CHAPTER 1

INTRODUCTION

Stability failures at *waste containment facilities* are associated with many risks. These include risks to human health, the environment, communities, governments, and *responsible parties*. Risks to human health include the possibility of injury or death to individuals and disease from exposed waste. Many risks to the environment exist from stability failures. Ground water contamination can occur from ruptured lining systems or infiltration through an impaired cover system. Surface water contamination and flooding can occur from waste, wastewater, or engineered components that slide into rivers, creeks, and lakes; and from contaminated runoff from exposed waste due to a damaged cover system. Air contamination can occur from fires that ignite exposed waste or gases released during stability failures. Waste collection, treatment, and disposal may be interrupted for communities or for the *responsible party* (for a captive facility) serviced by a particular *waste containment facility*.

Figure 1-1 An Ohio landfill near Cincinnati experienced a massive slope failure in 1996 that resulted in 18 fires during the 9 months it took to cover the exposed waste.

Stability failures can present large unanticipated costs to federal, state, and local governments for oversight of mitigation and remediation efforts. *Responsible parties* may accrue liabilities that include financial and legal responsibility for injuries, damages, lost income, redesign, agency re-approval, repair, and extended monitoring and maintenance.

Stability failures are not necessarily large mass movements of materials. Damaging stability failures can be slight movements of a waste mass or cover system that may not be detectable through casual observation.

In 1996, at an Ohio landfill near Youngstown, approximately 300,000 cubic yards of waste shifted and destroyed several acres of the composite liner system. The only indications that a slope failure occurred were the appearance of cracks in the daily cover soils and a slight heave near the toe of the slope (Stark et al, 1998).

The complexities involved in estimating the stability of a modern *waste containment facility* cannot be overstated. These projects are often massive structures that heavily affect the structural integrity of the in situ soils, support structures, and geosynthetics. Often, the largest variables to contend with are the interactions that occur between the individual components of a *waste containment system*. Interactions between these materials occur during the construction, filling, and any settlement or deformation of the facility, and are difficult to predict with a high degree of accuracy. Because of this, site-specific, *higher quality data*, state of the practice analysis, and factors of safety are employed to ensure that *waste containment facilities* will be stable when they are constructed.

FACTORS CONTRIBUTING TO STABILITY FAILURES

Stability failures are often caused by processes that increase the applied shear stress or decrease the shear resistance of a soil mass, an interface between two geosynthetics, or an interface between a geosynthetic and soil (see Table 1 on page 1-3). Engineering design attempts to identify any vulnerable materials or configurations so that *waste containment facilities* can be designed to account for natural forces such as gravity, water flow, and biodegradation. Even so, construction and operational activities trigger most slope failures at *waste containment facilities*. These activities are often planned or performed independently of the design process and subsequently cause circumstances that were unforseen during the design of the facility. Examples of these activities include, but are not limited to:

- placement of soil or waste from the top of a slope downward,
- lengthy or unplanned excavations,
- regrading of waste for operational or closure purposes,
- leachate recirculation,
- overfilling,
- blasting,
- stockpiling materials,
- waste relocation,
- relocation of access roads,
- suddenly increasing or reducing the freeboard in lagoons, and
- inadequate base liner length on the *facility bottom* to resist driving forces caused by the waste on the associated *internal slope*.

The numerous failures that have occurred due to these activities underscore the need for ongoing coordination and involvement between the persons involved in design, construction, and operations.

An example of an operational or construction activity that may affect the stability of a *waste containment facility* is the necessity for providing ample tie-in distance beyond the previously constructed portion of the facility. This is so that no excavation of previously placed waste, cover soils, or berms will be needed in order to expose the engineered components from the previous construction. This is important for stability purposes because removing waste or soil from the tie-in area may decrease the resisting force for that portion of the facility and trigger a stability failure, especially if the tie-in is at the toe of a slope.

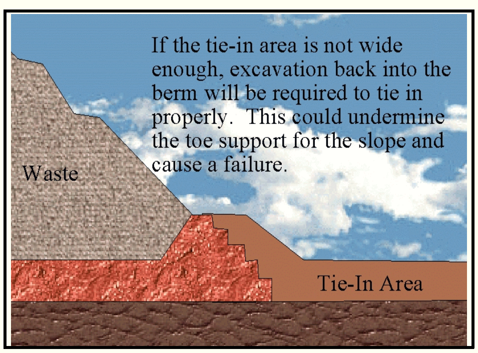

Table 1. Some factors that can adversely affect stability of *waste containment facilities*.

TYPES	COMMON CAUSES
Removal of toe support	
Natural causes	Erosion due to flow of ditches, streams, and rivers; wave action or lake currents; successive wetting and drying.
	Natural movement due to gravity such as falls, slides, and settlements away from toe; reduction in water levels after flooding.
Human activity	Cuts and excavations; removal of retaining walls or sheet piles; draw-down or filling of bodies of water (e.g., ponds, lagoons); excavation of waste; quarrying; borrowing soil.
Removal of underlying materials that provide support	
Natural causes	Weathering; underground erosion due to seepage (piping); solution of foundation materials from groundwater.
Human activity	Excavating; mining.
Decreasing the shear resistance of materials	
Natural causes	Water infiltration into cracks, fissures, and interfaces of engineered components; freeze/thaw cycles; expansion of clays; hydrostatic uplift.
Human activity	Using different materials causing lower interface shear strengths; using different or inappropriate construction methods causing lower internal or interface shear strengths of installed materials.
Increasing shear stresses	
Natural causes	Weight of precipitation (e.g., rains, snow, ice); increase in water levels in lagoons and ponds due to flooding; earthquakes.
Human activity	Stockpiling or overfilling; equipment travel or staging; water leakage from culverts, water pipes, and sewers; constructing haul roads; regrading of waste; increasing water levels in lagoons and ponds; increasing the density or loading rate of waste; blasting; vibrations from long trains passing by a location.

WHEN GEOTECHNICAL AND STABILITY ANALYSES ARE NEEDED

The appropriateness of conducting geotechnical and stability analyses must be considered whenever a *responsible party* is applying to Ohio EPA for authorization to permit, establish, modify, alter, revise, or close any type of *waste containment facility*. Usually, geotechnical and stability analyses are required by rule for these types of projects. Geotechnical and stability analyses should also be considered whenever circumstances indicate that doing so is prudent. Examples of circumstances indicating the need for geotechnical and stability analyses to be conducted include, but are not limited to:

- The facility experiences an earthquake that has a horizontal ground acceleration that approaches or exceeds the acceleration used in the stability analyses.

- A *phreatic surface* exceeds the maximum level evaluated in the stability analyses. This applies to flood waters against exterior berms, increased water levels in lagoons and ponds, and excessive leachate head in landfills, among others.

- New information is discovered about the characteristics of the *soil units* or engineered components that indicates the data used in the stability analyses may be incorrect or unconservative.

- After a failure, slip, or slump occurs that affects any engineered component of the facility.

- It becomes apparent to the *responsible party* that the design in the authorizing document must be changed while construction is occurring.

When a facility has experienced a failure or an earthquake or flood that approaches or exceeds design assumptions, a forensic geotechnical investigation and subsequent stability analyses should be conducted. These activities are conducted to evaluate the effects, if any, that the occurrence had on the engineered components and the stability of the *waste containment facility*. The results of all geotechnical investigations, stability analyses, and forensic investigations must be promptly submitted to Ohio EPA for review.

REFERENCES

Abramson, L. W., Lee, T. S., Sharma, S., and Boyce, G. M., 1996, Slope Stability and Stabilization Methods. John Wiley and Sons, Inc. New York.

Stark, T. D., Arellano, D., Evans, W. D., Wilson, V., and Gonda, J., 1998, "Unreinforced Geosynthetic Clay Liner Case History," Geosynthetics International Journal, Industrial Fabrics Association International (IFAI), Vol. 5, No. 5, pp. 521-544.