ABSTRACT

The stabilization and reclamation of old disposal sites is becoming more important as significant numbers of disposal sites are closed and abandoned.
This technical paper covers an overview of the key issues and methodologies for stabilizing and constructing facilities on old landfills. The slide portion of this presentation also include photographs showing actual construction activities.

The key issues that are prevalent in remediating and closing old landfills are : correcting the stormwater flow, leachate breakout, constructing cover caps, controlling landfill gas migration and odors, cleanup groundwater and stabilizing side slopes. Some key techniques for constructing facilities on old landfills include : use of piling, installation of active landfill gas systems, providing LFG barriers under buildings, using utilidors and flexible utility interfaces and designing for site settlement.

This paper provides proven conceptual methods for solving these problems.

STABILIZATION AND RECLAMATION OF OLD LANDFILL DISPOSAL SITES

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This technical paper covers the remediating old and abandoned disposal sites and constructing facilities on old landfills. This overview describes proven conceptual methods for providing solutions to performing these activities.

Key Issues for Stabilizing Old Landfill Sites

The key issues to be discussed for stabilizing closed landfill sites include : stormwater erosion and infiltration, construction of cover caps, leachate buildup and breakout, surface in infiltration, landfill gas generation, migration, and odors, potential for explosion and fire, contamination of groundwater, and unstable side slopes. These issues are inter-related where the solution of one can impact the solutions of the others.

Controlling Stormwater

In order to control stormwater, cutoff channels and stormwater routing systems need to be installed to prevent infiltration. These open channels can be easily constructed to keep rainwater from contacting the waste pile. Usually, the open channels are constructed as V-trenches and follow contours to carry the water safely away from the edge of refuse. In some cases, the channel is lined to prevent ex-filtration due to high permeable soils. Once the surface water is re-routed, then proper cover caps can be installed to mitigate infiltration directly into the waste pile.

Impermeable Cover Cap

Installation of an impermeable cover cap is probably the most important element in stabilizing an old landfill site. Reduction of infiltrated precipitation will reduce the possibility of leachate buildup and the generation of landfill gas. Depending upon the availability of low permeable clays and local regulations, the cover cap can be constructed completely of soil or include impermeable geomembrane materials. Using geomembrane materials in a cover cap system can more complicated and more expensive

Leachate Buildup and Breakout

Infiltration of precipitation into the waste pile results in the buildup of leachate and can cause side slope breakouts. Because the waste is non-homogeneous and because waste is placed in layers, liquids will buildup in perched zones throughout the waste pile. When that buildup occurs over a lower permeable zones of material, the leachate can flow toward the side and if allowed will breakout and flow downslope. This can result in contamination of surface water and cause significant odors.

Several methods are employed to remediate the conditions. Vertical wells can be installed, however, they often result in low production because perched zones are difficult to determine. Horizontal wells can also be installed where the perched zone is known and where internal gas pressures are high. However, again the production utilizing this method is also low. Cutoff trenches are often constructed around that portion of the site where conditions warrant. Side slope trenches are also constructed

to collect leachate. These trenches usually route the liquid down slope to be connected to the leachate collection system. Temporary measures to restrict breakout can installing soil over the break zone.

Landfill Gas Control

Landfill gas, which is generated from commingling liquids with waste, needs to be controlled using both horizontal and vertical gas collection pipes. However, for closed landfills, installing horizontal pipes is difficult. Vertical wells need to be carefully engineered to assure that landfill gas can be completely removed. The best way is to use evacuation systems(blowers) because the influence from the collection system in increased. This will increase the chances that all gas can be removed.

In some cases, off-site gas removal systems will be installed to remove potentially dangerous gas that can affect off-site buildings. In all cases, experienced landfill gas engineers need to be used to assure that conditions where explosions and fire are potential will not exist.

Groundwater Contamination

Contamination of groundwater can be caused by several mechanisms including, impacts from landfill gas, and migration of leachate. Methods to mitigate groundwater contamination include limiting the amount of leachate through methods described earlier, collecting the contaminated water using pumping and treatment systems. A series of wells and collection systems followed by treatment have proven to cleanup groundwater over time. When volatile organic compounds are present air, scrubbing methods are employed are effective.

Stabilizing Side Slopes

Often old landfills are constructed with steep slopes(about 45% or steeper) that can become unstable. In order to stabilize side slopes, geotechnical conditions need to be evaluated, and if effected by seismic conditions, mitigated for those conditions. Examples, of proven methods are : reforming the slide slopes, installing soil buttress, and re-contouring side slopes. In addition, side slope drains are also installed.

When these normal remediation activities are implemented, the site will be stabilized, and with the addition of landscaping and continuous annual maintenance, the site can be used for other beneficial purposes.

Constructing Facilities on Old Landfills

Historically, reuse of old landfill sites has been limited to golf courses, parks or temporary low value facilities. These uses accommodate ground settlement or have short design lives where the effects of settlement are often ignored. Over the past 15 years, old landfills in major urban areas have been increasingly viewed as potential for traditional developments, such as office parks and commercial/industrial centers, due to the scarcity of developable lands. When developed correctly a nuisance site can be returned to productive use.

The types of beneficial uses can include :

Parks
Golf courses
Driving ranges
Commercial buildings
Industrial buildings
Landscape greenhouses
Equipment parking

The design process for constructing facilities on old landfills begins with a review of the geotechnical site conditions, and followed by defining site characteristics, review of fill plans, determination of site settlement, and conceptual design arrangements, including annual maintenance requirements. The following table describes characteristics of landfill sites to be re-developed.

Develop	Comments
Site Conditions	Natural soil cap Closed with cover cap Low land value Usually urban location
Characteristics for Development	Deep foundations or piles Major sensitivity to settlement Project driven by economics
Considerations for Developing Sites	Increases residual land value Avoid penetrations of cover barrier Minimize future maintenance requirements Simplify development approval process Minimize cover cap/development conflicts Begin planning before site closure

Develop	Comments
Site Conditions	Schematic plan submitted during closure approval Plan for increased annual operating costs
Site Development Design Process	Analyze historical documents Perform geotechnical studies Define boundary conditions Design for predictable settlement Define future site inspection and maintenance requirements Major sensitivity to settlement Preparation of operating plans

The key issues for developing facilities on old landfill sites are :

Use of site pilings to support buildings

Installation of active landfill gas systems

Landfill gas barriers to buildings

Utilidors for routing site utilities

Flexible utility interfaces

Stabilizing side slopes

Site settlement

Pilings to Support Buildings

For buildings placed on old landfills, use of piling is often used. On one site, we used 14 inch H piles that were driven through the waste pile and 20 feet into sub-surface soils. The reinforced concrete beams and slabs were constructed with support of the H piles. Pilings can span over 100 feet of thickness. Cathodic protection systems need to be installed to protect against corrosive action. For smaller buildings floating slabs can sometimes be used for support.

Active Landfill Gas Collection and Building Barriers

In order to protect the buildings from landfill gas migration and eliminating the potential for explosion and fire, a gravel layer and collection pipe system should be constructed under the building. When blowers are connected to the pipe system, a partial pressure is imparted evacuating the gas. This system is often combined with impermeable barriers which are placed above the collection pipe system to restrict migration from the building. The buildings are often installed with gas detectors and alarm system as a backup.

Utilidors and Flexible Utility Interfaces

Designing utility penetrations are very important in the development of new facilities on old landfills. Utilidors, which are reinforced concrete boxes, are used to house and route utilities. These units are initially placed at grade to allow utilities to cross areas where settlement will occur. At building interface points, flexible joints and pipes will be used to cross the interface. Access to utilidors is provided with panels on the top of utilidor. Typical utilities using this system are : power, gas, telephone, water, and sometimes steam lines.

Stabilizing Side Slopes

The systems described in the first section of this report can be used stabilizing side slopes For commercial buildings, safety is the most important reason for maintaining side slopes. Where 25% side slopes are planned for closed sites, often 10% slopes are needed at developments with buildings and industrial uses.

Site Settlement

The major design requirement(for developing facilities on old landfills is dealing with settlement. A site can settle 25% of the waste thickness over a 20 year period. This settling occurs over time as a non-linear function. When piling is used and utilities are carried in supported utilidors, settlement needs to be observed and usually settled areas are filled with soil to maintain grades. Of particular concern is ineffective maintenance can allow surface water access into the waste pile. Good engineering initially can provide predictability to the maintenance on the site. A 20-year straight line contour map should be prepared to show how the settlement will occur. This will result in an efficient maintenance program.

Conditions that will effect settlement are : depth of refuse, methods of compaction, topography of the landfill bottom, composition of landfill refuse, age of landfill refuse, thickness of landfill cover, and previous uses at the site. In order to provide effective site development, the following design goals and solutions need to be applied :

- Minimize additional fill
- Avoid penetration of the barrier layer
- Avoid or mitigate difficult boundary areas
- Mitigate difficult boundary areas with landscaping
- Mitigate difficult boundary areas with surcharge
- Use dynamic compaction where appropriate
- Provide for relocation of refuse
- Provide for flexible hinged slabs adjacent to buildings
- Provide for settlement inspection

Summary

In summary, the stabilization and reuse of old landfill sites will increase as additional old landfill sites are closed and abandoned. Reuse of those sites will occur in urban areas first because of limited high value land. When stabilization and redevelopment can be accomplished at the same time, economies will result. There are good examples of old landfill sites partially or completely redeveloped and reused. Over the last several years we have learned new ways to implement new developments, however all of them utilize the conceptual methods described herein.