if the soil moisture can be maintained to prevent cracks from shrinking and swelling. Design specifications in Chapter 3 should be followed for placing cover material. In addition, cells that will not have additional wastes placed on them for three months or more should be covered with 30 cm (12 in.) of cover material. Cover material minimizes fire hazards, reduces odors, controls blowing litter, and discourages scavenging. Covers also reduce exposure to birds, insects, and rodents, which can transmit human disease.

5-1.3 Working Face.

The working face is an area of active waste placement. The slope of the working face controls area to volume of the landfill and compaction of waste. The daily and intermittent cover should be obtained from the adjacent cell under construction. The waste should always be placed at the toe of the working face. Uncompacted waste will be spread in layers no more than 1 m (3 ft) thick before compacting. Once compacted, another layer of waste can be added and compacted so the waste cell will be several meters/feet thick before the daily soil cover is added. The working face should have a 20 percent to 30 percent slope and be as narrow as feasible to accommodate the number of trucks using the landfill.

Several layers may be compacted on top of one another. Each layer of waste may be spread with a thickness of no more than 0.5 m to 1 m (1.5 ft to 3 ft) and then compacted. The compacted waste occupies about one-quarter of its original loose volume. At the end of each day's operation, the waste is covered with a daily layer of 15 cm (6 in.) soil to eliminate windblown litter, odors, and insect or rodent problems. Thus, one cell contains a daily volume of compacted solid waste and soil cover. There are three basic methods of burying the waste: trench, area, and ramp. All three methods involve shaping one day's waste into a cell by spreading and compacting it in layers. Chapter 3 provides design specifications for these methods.

5-1.4 Entry Control.

Public access to landfills must be controlled by artificial and/or natural barriers to prevent unauthorized vehicular traffic and illegal waste dumping. A fence can be used to control or limit access. A wooden fence may be used to screen the operation from view. Litter fences or movable fences are used to control blowing paper in the immediate vicinity of the working face. Generally, trench operations require less litter fencing as the solid waste tends to be confined within the walls of the trench. At a windy trench site, a 1.5-m (5-ft) fence will usually suffice. When blowing paper is more of a problem in an area operation, higher litter fences are often needed. Gates that can be locked when the site is unsupervised will also control access.

5-1.5 Prohibited Items.

In general, only wastes for which the facility has been specifically designed should be accepted for disposal. Specific waste types that have chemical, biological, or physical characteristics that are not compatible with disposal site design, location, or operation; that pose an unacceptable environmental or health effect; or pose a threat to the safety of personnel or users of the facility should be prohibited from acceptance for disposal. A container holding liquid wastes cannot be placed in a landfill.

There must be a systematic process to exclude unauthorized wastes from the landfill. This will include:

- Random inspections of incoming loads
- Records of inspection
- Training for operators
- Notifying the chain of command if hazardous waste, PCBs, bulk liquids, or non-containerized liquids are discovered

5-1.6 Landfill Inspection Program.

One of the most important considerations is to design the system to facilitate inspection and maintenance. There should be access to all parts of the system to facilitate inspection. The landfill should be inspected for signs of erosion, cracking, or sloughing. The landfill should also be inspected for birds, insects, and rodents. Ensure entry roads are safe and provide all-weather access. Chapter 3 outlines procedures for operation and maintenance of leachate and landfill gas.

5-1.7 Groundwater Monitoring.

The groundwater around the perimeter of the landfill must be monitored, at least quarterly, to ensure the landfill is not leaking. It requires an expert to determine the number and location of groundwater wells to install and monitor. Table 3-3 lists some constituents that could signal the presence of leachate. Values must be compared to background groundwater levels.

5-2 OPERATING RECORDS AND CONTROLS.

The landfill operating record must be maintained and must include the types and amount of waste being buried, a topographical map, and documentation of the dimensions of the area being used for landfill.

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CHAPTER 6 CLOSURE

6-1 FINAL COVER.

Installing the final cover is as important as installing the liner at the base of the landfill. The main purpose of the final cover is to minimize the infiltration of water from precipitation or surface runoff; therefore, the final cover should be installed in the shortest possible time. As outlined in paragraph 3-5, the final cover of the landfill consists of 45 cm (18 in.) of compacted clay with a hydraulic conductivity less than 10^{-7} cm/sec ($4x10^{-8}$ in/s) plus 15 cm (6 in.) of earthen material capable of sustaining native plant growth; the final cover must be graded with a 2 percent slope at the top to form a crown. The clay liner compaction should be done at optimum moisture with uniform distribution of moisture. A clay cover should be installed when each cell of the landfill is completed. Restrict the travel of heavy equipment over the closed landfill once the final cover installation is complete.

6-2 MAINTAIN FENCES.

A security fence should be maintained at the closed landfill to control or limit access and discourage vandalism and trespassing. Digging by unauthorized personnel may compromise the integrity of the landfill cover and may initiate erosion of the final cover.

6-3 SIGNS IN LOCAL LANGUAGE.

Warning signs must be posted at the perimeter in both English and the local language, with a letter size in compliance with the contingency location standards. At a minimum, the sign should say “Warning: Landfill - No Unauthorized Access.” In addition, the sign should state the landfill closure date if the landfill is closed.

6-4 POST-CLOSURE CARE.

A properly designed and constructed landfill should require minimal post-closure maintenance. It is important to periodically inspect the cap for integrity and erosion. A closure plan must be prepared outlining the necessary steps to close a landfill unit, especially the installation and maintenance of the final cover. The closure plan must ensure the site is not disturbed as long as the site is controlled by the United States. Also, the closure plan may be beneficial when handing the landfill over to the HN to give them a starting point along with an environmental condition report. The main objective of a closure plan is to ensure a closed landfill does not affect public health and the local environment. A closure plan should include instructions for post-closure care and maintenance, including a groundwater, leachate, and gas-monitoring program, instructions for maintaining the final cover, a point of contact for the closed landfill, and a description of post-closure use of the land. These inspections and monitoring must continue as long as the US controls the site. Once the landfill is closed, the site must be identified on a contingency area map and must be recorded in the closure document when the base camp is closed. As part of the SOFA or any other agreement with the HN, the post-closure care and maintenance plan may transfer to the HN.

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APPENDIX A GLOSSARY

A-1 ACRONYMS.

°C	Degree Celsius
°F	Degree Fahrenheit
AFI	Air Force Instruction
ATP	Army Techniques Publication
BOD	Biochemical Oxygen Demand
BUMEDINST	Bureau of Medicine and Surgery Instruction (Navy)
CCDR	Combatant Commander
CCMD	Combatant Command
CLES	Contingency Location Environmental Standards
cm	Centimeter
cm/s	Centimeter per Second
CONUS	Continental United States
DoD	Department of Defense
DoDD	Department of Defense Directive
DoDI	Department of Defense Instruction
DoDM	Department of Defense Manual
EM	Army Engineering Manual
FGS	Final Governing Standards
FM	Field Manual
ft	Foot
ft^3	Cubic Foot
HN	Host Nation
HW	Hazardous Waste
in.	Inch

in./s	Inch per Second
ISWM	Integrated Solid Waste Management
kg	Kilogram
kg/m^3	Kilogram per Cubic Meter
km	Kilometer
lb	Pound
lb/yd^3	Pound per Cubic Yard
m	Meter
m/s	Meter per Second
m^2	Square Meter
m^3	Cubic Meter
mg/L	Milligram per Liter
mm	Millimeter
PCB	Polychlorinated Biphenyls
pH	Measure of the acidity or basicity of aqueous solutions
SOFA	Status of Forces Agreement
SOP	Standard Operating Procedure
TM	Army Technical Manual
UFC	Unified Facilities Criteria
yd^3	Cubic Yard

A-2 DEFINITION OF TERMS.

A-2.1 Waste.

Any discarded material. Waste is generally categorized as nonhazardous solid waste, hazardous waste (HW), or medical waste. Nonhazardous solid waste includes items such as food waste, discarded paper, cardboard, plastic, wood, construction debris, and glass.

A-2.2 Hazardous Waste (HW).

Any solid waste listed under the Resource Conservation and Recovery Act (RCRA), 40 CFR 261, as hazardous waste or exhibits any of the four hazardous characteristics of toxicity, reactivity, ignitability, or corrosivity. HW items include used solvents, contaminated fuel, petroleum-contaminated soils, paint waste, and batteries. HW management and disposal is outside the scope of this UFC.

A-2.3 Medical Waste

Any waste that is generated in diagnosis, treatment, or immunization of human beings or animals, that is capable of causing disease, or that, if not handled properly, poses a risk to individuals or a community. Medical waste requires special precautions due to its unique characteristics and potential to cause infection. Management of medical waste is outside the scope of this UFC. Refer to Service public health staff and the following publications:

- U.S. Army Medical Command Regulation 40-35, *Management of Regulated Medical Waste (RMW)*, provides information on management of regulated medical waste.

- AFI 41-201, *Managing Clinical Engineering Programs*, gives basic guidance on appropriate handling of medical waste in paragraph 5.16.

- BUMEDINST 6280.1C, *Management of Regulated Medical Waste,* gives detailed instructions on medical waste handling and disposal.

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FM 3-34, *Engineer Operations*, https://usacac.army.mil/sites/default/files/misc/doctrine/CDG/cdg_resources/manuals/fm/fm3_34.pdf

MEDCOM Regulation 40-35, *Management of Regulated Medical Waste (RMW),* https://www.qmo.amedd.army.mil/riskmgt/MEDCOM_Reg_40_35.pdf

TM 3-34.56, *Waste Management for Deployed Forces*, https://armypubs.army.mil/ProductMaps/PubForm/Details.aspx?PUB_ID=1006600

TM 5-634, *Solid Waste Management*, https://armypubs.army.mil/ProductMaps/PubForm/Details.aspx?PUB_ID=5253

AIR FORCE

AFI 41-201, *Managing Clinical Engineering Programs*, https://www.e-publishing.af.mil/

ASTM INTERNATIONAL

https://www.astm.org/

ASTM D2487, *Standard Practice for Classification of Soils for Engineering Purposes*

ASTM D4318, *Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils*

ASTM D5084, *Standard Test Methods for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter*

DEPARTMENT OF DEFENSE

DoDD 3000.10, *Contingency Basing Outside the United States*, https://www.esd.whs.mil/Directives/issuances/dodd/

DoDD 4715.1E, *Environment, Safety, and Occupational Health (ESOH)*, https://www.esd.whs.mil/Directives/issuances/dodd/

DoDI 4715.19, *Use of Open-Air Burn Pits in Contingency Operations*, https://www.esd.whs.mil/Directives/issuances/dodi/

DoDI 4715.22, *Environmental Management Policy for Contingency Locations*, https://www.esd.whs.mil/Directives/issuances/dodi/

DoDM 4715.05, Volumes 1–5, *Overseas Environmental Baseline Guidance Document*, https://www.esd.whs.mil/Directives/issuances/dodm/

Military Item Disposal Instructions (MIDI), https://phc.amedd.army.mil/topics/envirohealth/wm/Pages/Military-Item-Disposal-Instructions.aspx

UFC 1-201-01, *Non-Permanent DoD Facilities in Support of Military Operations*, https://www.wbdg.org/ffc/dod/unified-facilities-criteria-ufc.

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BUMEDINST 6280.1C, *Management of Regulated Medical Waste*, https://www.med.navy.mil/directives/ExternalDirectives/6280.1C.pdf

RESOURCE CONSERVATION AND RECOVERY ACT (RCRA)

40 CFR 261, “Identification and Listing of Hazardous Waste,” https://www.epa.gov/rcra/resource-conservation-and-recovery-act-rcra-regulations