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Project Summary

Guidance Manual on Overtopping Control Techniques for Hazardous Waste Impoundments

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The overall objective of this project was to provide guidance for selecting cost-effective interim management methods to control overtopping of impoundments, pits, ponds, or lagoons at uncontrolled hazardous waste sites until final remedial actions could be initiated.

Hazardous waste impoundments are subject to overtopping through the collection of rainwater, run-on, or other uncontrolled inflow. Lagoon overflows are generally the result of insufficient capacity due to either insufficient freeboard (high level of lagoon contents) or structural problems that reduce the effective capacity. No matter what the cause, lagoon overflows can pose significant environmental and public health risks through the contamination of soils, ground water, and surface water, as well as the potential to spread the contamination into areas not currently impacted by the lagoon. Thus, interim measures may be necessary to control lagoon overflows prior to identification and selection of a final remedial measure.

A manual has been prepared that addresses both immediate control measures for emergencies and longer term measures lasting several months to several years. The technology and cost guidance presented is general in nature because of the variability of waste lagoons and impoundments and the unique conditions and considerations that exist at each site. Where possible, factors affecting application, technology selection, and costs are identified, as well as their likely impact on implementation and cost-effectiveness. Design issues are briefly presented as background to each option; however, the manual is not intended to replace the services of a qualified engineer in designing site-specific systems.

This Project Summary was developed by EPA's Hazardous Waste Engineering Research Laboratory, Cincinnati, OH, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

The Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) established a nationwide program for the cleanup of uncontrolled hazardous waste sites. Under this program, uncontrolled waste sites are identified and ranked, and removal or remedial actions are identified, studied, and implemented to eliminate or reduce contamination problems. Interim measures must often be applied to prevent or reduce further environmental contamination or threats to public health until final actions can be taken. The objective of this manual is to provide guidance on selecting cost-effective interim management methods to control overtopping of impoundments, pits, ponds, or lagoons at uncontrolled hazardous waste sites.

Impoundments are subject to overtopping through the collection of rainwater, run-on, or other uncontrolled inflow.

Lagoon overflows are generally the result of insufficient capacity due to either insufficient freeboard (high level of lagoon contents) or structural problems that reduce the effective capacity. No matter what the cause, lagoon overflows can pose significant environmental and public health risks through the contamination of soils, ground water, and surface water, as well as the potential to spread the contamination into areas not currently impacted by the lagoon. Thus, interim measures may be necessary to control lagoon overflows prior to identification and selection of a final response measure.

Typical response actions to temporarily control an overflow problem have included reconstruction of the impoundment berm to increase the freeboard, removal of liquid to lower the lagoon level, or both. However, other response methods such as run-on diversions and covers are available, and may often be more cost-effective.

Surface impoundments are highly variable in size, structure, design, and purpose. Lagoons have been used for treatment, storage, or disposal of liquid, solid, and semi-solid wastes from industrial, mining, oil and gas, and agricultural operations. They may be square, rectangular, circular, or irregular in shape and may be unlined causing seepage to underlying soils or lined to prevent seepage. Furthermore, lagoons may be built aboveground or belowground via natural or manmade depressions. Commonly, more than one surface impoundment may be found at a particular site and these multiple impoundments may be interconnected. These features, in conjunction with site-specific characteristics, can significantly affect the choice of overtopping control measures.

Manual Content

The manual has been prepared to provide technical guidance to On-Scene Coordinators (OSCs); Federal, state, and local officials; private firms; and field personnel. It presents guidance for selecting impoundment overtopping controls as a temporary solution pending final response action. As such, it addresses both immediate control measures for emergencies and longer term measures lasting several months to several years.

The technology and cost guidance presented are general in nature because of the variability of waste lagoons and impoundments and the unique conditions and considerations that exist at each site. Where possible, factors affecting application, technology selection, and costs are identified, as well as their likely impact on implementation and cost-effectiveness. Furthermore, while design issues are briefly presented as background to each option, this manual is not intended to replace the services of a qualified design engineer in designing site-specific systems.

The manual presents the selection process for overtopping control decision-making and key factors affecting selection decisions. Details are provided on pumping and wastewater management options; structural, floating, and air-supported cover systems; and surface water diversion and berm reconstruction technologies.

Selection of Overtopping Control Measures

The selection of overtopping control measures proceeds in four steps:

1. Identification of the site problem; i.e., specifically why the lagoon overflows and what site characteristics contribute to the overflow. At the same time, the site situation is assessed regarding the need for immediate emergency measures to be applied prior to identifying further interim control measures.
2. Preliminary selection of response options that may be applicable based on the site problem. Thus, the first and second steps of the selection process are closely linked.
3. Evaluation of the site characteristics affecting the applicability of a particular response. These characteristics are defined by the response technologies identified in Step 2 and are critical to the final evaluation and selection of a response in Step 4.
4. Selection of a single response option or combination of options that best controls the overflow problem until the final remedial action is undertaken. This selection process is highly site-specific and requires consideration of site-related decision factors relative to the applicable technologies and their costs.

Characterization of Overtopping Problem

Waste lagoon overtopping may be caused by insufficient lagoon capacity to accommodate liquid inflows to the lagoon or reduced lagoon capacity due to structural damage to the upper portion of the lagoon berm. Insufficient capacity may be the result of insufficient freeboard in the lagoon; precipitation; or run-on or overflows/liquid feeds from a connecting lagoon or other system. Structural damage reducing the effective lagoon capacity would include erosion, cracks, subsidence, breach, or other penetration of the lagoon berm in the area of the lagoon level.

In general, the nature of the overtopping problem is highly site-specific and must be evaluated in terms of the causal and contributing factors. For example, a crack in the top of an impoundment berm reduces the capacity of the lagoon if it penetrates from the interior berm wall to the exterior. Where the crack or break is sufficiently deep, there may be a single event of lagoon spillage. However, precipitation may quickly cause an overflow to recur.

Thus, the first step in selecting appropriate overtopping control measures is to identify the problem, including both the cause and the contributing factors. Once the reasons for the lagoon overflow have been defined, they can be used to identify potential actions to control the general problem until a final site action is developed.

If the lagoon is overflowing or overflow is imminent, immediate control measures are required. These control measures consist of constructing a temporary holding pond to contain the overflow or using a temporary pumping system to lower the lagoon level. Once the urgency of the problem has been reduced, appropriate control measures for the interim period prior to response should be identified and implemented. These measures will supplement or replace the stop-gap measures employed to control the immediate problem by identifying and addressing the contributing factors.

Identification of Applicable Response Options

Each problem has a choice of several technologies that may be applied. The selection of a single response will depend on site-specific factors. Where more than one problem is involved, the response options are expanded. Possible responses for overflow caused by precipitation include pumping, covering the lagoon, or raising the berm height. If both precipitation and run-on are causing lagoon overflow, the response options expand to include run-on diversions. Furthermore, the selected response may involve a single response option (e.g., pumping) or a combination of response options (e.g., construct diversion, pump, and cover).

It should be noted that certain response options require specific associated

responses. Pumping lagoons to remove liquid and increase freeboard requires management of the waste liquid. Similarly, raised covers such as air-supported and arch-supported structures may require vapor or condensate control to prevent the buildup of hazardous gases inside the structures or release of liquids outside the lagoon berm. The impact of these requirements must be considered in the selection process.

Evaluation and Selection of Overtopping Controls

A specific control measure is selected based on technology and site-related decision factors. This process involves a simple cost-effectiveness evaluation to decide among competing control responses. The manual presents summary tables for the potentially applicable technologies (e.g., pumping, wastewater management, lagoon cover systems, berm reconstruction, and surface water diversion systems) which include specific, decision-related criteria regarding technology applicability, limitations, and costs.

The technology evaluation should screen the options based on applicability to the site problem (defined through the site criteria) as well as the potential to reuse any permanent systems or materials or the need to demolish structures such as covers or diversion structures for final site action. The reuse of a system will impact its cost-effectiveness since the capital investment is spread over several applications. Alternatively, the removal of a cover and its anchoring system or the demolition of diversion structures may impact the costs of the final remedial action.

Other criteria included in the technology evaluation are:

- Anticipated length of time before remedial measures are implemented
  - Short time intervals (less that 3 months) would support a pumping system or diversion structures.
  - Long time intervals (3 to 5 years) would support cover systems.
- Urgency of problem
  - Where lagoon overflow is imminent, pumping or construction of a temporary holding pond would be indicated.
  - Where the situation is less urgent, pumping may be used as an initial measure prior to another control response or pumping alone may be implemented as a control measure.
- Time to implement control measures
  - Cover systems will require more time to implement than the use of pumps or site reconstruction.
- Size of lagoon
  - Structural covers cannot be used where the smallest dimension exceeds the greatest width available.
  - Multiple pumping stations or berm reconstruction may be more cost-effective than a floating cover for large lagoons.
  - Covers may be more applicable to small and moderate sized lagoons where frequent pumping may be necessary.
- Volume of liquid to be removed
  - Areas with heavy or frequent rainfall would favor a permanent pumping station, berm reconstruction, diversion structures, a cover, or a combination of these options.
  - Areas with isolated precipitation events would favor temporary pumping stations.

As part of the cost-effective selection effort, general estimates can be made for rapid comparisons of responses and decisionmaking. One method would be to average the costs over the length of time that the control measure is in effect. In such cases, the costs should include gross estimates of maintenance, inspection, and repair activities that would be likely within the time period. Detailed cost guidance is available through EPA procedural manuals.

Both the technology and cost comparisons should consider single-response options and multiple-response options. In some instances, a technologically complex solution may be more cost-effective than a technologically simpler solution. For example, under certain conditions it may be more cost-effective to install a floating cover on a lagoon (including an initial pumpdown and some berm strengthening) to control overflow resulting from precipitation than to pump down the lagoon level several times a year while the final response action is under study. Of course, this decision depends on the expected length of time before final measures are implemented, the technology costs, and on-site features such as precipitation patterns.

Of special importance is the evaluation of pumping options. Either a temporary pumping system can be brought in when needed or a permanent pumping system can be constructed. The decision would depend on the number of times pumping would be necessary and the relationship of pumping to other options. However, where frequent pumpdowns are necessary (e.g., due to heavy annual rainfall), a permanent pumping station should be selected unless a more cost-effective control option is available. Lagoon size, volume of liquid to be pumped, frequency of pumping, and wastewater management requirements would all affect the selection of this option.

Wastewater management options also involve a complex evaluation. Wastewater management is always necessary in conjunction with pumping. Management options involve a number of on-site and off-site methods to store, transport, treat, or dispose of pumped liquids. Liquids could be pumped to a storage tank on-site or a tank truck may be used to transport wastewater to an off-site Publicly Owned Treatment Works (POTW) or commercially operated treatment facility. Mobile treatment units may be brought on-site to pretreat wastewater in order to make it acceptable for a POTW. Wastewater can also be discharged directly from the site to a surface water body if it meets water quality standards. Finally, the liquid may be discharged directly to a POTW provided that sewer connections are available and the composition of the liquid is acceptable for the POTW. Key decision factors will involve the type of pumping system selected (temporary or permanent), wastewater quantities, wastewater characteristics, available facilities, etc.

The manual discusses factors affecting selection, installation, and costs of pumping systems as well as various wastewater management options.

Lagoon Cover Systems

Waste lagoons may be covered to prevent precipitation accumulation that may cause the impoundment to overflow. A variety of commercially available cover systems have been used in similar applications.

Frame-Supported Tension Membrane Structures

Frame-supported tension membrane structures provide an efficient and stable building with a free span coverage of a site. These structures consist of fabric panels tensioned between specially designed arches. Such structures are available commercially from a number of manufacturers and have been used in exhibitions and fairs, and in aviation, manufacturing, recreation, military, and mining applications.

Frame-supported tension membrane structures are available at total costs ranging from $8/ft^2$ to $19/ft^2$. There are

limited operational costs unless special control systems are required. They cannot be used if the smallest lagoon dimension is greater than 140 feet or if the soil conditions are inadequate to support the load of the structure and/or the construction equipment. The site must also be easily accessible in order to erect the structure. The frame is susceptible to attack by strong acids and may require treatment with special coatings in an acidic environment.

In general, this option is not feasible for short-term usage at a single site. This type of structure is reusable and can be decontaminated; accordingly, its application may be cost-effective if reuse at other sites is practicable.

Prefabricated Steel Frame Buildings

Prefabricated steel frame buildings such as those used for warehousing may also be used to cover lagoons. There are many manufacturers of steel frame buildings and various types of structures. The rigid frame system is one of the more common and most practical to use over moderately sized lagoons.

The total costs of a prefabricated steel frame structure to cover a lagoon varies from $\$14/ft^2$ to $\$23/ft^2$ depending on the site, design of the structure, coating required, and manufacturer. (In most cases, a special coating may be required to increase the longevity of the structure). The structure can be decontaminated, dismantled, and reused. This structure cannot be used if the smallest lagoon dimension is greater than 200 feet. As with other structures, it is necessary to determine the stability of the soil to withstand the loading of the building and construction equipment.

In general, the high costs of a prefabricated steel frame structure make this control measure infeasible unless it can be reused at other sites.

Air-Supported Structures

Air-supported structures have been used for warehouses and construction shelters, and for covering recreational and sewage treatment facilities. This type of structure is a totally free-span structure that maintains stability in space and resistance to loads through a pressure differential between the interior and exterior of the structure. This method of support leaves the interior free of poles, pillars, or other support devices that would be impractical to erect over a lagoon.

Air-supported structures can cover lagoons of many configurations and sizes. Their total costs range from $\$3.25/ft^2$ to $\$10/ft^2$ and are thus highly competitive with other technologies used for overtopping control. The coated fabric used in the structure can be selected to be compatible with the contents of the lagoon. Heating, ventilation, condensate, and air pollution controls can also be designed to meet specific lagoon and site requirements. These auxiliary systems impose additional costs to the cover system; however, the cover can be decontaminated and is reusable.

There are several limiting factors for the application of air-supported structures. If the smallest lagoon dimension is greater than 550 feet, this system cannot be used. The soil conditions may preclude certain anchoring systems or require the construction of concrete anchoring bases, which will increase the system cost.

Floating Cover Systems

A floating cover consists of a lining placed in one piece over an impoundment with proper anchoring at the edges and floats to prevent the lining from submerging. According to industry officials, approximately 80 to 85 percent of all floating covers have been constructed over potable water reservoirs. The remaining 15 to 20 percent have been used at biodegradation facilities, slaughterhouses, chemical treatment ponds, and toxic waste lagoons.

Floating covers are less expensive than any other type of covering system, ranging in total cost between $\$2.50/ft^2$ and $\$6.50/ft^2$. The lining material used can vary according to the contents of the lagoon; Hypalon is the most common type of liner used. Use of a floating cover is limited if there is a substantial amount of debris on the surface of the lagoon or submerged in the lagoon that may puncture the cover. Another limitation of the floating cover is that the fabric may not be reusable due to swelling from exposure to lagoon contents.

Surface Water Diversion and Berm Improvements

Lagoons may overflow due to surface water run-on or berm degradation. The manual discusses options that either maintain or increase the holding capacity of the lagoon by:

- Diversion of liquid inflow from surface run-on through the use of ditches, diversions, dikes, and berms.
- Prevention of waste material outflow through the construction or reconstruction of berms.

These control options are unique relative to other overtopping controls discussed because they are directed at preventing overtopping through measures applied, *external* to the impoundment (i.e., on the walls or surrounding areas).

Surface Water Controls

Surface water controls are improvements external to the impoundment and its immediate area that prevent liquids from entering the impoundment or eroding impoundment walls. When designed, constructed, and maintained correctly, surface water controls can extend the useful life of the impoundment by either preventing run-on, which fills available lagoon capacity, or reducing wall degradation, which lessens available lagoon capacity. Surface water control techniques include:

- Ditches, diversions, and waterways: small drainage ways that intercept and divert run-on away from an impoundment.
- Diversion and interceptor berms and dikes: structures that intercept and divert run-on away from an impoundment.
- Terraces and benches: wide drainage ways that slow down run-on and divert it to ditches and diversions.
- Levees and floodwalls: embankments used to prevent contact of floodwaters and tides with the impoundment.

These options are discussed in detail in the manual. Also included are unit costs for construction of ditches, diversions, and waterways, as well as costs for other diversion structures. In general, costs of surface water controls are very dependent on such items as:

- Extensiveness and terrain of area requiring control.
- Number and size of structures required.
- Amount and type of non-local materials required (e.g., cement, asphalt, synthetic liners, etc.).
- Accessibility of the site (especially for heavy machinery).
- Severity of weather patterns.
- Design life of control.

Impoundment Wall Construction and Repair

When designed, constructed, and maintained correctly, improvements to surface impoundment walls can extend the useful life of the impoundment by either maintaining or increasing its capacity until final response actions are implemented. This can be accomplished by either repairing existing defective walls and/or

increasing the height of berms to increase capacity. These options, along with associated costs, are discussed in detail in the manual. Factors influencing the costs are similar to those identified for surface water controls.

Conclusion

Presently, the most common method of preventing overtopping of abandoned waste lagoons is pumpdown/treatment of the upper two feet of the waste liquid. Since this costs between $0.10/gal and $.40/gal, this method can be expensive, especially if it must be performed several times prior to final cleanup of a site. Alternative methodologies are available; however, the final costs will depend on many site-specific factors. These factors, along with details on alternative technologies such as: pumping and wastewater management, various lagoon cover systems, surface water controls, and impoundment wall construction and repair, are presented in the manual. The manual will enable Federal, state, and local officials to select a technology or series of technologies for short-term control of impoundments that are subject to overtopping through collection of rainwater, run-on, or other uncontrolled inflow.

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The complete report, entitled "Guidance Manual on Overtopping Control Techniques for Hazardous Waste Impoundments," (Order No. PB 86-154 168/AS; Cost: $16.95, subject to change) will be available only from:

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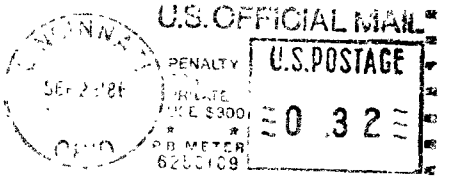

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