



Ensuring safety during landfill design

Ensuring landfill operator and customer safety starts with the landfill's design.

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Landfill safety starts with intentional design. Landfills are complex operations with many hazardous environments, physical settings and people and equipment interactions that can pose risks to landfill workers and customers. However, through more intuitive design considerations, today's professionals can help eliminate unsafe configurations and institute features that can proactively warn of and minimize hazards.



Figure 1: Steeply sloped landfill—difficult to maintain and poses safety challenges

Slope configuration design

Slope angle is a critical design parameter that determines the shape and available capacity of a site. There are the obvious factors, such as slope stability, that govern the maximum allowable slope angles of interim and final slopes as well as regulatory limits that influence maximum slope angles in a site. Designers must consider subgrade conditions, geotechnical factors and regulatory requirements when specifying how steep a landfill can be constructed.

Steeper slopes increase disposal capacity. As such, owners often push landfill designers to go as steep as possible with the slopes to maximize disposal capacity. The downside is that steeper slopes can pose increased hazards for maintenance and monitoring. Figures 1 and 2 on Page 33 illustrate steep and moderately sloped landfill configurations. Steeper slopes make mowing and maintenance of the sloped areas more difficult and dangerous. There are plenty of examples of overturned tractors and other heavy equipment mishaps occurring from operators mowing or working on slopes with aggressive inclines.

In addition to slope configurations, designers have to ensure easy access to important monitoring points and environmental control features such as landfill gas wells, condensate sumps and leachate sumps. Steep slopes can increase the difficulty of accessing and monitoring these features. Design criteria should consider the practical aspects of using equipment and potential personnel limitations during all phases of the landfill life to account for changing configurations.

Many states regulate the maximum design slope that can be constructed before settlement while other states allow slopes to be constructed greater than the design limit to allow for settling back to the maximum allowed slope. In the latter case, if the maximum allowable final slope is 4H:1V, the operator might construct to 3H:1V or steeper and allow the slopes to settle back to 4H:1V. As an example of state requirements, Pennsylvania specifies a maximum slope of 3H:1V. However, use of a settlement accommodation plan allows for construction of slopes greater than 3H:1V to a maximum of 40 percent as long as the slopes settle back to a maximum of 3H:1V within 5 years and the maximum permitted height is not exceeded by 10 percent. Pennsylvania also requires terraces be installed every 25 vertical feet if the slopes are approved greater than 15 percent. The risk of this type of design is that if the slope does not settle back as anticipated to a maximum of 3H:1V, waste material will have to be removed to ensure compliance.

In contrast, Virginia has no such settlement accommodation provision. Although 3H:1V slopes are relatively steep and pose some challenges for mowing and monitoring, especially in wet, icy, or snowy conditions, operators have been able to deploy equipment to maintain and mow these steeper slopes safely. Although state laws vary, it is up to the designers to take practical, safety and regulatory considerations into account when establishing the configuration of a landfill.



Figure 2: Landfill bench and well-vegetated side slopes with easy access to landfill gas well near the bench

Site monitoring design

Most landfills have monitoring points for groundwater and surface water. Some of these monitoring points can be in remote and difficult-to-access areas. That's why site access for safe environmental monitoring should be a design and operational consideration. Designing all-weather and maintainable access paths and establishing clear markers for these monitoring points can improve access safety and ease of monitoring. Figure 3 on Page 34 shows a challenging access configuration on an older closed landfill, and Figure 4 illustrates a better-defined and safer access example for monitoring on a newer landfill.

In Figure 3, there are no defined paths to the monitor wells, consequently mowing of the vegetation is infrequent, and ropes are needed to safely navigate from the top of the landfill slope to the bottom of the slopes to access the monitoring wells. Finding the monitoring wells can be a challenge, and the overgrowth of vegetation creates an environment friendly to snakes, mosquitoes and ticks. Figure 4 depicts a safer monitoring point configuration. The well is clearly marked, the area is free of debris and the monitoring area is protected from damage with bollards and a concrete collar that is easily accessible. Considering these features during the design process makes monitoring the landfill probes and the landfill groundwater, surface water or subsurface gases less costly.

Signage design

Simple and clear signage is a design element sometimes overlooked. Entering a landfill facility can be confusing for citizens. Questions regarding where to go in relation to the scale, the location of the active disposal area and the citizen drop-off area, and any vehicle restrictions that are in place can lead to unsafe behavior. Clear, large and visible signage is helpful for site users in explaining where they should go and how they should operate when navigating a landfill. For these reasons, the signage should be an important consideration during the design process and should be adjusted in the field depending on site operations.



Figure 3: Difficult access for environmental monitoring

Site access and traffic area design

Large garbage trucks and smaller passenger vehicles enter landfills daily. Safe landfill design protocols provide for the separation of these vehicle types through the presence of separate disposal areas. Distinguishing two areas for citizens and haulers helps minimize potential collision hazards in a busy, comingled dumping area. Many municipalities and private companies provide a safe disposal environment for the public using citizen convenience disposal areas away from the landfill itself.

The design width, surfacing material type and presence of traffic speed control measures can help create safer driving conditions. Specifically, sufficiently wide roads allow for safe two-way traffic between larger trucks. This helps prevent turnover that can occur when a truck is forced to move off the roadway edge on to softer landfill areas.

Citizen convenience center design

Citizen convenience centers keep public traffic separate from the large commercial and municipal collection vehicles that deliver waste to landfills. Despite design considerations enforced by the U.S. Department of Labor's Occupational Safety and Health Administration (OSHA) (<https://www.osha.gov/>) and other regulatory bodies, the design of these facilities can still pose unique safety challenges. Many of these facilities have elevated areas from which the public can unload into roll-off containers, which are located 8 to 12 feet below where the vehicles pull up. The primary hazard is citizens falling into the roll-off containers from the unloading area. Design features such as walls, railings and signage can help protect customers from slipping or otherwise falling into dumpsters. Designing these facilities on a grade can also help eliminate these fall hazards.



Figure 4: Well-designed monitor well access and protection

Landfill construction design

Safety concerns can arise during the construction of the environmental control systems at a landfill. For example, leachate and condensate sumps can accumulate explosive gases. Proper design of these mechanical/electrical systems and enclosure access points can help address these hazards. Also, appropriate signage needs to be installed to identify hazardous areas. Landfill gas wells should be designed with grates at the top of the borehole to protect construction and site workers from falling into these areas.

Achieving objectives

Every phase of landfill design should involve considerations of safety. Landfill designers should include features that minimize health and safety concerns associated with landfill construction and operation, including ways to configure landfills to allow for safe operation, access features to allow for easier and safer monitoring of the landfill's environmental control systems, and design elements that provide appropriate protection against the hazards that develop in a landfill environment. In order to meet these objectives, landfill designers must be willing to work in close collaboration with field and operations staff to incorporate a design that is user friendly, effective and safe.

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