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EPA

Project Summary

Design, Construction, and Operation of Hazardous and Nonhazardous Waste Surface Impoundments

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The document outlined here summarizes the state of knowledge regarding the design, construction, and operation of hazardous and nonhazardous waste surface impoundments containing liquids and sludges. The document draws upon research, mainly sponsored by the U.S. Environmental Protection Agency (EPA), and the practical experience of impoundment design engineers. It also draws upon the experience of the manufacturers and fabricators of containment materials who continually strive to improve the material's resistance to failure when exposed to various waste chemicals. Rather than providing details, the document summarizes and directs the reader to appropriate references.

The document first outlines the federal regulations under the Resource Conservation and Recovery Act (RCRA) that apply to waste-containing surface impoundments. It then describes predesign considerations, design characteristics, construction, and operation and maintenance of a completed facility. Contingency planning and response action plans to be implemented in the event of system failure or excessive leaks are discussed in some detail. Finally, a chapter is devoted to the closure of surface impoundments, with particular attention directed at hazardous waste surface impoundments. The chapter includes a description of final covers and post-closure maintenance.

This Project Summary was developed by EPA's Risk Reduction Engineering Laboratory, Cincinnati, OH, to announce key findings of the research project that is fully documented in a Technical Resource Document of the same title (see Project Report ordering information at back).

Introduction

There are approximately 180,000 waste-containing surface impoundments in the United States. The majority are used for the storage of nonhazardous waste, but many are used for the treatment, storage, and disposal of hazardous waste. Hazardous waste surface impoundments are subject to more restrictive regulation than are nonhazardous waste impoundments. Much of the waste impoundment technology development has been directed at hazardous waste containment, but it appears that most of that technology is also applicable to nonhazardous waste surface impoundments.

Regulatory Requirements

In general, RCRA regulations require that hazardous waste surface impoundments have double liners with a leak collection layer between the liners (Figure 1). EPA guidance recommends that the bottom liner be a composite of a geomembrane in direct contact with low-permeability soil. They must operate effectively through active impoundment use and a 30-yr post-closure period. All parts of the system must meet performance requirements. For example, chemical constituents of the waste must not migrate into the top liner nor migrate through the bottom liner.

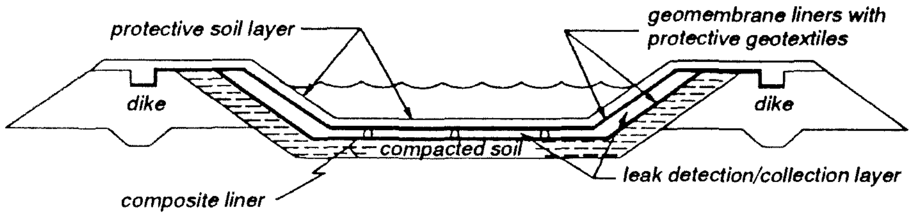

Figure 1. Cross section of double liner with composite bottom liner for a hazardous or nonhazardous surface impoundment.

Monitoring and inspection is required during construction and during the impoundment's operation for leaks, damage, and imperfections. Repairs must be made when necessary, or the unit must be removed from service. Contingency plans and response action plans are required as part of the permit process.

Closure must be either "clean closure," in which all contaminated residues are removed, or "in-place closure," in which the wastes are permanently stabilized and covered in place. Post-closure care is required for a 30-yr period for those facilities closed in place. It is not required for clean closure.

Pre-Design Considerations

A surface impoundment design engineer must consider the environmental surroundings and his design must include features that will protect against any potential failures that could be induced or promoted by the characteristics of those surroundings. Factors that must be considered are topography, surface and subsurface hydrology, geology, soil conditions, existing and future land uses, climate, and air quality. These factors should first be used in determining whether a surface impoundment is appropriate at the proposed site. If appropriate, then they will influence the magnitude of engineering safety factors used for structural component design.

Design

The first step in the impoundment design process is selecting the number, size, position, area, and depth of the desired structures. Generally these are most dependent on the type and amount of waste liquid to be handled and the rate of precipitation and evaporation.

An analysis must be made of the bearing capacity of the native soil in addition to a stability analysis of proposed dikes. A critical part of the design is the selection of liner materials for the required double liner system. Geomembrane liners are an essential part of the system to achieve impermeability, but they first must be proven capable of long-term containment of the waste that is to be handled. EPA guidance recommends a composite geomembrane-soil bottom liner. The hydraulic conductivity of the compacted soil component must be no greater than 1 x 10^{-7} cm/sec. The geomembrane and soil must be in direct contact to minimize lateral flow between them should a leak develop in the geomembrane.

The top and bottom liners of a double-liner system must be separated by a drainage layer that will allow liquid flow sufficient to remove any potential leakage through the top liner (Figure 2). The drainage layer may be of granular soil or geosynthetic material, so long as it can maintain a transmissivity of 3 x 10^{-3} m^2/sec over the long term.

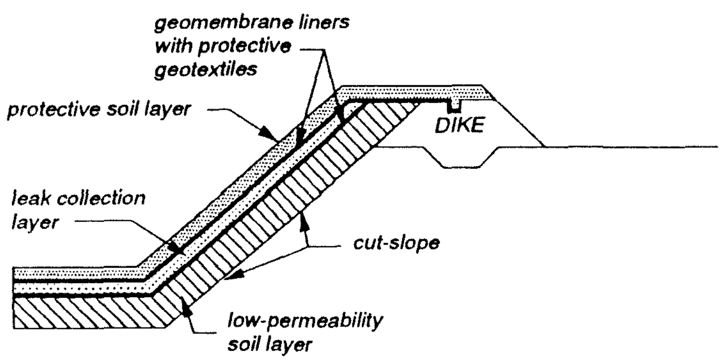

Figure 2. Surface impoundment dike and liner interfaces and layers.

Other layers may be required in the liner system to prevent intrusion of one layer into another or to facilitate liquid drainage or escape of gases. Generally, geotextile filters or geosynthetic drainage materials are most appropriate for these uses. They must be shown to be chemically resistant to any liquid or gaseous waste to be contained in the impoundment that the material potentially could contact.

Other components of the design include active and passive liquid level controls and warning devices, leak detection systems (mechanical or electronic) to detect leaks through the top liner, secondary containment to contain potential large sudden losses, and surface water drainage and diversion away from the impoundment. Controls should be designed for any potential volatile organic emissions. Finally, the design should include a construction quality assurance plan that addresses all structural components of the impoundment system during the construction phase. Lack of construction quality has been found to be the greatest controlling factor in system failures.

Construction

Foundation soils and any dikes must be cut and/or compacted to the design bearing strength. A compacted soil liner is then constructed. The desired degree of compaction, in all cases, is generally achieved with footed compactors. Compacted layers are usually finished with smooth rollers. A smooth surface on the compacted low-permeability soil component of the composite secondary (bottom) liner is critically important, as it must facilitate uninterrupted direct contact with the geomembrane on top of it.

Soils are generally placed in several lifts, individually compacted, to achieve the desired thickness, shape, bearing strength, and hydraulic conductivity. Test pads are first required, before actual construction, to determine if the design soil characteristics are achievable with the equipment to be used. Again, the finished soil liner is compacted as smoothly as possible to accommodate full contact with the overlying geomembrane.

Geomembranes and geosynthetic drainage materials are installed by experts in the techniques involved so that seams are sealed continuously and stress areas, such as wrinkles and folds, are minimized. Seams are placed up and down the sidewalls to minimize tensional stresses across the seams (Figure 3). Great care should be taken to make seams as strong as the panels they are connecting.

All construction should be subjected to a rigid construction quality assurance program, carried out by a third party who employs an experienced quality control engineer. Inspections and testing of potential points of weakness are done in a statistically valid manner. After completion of construction, the impoundment should be finally tested, preferably by filling with water and testing for leaks. Any discovered leaks must be eliminated.

Operation, Maintenance, Monitoring, and Contingency Planning

Operation, maintenance, and monitoring procedures should be spelled out before wastes are received, and the operating personnel should be fully familiar with the procedures. Maintenance and monitoring should be routine programs with scheduled periodic inspection and maintenance activities.

The procedures described in contingency plans and leak response plans should be instilled in operating personnel so that there is no question about their importance and the emergency responses that will be employed. These plans are of utmost importance, because they may prevent widespread damage in case of facility failure.

Closure

All waste-containing surface impoundments must eventually be closed. By regulation, two options are generally available, clean closure and in-place closure. Clean closure requires removal and/or decontamination of all contaminated materials. Removal generally requires the removed materials to be landfilled. In-place closure means that the contaminated materials are decontaminated to the extent possible and kept on the site permanently. In either case, the waste requires solidification with no free liquids remaining. Many treatment options are available for decontamination and solidification, but their effectiveness will be site-specific.

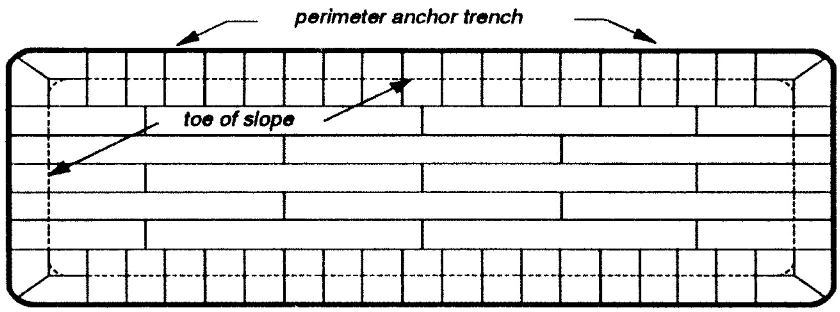

Figure 3. Layout for surface impoundment geomembrane panels.

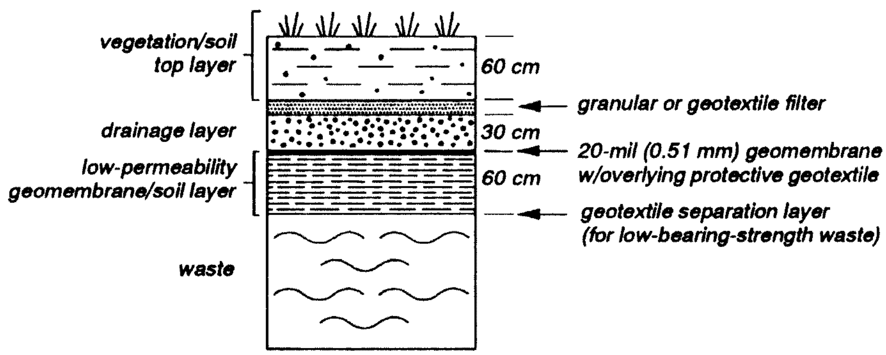

Figure 4. EPA-recommended cover system for hazardous and nonhazardous waste surface impoundments.

In-place closure requires a permanent landfill cover that meets the requirements of RCRA and EPA's minimum technology guidance for landfill covers (Figure 4). The cover must include a low-permeability hydraulic barrier, and USEPA recommends a composite geomembrane-soil layer much like the composite bottom liner recommended for a double-liner system. The cover requires monitoring and maintenance throughout a 30-yr post-closure period in accordance with an approved closure plan.

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***Robert E. Landreth** is the EPA Project Officer (see below).*
The complete report, entitled "Design, Construction, and Operations of Hazardous and Nonhazardous Waste Surface Impoundments," (Order No. PB91-204354/AS; Cost: $35.00, subject to change) will be available only from:
National Technical Information Service
5285 Port Royal Road
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